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ISEE National Seminar 2026

Digital Technologies for sustainable food systems and Atmanirbhar Bharat

29-31 January 2026

Venue :
SALA de GASPAR HALL
MIRAMAR GOA

Organized by



Indian Society of Extension Education, New Delhi
in collaboration with

University of Agricultural Sciences, Dharwad
Goa College of Agriculture, Goa

ICAR-Agricultural Technology Application Research
Institute, Bengaluru and Pune



Centre for Multi Disciplinary Development Research, Dharwad
Goa Chambers of Commerce and Industries, Panjim, Goa





National Seminar on Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat
29-31 January 2026

Indian Society of Extension Education
New Delhi

National Seminar on
Digital Technologies for Sustainable
Food Systems and Atmanirbhar Bharat

29-31 January 2026

BOOK OF ABSTRACT

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New Delhi



**ISEE National Seminar on
Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat**

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DR. PRAMOD SAWANT
CHIEF MINISTER, GOA



Date: 28th January 2026

MESSAGE

It gives me immense pleasure to learn that the Indian Society of Extension Education (ISEE) is organizing its National Seminar on “Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat” at ICAR-CCARI, Goa from 29 to 31 January 2026.

Agriculture is the backbone of our nation’s economy, and the path to a truly Atmanirbhar Bharat (Self-Reliant India) lies in the seamless integration of modern digital tools with sustainable farming practices. This seminar provides a timely platform to explore how innovations like AI, smart farming, and climate-resilient technologies can empower our farmers and ensure long-term food security.

I extend my warmest greetings to the distinguished scientists, extension educators, and technology experts participating in this event. I am confident that the deliberations held during these three days will yield actionable strategies to transform India’s agricultural landscape.

I wish the organizers and all the participants a highly productive seminar and a pleasant stay in the beautiful state of Goa.

(Dr Pramod Sawant)



Shri Digambar V. Kamat

Minister for Public Works, Captain of Ports and Legal Metrology and ex Chief Minister
Government of Goa

No: 4/1/2026/Min (Pwd)/101

Date: 28/01/2026

MESSAGE

I am pleased to extend my heartfelt greetings to all the distinguished delegates, researchers, policymakers, and innovators participating in the ISEE National Seminar 2026 on "Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat", being held at Goa from 29-31 January, 2026. This seminar is a timely and significant initiative that reflects the growing importance of digital innovation in shaping the future of Indian agriculture.

Agriculture is the lifeline of our nation; it is the foundation of rural livelihoods, food security, and cultural identity. Over the past decade, we have witnessed how digital technologies are revolutionizing farming practices – whether through precision agriculture, satellite – based crop monitoring, mobile advisory services, or digital marketplaces. These innovations are not only improving productivity but also empowering farmers with real-time information, better access to credit, and transparent market linkages. The Goa government is committed to empowering smallholders, encouraging sustainable practices, and fostering innovation to ensure food security and prosperity.

The theme of this seminar, Digital Technologies for Sustainable Food System and Atmanirbhar Bharat, is deeply aligned with our national vision of self-reliance and sustainability. Atmanirbhar Bharat is agriculture means creating resilient food system that are resource-efficient, climate- smart, and farmer- centric. It means reducing dependency on imports, strengthening domestic production, and ensuring that farmers are equipped with tools and knowledge to thrive in a rapidly changing global environment. Digital Technologies are the bridge that connects traditional wisdom with modern innovation, enabling us to achieve this vision.



This seminar provides an excellent platform for dialogue and collaboration. The participation of experts across India and beyond will enrich our understanding of how digital tools can volatility.

I firmly believe that the path to Atmanirbhar Bharat lies in empowering our farmers, embracing innovation, and ensuring sustainability at every stage of the food system. I am confident that the discussion at this seminar will inspire new ideas and partnerships that will strengthen our collective journey towards a self-reliant and digitally empowered India.

I extend my best wishes for the success of the seminar and hope that the outcomes will contribute meaningfully to the future of Indian agriculture.

Shri. Digambar V. Kamat
Minister for Public Works,
Captain of Ports, Legal Metrology



डॉ. राजबीर सिंह
उप महानिदेशक (कृषि विस्तार)

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Dated: 29.12.2025

Message

I am pleased to learn that the Indian Society of Extension Education (ISEE) is organizing the National Seminar on "Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat" during 29-31 January 2026 at ICAR-Central Coastal Agricultural Research Institute (CCARI), Ela, Goa.

Indian agriculture is undergoing a profound transition, shaped by climate variability, resource constraints, and the need to ensure food and nutritional security for a growing population. These challenges call for strong, responsive, and technology-enabled extension systems that can rapidly translate scientific advances into field-level impact. In this context, digital technologies have emerged as critical enablers for strengthening agricultural extension, improving service delivery, and empowering farmers with timely, location-specific, and actionable knowledge.

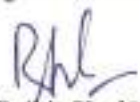
The seminar is highly relevant to the mandate of agricultural extension, as it seeks to critically examine the application of digital technologies with a clear focus on last-mile delivery, farmer engagement, and feedback integration. Krishi Vigyan Kendras (KVKs), as the frontline institutions of ICAR's extension system, are central to this transformation. Leveraging digital tools for real-time advisories, decision-support systems, participatory diagnostics, and systematic documentation of farmer feedback will be crucial for making extension more demand-driven, inclusive, and outcome-oriented.

The Indian Council of Agricultural Research (ICAR) is actively promoting the integration of digital solutions across research, extension, and education to strengthen the research-extension-farmer continuum. Initiatives such as digital soil health mapping, climate-smart village programmes, mobile-based advisory platforms, and e-enabled seed and input delivery systems illustrate ICAR's commitment to modernizing extension services. These efforts are aimed at enhancing the effectiveness of KVKs, improving outreach, and ensuring that technologies and innovations are customised to diverse agro-ecological and socio-economic contexts.

I firmly believe that the future of Indian agriculture lies in blending scientific innovation with farmers' knowledge and traditional wisdom, facilitated by robust extension systems. Digital technologies must be strategically deployed to empower small and marginal farmers, women farmers, and rural youth, while strengthening institutional convergence and partnerships at national and state levels. An extension system that is digitally enabled, participatory, and evidence-driven will be pivotal to achieving the goals of sustainable food systems and *Atmanirbhar Bharat*.

I extend my best wishes to all the distinguished delegates, extension professionals, researchers, policymakers, innovators, and development practitioners participating in this seminar. I commend the Indian Society of Extension Education for this important initiative. I am sure that the deliberations and outcomes will inspire new ideas, partnerships, and strategies to strengthen KVK-led digital extension and build a digitally empowered and self-reliant India.

Jai Hind


(Rajbir Singh)



ಡಾ. ಪಿ. ಎಲ್. ಪಾಟೀಲ
ಕುಲಸಚಿವ
Dr. P. L. Patil
M.Sc. (Agri.), Ph.D.
VICE-CHANCELLOR



ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಧಾರವಾಡ
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD
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Message

It is a matter of great pride and privilege to extend my greetings to all participants of the **National Seminar of the Indian Society of Extension Education (ISEE) 2026**, being held at Goa on the theme “*Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat*.” This seminar is a significant step in advancing the discourse on how digital technologies can transform agriculture, empower farming communities, and strengthen agricultural education and extension services in India.

Agriculture today stands at a critical juncture. While India has achieved remarkable progress in food production and self-sufficiency, the challenges of climate change, resource degradation, market volatility, and rural livelihood security demand innovative responses. The objectives of this seminar, examining the current landscape of digital technologies in extension education, exploring inclusive and scalable models for farmer empowerment, identifying challenges in adopting emerging tools, and deliberating on curriculum redesign and capacity-building strategies, are timely and essential. They provide a roadmap for integrating digital innovations into agricultural education and extension systems, ensuring that farmers are not only beneficiaries but also active participants in shaping sustainable food systems.

The themes of this seminar are deeply connected to the farming community and agricultural education. Discussions on intelligent technologies in digital extension for next-generation agriculture will highlight how tools like artificial intelligence, drones, and IoT can optimise resource use and enhance productivity. The theme of digital extension and education to empower farmers for Atmanirbhar Bharat emphasises inclusivity, ensuring that smallholders, women, and youth are equipped with digital literacy and entrepreneurial skills. By focusing on digital tools for sustainable food systems, the seminar underscores the importance of resilience, efficiency, and environmental stewardship in farming practices.

Equally important are the themes on global and local experiences in digital extension, which will enrich our understanding by drawing lessons from diverse contexts. The emphasis on digital applications in start-ups and entrepreneurship development resonates strongly with rural youth, who can harness innovation to create agri-businesses and contribute to self-reliance. The seminar also rightly addresses gender concerns in digital tools, recognizing that women farmers are central to food systems and must be empowered through targeted interventions.

Themes such as digital technology for climate-smart agriculture, market intelligence and digital applications are critical for risk management and fair market integration. Farmers equipped with digital advisories can mitigate climate risks, while e-platforms can ensure transparency and profitability in markets. Finally, the focus on quality control and food safety through digital applications is vital for



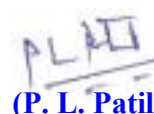
consumer trust and global competitiveness, ensuring that Indian agriculture meets international standards.

For agricultural education, these themes open new horizons. Curriculum redesign must integrate digital competencies, preparing students to be innovators and extension professionals who can navigate the digital landscape. Capacity-building strategies must emphasise participatory approaches, blending traditional wisdom with modern tools. Farmer-Producer Organisations (FPOs), when empowered through digital platforms, can become engines of collective action, enhancing bargaining power, market access, and resilience.

The success of this seminar is made possible through the collaboration of esteemed institutions. I wish to acknowledge the University of Agricultural Sciences, Dharwad, the Goa College of Agriculture, the ICAR–Agricultural Technology Application Research Institutes at Bengaluru, Pune, and Hyderabad (Zone-X), the Centre for Multi-Disciplinary Development Research (CMDR), Dharwad, and the Goa Chambers of Commerce and Industry, Panjim. Their partnership reflects the spirit of cross-sectoral collaboration that is essential for advancing agricultural education and extension. Together, these institutions bring academic rigor, grassroots experience, policy insights, and industry perspectives, ensuring that the seminar is both comprehensive and impactful.

As Vice-Chancellor of UAS Dharwad, I firmly believe that agricultural universities must play a pivotal role in this transformation. By integrating digital technologies into teaching, research, and extension, we can prepare the next generation of professionals to lead India’s agricultural renaissance. Our responsibility is not only to impart knowledge but also to create ecosystems where farmers, researchers, policymakers, and entrepreneurs collaborate for sustainable and self-reliant food systems.

In conclusion, the ISEE National Seminar 2026 is more than an academic event; it is a collective endeavour to envision and realise a future where digital technologies empower farmers, strengthen food systems, and contribute to the national mission of *Atmanirbhar Bharat*. I extend my heartfelt gratitude to the organisers, collaborators, and participants for their dedication and commitment. May the deliberations of this seminar inspire us to move forward with conviction, creativity, and compassion in building a resilient and self-reliant agricultural future.



(P. L. Patil)

Vice-Chancellor

University of Agricultural Sciences
Dharwad



Message

It is a matter of immense honor and privilege to extend my greetings to all participants of the National Seminar of the Indian Society of Extension Education (ISEE) 2026, being held at Goa on the theme "Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat." This seminar is a landmark occasion, bringing together scholars, extension professionals, policymakers, entrepreneurs, and farmers to deliberate on how digital innovations can reshape agriculture, strengthen food systems, and contribute to the national vision of self-reliance.

The themes of this seminar are deeply relevant to both farming communities and agricultural education. The focus on intelligent technologies in digital extension for next-generation agriculture highlights how tools such as artificial intelligence, drones, sensors, and IoT can optimize crop management, reduce input costs, and enhance productivity. The theme of digital extension and education to empower farmers for Atmanirbhar Bharat underscores the importance of inclusivity. Smallholders, women, and rural youth must be equipped with digital literacy and entrepreneurial skills to participate meaningfully in the digital economy.

The seminar's emphasis on global and local experiences in digital extension will enrich our understanding by drawing lessons from diverse contexts. Agricultural education must encourage comparative studies, enabling students and professionals to adapt best practices to local realities. Digital technology for climate-smart agriculture is critical for risk management, enabling farmers to adapt to changing weather patterns. Market intelligence and digital applications can revolutionise transparency and profitability, while quality control and food safety through digital applications are indispensable for consumer trust and global competitiveness.

The success of this seminar is made possible through the collaboration of esteemed institutions. I wish to acknowledge the University of Agricultural Sciences, Dharwad, the Goa College of Agriculture, the ICAR-Agricultural Technology Application Research Institutes at Bengaluru, Pune, and Hyderabad (Zone-X), the Centre for Multi-Disciplinary Development Research (CMDR), Dharwad, and the Goa Chambers of Commerce and Industry, Panjim. Their partnership reflects the spirit of cross-sectoral collaboration that is essential for advancing agricultural education and extension.

As Vice-Chancellor of UAS Bengaluru, I firmly believe that agricultural universities must play a pivotal role in this transformation. By integrating digital technologies into teaching, research, and extension, we can prepare the next generation of professionals to lead India's agricultural renaissance.

In conclusion, the ISEE National Seminar 2026 is more than an academic event; it is a collective endeavor to envision and realize a future where digital technologies empower farmers, strengthen food systems, and contribute to the national mission of Atmanirbhar Bharat. I extend my heartfelt gratitude to the organizers, collaborators, and participants for their dedication and commitment. May the deliberations of this seminar inspire us to move forward with conviction, creativity, and compassion in building a resilient and self-reliant agricultural future.

(S. V. Suresha)

Vice-Chancellor

University of Agricultural Sciences
Bangaluru



INDIAN SOCIETY OF EXTENSION EDUCATION

(Regd. under Society Registration Act 1860 (Regd. S-2504 of 1964-65)

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Message

It is with great pride and profound satisfaction that I extend my greetings to all participants of the **National Seminar of the Indian Society of Extension Education (ISEE) 2026**, being held in Goa on the theme “*Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat.*” This seminar marks yet another milestone in the illustrious journey of ISEE, which was established in 1964 with the mission of advancing the discipline of extension education and bridging the gap between agricultural research and farming communities. Over the decades, the Society has nurtured scholarship, organised national and international conventions, and published the *Indian Journal of Extension Education*, a Scopus-indexed quarterly journal that continues to be a beacon for extension scientists and practitioners.

The present seminar comes at a time when Indian agriculture is undergoing a paradigm shift. Traditional extension methods, once reliant on interpersonal communication and field demonstrations, must now integrate with digital technologies that promise precision, inclusivity, and sustainability. The objectives of this seminar are therefore both timely and transformative: to examine the current landscape of digital technologies in extension education, to explore inclusive and scalable models for farmer empowerment, to identify challenges and opportunities in adopting emerging tools, and to deliberate on curriculum redesign and capacity-building strategies that strengthen Farmer-Producer Organisations (FPOs) in the march towards *Atmanirbhar Bharat*.

The themes of this seminar have been carefully curated to reflect the breadth of this transformation. We shall deliberate on intelligent technologies in digital extension for next-generation agriculture, assessing progress and possibilities. We shall explore how digital extension and education can empower farmers for *Atmanirbhar Bharat*, addressing challenges and opportunities. The seminar will highlight digital tools to ensure sustainable food systems, examining both opportunities and constraints. It will bring together global and local experiences in digital extension and education, enriching our perspectives with comparative insights. The role of digital applications in start-ups and entrepreneurship development will be emphasised, recognising that rural youth and innovators are central to self-reliance.

Equally important are the cross-cutting concerns: gender dimensions in the application of digital tools, ensuring that women farmers and professionals are empowered and included; climate-smart agriculture through digital technologies, which is critical in mitigating risks of climate variability; market intelligence and digital applications, which can revolutionize transparency and profitability in agricultural markets; and finally, quality control and food safety through digital applications, which are indispensable for building consumer trust and ensuring sustainable food systems. Together, these themes provide a holistic framework for reimagining extension education in the digital age.



The success of this seminar is made possible through the invaluable collaboration of leading institutions. I wish to acknowledge with deep appreciation the University of Agricultural Sciences, Dharwad, the Goa College of Agriculture, the ICAR–Agricultural Technology Application Research Institutes at Bengaluru, Pune, and Hyderabad (Zone-X), the Centre for Multi-Disciplinary Development Research (CMDR), Dharwad, and the Goa Chambers of Commerce and Industry, Panjim. Their partnership reflects the spirit of cross-sectoral collaboration that is essential for advancing extension education. By bringing together academia, research institutions, policymakers, grassroots practitioners, agri-tech startups, and farmers, this seminar embodies the very essence of participatory knowledge creation and dissemination.

ISEE has always believed that extension education is not merely about transferring technology but about empowering communities. In the digital era, this empowerment must be inclusive, ensuring that small and marginal farmers, women, and youth are not left behind. It must be participatory, integrating traditional agricultural wisdom with modern digital tools. And it must be sustainable, aligning with the national vision of *Atmanirbhar Bharat*, a self-reliant India where farmers are innovators, entrepreneurs, and custodians of food security.

As President of ISEE, I am self-assured that the deliberations of this seminar will generate actionable insights, innovative strategies, and collaborative frameworks. The discussions will enrich academic discourse, inform policy, and inspire grassroots action. More importantly, they will reaffirm our collective commitment to building resilient food systems that are efficient, equitable, and sustainable.

On behalf of the Indian Society of Extension Education, I extend my heartfelt gratitude to all participants, collaborators, and sponsors for their dedication and support. May this seminar in Goa inspire us to move forward with conviction, creativity, and compassion, as we harness digital technologies to empower farmers, strengthen food systems, and realise the dream of *Atmanirbhar Bharat*.

Dr. U. S. Gautam

President

Indian Society of Extension Education



Professor and Head
Department of Agricultural Extension
UAS Dharwad
and
National Organizing Secretary
ISEE National Seminar 2026

Message

We are proud to organize the ISEE seminar on “Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat”. A digital extension system is an integrated and technology-driven method that uses digital technologies to extend and improve traditional extension and advisory services. It uses digital technologies, platforms, and communication channels to disseminate information efficiently, give advisory support, and deliver services to target audiences in industries such as agriculture, education, healthcare, and community development.

With a widening gap of extension worker to farmers ratio, digital technologies, digital tools have become handy and necessary. The seminar theme enables to discuss on the developments made in the field of digital technologies especially their applications, challenges and also possible opportunities. By employing digital tools, extension staff can communicate with a significant number of farmers more efficiently, and farmers receive access to the most up-to-date information, best practices, market possibilities, and climate related advisories, resulting in increased productivity, income, and overall sustainability.

The seminar topic is divided in to nine themes to facilitate meaningful discussion and also evolve suitable strategies to adopt digital tools in extension and also education. Lead paper presentation are included from the experienced and eminent scholars in the field.

I am happy to inform that total 310 abstracts were received for the seminar which is presented categorized under nine themes. The seminar provides a plat form for presentation of all the research work either as an oral presentation or poster presentation. I hope the deliberations will bring out the appropriate strategies for the research and extension systems. I wish all the delegates a fruitful presentation, pleasant stay and learning experience.

(Dr. S. S. Dolli)



Director, CMDR, Dharwad and
Organising Secretary
ISEE National Seminar 2026

Message

It gives me immense pleasure to welcome all distinguished delegates, scholars, extension professionals, entrepreneurs, and farmers to the **National Seminar of the Indian Society of Extension Education (ISEE) 2026**, being held at the vibrant city of Goa. The theme of this year's seminar on "*Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat*" **29–31 January 2026** is both timely and transformative, reflecting the urgent need to harness intelligent technologies for agricultural sustainability and national self-reliance.

India today stands at a crossroads where traditional agricultural wisdom must converge with modern digital innovations. The seminar has been carefully designed to deliberate on ten thematic areas that capture the breadth of this transformation viz., Intelligent technologies in digital extension for next-generation agriculture, Digital extension and education to empower farmers for Atmanirbhar Bharat, Digital tools to ensure sustainable food systems, Global and local experiences in digital extension and education, Digital applications in start-ups and entrepreneurship development, Gender concerns in application of digital tools, Intelligent technologies and sustainable food systems, Digital technology for climate-smart agriculture, Market intelligence and digital applications, and Quality control and food safety through digital applications.

These themes reflect our collective aspiration to build inclusive, scalable, and farmer-centric models of extension education that integrate cutting-edge digital tools with the realities of rural India.

This seminar is not merely an academic exercise; it is a platform for cross-sectoral collaboration. We are privileged to have the support and partnership of several esteemed institutions, including the University of Agricultural Sciences, Dharwad, Goa College of Agriculture, Goa, ICAR–Agricultural Technology Application Research Institutes (Bengaluru, Pune, Hyderabad Zone-X), Centre for Multi-Disciplinary Development Research (CMDR), Dharwad and Goa Chambers of Commerce and Industry, Panjim. Their collaboration underscores the importance of bridging research, practice, and policy, while also connecting academia with industry and grassroots communities.

Implications of Digital Extension Services in Agriculture in transforming the agricultural sector by bridging the gap between scientific innovations and farming communities. Their implications are wide-ranging:

- **Enhanced Access to Knowledge:** Farmers receive real-time, localized advisory services through mobile apps, AI-driven platforms, and IoT devices, improving decision-making on crop management, pest control, and resource use.
- **Precision and Sustainability:** Digital tools enable precision farming, optimizing inputs like water, fertilizers, and energy, thereby reducing costs and environmental footprints.
- **Market Integration:** E-platforms and blockchain systems connect farmers directly to consumers and markets, ensuring transparency, fair pricing, and reduced post-harvest losses.



- Risk Management: Weather forecasting, early warning systems, and climate-smart advisories help farmers mitigate risks associated with climate variability.
- Capacity Building: Digital libraries, MOOCs, and interactive platforms strengthen extension education, empowering farmers, youth, and women with new skills.

The role of stakeholders in the success of digital extension depends on coordinated efforts of diverse stakeholders:

- Government: Policy frameworks, infrastructure investment, and digital literacy programs.
- Research Institutions & Universities: Development of context-specific digital tools and training modules.
- Private Sector & Startups: Innovation in agri-tech solutions, market linkages, and entrepreneurship opportunities.
- NGOs & Civil Society: Ensuring inclusivity, bridging digital divides, and supporting marginalized groups.
- Farmers & FPOs: Active participation, feedback, and adoption of digital practices to strengthen self-reliance.

Sustainable food systems efficient production, equitable distribution, and safe consumption are central to the vision of *Atmanirbhar Bharat*. Digital extension empowers farmers to produce more sustainably, access markets fairly, and adopt climate-smart practices. By integrating traditional wisdom with modern digital tools, India can build resilient food systems that ensure food security, reduce dependency on imports, and foster rural entrepreneurship. Thus, digital extension is not only a technological intervention but a pathway to national self-reliance and inclusive growth.

The seminar's objectives are ambitious yet essential: to examine the current landscape of digital technologies in extension education, to explore inclusive models for farmer empowerment, to identify challenges in adopting emerging tools, and to deliberate on curriculum redesign and capacity-building strategies. These discussions will not only enrich academic discourse but also provide actionable insights for policymakers, NGOs, and farmer organizations.

We must recognize that while digital technologies offer immense promise, their adoption is uneven due to digital divides, infrastructural gaps, and knowledge asymmetries. This seminar, therefore emphasizes inclusivity—ensuring that women, youth, and marginalized farmers are not left behind in the digital revolution. It also highlights the importance of farmer producer organizations (FPOs) as engines of collective empowerment and self-reliance.

I am confident that the deliberations, paper presentations, and discussions during these three days will generate actionable insights, innovative strategies, and collaborative frameworks to advance digital extension for sustainable food systems. Together, we can empower farmers, strengthen food security, and contribute meaningfully to the vision of *Atmanirbhar Bharat*.

On behalf of the Organising Committee, I extend my heartfelt gratitude to all participants, collaborators, and sponsors for their commitment and support. May this seminar inspire us to move forward with conviction, creativity, and compassion in building a resilient agricultural future.

With warm regards,

(Dr. Basavaprabhu Jirli)



Principal Scientist (Agri. Extension)

Division of Agricultural Extension

ICAR-IARI, New Delhi

and

National Organizing Secretary, ISEE

Message

I extend my greetings to all the distinguished delegates, researchers, policy makers, innovators and students participating in the ISEE National Seminar “**Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat**”, being held at Goa from 29–31 January 2026. This seminar is need based, timely and significant initiative to address all stakeholder of agriculture.

India has digitally intervened in the agriculture sector through its policies and project. Today, India is in progress of adopting digital technologies at the farm level as most of the government initiatives are directed towards benefit of farmers. The mission of Doubling Farmers Income has emphasised the introduction of emerging advanced digital technologies in agriculture. However, any government-led initiative will be successful when it receives maximum public and private participation and support. An ecosystem has to be created involving all stakeholders to digitalise agriculture in India. It is essential to promote digital literacy among farmers, youth in rural villages, public and private extension personnel. Institutions play a significant role in assimilating new technologies into society. It is required to upgrade the existing agriculture extension system inculcating the digital technologies. Agricultural institutions like ICAR, State Agricultural Universities, Krishi Vigyan Kendras (KVKs), agriculture and allied departments are key institutions to disseminate information related to Digital Agriculture technologies.

Data is one of the important elements for digital agriculture practices as it is the life source of digital technologies i.e. AI, Satellite Image processing etc. Accurate and updated data on weather conditions, soil type, market, demand- supply, Price, crop variety, crop yield is required to develop and implement innovations and interventions. There is a need to create a trusted and centralised digital data repository to enable efficient data access to different stakeholders, which will help reduce time and cost for digital intervention. Further there is a need for data sharing, data validation and interoperability and data privacy mechanisms.

Digital infrastructure such as internet connectivity, mobile phone network, and the cost of internet and digital devices are crucial for the farming community's extensive adoption and continuous use of digital technologies. People in rural areas still do not have access to basic facilities. Thus, creating digital infrastructure in a rural area may take time and require huge investment, which may delay the digitalisation

As a Secretary, ISEE I firmly believe Digital Extension is a powerful vehicle for accelerating agriculture and rural transformation. It has the potential to mobilize farmers, revolutionize farming practices, enhance market access, and overcome persistent challenges in the agricultural sector. Extension research by using latest digital technologies in smallholder agriculture will help in bringing out pros and cons of digital extension and will help in scaling up of proven technologies to achieve our Viksit Bharat goal.

My best wishes for grand success of the seminar and expecting the outcomes will contribute meaningfully to the future of Indian farmers.

Jai Jawan, Jai Kissan, Jai Vigyan

Dr. J R Mishra



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DR. D. K. MISHRA MEMORIAL LECTURE



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Enhancing Technology Delivery through KVK-led Convergence and Complementarity

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Background and rationale

Indian agriculture is increasingly becoming knowledge, technology, and learning-intensive in the face of mounting challenges such as climate change, market volatility, natural resource degradation, and youth disengagement from farming. This necessitates a robust and dynamic agricultural extension system that is farmer-centric, digitally empowered, and innovation-driven. India's agricultural extension system has evolved into a pluralistic model, involving multiple stakeholders beyond just government agencies. Traditionally, agricultural extension system is pluralistic and extension services were primarily provided by leveraging multiple channels and expertise of the government through departments like the central and state Departments of Agriculture, Indian Council of Agricultural Research through a network of research institutions and Krishi Vigyan Kendras (KVKs), State Agricultural Universities (SAUs) and private sectors including input suppliers, agrochemical firms, machinery providers, NGOs and Farmers' Organizations. India's pluralistic agricultural extension system offers a broader platform for technology dissemination. Despite this vast architecture, extension services often remain fragmented, supply-driven, and inconsistent across regions. Significant technology delivery and adoption gaps continue to challenge agricultural productivity improvements. Strengthening coordination, improving extension infrastructure, enhancing farmer education, and involving private and community actors more actively are key to bridging these gaps for sustainable agricultural development. Robust extension delivery is needed to strengthen the "Lab-to-Land" approach by ensuring effective knowledge dissemination and fostering demand driven research based on farmers' field realities.

Key Challenges

The agricultural extension system continues to face critical capacity and structural challenges, including insufficient and unevenly skilled extension personnel, which constrains effective advisory delivery. The two-way flow of knowledge between research institutions and the field remains weak, limiting timely feedback, refinement, and adoption of technologies. Extension services also suffer from the inadequate integration of ICT tools, climate advisories, and market intelligence, reducing their relevance in a risk-prone and market-driven agricultural environment. These limitations contribute to a restricted last-mile reach, particularly in remote and underserved areas. Additionally, the system lacks robust mechanisms for the scientific validation, documentation, and upscaling of farmer-led innovations, while participation of women farmers, rural youth, and marginalized groups remains limited, affecting inclusiveness, equity, and overall impact of extension interventions. To overcome these systemic gaps, a National Mission on Modernizing Agricultural Extension (NMMAE) is proposed with convergence at its core facilitating coordinated, efficient, and farmer-centric extension delivery.



Proposed Convergence for effective extension delivery

Initially, the Ministry of Agriculture functioned as a single, larger entity, from which several specialized Ministries and Departments have since been carved out. While this specialization has strengthened sectoral focus, it has also underscored the need for close collaboration and convergence among these Ministries to achieve shared agricultural development goals. To address this, it is proposed to establish a structured convergence mechanism involving all related Departments. This mechanism would be anchored in a joint declaration of intent, supported by a robust, time-bound action plan and a well-defined monitoring framework to ensure accountability and effective implementation. Such coordinated action will strengthen extension delivery systems through close collaboration with the Agricultural Technology Management Agency (ATMA) and strategic engagement with private-sector partners, thereby enhancing outreach, efficiency, and impact at the field level. Convergence is proposed with the Ministries/Departments (DA&FW, DAHD, DoF, MoRD, MoPR, MoEFCC, MoFPI, DoNER, DoF, MoC, MNRE) for close collaboration. The convergence of flagship schemes of the Government e.g., National Mission on Natural Farming (NMNF), PM Dhan Dhanya Krishi Yojana (PM-DDKY), Pulses Mission, Edible Oil Mission is also envisaged for accelerated extension delivery.

The KVKs in the districts are conceptualised to forge partnership with other existing agencies to enhance the outreach for wider dissemination of improved technologies and capacity development of farmers, farm women, rural youth and other related stakeholders. Earlier the reach of KVK was 3 % farmers (in 2014) to 5-7% (in 2020) to 18% (in 2025) speak volume about speedy increasing the number of farmers and villages by designing the special awareness programs like Viksit Krishi Sankalp Abhiyan (VKSA), improving the footfall of farmers through aligned progs like PMKISAN Yojana, Jal Shakti Abhiyan, Viksit Bharat Sankalp Yatra where in KVK took lead role in reaching out the farmers. Despite several achievements in agriculture, significant technology and extension gaps still persist. This highlights the urgent need to strengthen extension efforts to bridge the 'Lab to Land' gap. In response, the Viksit Krishi Sankalp Abhiyan (VKSA) was conceptualized as a national initiative to raise awareness among farmers about the latest improved technologies ahead of the Kharif season. It promotes direct farmer-scientist interactions focused on improved technologies for the upcoming Kharif season.

It is very heartening that reach of KVKs to villages has remarkably increased from 42 to 115 in district which has to be increased to 250 by 2030 and 500 by 2040 by use of digital technologies and by making robust skilling mechanism and thus developing Masters' Trainers and Professors of Practices so that the reach can be enhanced to desired level. Continuous farmers contact particularly rural youth and farm women and involving them in capacity development programs and by making effective environmental building programs. Development of volunteers and key agents has to be enhanced to making more and more farmers in the loop. Strengthening KVKs as District level nodal agency is the need of the hour by involving several ministries and other NGOs, civil societies, private partners etc

Lessons from Extension Systems in other developing and developed countries

International experience offers persuasive evidence for such a transition. Countries with strong public extension foundations have progressively adopted pluralistic models to complement state efforts. Japan operates a publicly funded but locally administered system that increasingly integrates private actors and advanced technologies. In the United Kingdom, public institutions define strategic priorities while private consultants and industry bodies deliver specialized advisory services under public oversight. Israel, despite maintaining a predominantly government-led extension system, actively collaborates with private firms on R&D and is exploring greater private participation in advisory services. Similar convergence-



driven approaches are evident in China's company-led partnership models, PPP-supported extension systems in Vietnam and Brazil, the Cooperative Extension framework in the United States, Australia's industry co-funded research farms, and the Netherlands' public-industry knowledge hubs. These experiences demonstrate that even countries with favorable extension agent-farmer ratios continue to rely on pluralistic arrangements to bridge remaining gaps and respond to evolving farmer demands. The extension worker: farmer ratio is very high in India comparing to other countries like China, Vietnam etc.

In this context, strengthening KVKs through structured PPPs is both necessary and timely. Strategic linkages with private and non-state actors can enhance infrastructure development, digital advisory platforms, skill-oriented training, market-linked demonstrations, and agri-entrepreneurship support. Such convergence can also facilitate access to global best practices, specialized technical expertise, and performance-based financing mechanisms. By embracing pluralism, KVKs can transition from being predominantly technology transfer units to dynamic innovation, incubation, and knowledge-integration centres. This shift would modernize India's extension ecosystem, improve last-mile service delivery to small and marginal farmers, and align KVK operations with globally evolving, multi-stakeholder agricultural extension models.

Role of KVKs

KVKs being frontline extension model, if strengthened, can act as a Centre of excellence in connecting research outputs with real-time farmer needs through adaptive and applied location-specific solutions. KVKs, since the time of inception in 1974, are devoted to build capacity of farmers and extension workers to address their immediate agricultural problems, develop competence and confidence for practicing modern farming, and strengthen scientific information support to the rural community. Currently, 731 KVKs operate across the country under the administrative control of diverse institutions including ICAR Institutes, Agricultural Universities, NGOs, and State Departments. While KVKs are playing a pivotal role in technology assessment, demonstrations, and capacity building, the need has emerged to scale their outreach through a convergence-led extension framework. This involves integrating efforts across departments, institutions, and stakeholders for cohesive, adaptive, and demand-driven agricultural development.

In this process, stakeholders, including FPOs, SHGs, FIGs, and para-extension agents, can play vital role as game changers. Therefore, such collaborative learning amongst multi-institutions can enhance resource convergence and ownerships to collectively address agricultural issues. Other than conventional knowledge, farmer-led innovations and knowledge can also be integrated with real-time and accessible solutions using digital agriculture for speedy adoption by the end users. The adaptive, innovative, scientific extension and skilling programmes also need to be designed in such a way that it motivates women, youth, and farmers to build social-ecological resilience in farming. Strengthening KVKs with these approaches and models can be piloted in potential zones to generate scalable extension frameworks and policy insights to be replicated in all states. Modernization of KVK infrastructure and facilities, leveraging digital platforms, customized advisories and data-driven decision support systems to improve technology adoption, translate research outputs into outcomes with minimal time lag, scalability and impact at the farm level. Inter-linking ICAR developed technologies with on-going central and state schemes to ensure seamless, last-mile access for small and marginal farmers through cluster-based and mission-mode approaches. By following the strengthened continuum will enhance adoption, productivity, and sustainability in diverse farming systems in India.



Building a Future-Ready Agricultural Workforce

Agriculture and allied sectors remain central, engaging nearly 46% of the workforce, yet face challenges from climate change, resource degradation, low productivity, limited value addition, weak market integration, and declining youth interest. A major constraint is the skill gap in the agricultural workforce. Many rural youths lack future-ready skills aligned with emerging technologies such as digital and precision agriculture, AI, mechanisation, and climate-smart practices, leading to underemployment and reduced attractiveness of agriculture. In this context, KVKs can act as district-level hubs for skilling, technology incubation, and enterprise development, supporting rural employment and sustainable agricultural growth in line with Viksit Bharat @2047. KVKs' strengths include direct farmer engagement, strong technical backstopping from ICAR institutes and Agricultural Universities, experience in entrepreneurship development, established training infrastructure, and partnerships with state departments, ATMA, FPOs, NGOs, SHGs, cooperatives, and the private sector, including in aspirational and remote districts. Through hands-on training, demonstrations, and exposure visits, KVKs promote experiential learning and rapid technology adoption. Early skill exposure in horticulture, food processing, seed systems, integrated farming, and allied activities enables rural youth to diversify incomes beyond subsistence agriculture.

KVKs as Technology Incubation Platforms

A key element of the future strategy is to strengthen KVKs as technology incubation platforms for agro-based rural enterprises. With only 13 incubation facilities currently available in ICAR institutes and Agricultural Universities, KVKs can fill a critical gap by bridging research institutions and rural markets through adaptation and demonstration of viable, scalable technologies suited to small and marginal farmers. Through on-farm trials, pilot demonstrations, and enterprise-oriented training, KVKs support incubation in high-value horticulture, secondary agriculture, seed and nursery enterprises, value addition and post-harvest management, custom hiring centres, digital and drone-based solutions, renewable energy and waste-to-wealth initiatives, integrated and natural farming, soil health management, and integrated pest management. By providing technical mentoring, access to infrastructure, pilot testing, and continuous handholding, KVKs lower entry barriers for rural youth and first-generation entrepreneurs, enabling the conversion of innovative ideas into sustainable enterprises.

Business Model Development and Agripreneurship Promotion

Beyond technical skilling, KVKs play a crucial role in enterprise planning and business model development. They support rural youth in understanding market dynamics, assessing profitability, preparing project reports, and complying with quality and regulatory standards. A special focus is placed on service-based and cluster-oriented business models, such as custom hiring centres, agri-input services, drone as a service, soil and water testing, and agri-logistics. These models not only provide self-employment to trained youth but also generate additional wage employment, strengthening the rural non-farm economy.

Employment Generation and Inclusive Rural Growth

KVKs have demonstrated significant potential in promoting self-employment and rural job creation, particularly through convergence with initiatives such as ICAR's *Attracting and Retaining Youth in Agriculture (ARYA)* programme, Farmer Producer Organisation (FPO) promotion initiatives, and state skill development missions. Thousands of agro-enterprises established through these efforts have led to increased incomes, reduced migration, and strengthened rural value chains. KVKs also prioritise inclusion of women,



smallholders, and marginalised groups, ensuring equitable access to skills, entrepreneurship opportunities, and resources. Cluster-based and collective enterprise approaches further enhance economies of scale, community ownership, and employment generation.

Strengthened KVKs as Single Window District Level Nodal Agency

KVKs would assume specific role of district level nodal agency as Agricultural Technology Information Centre (ATIC) in a single-window concept through public private partnership for enhancing its outreach through production of quality seeds, planting materials, fingerlings, value-added products, publications, prototypes of small implements, etc. KVKs would develop interventions keeping in view of Comprehensive District Agriculture Plan (CDAP) developed in convergence with all related stakeholders.

Expected Outcomes

- Strong convergence model for enhancing technology delivery.
- Strengthened last-mile connectivity and speedy extension services.
- Enhanced technology adoption, productivity, and farm resilience.
- Active engagement of women, youth, and agri-preneurs in farming.
- Integrated development of agriculture and allied sectors through participation of private sectors.
- Workable models of value chain and Business Cell.
- Improved preparedness for climate risks and market challenges.



Beyond Apps and Advisories: Re-engineering Agricultural Extension as a Science of Delivery for Technology Transfer, Employability, and Atmanirbhar Bharat

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Context and Rationale

Agricultural extension stands today at a decisive crossroads. While digital technologies—mobile advisories, artificial intelligence, remote sensing, drones, and platform-based services—have rapidly expanded the reach of information, their translation into **sustained farmer outcomes, rural employability, and resilient food systems remains uneven**. This paradox is particularly evident in smallholder-dominated agrarian systems, where risk, trust, institutional credibility, and contextual relevance shape adoption decisions far more than information availability alone.

The late **Dr. D.K. Mishra**, a towering figure in Extension Education, consistently emphasised that **technology transfer is not a technical act but a social, institutional, and educational process**. His work highlighted the indispensable role of extension systems in transforming scientific knowledge into livelihood-enhancing action. This memorial lecture is inspired by that foundational insight and seeks to reinterpret it for the digital age.

Drawing on over two decades of professional engagement—spanning grassroots extension, national program leadership, and global advisory roles—the proposed lecture argues that the central challenge facing extension today is **not digital scarcity but delivery design**. The future of extension lies in consciously re-engineering it as a **science of delivery**, where technologies are embedded within accountable institutions, professional capabilities, and farmer-centred learning systems.

Core Argument of the Lecture

The lecture advances three interlinked propositions.

First, **digital technologies amplify extension capacity but cannot substitute extension systems**. Systematic reviews and meta-analyses across regions show that while digital advisories often improve access to information and short-term practices, their impact on income stability, climate resilience, and sustainability is highly variable. Where digital tools are deployed as stand-alone solutions, adoption tends to be episodic. Where they are embedded within trusted extension institutions—through demonstrations, diagnostics, feedback loops, and professional facilitation—impacts are more durable. This reinforces the continued centrality of extension services as the structural determinant of technology adoption.

Second, the lecture argues for a conceptual shift **from the “art of extension” to the “science of delivery.”** Traditional extension relied heavily on interpersonal skills, persuasion, and experiential learning. Digitalisation introduces algorithmic recommendations, automated messaging, and platform-mediated trust, fundamentally altering advisory relationships. In this context, extension must move beyond intuition-driven practice to deliberate system design—defining how data becomes decisions, how decisions become outcomes, and how accountability is maintained. A science-of-delivery approach foregrounds validation, contextualisation, professional responsibility, and learning feedback as core extension functions.

Third, the lecture positions **extension as a critical driver of rural employability and Atmanirbhar Bharat**. Technology transfer today is inseparable from skills, entrepreneurship, and value-chain integration. Extension systems—particularly Krishi Vigyan Kendras—are uniquely placed to function as local skill hubs, enterprise incubators, and trust anchors linking farmers with markets, finance, and services. When extension is aligned with skilling initiatives, youth entrepreneurship, and climate-resilient practices, technology transfer generates not only productivity gains but also dignified rural livelihoods.



Empirical and Practice-Based Foundations

The lecture integrates insights from peer-reviewed research and field leadership experience.

Meta-analyses on digital agricultural interventions demonstrate statistically significant average impacts on yields and income but reveal high heterogeneity driven by delivery mechanisms. Adoption studies consistently identify access to extension services as one of the strongest predictors of technology uptake across contexts. Climate information services research shows that advisories translate into adaptive action only when co-designed with farmers, downscaled to local conditions, and mediated through trusted institutions.

Practice-based evidence from large-scale extension leadership further reinforces these findings. Experiences from coordinating national frontline demonstrations, leading KVK networks, and advising extension reforms across multiple countries show that digital tools gain legitimacy when integrated into institutional routines—diagnostic visits, demonstrations, seasonal planning, and follow-up. Conversely, pilots that bypass extension systems often struggle to scale or sustain impact.

Artificial Intelligence, Platforms, and Governance

A dedicated section of the lecture addresses emerging frontiers—particularly artificial intelligence and platformisation. AI-enabled diagnostics and decision tools offer unprecedented speed and scale but introduce new risks related to opacity, accountability, and misalignment with local contexts. Technology foresight indicates that many AI initiatives fail due to weak value propositions and governance gaps. In extension, such failures carry livelihood and ecological consequences.

The lecture argues that AI must be positioned as **decision support rather than decision authority**, with extension institutions retaining responsibility for validation and ethical oversight. Similarly, digital platforms that bundle advisory services with inputs, finance, and markets create efficiencies but also risk power asymmetries. Public-interest extension institutions play a critical role in safeguarding pluralism, transparency, and farmer agency.

Proposed Framework: Digital Extension as a Science of Delivery

The lecture proposes a practical framework anchored in five pillars:

1. **Delivery Science** – systematic translation of data into decisions and outcomes
2. **Institutional Governance** – accountability, validation, and trust
3. **Professional Capacity** – redefining extension roles and skills
4. **Public Digital Goods** – open, interoperable advisory infrastructures
5. **Equity and Inclusion** – gender-responsive and smallholder-centred delivery

This framework shifts attention from tools to **institutional capability**, aligning digital extension with sustainability, employability, and public value.

Relevance to the Dr. D.K. Mishra Memorial Lecture

This lecture directly reflects Dr. D.K. Mishra's enduring vision: that extension education must remain **field-rooted, socially relevant, and institutionally strong**, even as technologies evolve. It demonstrates how contemporary digital tools, when governed and delivered through robust extension systems, can advance **technology transfer, rural employment, and Atmanirbhar Bharat**.

The lecture is addressed to extension professionals, educators, policymakers, and researchers globally, reaffirming extension not as a fading intermediary, but as a **strategic institution for sustainable food systems in the digital age**.





LEAD PAPERS





Digital Interventions for Climate-Resilient Crop Improvement and Seed Sovereignty

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Digital interventions are rapidly reshaping agricultural research and practice, offering transformative pathways for climate-resilient crop improvement and strengthening seed sovereignty (Finger, R. 2023). Traditional breeding cycles are often slow and labor-intensive. The integration of **Digital Technologies** offers a transformative pathway to bridge the gap between genotype and phenotype, ensuring long-term sustainable food systems. This paper explores the application of cutting-edge digital tools in modern crop improvement programs and seed sovereignty, focusing on:

- Enhancing the precision and speed of trait discovery.
- Optimizing breeding pipelines through data-driven decision-making.
- Ensuring the scalability of improved varieties for smallholder farmers.
- Distributed ledger technologies ensure transparent seed supply chains, protecting farmers' rights and preventing biopiracy.
- Mobile apps and online repositories strengthen local seed systems by documenting indigenous varieties and facilitating exchange among farmers.
- Digital records support participatory breeding and farmer-led innovation, reinforcing sovereignty by recognizing traditional knowledge alongside modern science.

The core of the discussion focuses on three pivotal technological pillars:

1. **High-Throughput Phenotyping (HTP):** The use of **UAVs (Drones)** and ground-based sensors equipped with multispectral imaging to monitor plant health, biomass, and stress responses in real-time. This reduces human error and captures temporal data that manual scouting misses. (Ampatzidis, Y, & Partel, V. 2019).
2. **Genomic Selection and AI:** Utilizing Machine Learning (ML) algorithms to analyse vast datasets of genomic information (G) and environmental variables (E). Predictive modelling allows breeders to simulate G x E interactions, significantly shortening the breeding cycle by selecting superior lines before field testing. (Varshney et al 2021)
3. **Digital Seed Traceability:** Implementing **Blockchain and IoT** in the post-improvement phase to ensure that the genetic purity of "Atmanirbhar" varieties is maintained from the lab to the last-mile farmer. (Das, K. 2024).

Digital technologies democratize access to resilient crop varieties, reduce environmental footprints, and strengthen farmer participation. However, challenges such as the digital divide, data ownership, and risks of corporate monopolization must be addressed through inclusive policies and capacity building. Digital interventions represent a paradigm shift in agricultural innovation. They not only accelerate the development of climate-resilient crops but also empower farmers to reclaim agency over seeds, ensuring seed sovereignty in the face of climate uncertainty. A balanced approach—combining technological innovation with participatory governance—is essential to achieve sustainable and equitable outcomes.



Digital Extension and Education for Agricultural Innovation and Farmer Empowerment in India: Challenges and Opportunities

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Abstract

Indian agriculture is undergoing a profound structural transformation catalyzed by rapid digitalization, advancements in information and communication technologies (ICTs), and the expansion of government-supported digital public infrastructure. Traditional agricultural extension systems, predominantly reliant on manpower-intensive, face-to-face, and geographically limited delivery mechanisms, have become increasingly inadequate in addressing the complex and dynamic challenges faced by farmers, including climate variability, emerging pest and disease threats, resource depletion, and market volatility. This study provides a systematic analysis of India's evolving digital extension ecosystem and critically examines its effectiveness in bridging the interface between scientific research and farm-level adoption of innovations.

Drawing on empirical and institutional evidence from national digital platforms such as e-NAM, mKisan, Kisan Call Centres, and AgriStack, the paper elucidates the expanding scope, reach, and functionality of ICT-enabled advisory and decision-support systems. While digital technologies have demonstrated considerable potential in enhancing agricultural productivity, improving market integration, strengthening risk mitigation, and promoting inclusivity, significant constraints persist. These include uneven digital connectivity, limited functional digital literacy among farmers, institutional fragmentation of digital services, and emerging concerns related to data governance, privacy, and ethical deployment of digital tools.

The paper concludes that sustainable farmer empowerment can only be achieved through a hybrid extension framework that synergistically integrates the scalability of digital platforms with human facilitation mediated by Krishi Vigyan Kendras (KVKs), Farmer Producer Organizations (FPOs), and grassroots institutions. A policy framework prioritizing system interoperability, context-specific digital education, inclusive technology design, and robust data governance mechanisms is essential for harnessing the full potential of digital agriculture in India.

1. Introduction

Agriculture continues to constitute the backbone of India's socio-economic structure, playing a critical role in rural livelihood generation, national food security, and the sustenance of a large segment of the population. Traditionally, agricultural development in the country has been predominantly supported by public extension systems tasked with transferring scientific knowledge and technological innovations from research institutions to farming communities. However, the present agricultural scenario has become increasingly dynamic and uncertain. Contemporary farmers are confronted with climate variability, emerging pest and disease pressures, escalating input costs, and rapidly changing market conditions. These evolving complexities necessitate real-time, location-specific, and data-driven advisory services that go beyond the capacity of conventional, manpower-intensive extension mechanisms.

Consequently, traditional extension approaches, which are largely uniform, linear, and supply-driven, are no longer sufficient to effectively address the diverse and rapidly changing needs of Indian agriculture. The conventional extension model is increasingly constrained by inadequate human resources, operational inefficiencies, slow information dissemination, and limited mechanisms for farmer feedback and learning. These realities demand timely, context-specific, and precision-driven advisory services—requirements in the present context. In response to these structural limitations, India has strategically



adopted digital transformation as a key instrument for revitalizing and modernizing agricultural advisory services. Consequently, digital extension and technology-enabled farmer education have emerged as pivotal drivers for enhancing the scalability of innovations, strengthening evidence-based decision-making, and fostering farmer empowerment across varied agro-ecological zones and socio-economic conditions.

India is well-positioned to lead in digital extension due to:

1. **Strong institutional capacity** (731+ Krishi Vigyan Kendras, ICAR research network, ATMA, State Agricultural Universities).
2. **Large-scale government ICT platforms** (mKisan, KCC, eNAM, Soil Health Card).
3. **An expanding agri-tech startup ecosystem** offering advisory, credit, input delivery, and market linkages.
4. **Growing Farmer Producer Organisations (FPOs)** which can act as decentralised digital hubs.

2. Evolution of Digital Extension in India

The evolution of digital agricultural extension in India represents a gradual yet transformative shift from conventional, manpower-driven advisory systems toward technology-enabled, scalable, and data-centric knowledge dissemination models. This transition has been shaped by structural inefficiencies in traditional extension, rapid expansion of rural connectivity, policy interventions under Digital India, and the emergence of digital public infrastructure tailored for agriculture.

2.1 From Conventional Dissemination to Digital Interfaces

Historically, agricultural extension in India followed a linear “lab-to-land” framework, wherein research outputs generated by institutions such as the Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) were transferred to farmers via field demonstrations, training programs, and personal visits. While effective during the Green Revolution era, this model became increasingly inadequate due to the expanding farmer population, diversification of crops, and complexity of farm-level decision-making.

One of the most critical structural limitations has been the extremely low extension worker-to-farmer ratio, estimated at less than 1:5000. This shortage restricted personalized advisory, reduced frequency of field interactions, and left remote regions underserved. Moreover, communication was largely one-directional, offering minimal scope for farmer feedback or adaptive learning. The inadequacy of this model created the necessity for alternative channels capable of delivering timely, location-specific information at scale—laying the foundation for digital extension.

2.2 Early ICT Interventions (2000–2013)

India’s first wave of digital agricultural outreach began with pilot ICT-based initiatives:

- e-Choupal (ITC) for digital procurement and advisory
- Village Knowledge Centres (MSSRF)
- Kisan Call Centres (2004 onward)
- SMS-based agro-advisory services

These early initiatives demonstrated that digital platforms could reduce information asymmetry, enhance market awareness, and support farmer decision-making. However, they remained fragmented and localized, lacking integration with mainstream public extension systems.

2.3 Policy Push under Digital India (Post-2014)

The launch of the Digital India Programme accelerated rural digitization and marked a turning point in agricultural extension. Expansion of mobile connectivity, declining data costs, and increasing smartphone penetration enabled wider farmer access to digital services.



During this phase, the Government introduced scalable digital platforms:

- **mKisan Portal** for mass SMS advisories
- **Kisan Call Centres** offering multilingual expert consultation
- **e-NAM** integrating agricultural markets
- **Digital Crop Insurance Systems (PMFBY)**
- **Soil Health Card digital databases**

These initiatives shifted extension from static knowledge transfer to dynamic, real-time information delivery. The integration of digital advisory into existing institutional frameworks strengthened outreach while maintaining scientific credibility

2.4 Emergence of Digital Public Infrastructure for Agriculture

India's digital extension evolution entered a new phase with the conceptualization of **AgriStack**, designed to create a unified farmer database and enable interoperable digital services across advisory, insurance, market access, and financial inclusion

This aligns agriculture with India's broader Digital Public Infrastructure (DPI) model seen in Aadhaar and UPI.

The layered architecture includes:

- Farmer Identity Layer
- Advisory & Interaction Platforms
- Economic & Risk Management Systems
- Decision Support & Analytics

This systemic integration represents a paradigm shift from isolated digital interventions to a coordinated digital ecosystem supporting personalized and data-driven extension.

2.5 Role of Community-Embedded Digital Models

Parallel to government platforms, community-led digital extension models gained prominence. Case evidence shows that farmer engagement is significantly higher when digital tools are mediated through trusted local institutions and peer networks

These models emphasized:

- Participatory video dissemination
- Village-level facilitators
- Localized advisory content

Such approaches highlighted that technology adoption depends not only on access but also on social embedding and human facilitation.

2.6 Transition toward Precision and Hybrid Extension

With advancements in artificial intelligence, satellite monitoring, IoT sensors, and hyper-local weather analytics, extension is now evolving beyond information broadcasting toward precision advisory tailored to specific plots and crop stages .

Recognizing persistent digital divides and trust gaps, the emerging consensus supports a **Hybrid Extension Model** that combines:

- Digital scale and analytics
- Institutional validation
- Local facilitation through KVKs and FPOs



2.7 Summary of Evolutionary Phases

Table 1: Phases of Extension Journey

Phase	Characteristics
Pre-2000	Purely conventional, field-based extension
2000–2013	Pilot ICT interventions, fragmented adoption
2014–2020	Digital India expansion, platform-based advisory
2020 onward	AgriStack, AI tools, integrated hybrid extension

India's digital extension journey thus reflects a structural transition from manpower-constrained dissemination toward a technology-enabled, institutionally anchored, and farmer-centric advisory ecosystem. The evolution underscores that digital extension is not merely a technological upgrade but a systemic reform in agricultural knowledge delivery.

Table 2: Comparative Performance: Digital vs. Traditional Extension Approaches

Parameter	Traditional Extension	Digital Extension	Hybrid Extension (Best Practice)
Reach	Limited to contact area	Nationwide / scalable	High reach with local facilitation
Cost per Farmer	High	Very low	Moderate but impactful
Localisation	High	Medium (depends on platform)	High (digital + field validation)
Timeliness	Moderate	Instant	Very high
Two-way Communication	Strong	Weak–moderate	Very strong
Adoption Rate	Moderate	Variable	Highest across models

Table 3: Major Digital Extension Platforms in India: Functions, Coverage and Institutional Roles

Platform / Institution	Coverage / Users	Key Functionalities	Institutional Ownership
mKisan	8.9 crore farm families	SMS/IVR advisories, weather alerts	Ministry of Agriculture & Farmers' Welfare
Kisan Call Centre (KCC)	Nationwide; 22 languages	Farmer queries, expert advice	Govt. of India + outsourcing partners
eNAM	1,389 mandis; 1.77 crore farmers	Digital trading, e-bidding, logistic linkages	Small Farmers Agri-Marketing Consortium
Soil Health Card Portal	22 crore cards issued	Nutrient mapping, fertilizer recommendation	DAC&FW, GoI
PMFBY Portal	5.5 crore annual enrolments	Crop insurance tracking, claim settlement	Govt. of India
KVK ICT Modules	731+ KVKs	Digital videos, WhatsApp advisories, online trainings	ICAR
Digital Green	15+ states	Community videos & mediated learning	NGO + Govt. partnerships
Startups (DeHaat, CropIn, Gramophone)	20M+ farmers collectively	AI advisory, input delivery, market linkage	Private sector



3. Digital Education as a Pillar of Farmer Empowerment

Digital education has emerged as a foundational pillar in strengthening farmer capacity, accelerating technology adoption, and enabling inclusive agricultural transformation in India. While digital connectivity provides access to information, it is digital education that converts access into meaningful capability. In the context of agricultural extension, digital education represents a paradigm shift from episodic training toward continuous, learner-centered, and technology-mediated knowledge engagement.

3.1 From Information Access to Knowledge Empowerment

The digital transformation of agriculture has significantly expanded the flow of information through mobile networks and online platforms. However, mere exposure to digital tools does not guarantee effective utilization. For digital extension to be truly effective, farmers must be equipped with the capacity to interpret, critically assess, and apply technology-mediated information in their farming practices. In this context, digital education functions as a crucial linkage between mere technological access and meaningful practical empowerment.

Access to digital tools without corresponding skills and competencies often results in suboptimal utilization and may even exacerbate existing inequalities. Hence, well-structured and systematic digital learning frameworks are essential to ensure that farmers evolve from passive recipients of information into informed, autonomous, and adaptive decision-makers in agriculture.

3.2 Multi-Modal Digital Learning Frameworks

India's farming population is diverse in literacy, language, socio-economic background, and technological familiarity. To address this heterogeneity, digital education must adopt multi-channel pedagogies, including:

- Interactive Voice Response (IVR) systems for non-literate farmers
- Mobile-based video demonstrations for visual learning
- Short modular lessons in regional languages
- Community digital classrooms facilitated by local institutions
- Peer-to-peer digital knowledge sharing platforms

These tools democratize agricultural learning by making knowledge accessible irrespective of educational barriers.

3.3 Community-Centric Digital Education Models

Field-based ICT interventions demonstrate that learning outcomes improve when digital content is embedded within social and community structures. Community video approaches enable farmers to learn from localized success stories and relatable contexts, significantly enhancing trust and adoption. Such participatory digital education models reduce dependency on formal literacy and encourage experiential learning, collective problem-solving, and faster behavioural change.

3.4 Digital Education and Decision-Making Capacity

Digital education strengthens farmer autonomy across key dimensions:

- Crop planning based on climate advisories
- Pest and disease recognition through visual tools
- Efficient input management
- Market-oriented production decisions
- Risk mitigation and insurance awareness

Digital pathways correlate directly with productivity enhancement and income improvement.



3.5 Inclusion through Digital Pedagogy

Digital education plays a transformative role in reaching traditionally excluded groups:

- Women farmers gain indirect mobility via digital groups
- Youth re-engage through technology-driven agriculture
- Remote and tribal communities access voice-based advisory

Inclusive digital pedagogy ensures equity in knowledge dissemination.

3.6 Institutional Role in Scaling Digital Education

Grassroots institutions act as human interfaces for digital learning:

- KVKs as scientific knowledge hubs
- FPOs as aggregation and dissemination channels
- Local community bodies as trust anchors

The hybrid model relies on these institutions to contextualize digital education and enhance adoption.

3.7 Persistent barriers in Digital Learning

- Functional digital illiteracy
- Language mismatch in interfaces
- Limited smartphone skills
- Socio-cultural resistance
- Weak localization of content

These barriers restrict the transformative potential of digital education.

3.8 Strategic Imperative: Building Agri-Digital Literacy

Future extension success depends largely on targeted digital education that:

- Focuses on rural users
- Empowers frontline extension workers
- Designs video-first interfaces for low-literacy populations

Digital education must evolve from awareness-building to capability creation.

Digital education is therefore not a supplementary activity but a central pillar for sustainable farmer empowerment. It transforms connectivity into competence, enhances inclusion, and strengthens innovation adoption, positioning farmers as active participants in India's digital agricultural future.

4. Digital Public Infrastructure for Agriculture

Digital Public Infrastructure (DPI) for agriculture in India represents a systemic transformation in how agricultural services are delivered, accessed, and scaled across the country. Drawing inspiration from India's success in building interoperable digital public goods such as Aadhaar, UPI, and DigiLocker, the agricultural sector is now witnessing the creation of a structured digital stack designed to unify farmer data, enhance service efficiency, and enable precision-driven extension and governance. This emerging digital ecosystem forms the backbone for scalable, inclusive, and data-driven agricultural development.

4.1 Conceptual Foundation of Agricultural DPI

Traditional agricultural service delivery has long been fragmented, slow, and administratively complex. Farmers often face challenges in accessing subsidies, insurance claims, market linkages, and advisory services due to disconnected institutional databases and manual processes. The agricultural DPI framework seeks to overcome these inefficiencies by establishing a unified and interoperable digital



architecture that connects stakeholders across the agricultural value chain. DPI thus shifts agriculture from scheme-driven delivery toward ecosystem-based governance.

4.2 Core Components of India's Agricultural Digital Stack

India's agricultural DPI is being developed as a layered architecture comprising:

- 1. Farmer Identity & Database Layer (AgriStack)**
 - Creation of a unified farmer registry
 - Integration of land records, cropping data, and farmer profiles
 - Enables targeted delivery of schemes and advisory
- 2. Advisory & Interaction Layer**
 - mKisan SMS Portal
 - Kisan Call Centres (multilingual)
 - Digital extension platforms connecting farmers with experts
- 3. Economic & Market Layer**
 - e-NAM for national market integration
 - Digital trade and price transparency
- 4. Risk & Financial Security Layer**
 - PMFBY digital crop insurance
 - Direct benefit transfers and financial inclusion

Together, these components form a structured digital ecosystem capable of linking advisory, markets, risk mitigation, and governance.

4.3 Role of DPI in Strengthening Extension Delivery

Digital public infrastructure enhances extension efficiency by enabling:

- Real-time farmer identification and targeting
- Personalized advisory based on geo-tagged farm data
- Faster dissemination across multiple channels
- Seamless integration between advisory, insurance, and markets
- Data-driven monitoring and feedback loops

DPI transforms extension from generalized outreach to farmer-centric service delivery.

4.4 Institutional Integration through Public Platforms

The DPI framework ensures coordination among:

- Research Institutions (ICAR & SAUs)
- Krishi Vigyan Kendras (KVKs)
- FPOs and farmer collectives
- Market systems
- Insurance and financial agencies

Digital platforms act as connective layers linking these institutions efficiently

4.5 Market modernization enabled by DPI

The e-NAM case demonstrates how DPI-driven integration can dismantle traditional barriers, enabling:



- Inter-state trade
- Transparent bidding
- Removal of local monopolies
- Farmer access to national buyers

This highlights the economic empowerment potential embedded in digital public systems.

4.6 Scalability and Inclusion Advantages

Agricultural DPI allows:

- National-scale outreach without proportional manpower expansion
- Access for smallholders via mobile-based services
- Multilingual advisory delivery
- Inclusion of remote geographies

Digital public goods thus democratize agricultural services across socio-economic groups.

4.7 Governance and Ethical Concerns

Despite transformative potential, DPI introduces risks:

- Farmer data privacy and ownership ambiguity
- Consent management challenges
- Algorithmic bias leading to exclusion
- Cybersecurity vulnerabilities

These concerns underscore the need for robust regulatory safeguards.

4.8 Strategic Importance of Agricultural DPI

India's agricultural DPI represents a foundational shift from isolated digital initiatives toward an integrated ecosystem that supports advisory, markets, financial security, and governance under a unified framework. By enabling interoperability and precision targeting, DPI forms the digital backbone for the next generation of agricultural extension and farmer empowerment.

5. Evidence of Impact

The impact of digital extension and digital public platforms in Indian agriculture is increasingly visible across multiple dimensions including market efficiency, advisory outreach, learning adoption, service delivery, and farmer empowerment. Although digital agriculture remains an evolving domain, empirical evidence from national platforms and community-led digital models provides strong validation of its transformative potential.

5.1 Market Transparency and Price Realization: The e-NAM Experience

The National Agriculture Market (e-NAM) stands as one of India's most significant digital interventions in agricultural marketing. By integrating mandis across states under a unified electronic trading system, e-NAM has reduced market fragmentation and improved price discovery.

e-NAM has:

- Integrated 1,389 regulated mandis across India
- Onboarded approximately 1.78 crore farmers and over 2.6 lakh traders
- Recorded cumulative trade exceeding ₹3.79 lakh crore

This digital integration has enabled inter-state trade, reduced intermediary dependence, and enhanced farmers' bargaining power. The platform illustrates how digital infrastructure can generate tangible economic outcomes when linked to institutional markets.



5.2 Expansion of Advisory Reach: mKisan and Call Centre Systems

Digital advisory platforms have significantly expanded the scale of agricultural information delivery:

- mKisan portal delivering SMS-based advisories to 8.9 crore farm families
- Digital Roadmap of Farmer Empowerment
- Kisan Call Centres providing real-time consultation in more than 20 regional languages

These tools have democratized access to expert guidance, especially in regions where physical extension coverage is limited. The shift from periodic field visits to on-demand advisory represents a major leap in extension efficiency.

5.3 Adoption through Participatory Digital Learning Models

Community-embedded digital extension initiatives demonstrate higher adoption rates when digital tools are localized and socially contextualized. The uploaded roadmap highlights successful outcomes from participatory video dissemination models where farmers learn from peers in their own language and agro-ecological settings .

Such approaches have resulted in:

- Faster behavioural change
- Improved trust in advisory
- Greater participation by women and marginal farmers
- Higher adoption compared to conventional classroom training

These findings underscore the importance of integrating digital learning within community structures.

5.4 Improved Access to Government Services

Digital platforms have streamlined farmer access to:

- Crop insurance enrolment and claim tracking
- Soil Health Card databases
- Market registration systems
- Direct benefit transfers

By reducing bureaucratic delays and information asymmetry, digital systems enhance transparency and administrative efficiency.

5.5 Empowerment through Information Equity

Evidence indicates that farmers using digital tools exhibit:

- Better awareness of market prices
- Improved input decision-making
- Enhanced ability to respond to climate advisories
- Increased participation in organized value chains

Digital extension strengthens farmer agency by transforming information from a scarce resource into a widely accessible asset.

5.6 Institutional Strengthening Effects

Digital tools have also strengthened extension institutions by:

- Expanding outreach without proportional manpower increase
- Improving monitoring and data feedback
- Enhancing linkages among KVKs, researchers, and farmers

This institutional efficiency reinforces the sustainability of digital extension systems.



6. Emerging Technologies Driving Precision Extension

The rapid advancement of digital technologies is fundamentally reshaping the landscape of agricultural extension in India. Unlike earlier ICT tools that primarily focused on disseminating generic information, emerging technologies now enable precision-based, data-driven, and location-specific advisory tailored to individual farmers and plots. This technological evolution marks a transition from broad-based extension approaches toward intelligent, real-time decision-support systems that enhance productivity, sustainability, and risk management.

6.1 Shift from Generalized to Precision Advisory

Traditional extension typically provided uniform recommendations across regions, often overlooking micro-level variations in soil conditions, climatic patterns, crop stages, and pest dynamics. Emerging technologies allow extension services to move toward hyper-local, personalized advisories based on real-time data streams. This precision reduces uncertainty, minimizes input misuse, and improves efficiency at the farm level.

6.2 Artificial Intelligence (AI) in Agricultural Advisory

AI-powered systems are increasingly used to analyze complex agricultural datasets and deliver customized solutions. In the Indian context, AI applications support:

- Pest and disease identification through image recognition
- Predictive modelling for crop health and yield forecasting
- Decision support for nutrient and irrigation management
- Automated chat-based advisory systems

These tools accelerate diagnosis and reduce dependency on physical expert visits.

6.3 Remote Sensing and Satellite Monitoring

Satellite-based crop observation technologies enable:

- Monitoring crop growth and stress
- Detecting drought and flood impacts
- Identifying pest-prone zones
- Assessing acreage and crop conditions for insurance

Such technologies support proactive and region-specific advisories, enhancing extension accuracy.

6.4 Internet of Things (IoT) for Farm-Level Decision Support

IoT-enabled sensors collect real-time data on:

- Soil moisture
- Temperature and humidity
- Water usage
- Crop growth parameters

These inputs allow precise irrigation scheduling, nutrient management, and early-warning alerts, contributing to resource-efficient agriculture.

6.5 Big Data Analytics and Geo-Spatial Intelligence

Integration of farmer databases with geo-tagged information enables:

- Micro-level advisory targeting
- Risk profiling
- Customized cropping recommendations
- Efficient scheme implementation

Big data strengthens predictive extension and evidence-based policymaking.



6.6 Climate-Smart Technologies

Advanced weather analytics now deliver:

- Block-level forecasts
- Crop-stage specific alerts
- Early warning for extreme events

These systems enhance climate resilience and reduce vulnerability of smallholders

6.7 Agri-Tech Startups and Innovation Ecosystem

Private-sector innovation has accelerated technology adoption by introducing:

- AI advisory apps
- Drone-based crop monitoring
- Smart input recommendation tools
- Farm analytics platforms

These actors complement public extension by filling service gaps.

6.8 Implications for Extension Systems

Emerging technologies are transforming extension in four key ways:

1. Personalization of advisory
2. Real-time problem diagnosis
3. Data-driven service delivery
4. Enhanced monitoring and feedback loops

However, their effectiveness depends on integration with institutional validation and farmer trust mechanisms.

7. Constraints in Digital Agricultural Extension

Despite rapid advancements in digital infrastructure and the proliferation of ICT-enabled agricultural services, several structural and systemic barriers continue to limit the effectiveness, inclusivity, and sustainability of digital agricultural extension in India. These constraints are technological, socio-economic, institutional, and governance-related, and they significantly influence adoption outcomes at the grassroots level.

7.1 Connectivity and Device Access

While rural internet penetration has expanded substantially, equitable access to digital devices remains uneven across farmer categories. A significant proportion of small and marginal farmers either lack smartphones or share devices within households, limiting their ability to independently access digital advisory platforms. Poor network reliability, low bandwidth in remote regions, and frequent connectivity disruptions further restrict real-time usage of digital extension tools

The digital divide is particularly evident in:

- Rainfed and tribal regions with weak network infrastructure
- Economically weaker households unable to afford smartphones
- Older farmers with limited familiarity with mobile technologies

As digital extension largely depends on mobile interfaces, unequal device ownership directly undermines inclusivity and exacerbates disparities in information access.



7.2 Capability and Trust Deficit

Access to technology does not automatically translate into effective utilization. Many farmers lack functional digital literacy to interpret advisory messages, navigate applications, or evaluate the credibility of digital recommendations. Automated advisories—especially AI-generated ones—often face skepticism among farmers who prefer validation from trusted human sources such as KVK scientists or local extension officers

Key trust-related barriers include:

- Fear of incorrect advisories leading to crop loss
- Misinformation circulating via social media
- Limited interaction or feedback mechanisms
- Absence of localized contextual explanation

Credibility remains central to adoption; without human mediation, digital advisories often fail to influence behavioural change

7.3 Gender Gap in Digital Access

Women farmers—who constitute a major share of India’s agricultural workforce—face systemic exclusion from digital platforms due to socio-cultural and economic barriers. Limited control over digital devices, lower literacy levels, restricted mobility, and gendered household norms reduce their participation in digital extension ecosystems

This gendered divide results in:

- Lower access to market and price information
- Reduced participation in digital training
- Exclusion from scheme-related digital services
- Dependence on male intermediaries for information

Consequently, digital extension risks reinforcing existing inequalities unless gender-inclusive strategies are explicitly embedded in design and delivery.

7.4 Institutional Fragmentation and Platform Silos

India’s digital agriculture ecosystem comprises multiple government and private platforms operating independently without standardized interoperability. The lack of integration among advisory services, market platforms, insurance databases, and farmer registries leads to duplication, inefficiency, and confusion at the user level

Major institutional issues include:

- Disconnected databases across departments
- Overlapping advisory applications
- Absence of unified farmer interface
- Weak coordination between public and private actors

This fragmentation prevents seamless service delivery and limits the potential of digital extension to function as a cohesive ecosystem.

7.5 Governance and Ethical Risks

The expansion of digital platforms introduces critical governance challenges related to data privacy, ownership, consent, algorithmic transparency, and cyber security. Farmers often remain unaware of how their data is collected, stored, and utilized. Weak regulatory safeguards may expose them to exploitation, exclusion, or misuse of sensitive agricultural data

Emerging risks include:

- Unauthorized data sharing



- Algorithmic bias disadvantaging smallholders
- Cyber security vulnerabilities
- Lack of grievance redressal mechanisms

Without strong ethical and legal frameworks, digital extension systems may compromise farmer rights and erode trust in digital governance.

8. Blended Extension: Integrating Technology with Human Facilitation

The future of agricultural extension in India increasingly lies in a blended or hybrid model that strategically combines the scalability of digital technologies with the credibility, contextual intelligence, and trust associated with human intermediaries. While digital platforms enable rapid dissemination of information at unprecedented scale, their effectiveness at the farm level often depends on localized interpretation and validation by trusted institutional actors. Recognizing this, the strategic roadmap emphasizes a blended extension ecosystem where digital tools are embedded within grassroots delivery structures such as Krishi Vigyan Kendras (KVKs), Farmer Producer Organizations (FPOs), and community-based facilitators

This integrated framework bridges the gap between technological potential and behavioural adoption by aligning digital outreach with human engagement, thereby ensuring that innovations are not only accessible but also understandable, credible, and actionable.

8.1 Rationale for a Hybrid Extension Model

Digital advisories alone often fail to achieve sustained adoption due to literacy barriers, lack of trust, and absence of contextual guidance. Farmers tend to rely more heavily on recommendations that are endorsed by local experts or delivered through familiar institutional channels. The blended extension approach acknowledges that:

- Technology excels in scale and speed
- Human agents excel in trust, contextualization, and persuasion
- Combined delivery enhances both reach and impact

Thus, hybrid extension represents a complementary, rather than substitutive, evolution of agricultural advisory systems.

Table 4: Proposed Hybrid Digital Extension Model: Components and Expected Outcomes

Model Component	Digital Tools	Human-Mediation Mechanisms	Expected Outcomes
Information Dissemination	Apps, SMS, WhatsApp	KVK staff, field agents	Higher awareness and coverage
Skill Training	Video modules	Demonstrations & field days	Higher skill adoption
Decision Support	AI advisory systems	Expert review panels	Reliable recommendations
Market Linkages	eNAM, digital procurement	FPO aggregation	Better price realization
Monitoring & Evaluation	Remote sensing tools	Farmer feedback groups	Transparent, accountable extension

8.2 Role of KVKs as Digital Facilitation Hubs

KVKs, being the frontline institutions for technology transfer, play a central role in validating digital advisories and contextualizing them for local agro-climatic conditions. Their involvement ensures scientific credibility and strengthens farmer confidence in digital recommendations



KVKs contribute by:

- Translating digital advisories into localized guidance
- Demonstrating technologies physically
- Acting as feedback nodes between farmers and digital systems
- Supporting capacity-building for digital usage

8.3 FPOs as Collective Digital Intermediaries

FPOs serve as critical aggregators and facilitators, enabling group-based digital learning and advisory dissemination. By mediating digital services through collective institutions, farmers gain easier access to technology and benefit from peer reinforcement.

Their role includes:

- Disseminating digital advisories to member farmers
- Assisting with platform registration and service access
- Aggregating farmer feedback
- Linking digital advisory with market and input services

8.4 Grassroots Institutions and Local Trust Networks

Village-level facilitators, progressive farmers, and community organizations function as trusted intermediaries who interpret digital messages and encourage behavioral adoption. The roadmap highlights that digital tools embedded in community networks yield significantly higher acceptance and practical uptake

8.5 Outcomes Enabled by Blended Extension

The integration of human facilitation with ICT platforms ensures:

- Contextual interpretation of advisories suited to local farming realities
- Local trust-building through familiar institutional actors
- Inclusive outreach to digitally marginalized groups
- Improved adoption rates and behavioural change

This blended ecosystem reduces technological alienation and enhances practical effectiveness.

9. Policy Recommendations

To fully harness the transformative potential of digital agricultural extension and education in India, policy interventions must move beyond technology deployment toward ecosystem strengthening, inclusivity, institutional integration, and governance safeguards. Based on the identified constraints and emerging opportunities, the following strategic policy directions are proposed.

9.1 Enhancement of Rural Broadband Quality and Last-Mile Connectivity

Although rural internet penetration has expanded significantly, the reliability, speed, and affordability of broadband services remain inconsistent across geographies. Many digitally underserved regions—including tribal belts, rainfed zones, and remote villages—continue to experience weak signal strength and network instability, undermining the effectiveness of real-time digital advisory.

Policy priorities should include:

- Accelerating BharatNet and fiber-to-village infrastructure
- Expanding 4G/5G coverage in low-connectivity blocks
- Ensuring affordable rural data packages
- Establishing community Wi-Fi hubs in village clusters

Reliable connectivity is the foundational enabler for any digital extension ecosystem.



9.2 Integrate Digital Platforms Under a Unified AgriStack Architecture

India's digital agriculture landscape is currently fragmented across multiple platforms operating in silos. Lack of interoperability between advisory services, insurance databases, market platforms, and farmer registries results in duplication and inefficiency.

Policy focus must aim to:

- Build AgriStack as a common digital backbone
- Enable seamless data exchange across ministries
- Develop single-window farmer interfaces
- Standardize APIs and service protocols

Integrated platforms will ensure coordinated service delivery and personalized advisory.

9.3 Strengthen KVK-Led Digital Facilitation and Grassroots Anchoring

KVKs are the most trusted frontline agricultural institutions and must be positioned as digital extension hubs at the district level. Their role in validating digital advisories and contextualizing them locally is critical for adoption.

Recommended actions:

- KVKs should be equipped with digital infrastructure and analytics tools
- Train scientists to generate localized digital content
- Integrate KVK advisory with AgriStack databases
- Develop village-level digital facilitation through KVK outreach

Human-backed digital extension enhances credibility and farmer trust.

9.4 Promote Multilingual and Voice-Based Digital Systems

Language remains a major barrier in digital agriculture adoption. Many farmers are unable to benefit from text-heavy or English-dominated platforms.

Policy must prioritize:

- Voice-first advisory interfaces
- Regional language content across platforms
- IVR-based learning modules
- Audio-visual advisory for low-literacy users

Localization ensures inclusivity and expands digital reach among marginalized farmers.

9.5 Build Digital Capacity of Extension Personnel

Extension staff often lacks digital competencies necessary to effectively mediate ICT tools and guide farmers. Capacity building is essential for transitioning toward blended extension systems.

Key measures to be undertaken:

- Nationwide digital training for extension officers
- ICT modules in agricultural education curricula
- Incentives for digital service facilitation
- Exposure to AI and precision advisory tools

Digitally empowered extension workers act as catalysts for farmer adoption.

9.6 Develop Farmer-Centric Data Governance Frameworks

As digital agriculture increasingly relies on data, robust governance mechanisms must safeguard farmer rights, privacy, and consent. Ethical data use is fundamental to sustaining trust in digital platforms.

Policy actions should include:



- Clear protocols for data ownership and consent
- Transparent data-sharing regulations
- Farmer awareness on data rights
- Cybersecurity safeguards for agricultural databases

A rights-based digital framework is critical for long-term sustainability.

10. Conclusion

Digital extension has emerged as a transformative force in reshaping agricultural knowledge systems in India. The rapid expansion of rural connectivity, combined with government-led digital platforms and advances in emerging technologies, has created unprecedented opportunities to bridge the long-standing gap between scientific innovation and farm-level practice. Digital advisory tools, market platforms, and data-driven decision-support systems have demonstrated that agricultural information can now be delivered at scale, with speed and precision, reaching millions of farmers beyond the traditional limits of manpower-intensive extension systems.

However, the presence of digital infrastructure alone does not guarantee meaningful empowerment. The study underscores that digital agriculture in India continues to face structural constraints rooted in unequal device access, functional digital illiteracy, trust deficits, gendered exclusion, institutional fragmentation, and unresolved governance concerns. These barriers highlight that digital transformation is as much a socio-institutional challenge as it is a technological one. Without inclusive design and institutional mediation, digital platforms risk amplifying disparities rather than democratizing knowledge.

The evolving agricultural digital ecosystem—particularly initiatives such as AgriStack and national digital advisory platforms—has laid a strong structural foundation for personalized, data-driven extension. Yet their long-term success depends on integrating technology with grassroots institutional credibility. Farmers remain more receptive to innovations that are locally contextualized, validated by trusted intermediaries, and delivered through familiar community channels. In this context, the blended extension model emerges as the most viable pathway for sustaining digital transformation in agriculture. By combining ICT-enabled precision with human facilitation through Krishi Vigyan Kendras (KVKs), Farmer Producer Organizations (FPOs), and village-level networks, India can ensure greater trust, inclusivity, and adoption.

Furthermore, ethical governance must become central to the future of digital extension. Safeguarding farmer data, ensuring transparency in digital decision-making, and preventing exclusion through algorithmic bias are critical to building a responsible and farmer-centric digital ecosystem. Empowerment must not only be technological but also institutional, social, and rights-based.

Digital extension is fundamentally transforming agricultural advisory services in India by shifting from a slow, uniform, and supply-driven dissemination model to a responsive, real-time, and personalized knowledge system. Although large-scale digital infrastructure is now in place, the effectiveness of this transformation will ultimately depend on addressing persistent digital inequalities, strengthening institutional coordination, and integrating human facilitation within technology-enabled delivery mechanisms. A blended, well-governed, and ethically grounded extension framework provides the most viable pathway for promoting inclusive agricultural innovation, enhancing farmer resilience, and fostering equitable rural development across India.

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Innovations and Reforms for Transformative Agricultural Extension: Policy Implications and A Way Forward

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Impressive Performance of the Farm Sector

Indian agriculture has come a long way since independence, with a change of priorities over the decades. It has reached the stage of unprecedented achievements, accompanied by unprecedented challenges. India has made tremendous advancements in food grain production, moving from a food-deficient to a food-surplus country, as a result of scientific research, innovations, technological advancements, and extension services to the farmers. Food grains production, which increased more than six times since independence, from 51 mt in 1950-51 to 332.22 mt(2023-24). All India production of pulses has increased from 16mt during 2015-16 to 24.49mt during 2023-24 (as per 3rd Advance Estimates). Also, all India oilseed production increased to 39.66 mt(2023-24), and horticulture production during 2024-25 increased to 363.08 mt (Directorate of Economics and Statistics, 2023). The livestock and dairy sector has emerged as a significant engine of growth in agriculture, playing a vital role in the overall agricultural landscape. Today, India's milk production reached 239.30 mt, egg production reached 142.77 billion, and fish production increased to an impressive 18.40 mt during 2023-24. Agriculture must be seen as an important sector of the national economy, which has a direct role to contribute towards Sustainable Development Goals (SDGs), promote inclusive development and welfare of millions of smallholder farmers, and accelerate growth of the national economy.

The 'Agriculture and Allied Activities' sector has long been the backbone of the Indian economy, playing a vital role in national income and employment. This sector contributes approximately 16 per cent of the country's GDP for FY24 at current prices and supports about 46.1 per cent of the population. Not only does its performance directly impact food security, but it also influences other sectors, sustaining livelihoods and supporting economic growth (Economic Survey, 2024-25). There is also an urgent need for scientific agro-eco- regional planning and a balanced 'agri-food system-based' multi-sectoral approach for faster agricultural growth and to contribute at least one trillion (20%) of the targeted five trillion economy, and to meet SDGs by 2030. The smallholders and marginal farmers (with < 2 ha), accounting for nearly 86.2 per cent of 146 million farm families, tilling to around 47.4 per cent of total cultivable land and accounting for > 50 per cent of the total agricultural production, are vital not only for India's agrarian economy (10th Agriculture Census 2015-16), but also for alleviating current major challenges of hunger and poverty before the country.

Agricultural Extension -A Huge Task

Extension Services, both public and private have played crucial role in technology delivery. Further, it's a huge task to cover over 700 districts, around 7000 blocks and nearly 7 lakh villages covering 127 agro-climatic zones & 14 Cr. Farmers, 86% of which are small and marginal ones spread over varied social dimensions, varied geographical dimensions, varied resource conditions. Hence, agricultural extension is a tough articulation and architecture.

Earlier Extension Efforts

Series of voluntary projects in pre-independence era, such as Community Development Program (CDP-1952) and National Extension Service Blocks (NES-1953) were the major earlier extension efforts. Subsequently, Pre-Green Revolution interventions implemented include: Intensive Agricultural District Program (IADP, 1961) and Intensive Agricultural Area Program (IAAP, 1964). Followed by Green Revolution (1967), duly supported by intensive extension efforts like National Demonstrations (ND- 1965),



Farmers Training Centres (FTC-1966), Small and Marginal Farmers Development Agencies (SMFDAs-1971), Krishi Vigyan Kendras (KVK-1974, 732) and lab to land program (1979- that subsumed in KVKs). In 1974-75, a very major extension intervention through World Bank Funded Training and Visit (T&V) system resulted in restructuring of the extension system. Following its significant impact, it was expanded throughout the country from 1984 to 1995 through National Agricultural Extension Project (NAEP). Further, the process of Extension Reforms was strengthened under National Agricultural Technology Project (NATP, 1998) by establishing Agricultural Technology Management Agency (ATMA) at district level, now covers 676 districts in 29 States/3 UTs under the National Mission on Agricultural Extension & Technology (NMAET).

Extension Constraints

The extension delivery is seriously affected by the major constraints like :(i) Policy support and systemic inadequacies, (ii) inadequate investments and extension infrastructure, (iii) gaps in need based deployment of manpower at various levels, (iv) weak extension set up in allied sectors like horticulture, livestock, fisheries, agro forestry and speciality agriculture, etc.(v) outreach constraints of existing extension models, inadequate capacities at the district /block level extension agencies to respond/address the field problems,(vi) need for convergence of extension efforts, (viii) need for promoting PPPs, start-ups, extension entrepreneurs & paid extension initiatives in commercial farm enterprises to begin with, (ix) need for farm youth and farm women specific extension strategies, (x) need for strengthening research- extension linkages and feedback management, (xi) enhancing media/ICT applications, (xii) need for value chain management, greater market integration and farm business orientation, (xiii) technology specific and location specific extension requirements, (xiv) skilling farmers, field functionaries and stakeholders, (xv) intensive research in extension systems for their efficacy, (xvi) need for in-built M&E for timely correctives in extension actions, and (xvii) need for capturing international experiences for strategic advantages. These constraints need addressal through systematic policy interventions, programmes, investments and operational measures at various levels.

Extension Models in Operation

Agricultural Extension Models evolved over a period of time would include:

- (i) Research Institutions Outlets like Krishi Vigyan Kendra (KVKs),
- (ii) Development Department outlets,
- (iii) Commodity Board Outlets (Spices, Coconut, NDDB, NFDB, Tea, Coffee, etc.,
- (iv) Private Sector Interventions: Entrepreneurs, PPPs, Start-ups, CSR provisions, Input agencies,
- (v) Financial Institution Interventions like NABARD, RRBs, DCBs, etc.
- (vi) NGOs: Local, Regional, National & International,
- (vii) Media (Print, Electronic),
- (viii) Social Media and Digital Interventions
- (ix) Externally Aided Projects and Donor Driven Reforms Models.
- (x) Farmer Aggregates (FOs, Coops, FPCs, etc.)
- (xi) Farmer to farmer

Innovations and Reforms Suggested

These delivery models have to get transformed to deal with the current and future challenges. Hence the Innovations and reforms suggested are as follows:



Schematic Provisions: Intensive Awareness Camps/Campaigns

1. Awareness campaigns are needed especially at the block levels through agriculture and allied sector departments, KVKs, NABARD, etc. Involving FPOs, NGOs, CSRs, PRIs, Gram panchayats, Cooperatives, SHGs, etc. with focus on availing provisions available under various schemes and modalities to avail them.

Promoting & Empowering Farmers Aggregates for Managing Extension Services at the Cutting Edge Level

2. Promote farmer aggregates like SHGs, FIGs, CIGs, FOs, FPCs, Cooperatives, etc., and enhance their skills for better production, marketing, and price negotiating / programme delivery capacities. Social capital formation, community led initiatives, participatory approaches, involvement of community resources need to be encouraged in the extension processes. Farmer Organizations (FOs) / Farmer Producer Companies (FPCs) should come upon a cluster basis with the strong market integration, where they may act as a single window service centres to all farmers/producers in a given production cluster. The small, marginal and weaker sections of the farming communities may be duly represented and sustained in such aggregations.

Enhancing Outreach of the Extension Models in Operation

3. It is important to improve outreach, interplay and performance of extension models to their optimum levels by (i) widening the sectoral and area coverage, (ii) partnerships and resource sharing, (iii) enhancing integrated delivery, (iv) improving penetration of services to the small producers, etc. There is need to promote chains of extension agents, formal / informal, such as Para techs, start-ups, ICT platforms, entrepreneurs, ACABCs across the production systems and build their capacities for effective extension delivery. Market-led extension strategies are required to be worked out involving farmer aggregates. Further, increased investment in market infrastructure (electricity, warehousing, rural roads, modern ICT etc.) by the government, private sector and local communities are urgently spelt and operationalized.

4. District / Area Level Farm Science Centres, like Krishi Vigyan Kendras (KVKs- Farm Science Centres-India) mechanism may be promoted and strengthened for technology assessment / refinement and demonstration of the frontline technologies. Eventually, they may stand up as strong knowledge resource base for public and private extension services and across the production systems.

5. In allied sectors like horticulture, animal husbandry, dairy, poultry, fisheries, nutri-cereals, etc., the extension outreach is very weak, although these sectors contribute significantly. Hence, extension needs to be re-organized in allied areas by way of: i) providing additional subject matter specialists (SMS) to the district / block levels in potential areas, ii) promoting growers' associations, commodity groups, entrepreneurs, iii) promoting dairy/fish cooperatives and using dairy/fisheries entrepreneurs as extension agents. Extension for disadvantaged areas/groups could be addressed through innovative extension solutions like i) combination of extension service provider (ESP), ii) involving NGOs / Para techs, iii) intensive use of print / electronic / mass media / ICTs / Social media / Folk media, and iv) participation of local communities and institutions, etc.

6. Farmers Field Schools (FFSs) / seed villages proved as an effective extension tool, practiced widely, needs to be up-scaled, and not only for crops but also in the allied sectors too, as these provided opportunity for farmer-to-farmer knowledge dissemination and capacity development, promoting farmer led innovations and farmer first extension. National Farmer's Innovation Fund could be established to promote farmer to farmer extension. Farmer first approach needs to be promoted with focus on critical needs of the farmers in a given micro ecology and work out options for their redressal. Farmer Business Schools tried by FAO in Africa, South East and Latin America may be tried and promoted.

7. It is important to create enabling environment for women extension personnel in extension services. Enhanced access to credit / inputs for farm women and providing gender sensitive and home scale nutritional extension services are crucial. Specific measures proposed include sensitising / reorienting the extension services on gender and nutrition issues, developing and piloting such extension models, promoting nutri-gardens and alternate nutri-foods, women empowerment, enhanced use of digital networks, public



awareness and stakeholder participation. Pilot studies in vulnerable areas and capacity building at various levels is strongly recommended.

8. There should be adequate focus on motivating and attracting youth as entrepreneurs in agriculture for which high-tech agriculture, secondary agriculture, processing and value-addition opportunities, innovative marketing, commercial enterprises, etc. should be targeted. Youth in agriculture needs to be provided institutional and financial support through R&D organizations, agri-clinics, financial institutions, etc. for promoting them as development agents / job providers. Committee of Food Security (FAO High Level Panel of Experts-2021) suggested youth engagement strategies like: securing dignified and rewarding livelihoods, social recognition, increasing equity and rights to resources, enhancing knowledge, education and skills, fostering sustainable innovation. Incubation programmes and start-ups be promoted involving youths.

9. Benchmarks for extension performance may now include: extent of adoption of IFS approach, extent of programmatic convergence with other departments, enhancement of production / income of the producers, enterprise combination, crops and cropping pattern diversification for the economic advantage of the farmers, market linkages, etc. Extension accountability to the farmer aggregates needs to be systematically designed, cultivated and promoted.

Integrating Private Sector Extension Services and Efforts for greater impact

10. Public-Private Partnerships (PPPs) are required down the line to promote MOU based participatory extension arrangements. Public sector would need to be oriented on contribution and strengthening of PPPs. The capacity of private agents also needs to be improved by strategic alliances which need policy directions. Agri-clinics and Agri-business Centres (ACABCs), agri-entrepreneurs, agri incubators, agri start-ups, e-platforms, etc. are found to be gaining space in extension operations. Agribusiness MBAs, IT graduates and farm youths (including school dropout, men and women) may be promoted for providing advisory services on payment basis in collaboration with public and private sectors. There is need to promote Private Paid Extension (PPE) services in commercial / horticultural crops as practiced in developed countries and in agriculturally well performing States.

Strengthening Research and Extension Linkages for Desired Outputs

11. There are various research and extension (R&E) linkage forums available in agriculture and allied sectors at various levels (national, regional, state, district and even at the block level). The performance of these linkage forums need a lot of improvement in terms of contents, coverage, joint actions and follow-up. Technology options for agro-climatic zones and sub-zones needs to be systematically worked out as per socio-economic dimensions of each micro agro-eco situation. This would enhance dynamism in extension processes. Farmer – Scientists Interactions (FSI) may be up scaled in knowledge driven technologies. Likewise, successfully demonstrated innovations by the research agencies should be up scaled by the Field Extension agencies. Greater involvement of the scientists is needed in technology driven extension like NRM, IPM, INM, conservation agriculture, farm mechanization, climate resilience, etc. Knowledge-driven innovations - extension agents may first work some time with scientists and then with the farmers for a considerable time, show the results through demonstrations and then upscale innovations, preferably through the farmer aggregates for wider footprints.

12. Feedback on collation of information from the farmers and field functionaries is seemed to be weak in present day extension system, so also its systematic documentation and analysis. The collation of feedback (both positive and otherwise) from the farmers and field functionaries may be the first essential step, followed by documentation / analysis at the district / block level. The review and reporting could be taken up by the regional set up. Such an arrangement would not only make the extension operations demand driven but may also facilitate providing policy signals to the higher-level R&E management. Feedback management mechanisms are pilot tested across the sectors and for micro agro situations then learning up scaled.



Streamlining Training & Capacity Building of the Field functionaries, Farmers and Stakeholders.

13. National /State and District Training frame work be suitably strengthened in terms of manpower and infrastructure. Interplay of these institutions needs to be worked out systematically, sharing the output – input relationships and the experiences. Farmer’s training in agriculture and allied sectors is shared by the large number of agencies / organizations at the district / block levels. It is suggested that focused and segregated training responsibility needs to be assigned to different agencies as per expertise and competence of the agency. Innovative farmers, credible farmer cooperatives and FPOs, successful Agri Clinics, effective IT platforms could be integrated in the training and CB strategies as applicable in agriculture and allied sectors and as per demands and special felt needs of each categories of farmers, farm women and farm youth.

14. With the change in present day farming scenario, farmers’ skills need to be up graded / oriented towards entrepreneurship, income / business orientation, value added /secondary agriculture, aggregated production and marketing, etc. Accordingly, extension workers’ skills need emphasis on social skills, entrepreneurial management skills, technical skills, and media management skills. Skill enhancement of the farmers, field functionaries and SMSs (subject matter specialists) need to be prioritized to make them ready for area-specific, commodity specific, technology-specific and eco-region-specific extension as applicable to the micro agro situations and vulnerable groups.

Priority Setting & Convergence of Extension Efforts at the Block/ Cluster levels

15. There are series of district level planning instruments, scheme-wise. The extension functionaries may scan these instruments for capturing the right priorities across the schemes / programmes. The crucial extension issues must reflect in the systematically developed Block Extension Plans (BEPs) at the cutting-edge levels, defining the role of various extension service providers (ESPs). Well established / networked R&D platforms at the cutting edge level could be a convergence arrangement. The resources from the converging departments would need to be pooled and the roles and responsibilities required to be delineated carefully harmonizing of work plans of the related Federal / State schemes. Convergence requires proper role space and resources amongst stakeholders for mutually agreed Block Action Plan (BAP). Matrix mode approach is required indicating the ongoing programs and the gaps to be bridged. Operational flexibilities to the converging partners need to be worked out in advance and provided for. Large number of convergence pilots be carried out both for resource poor and resource endowed areas and learning inculcated in the ongoing programmes and schemes.

ICT and Media Management to Accelerate the Extension Delivery Processes

16. Social media (WhatsApp, Facebook, Twitter, Instagram, emails, blogs, App-based services, block chains, etc.) are powerful communication tools that enhance the beneficiary coverage in the shortest period of time which could be used effectively in networking farmers’ and offering context-specific information. Further, dedicated tele- numbers could be provided by the R&D agencies like Kisan Call Centres (Farmers’ Call Centres) in India that provide country wide common eleven-digit toll free number 1800-180-1551 for providing tele replies to the farmers’ queries in local languages. ICTs are also being used to strengthen the capacity of extension officers and field staff to first reach the farmers with timely and accurate information and help capture data from the field. The e-Choupal initiative of ITC Corporate, as an example has had positive effect, the system enhanced supply chain efficiency.

17. Advanced ICTs like AI, ML, drones, satellite systems as well as artificial intelligence, machine learning etc. are used for precision farming, improved farm management, providing real-time data, etc. E-platforms and mobile applications are emerging very fast. However, the pertinent question is how to increase its access to the large number of farmers and reliability of the information. Therefore, need for promoting farmer / farm women knowledge groups (FKGs / FWKGs) at the grass roots level.

18. The farmers and the field functionaries may be thoroughly oriented and skilled in use and operations of advanced technologies like drones, sensors, robotics, machine learnings, artificial intelligence, data analytics, etc. This approach should be the game changer for future extension strategies and operations in developing countries in Asian and African regions. The R&D outlets of the Farm Universities and the



private organizations at the District / block levels should be capacitated to demonstrate impacts of such technologies. Successful demonstrations and experiences should be widely replicated.

19. Use of traditional media, field-days, campaigns, vernacular press, are also important and supportive extension methods in disadvantaged and far-flung areas. Location specific Farm Telecasts, Radio broadcasts and Community Radio Stations (CRS) would continue to play significant role in farm information dissemination process. Important considerations for farm radio / TV broadcasts are: content development, treatment, delivery mode and the real time impact in the field. Different media combinations should be worked out as per subject matter, agro-climatic and socio-economic criteria of the farmers. The Directorates of Extension of the Agri - Universities and farm information wings of the State Departments may need to revisit their role when the private players and IT platforms are proactive now.

Research in Extension- Revisit the Present Process to Make It Demand Driven

20. Research in Extension is a crucial area but not attended adequately. Strong extension research input is required from various academic and semi academic stakeholders to evolve a body of extension knowledge and strengthen it. Farmers, their field endowment, socio-economic setting, innovations / technologies, adoption process are to be looked in to seriously. Farm sectoral variations, are the research variables for overall impact of the extension interventions. The extension research labs need to be promoted in competent organizations and at various levels, for examples the Centres of Excellence of the MANAGE in India could take a lead in this process.

21. The future extension research strategies must draw strengths from international, private sector, NGOs and multilateral donor experiences. Future extension research may focus on systems interplay, convergence, agribusinesses and entrepreneurs, App based ICTs, extension for unreached, climate change adaptation, etc. Extension Research outcomes be ploughed back for reforming existing policies and operations. Suitable state specific mechanisms may be worked out by the SAMETIs, ATARIs and the Directorates of Extension of the SAUs.

The interventions aim to build the capacity of young farmers to adopt profitable, tech-enabled sustainable agricultural practices and business models.

Youth in Agriculture

22. By empowering young farmers with modern skills, tools, and entrepreneurial mind-sets, may facilitate to transform agriculture from a subsistence activity into a dynamic engine of rural prosperity. Through targeted interventions in training, mechanization, crop and income diversification, and entrepreneurship, etc. may harness the potential of India's youth (both men and women) to drive agricultural transformation. Moreover, there is need to gain strategic value by capturing field-level insights, developing evidence-based case studies, and engaging key stakeholders through policy dialogues and knowledge-sharing platforms ensuring that successful models are scaled and integrated into broader agricultural policy and practice. The following areas specific areas have a great potential to engage youths.

Climate-Smart Agriculture and Technology Adoption

There is need to promote climate-smart agriculture by equipping young farmers with knowledge and methods to improve productivity while building resilience to climate change. Structured trainings need to be provided on improved agricultural practices, including seed treatment, pest and disease management, soil health improvement, and vegetable cultivation. To further strengthen climate resilience, modern agri-technologies such as smart weather sensors, efficient water irrigation systems, laser land levelling, and precision nutrient management need to be demonstrated.

Farm Mechanization and Custom Hiring Entrepreneurship

Young farmers would need to be supported in establishing Custom Hiring Centres (CHCs) for providing easy access to modern farm machinery. They will not only use the machine improved tools and equipments in their land but also will rent it out to other neighbouring farmers at subsidized rate. This way will enable the entrepreneur farmers not only to receive business support to run agri-equipment on rental



basis thus providing them income diversification, but will also help in wider mechanization access for the rural communities.

Crop Diversification and Value Addition

There is need to focus on the cultivation of high-value crops along with hands-on learning in post-harvest handling, branding, and value addition. This will enhance market value and income, particularly attractive for entrepreneurial youth.

Entrepreneurship Development through FPOs and Market Linkages

Young farmers need to be trained in entrepreneurship skills including business planning, financial literacy, and access to credit. Special focus will have to be placed on strengthening Farmer Producer Organizations (FPOs) inducting farm youths to facilitate collective entrepreneurship, value addition on the commodities, resource sharing/leveraging, and enhanced market access.

Diversified Livelihoods through Integrated Farming and Value Chains

Farm Youth need to capture non-traditional income streams like goat farming, poultry, dairy processing, and small-scale value addition units (e.g., oil mills, flour units). This will reduce risk from mono-cropping and ensure more stable incomes.

Major ICT Initiatives- Public Private

23. The Game Changer – However, Intermediaries & Content validation is a challenge

ICAR initiatives: Kisan developed by DIKMA (integrates 300 mobile

Apps), KVK Portal, Network Program on Precision Agriculture (NePPA), Kisan Sarathi, etc.

IMD initiatives: MausamGram, Agro-met advisories, etc.

State Initiatives: Kerala – AIMS & VAIGA, Andhra Pradesh - D-Krishi, Maharashtra- Krishak App, Gujarat – i Farmer, Orissa- Go Sugam, Karnataka, K-Kisan, etc.

Private Initiatives: Jio Kisan, Ninjacart, e-Chaupal, Skymet, etc.

24. Intermediaries to facilitate ICT application may include

- FOs, FIGs, SHGs, FPCs,
- Primary Coop Societies
- Agri entrepreneurs, Startups, incubators,
- PPP Platforms
- Farm Aggregators, Marketing Platforms and export agents
- Farm Youths
- Agri Industries
- Input support industries
- Food processing and value addition industries
- Private extension service providers
- NGOs
- Farm Consultants
- Grass Root level Info Kiosks operators
- Field functionaries of KVKs, ATMAs, Research Stations, SAUs
- Field functionaries of the
- Farm Vendors at the cutting edge levels
- Gram Panchayat Functionaries
- Innovative farmers



- Agri Media workers/agents
- Farm training centers, public and private
- Rural Development field agencies like Krishi Sakhis,
- etc.

Digital Enablers for Agri Marketing Ease

24. Prominent Digital enablers having marketing intelligence impacts are: Mobile Apps, Portals, Websites, Robotics, Automation, Drones, IOT Sensors, Remote Sensing, Big Data Analysis, AI, ML, Block Chain, Cloud Computing, etc.

Tremendous benefits: Increased access, greater connectivity, precision farming, exploring new knowledge frontiers, efficient resource management and empowered farmers. Provides Win Win Situation for Farmers, Governments, Industries and Consumers.

Market Intelligence provides for Direct Engagement with the buyers, e-commerce, digital Market places, mobile apps, etc.

25. Key Initiatives by the Government: Digital Agriculture Mission, MoUs with private platforms, Virtually Integrated Systems (VISTAAR- IT intervention at each stage from soil health management to input management to PP to harvest to market, Evidence Based DSS, e-NAM, agmarketnet, DBT under PMKisan, Kisan Suvidha Apps, KCC, M-Kisan Portal, Farmer Portals, etc.

Upcoming Technologies that Need Intensive Extension Efforts

26. There are good number of upcoming farm innovations & technologies that need serious attention of the extension agencies for wider dissemination through effective integrated extension strategies and cost reduction applications. Such efforts must be location specific, at the same time it may call for involving farming community for wider actions.

27. Some of the crucial ones include the following and need intensive extension support for its piloting, scaling and wider dissemination:

- (i) Promoting barren lands as solar energy hubs,
- (ii) Roof top solar panels – its promotion in rural areas,
- (iii) Promoting climate resilient agriculture and climate smart farmers with involvement of farming community at the grass roots level,
- (iv) Soil health management, especially judicious and timely nutrient application as per the recommendations of soil health cards,
- (v) Promotion of one district one product scheme for export opportunities,
- (vi) Greater integrated developmental focus on the identified aspirational districts/blocks,
- (vii) Promotion of drip irrigation and protected cultivation,
- (viii) Promotion of Tissue culture technology produced planting material, especially in horticultural crops,
- (ix) Raised bed cultivation and zero tillage technologies, (x) Organic agriculture and natural farming,
- (xi) Popularization of green carbon credit scheme
- (xii) Small scale farm mechanization for hilly and mountainous areas and horticultural crops,
- (xiii) Promotion of nutri gardens in peri urban and rural areas,
- (xiv) Intensive application of drones, sensors, artificial intelligence, robotics, machine learnings, and making farmers ready for such take over gradually,
- (xv) Promotion of fodder technologies for animals and fish feeds and
- (xvi) Health management practices for the small ruminants & poultry, etc.



Crucial System Supportive Interventions Enabling Extension to Perform Efficiently

28. The emergence of pluralistic models suiting the macro and micro agro climatic zones need much needed flexibilities in extension dynamics by capturing best of technologies/extension innovations and their dissemination.

29. Needless to mention that the extension service delivery would be far more visible if it is suitably backed by the public policies, research support and more importantly input augmentation for efficient and dynamic performance with focus on self-sufficiency, food security and export opportunities.

30. Processing and value addition is essential to add to the farmer's income whenever there is marketable surplus particularly the perishable produce is more and is in excess to the demand. It has a great proven promise and extension services need to be geared up to address such value chain demands.

31. It is essential that extension functionaries should demonstrate and emphasize adopting the "Farming Systems Approach" by diversification of production portfolio (food crops, commercial crops, pulses, oilseeds, horticultural crops, animal husbandry, fishery, poultry, homestead farming, etc) for higher economic gains. It may prove to be the most effective system and win-win situation against climatic risks and calamities.

32. There is need to capture learnings and experiences from overseas successful extension models. It would call for exchange of extension operators, exposure visits, capture the good extension practices, etc. for mutual advantage.

Regional Alliances in Agricultural Extension

33. The international deliberations and SDG analysis projected a strong need for systematic cross learning of agricultural innovations and impactful success stories amongst the countries in the South Asia. Accordingly Agricultural Extension Platform for South Asia (AEPsA) was established on 8th March, 2024, with a mission of cross learning of agricultural extension innovations for mutual gains.

34. The specific activities include: documenting emerging innovations, promoting cross learnings, exchange of experiences, organizing country specific and regional dialogues, strategic partnerships and innovative pilots. The platform is unique and focused to build interventions on Country Agricultural Extension Profiles (C-AEPs). It has a strong Advisory Committee to steer the growth and interventions and has an inbuilt M&E mechanism and also a vibrant website. So far it's operating it as a program of Trust for Advancement of Agricultural Sciences (TAAS), the registration process is moving on a fast track mode. Already it's linked to the number of national and international networks and making a difference to the innovations in extension delivery.

35. Visit AEPsA Website for further details: www.taas.in then hit the AEPsA for details like Country Agricultural Extension Profiles (C-AEPs), Brochure, Advisory Committee, Membership Categories and Fee Structure, Publications, Media Coverage, Important Links, Impacting innovations, Agri -Virtual platforms, etc.

Visit us on Facebook, LinkedIn, Twitter, Instagram and YouTube.

Concluding

36. The Extension delivery is a very complex system dealing with farm technologies on one hand and the socio-economic dimensions on the other. In a given micro-situation in the absence of reformed extension services, the programme delivery to the targeted clientele is inadequate and of a weaker impact in the field.

37. Hence, strong extension innovations / organizational and management reforms are pleaded both in public and private extension systems and in the delivery mechanisms. Extension innovations and reforms need to be strengthened and a few others pilots tested to suit the local needs and resources.

38. There is need for greater convergence and coordination of extension efforts at various levels. Needless to say, that the extension service delivery would be far more visible, efficient and location specific and most productive if it is suitably backed by the public policies, investments, incentive linked good agricultural practices (GAPs), market reforms, strategic scaling innovations and credit –input augmentation.



39. We may have technologies, schemes, funding support, etc, however, in the absence of streamlined and reformed extension outreach, we may be back to square one. Further, the extension is a serious challenge as it deals with fast moving technologies on one hand the complex resource base and socio - economic conditions on other. Climate change, Credit market access, timely availability of the farm inputs and advisory on judicious application, etc. matters a lot in the extension delivery. Hence, those who struggle on this challenging task of working with the farmers need greater appreciation and recognition.

40. Finally, the 'wrongs' in farm sector could be addressed and settled only through 'rights' in extension delivery that is farmer friendly, forward looking, high tech led, matching the resource endowment of the farmers, enabling best value to the farm produce, enhancing the social value to the farming and responsive to the emerging challenges in agriculture and allied sectors.

41. **Performance** in farm sector totally depends on **perfection** in extension delivery.



Digital Agriculture for Sustainable Food Systems and Atmanirbhar Bharat

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ABSTRACT

India's agricultural sector is at a pivotal moment in its development trajectory. As the nation pursues the vision of Atmanirbhar Bharat (Self-Reliant India), the integration of digital technologies into the food and agriculture sector has become a national priority. This transformation is not merely technological; it is deeply socio-economic and environmental. Digital tools such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data, remote sensing, drones, robotics, blockchain, and mobile-based advisory systems have emerged as powerful enablers of productivity, sustainability, inclusiveness, and resilience. These technologies are helping address long-standing challenges including climate variability, resource degradation, low productivity, fragmented supply chains, market inefficiencies, and limited access to real-time information among farmers especially small and marginal farmers who constitute the backbone of Indian agriculture. It examines how digital agriculture can serve as a catalyst for building sustainable food systems aligned with the principles of Atmanirbhar Bharat. It highlights the role of digital innovation in enhancing productivity, optimizing inputs, strengthening climate-smart practices, improving food safety, reducing post-harvest losses, and creating transparent and efficient supply chains. In addition, it analyses the socioeconomic impacts of digitalization particularly how digital extension services, farmer-producer organizations (FPOs), e-commerce platforms, and agri-startups contribute to rural employment, entrepreneurship, and financial inclusion. The paper also discusses policy frameworks, national initiatives, and institutional mechanisms that are accelerating India's agricultural digital transformation. The write-up argues that a digitally empowered agricultural ecosystem is essential for achieving national goals such as doubling farmer income, reducing carbon intensity, achieving sustainable production, and ensuring food and nutritional security. It concludes by proposing a multi-dimensional roadmap encompassing policy reforms, infrastructure development, research and innovation, capacity building, and public-private partnerships. These interventions will be instrumental in steering India towards a resilient, technology-driven, and self-reliant food system for the future.

Key Words: Digital Agriculture; Sustainable Food Systems; Atmanirbhar Bharat; Smart Technologies and Climate-Smart Farming

INTRODUCTION

India's agricultural sector supports the livelihoods of more than half of its population and remains central to food and nutritional security, economic stability, and social well-being. Over the past few decades, India has undergone significant transformations in agricultural production, policy, and market systems. Yet the sector continues to face persistent challenges including climate uncertainty, land fragmentation, declining soil health, post-harvest losses, water scarcity, labour shortages, and market volatility. These challenges not only limit productivity but also threaten the long-term sustainability of food systems. At the same time, India is pursuing a national vision Atmanirbhar Bharat that emphasizes self-reliance, resilience, and innovation-driven growth. Agriculture forms a cornerstone of this vision. The convergence of agriculture with emerging digital technologies presents an unprecedented opportunity to reimagine food systems, empower farmers, and ensure sustainability. Digital technologies such as artificial intelligence (AI), machine learning (ML), drones, IoT sensors, mobile apps, GIS, satellites, blockchain, robotics, and digital financial tools are redefining agricultural production, supply chains, and decision-making systems. These



innovations can help India transition from input-intensive growth to knowledge-intensive, climate-resilient, and resource-efficient agriculture. This paper explores the transformative potential of digital technologies in building sustainable food systems that contribute to the strategic objectives of Atmanirbhar Bharat. It further highlights the challenges, policy needs, and roadmap required to scale digital agriculture for sustainable development.

A. DIGITAL AGRICULTURE AND SUSTAINABLE FOOD SYSTEMS: CONCEPTUAL LINKAGES

A food system becomes sustainable when it ensures economic viability, environmental protection, social inclusiveness, and resilience across all stages from production to consumption. Digital technologies influence each dimension:

1 Economic Sustainability

Digital farming tools increase productivity, reduce costs, improve market access, and promote efficient value chains, generating higher farm incomes.

2 Environmental Sustainability

Precision agriculture and climate-smart tools reduce excessive use of fertilizers, pesticides, water, and energy, enhancing soil and ecological health.

3 Social Sustainability

Digital extension services democratize access to information, empower smallholders, and support women and youth involvement.

4 Resilience

Predictive analytics, early warning systems, and real-time advisories enhance preparedness against climatic shocks, pests, and market fluctuations.

Thus, digital agriculture is not merely a technological upgrade; it fundamentally shifts India's agri-food system towards sustainability and self-reliance.

B. KEY DIGITAL TECHNOLOGIES TRANSFORMING INDIAN AGRICULTURE

1 Artificial Intelligence and Machine Learning

AI-driven models are revolutionizing decisions in crop health monitoring, yield forecasting, pest and disease prediction, and climate modelling. Examples include:

- **AI-based diagnostic tools** (e.g., plant disease identification apps)
- **Predictive analytics** for irrigation scheduling or crop insurance
- **AI-powered decision support systems** used by agri-startups and state agencies

AI helps optimize inputs and reduce losses, supporting sustainable intensification.

2 Internet of Things (IoT) and Sensor-Based Farming

Sensors for soil moisture, nutrient availability, weather conditions, and crop growth allow:

- real-time monitoring
- precision input application
- automated irrigation systems
- reduced water and energy usage

IoT-enabled drip and fertigation systems can reduce water use by 40–60% while increasing yield.



3 Remote Sensing, GIS, and Drones

Drones have gained substantial visibility in India after policy liberalization. They support:

- high-resolution crop monitoring
- variable rate application of fertilizers/pesticides
- land mapping
- crop insurance assessment

GIS and remote sensing support land-use planning, crop mapping, and drought monitoring.

4 Blockchain and Digital Supply Chains

Blockchain enhances transparency in supply chains by enabling:

- traceability
- reduction of fraud
- improved food safety
- fair price assurance

Farm-to-fork digital systems help strengthen trust and quality assurance, especially for export markets.

5 Mobile-Based Digital Extension Services

Mobile penetration in rural India makes digital advisory systems extremely powerful. Apps provide:

- e-advisories
- best-practice recommendations
- weather forecasts
- market prices

Digital platforms such as Kisan Suvidha, mKisan, and state-level apps have democratised access to information.

6 Robotics and Automation

Automated tools for harvesting, weeding, spraying, and sorting help address labour shortages and improve efficiency. They are increasingly adopted in horticulture and high-value crops.

7 Digital Financial Services and e-Commerce

Digital payment systems, Kisan Credit Card digitization, e-NAM markets, and farmer e-commerce support:

- financial inclusion
- faster credit access
- transparent market transactions

Agri-startups have enabled farmers to sell directly to consumers, thus enhancing income.

C. NATIONAL INITIATIVES SUPPORTING DIGITAL AGRICULTURE AND ATMANIRBHAR BHARAT

India has introduced a wide range of digital initiatives:

1. Digital Agriculture Mission (2021–2025)

Promotes use of AI, drones, blockchain, GIS, and data analytics.



2. India Digital Ecosystem for Agriculture (IDEA)

A unified data platform to support targeted advisories and innovation.

3. e-NAM (National Agriculture Market)

Integrates APMC mandis digitally for transparent, competitive markets.

4. Agri-Stack Infrastructure

Farmer-centric digital ecosystem for personalized services.

5. Krishi Vigyan Kendras (KVKs) and Digital Extension

KVKs are increasingly adopting digital tools for capacity building.

6. PMFBY and Digital Crop Insurance Tools

Use of remote sensing and smartphones for faster claim settlement.

Together, these initiatives support the Atmanirbhar Bharat objectives of modernization, empowerment, and resilience.

D. ROLE OF DIGITAL TECHNOLOGIES IN SUSTAINABLE FOOD SYSTEMS

This section discusses how digital tools address major sustainability challenges.

1. Enhancing Productivity with Fewer Resources

Precision input use reduces cost and enhances yields. For example:

- 20–30% reduction in fertilizer use
- 10–20% increase in productivity
- 15–25% reduction in pesticide use

2. Climate-Smart Agriculture (CSA) Integration

Digital tools support:

- climate forecasting
- drought/heat/cold stress advisories
- crop diversification strategies
- pest and disease prediction

This enhances climate resilience.

3. Reducing Post-Harvest Losses

Digital warehouses, cold chain sensors, and e-logistics platforms help reduce India's 10–20% post-harvest losses.

4. Improving Food Safety and Traceability

Blockchain and digital certification strengthen market trust and export competitiveness.

5. Market Integration and Fair Pricing

Digital platforms bridge the gap between farmers and consumers, improving profitability and reducing exploitation.

6. Strengthening Farmer Producer Organizations (FPOs)

Digital tools help FPOs in:

- aggregation
- market analytics



- quality control
- logistics coordination

Thus, FPOs become engines of rural transformation.

E. CHALLENGES AND CONSTRAINTS

Despite huge potential, India faces several challenges:

1. Digital Divide

Limited access to connectivity, smartphones, and digital literacy.

2. High Cost of Advanced Technologies

Drones, sensors, and automated systems remain expensive for smallholders.

3. Data Privacy and Security Issues

Concerns about ownership and misuse of farmer data.

4. Fragmented Innovation Ecosystem

Lack of coordination between government, private sector, and research institutions.

5. Capacity Gaps

Insufficient technical skills among farmers, extension workers, and local institutions. Addressing these requires systemic solutions.

F. ROADMAP FOR ACCELERATING DIGITAL AGRICULTURE FOR ATMANIRBHAR BHARAT

1. Strengthening Digital Infrastructure

- Rural broadband expansion
- Village-level digital resource centres
- Low-cost sensor manufacturing

2. Integrating Digital Tools into Extension Services

- AI-powered advisory systems
- Digital training modules
- Drone-based KVK field demonstrations

3. Promoting Inclusive Innovation

- Subsidy schemes for drones, sensors, and smart irrigation
- Women-led digital agriculture programs

4. Scaling Public–Private Partnerships

- Collaborations with startups
- Support for agri-innovation hubs

5. Building Farmer Capacity

- Digital literacy campaigns
- Village-level digital champions
- Skill development for youth



6. Ensuring Ethical and Secure Data Governance

- Clear frameworks for data protection
- Farmer-owned data cooperatives

By implementing this roadmap, India can transform its agricultural landscape.

CONCLUSION

Digital technologies are redefining agriculture and food systems globally, and India stands at the forefront of this transformation. As the country moves toward the vision of Atmanirbhar Bharat, digital innovations offer powerful tools to achieve sustainability, resilience, and self-reliance. From precision farming and climate-smart advisories to digital supply chains and financial innovations, the opportunities are immense. However, the success of digital agriculture depends on inclusive policies, strong infrastructure, effective capacity building, and coordinated efforts across sectors. If implemented effectively, digital agriculture can serve as the backbone of a sustainable, profitable, and resilient food system empowering millions of farmers and securing India's food future.

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Water-Soluble Fertigation as a Precision Agriculture Tool for Sustainable Food Systems

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ABSTRACT

Sustainable food production requires efficient use of water and nutrients while reducing environmental impacts. Precision agriculture provides technologies that enable accurate, crop-based input management. Among these, water-soluble fertigation has emerged as an effective precision nutrient management tool. It involves the application of fully water-soluble fertilizers through irrigation systems, allowing nutrients to be supplied directly to the root zone in synchronization with crop demand. Research evidence shows that water-soluble fertigation can increase crop yields by 12–40%, reduce fertilizer use by 20–30%, improve water-use efficiency by about 20–26% and lower nitrous oxide emissions by 30–46% compared to conventional fertilization methods. When integrated with digital tools such as sensors, automation and IoT-based monitoring systems, fertigation becomes a powerful approach for achieving sustainable food systems. This paper discusses the concept, benefits, sustainability impacts, economic advantages and future potential of water-soluble fertigation, with special reference to Indian agriculture and the goal of Atmanirbhar Bharat.

Keywords: Precision agriculture, fertigation, water-soluble fertilizers, sustainable food systems, nutrient use efficiency

1. Introduction

Agriculture today faces increasing pressure due to climate change, declining water resources, soil degradation and rising input costs. At the same time, food demand continues to grow. Conventional fertilizer application practices often result in low nutrient use efficiency, as a significant portion of applied nutrients is lost through leaching, runoff and volatilization. These losses reduce farm profitability and contribute to environmental problems such as groundwater pollution and greenhouse gas emissions.

Precision agriculture offers solutions by applying inputs in the right amount, at the right time and at the right place. Fertigation, particularly using water-soluble fertilizers, is one of the most practical precision agriculture tools currently available to farmers. By combining irrigation and fertilization, fertigation improves nutrient availability and uptake while reducing wastage. This approach is especially relevant in water-scarce regions and high-value cropping systems.

2. Water-Soluble Fertigation: Concept and Working

Water-soluble fertigation is the process of supplying nutrients in fully soluble form through irrigation water. These fertilizers dissolve completely, ensuring uniform nutrient distribution and preventing clogging of irrigation systems. Fertigation is commonly practiced through drip irrigation, micro-sprinklers and center-pivot systems.

The method follows the principles of the **4R nutrient stewardship**—right source, right rate, right time and right place. Nutrients are applied in small doses at frequent intervals, matching crop growth stages



and nutrient demand. This ensures better nutrient uptake and minimizes losses. The fertigation process includes soil and plant testing, preparation of nutrient solutions, controlled injection into the irrigation system and monitoring of crop response.

3. Role of Digital Technologies in Fertigation

The effectiveness of water-soluble fertigation increases significantly when integrated with digital and sensor-based technologies. Soil moisture sensors, EC and pH sensors and weather stations provide real-time information on soil and environmental conditions. These data help in deciding the timing and quantity of nutrient application.

Automated controllers and variable-rate injection systems allow precise nutrient delivery to different field zones. IoT-based platforms enable remote monitoring and real-time adjustments, reducing human error and improving efficiency. Such digital integration converts fertigation into a dynamic, responsive and data-driven nutrient management system.

4. Agronomic Benefits and Productivity Enhancement

Several research studies and global meta-analyses have reported consistent yield improvements under water-soluble fertigation. Yield increases ranging from 12% to 40% have been observed in crops such as maize, potato, cotton, vegetables and fruit crops. Improved nutrient synchronization results in uniform crop growth, better root development and improved produce quality.

Fertigation also enhances nutrient use efficiency by 25–50%, reducing the need for excessive fertilizer application. This is particularly beneficial in intensive cropping systems, where nutrient losses are otherwise high.

5. Environmental and Climate Benefits

Agriculture contributes significantly to greenhouse gas emissions, especially nitrous oxide released from nitrogen fertilizers. Studies indicate that 60–70% of nitrogen-related emissions occur after fertilizer application. Water-soluble fertigation reduces these emissions by improving nitrogen uptake and minimizing excess soil nitrogen.

Research shows that drip fertigation can reduce nitrous oxide emissions by 30–46% compared to conventional surface irrigation methods. Additionally, water savings of 20–26% help conserve scarce water resources, while reduced nutrient runoff improves soil and water quality.

6. Economic Advantages for Farmers

Water-soluble fertigation provides clear economic benefits to farmers. Fertilizer savings of 20–30%, reduced labor and fuel costs and fewer field operations lower production costs. Yield improvements and better crop quality often result in higher market returns.

Although initial investment in fertigation systems may be high, long-term benefits outweigh the costs. Studies have shown improved benefit–cost ratios in crops such as sugarcane, banana, vegetables and horticultural crops. Government support and subsidy programs further encourage adoption.

7. Relevance to Indian Agriculture and Atmanirbhar Bharat

India has made significant progress in micro-irrigation through schemes such as the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). Integrating water-soluble fertigation with micro-irrigation enhances the efficiency of these investments. Fertigation is particularly suitable for water-limited regions and high-value crops.



By improving resource-use efficiency, reducing fertilizer dependency and increasing farmer income, water-soluble fertigation supports the vision of Atmanirbhar Bharat. It strengthens farm resilience and contributes to sustainable food security.

8. Challenges and Future Scope

Major challenges in fertigation adoption include high initial costs, technical complexity and maintenance requirements. These can be addressed through training, extension support, standard operating procedures and phased implementation. Future developments such as AI-based fertigation scheduling, climate-responsive nutrient management, nano-chelated fertilizers and bio-enhanced formulations are expected to further improve the effectiveness of fertigation systems.

9. Conclusion

Water-soluble fertigation is a practical and efficient precision agriculture tool that enhances crop productivity, resource-use efficiency and environmental sustainability. Its integration with digital technologies enables precise, demand-based nutrient management. With appropriate policy support and capacity building, water-soluble fertigation can play a key role in achieving sustainable food systems and strengthening Indian agriculture.

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Converging Farmers' Innovation and Entrepreneurial Activities: Evidence from Empirical Learnings

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In the 1940s, biologists began developing high-yield varieties which paired with new fertilizers and pesticides, dramatically transformed the way we are able to eat today as the amount of food harvested per unit area increased manifolds. These science-based technologies triggered changes in agriculture and ultimately pressure on natural resources, including land and water, leading to compromised sustainability of agriculture, to cope with, small-scale producers need to continuously innovate to adapt to the changing environment and changing markets. Production systems will have to become more resilient, and technology for development must go well beyond raising yields to saving water and energy, reducing risk, improving product quality, protecting the environment, and tailoring to gender differences" (World Bank, 2008). , Innovation processes are looked at nowadays from an evolutionary perspective, that a variety of innovations and innovation processes compete in a dynamic selection environment in which the 'best fitting' survives in a given time and space context (Bijker et al., 1987; Rotmans et al., 2001). Such 'fitting' involves not only adaptation to prevailing contextual conditions, but also the active influencing, re-design or destruction of pre-existing conditions and frameworks, respectively the 'overthrowing' of previously dominant 'socio-technical regimes' (Geels and Schot, 2007).

Agrarian distress and farm level stresses are the issue of concern in the present situation. Farmers face a unique set of stressors, because many farmers could not imagine doing anything else for a living, since farming is part of their identity. The farm, the activity of farming and the social environment in which this occurs form a very important part of farming families' lives. In India agriculture is undergoing a structural change leading to a crisis situation. The relative contribution of agriculture to the GDP has been declining without proportionate decline in people dependent on it leading to huge pressure and distress. A positive or negative attitude influences a person's reaction to stressful situations. All change produces stress, even change that is positive. Whether positive or negative, change demands adjustment to the particular situation. Some physical fears that can cause stress are dangerous machinery, exposure to toxic chemicals or to extreme environmental conditions, and contact with diseased livestock. Psychological fears associated with stress include failure, not being able to get the crops in, inability to manage debts, and children giving up the agricultural way of life.

Innovations from R&D system play an important role in optimizing resource utilization, but apart from systematic experimentations, innovations in the form of grassroots-level technologies and methodologies developed by some of the innovative farmers are benefiting widely to farmers. Such innovative technologies and methodologies are largely confined to some locations. As per social learning framework strategy proposed by Noguera et al (2016), pro-environmental values and intentions with time as a determinant factor in the social learning process play role while trying to change values and attitudes through the dissemination of innovations. Reij and Waters-Bayer (2001) suggest participatory approaches to agricultural research that build on local knowledge and innovation can stimulate and diffuse innovation capacity among farmers and external scientists. Farmers' innovation in the context of sustainable agricultural and natural resource management can lead to innovative ways of reducing dependence on external inputs. Innovative techniques often represent adaptation of existing knowledge as their development is mostly through local creativity. Such innovations having additional advantage over conventional innovations to tackle second generations' problems require different set of capacities on the part of farm innovators to scale their innovations in addition to be innovative, learning institutes for which are yet to be come into existence. (Nain et al, 2018).

As such the benefits accrued from such innovative ideas need to be widely shared across the sections and the scientific talents behind such farmers' level innovations need to be encouraged and



recognized. Valuable ideas and techniques generated by them largely go unnoticed owing to lack of proper documentation and opportunities for wider dissemination as the geographical proximity is significant and positively affecting knowledge exchange within the *informal advice network*, but not important in the formal AKIS (Kabirigi et al., 2022). In the same wake a framework was conceptualized at Indian Agricultural Research Institute, New Delhi to institutionalize such farmers' innovative ideas and systematic investigation methodology was adopted.

Triggers of Distress

Farmers deal with everyday tasks of money management, decision-making and equipment maintenance. The physical and mental stress of farming can take a toll on a person's health. Uncertainty causes stress. Since the first domestic animal raised and the first seed sown, agricultural production has involved uncertainty. Uncertainty may cause feelings of being out of control, which often cause more stress. Attitudes also cause stress. A positive or negative attitude influences a person's reaction to stressful situations. All change produces stress, even change that is positive. Whether positive or negative, change demands adjustment to the particular situation. Farmers face a unique set of stressors, because many farmers could not imagine doing anything else for a living, since farming is part of their identity. The farm, the activity of farming and the social environment in which this occurs form a very important part of farming families' lives. A threat to any one of these can pose a significant emotional burden. The economic consequences of hard times on families living in rural areas can include; less money spent on recreation and time off, food, clothing, education, a holiday or entertainment for the family, household maintenance, increased risk of breakdowns and accidents with farm equipments, increased reliance on credit and personal debt, migration of family members and in extreme cases the sale of a portion of the farm resulting in the reduced remaining land holding being less financially viable into the future. Some of the hazards of ongoing stress for farming families may include; persistent fatigue, substance abuse (misuse of alcohol), withdrawal and self-imposed isolation from support networks, difficulty in making rational (or any) decisions, symptoms of depression and in the extreme, this may lead to thoughts of suicide.

All this gets compounded by varied climatic change, natural calamities, unbearable burden of debt and increased competition from imports and exploitation by middlemen which leads to farmer stress. It has been observed that suicides are concentrated mostly in low rainfall, poorly irrigated regions and has small fraction of the agrarian population. Poor imprudence in the use of land, water, fertilizers, and other key inputs due to failures of governance, poor management of public extension catering to agriculture and pricing, subsidy policies inimical to the prudent use of resources and effective exploitation of the potential of available technology. Little scope for expanding area being exhausted due to urbanization, industrialization and the scope for further expansion of irrigation getting diminished due to depletion of ground water, the institutional barrier comprising governance, the quality of public systems, and economic policies has become the most serious impediment to farmer stress. Production systems will have to become more resilient, and technology for development must go well beyond raising yields to saving water and energy, reducing risk, improving product quality, protecting the environment, and tailoring to gender differences

The continuum of Farmer Innovation



The significance of farmers' innovation however ranges from being useful only to the individual farmer, to a wider range of farmers. Innovation involves the interaction of individuals and organizations



possessing different types of knowledge within a particular social, political, policy, economic, and institutional context (World Bank 2006b). Important dimension of the concept of "farmer innovation" is that it embraces not only technological innovation, but also new ways of managing livelihood in general (networking, communication, institution building, information management, marketing, planning, accessing resources, etc). As a conceptual understanding platform, ProInnova-Ethiopia (2004) adopted the following schematic presentation (Figure 1) to explain the conceptual framework of farmer innovation.

Why farmers' innovations?

Agricultural development is innovation-driven, and ultimately, innovation makes the difference in farmers' adoption decision. To enable farm produce to be competitive, innovative farming practices within the framework of commercial agricultural production for long-term improvement and sustainability are important. Innovations from R&D system play an important role in optimizing resource utilization but apart from systematic experimentations, innovations in the form of grassroots-level technologies and methodologies developed by some of the innovative farmers are benefiting widely to farmers. Achiever farmers have been earning higher by innovating and exhibiting entrepreneurial behaviour than other farmers who seem to struggle. Such innovative technologies and methodologies are largely confined to some locations. Farmers are creative and generate relevant local innovations. Farmer-led innovation, in which farmers play a central role in the generation of new knowledge, technologies and ways of working, is increasingly recognised as necessary to secure the social, economic and environmental sustainability of farming.

Farmer-led innovations are evolving under specific agro-climatic and socio-economic conditions and such innovations should be widely adopted and sustained. The farmers identified a number of new/indigenous traditional crops and developed varieties with enhanced productivity and better quality through selection. Farmers also developed low cost processing technologies for value addition, increased shelf-life and better marketability for various farm products. In addition, a number of farm implements and tools were designed and manufactured by the farmers to increase operational efficiency and productivity. Women farmers have contributed in diverse germplasm conservation, postharvest management and value addition which helped in enhancing the farm income. Most of the farming practices traditionally adopted by the farmers are those which were evolved after long experiences of the farmers and communities under specific agro-climatic and socio-economic conditions.

Local innovations have been extended in different scales; however, 70 percent of local innovations were extended beyond the village and 30 % were confined only in village. As far as the impact of farmer-led innovation is concerned increased production has been the major outcome of most of the farmers' innovations, followed by increased satisfaction and knowledge. Another important area of impact of farmer led innovations may be farmers' capacity to continue the process of innovation to address other challenges through strengthening individual capacities, such as confidence, knowledge and handling experimentation and innovation. On the basis of case studies it has been inferred that strengthening institutional & individual capacities for scaling up technologies, facilitation of networking amongst extension service providers & farmers in the region, mobilising and allocating resources for scaling up of technological activities and facilitating the sharing of available knowledge on new technologies & innovations are the major determinants of maximizing farm income, whereas, regarding the perceived role of support system in innovating and enhanced farm profitability; market support system, financial institutional support system, informal networking, incentives & policies, technological backstopping and social acceptance & social support system played a major role. Regarding the perceived role of support system in innovating and enhanced farm profitability; market support system, financial institutional support system, informal networking, incentives & policies, technological backstopping and social acceptance & social support system played a major role.

Scaling up of Farmer led innovations

In order to scale-up valuable farmer- led innovations, it has become necessary to identify the potential farmers-led innovations, followed by their validation and refinement. This necessitates "bottom



up” approach with farmers’ participation in reorienting research and outreach programmes. Innovative technologies identified in one region need to be popularized in similar eco-regions elsewhere, through publication, documentation and dissemination of —Success Stories. Involvement of Research Institutions is quite critical to understand and blend the traditional innovations with scientific refinements for their large scale adoption and popularization. In addition to scaling out specific innovations, efforts are needed by all involved- ranging from farmers to international research scientists - to share and scale out the approaches of stimulating and supporting farmer experimentation. Farmer-led research can both generate and harvest social energy, so that people are willing to move beyond individual or household gains and engage in activities that benefit others in the community.

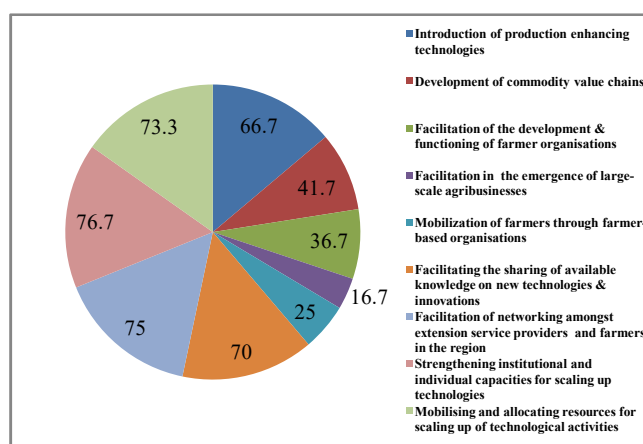


Fig 1: Perceived determinants for maximizing farm income

Requirement of different set of Capabilities

Conventional strategies for encouraging innovation in agriculture tend to focus on creating incentives for private sector investment, most commonly by creating strong intellectual property rights regimes, ensuring open access to markets and increasing technology adoption rates among farmers, whereas farmer innovations in formal agricultural research is desirable for; even farmer innovations run the risk of not becoming as geographically widespread as they theoretically could be, may be taken up into the agricultural advisory service after validation by research system and can gear towards real needs by taking men and women farmers’ priorities into account and involving them actively in the programmes of the research and development. Despite the huge amount spent on developmental aid, one cannot find many databases, either online or offline, of innovative solutions developed by the disadvantaged people themselves.

Table 1: Capacities required for scaling up of Farmers’ Innovations

Subject matter of capacities for Scaling up innovations	Rank
Documentation of the innovation/ intervention	IX
Distinguishing technical, organizational, and/or process elements	VIII
Analysis of need or demand for the service among the larger population	VII
Analysis of the required changes to make the innovation applicable to other parts of the country / other target groups	VI



Comparative analysis of the costs associated with the innovation	II
Evaluation of the innovation's comparative impact and success	III
Refinement and simplification of the innovation	IV
Analysis of the possibilities for achieving economies of scale	V
Analysis of the institutional requirements and linkage for implementing the innovation	I

Farmers need to be innovative to deal with 'second generation problems' like maintaining soil fertility, animal health, community issues related to resources etc., farmers will need to be innovative in how they apply these 'solutions' to fit their own situations. Institutionalization of any farmers' innovation is a complex process that requires capacity strengthening and change in individuals as well as change in organizations through all layers in addition to convergence of activities between institutions to share the resources and capital. The commercialization depended on many factors like feasibility and significant economic impact of the innovations. The farm innovators require certain distinguishing capacities like foreseeing institutional requirements and linkages, comparative financial impact and success analysis ability in addition to analyse projected demand and required changes in socio cultural and infrastructural domain.

Table 2: Perceived characteristics of the farmers' innovations for scaling up

S. No.	Parameters	Weighted Mean Score
a.	Credibility	5.95
1	Based on sound evidence	6.2
2	Can be subjected to independent external evaluation	5.6
3	Capable to work in diverse social and situational contexts	6.4
4	Supported by eminent individuals and institutions	5.0
5	Implementable within existing systems and infrastructure	6.8
6	Small deviation from current practices of perspective adopters	6.2
7	Involvement of less number of people in adoption decision	5.8
8	Low technical sophistication of the components and activities	6.0
9	Clear and easily replicable	5.6
b.	Complexity Vs Simplicity	6.2
1	Simple with few components	6.3
2	Easily added or adjusted on to existing systems	6.1
c.	Testability	5.6
1	Able to be tested by users on a limited scale	5.8
2	Little supervision and monitoring	5.3
3	Not particularly value or process intensive	5.7
d.	Observable results	6.43
1	Very visible and tangible impact to casual observation	6.7
2	Clearly associated with the intervention	6.4
3	Evidence and documentation exists with clear emotional appeal	6.2
e.	Relevancy	6.75
1	Addresses an objectively significant, persistent problem	6.7



2	Addresses a need which is sharply felt by potential beneficiaries	6.8
3.	Relative advantage over existing practices	6.65
4	Current solutions for this issue are considered inadequate	6.7
5	Superior effectiveness to other established options	6.6
f.	Sustainable source of funding	5.93
1	Superior cost-effectiveness to existing or other solutions clearly established	6.2
2	Does not require a large commitment of funds at scale	6.1
3	Scope for its own internal funding (user fees) or endowment	5.5
	Overall	6.33

FLIs having additional advantage over conventional innovations to tackle second generations' problems require different set of capacities on the part of farm innovators to scale their innovations in addition to be innovative, learning institutes for which are yet to be come into existence. World Health Organisation (WHO 2010) also emphasized on planning actions, increasing capacities, making strategic choice and assessing environment among the steps to scale up. Scaling up of innovations required commitment and greater budgetary support towards innovations mainstreaming in all location specific farmer-led innovations and suggested involvement of private sectors for commercialization of replicable innovations through corporate social responsibility fund. Documentation of the innovation, distinguishing the elements and types of innovations, assessing need among the larger population and analysis of the required changes to make the innovation applicable to other target groups were placed at lower end, may be due to their less importance in scaling process.

On the basis of 649 innovations analysis; relevancy, relative advantage, sustainable source of funding, observability of the results and complexity, respectively in overall were ranked as the top determinants of the scalability of farmer led innovations. Although 'credibility' of the innovation was not perceived as major determinant in overall but the sub components like 'implementable within existing systems and infrastructure', small deviation from current practices and cultures of perspective adopters', 'capable to work in diverse social and situational contexts' and 'sound evidence base' were among the high rated sub components of the major determinants. In case of testability, all three sub components were perceived almost equal determinant of scalability. In case of 'complexity', having few components leading to less confusion and modification of knowledge and skill was perceived important determinant.

Farmer Led Innovations and Entrepreneurial Behaviour

Farm Innovators could have effectively become consultants and entrepreneurs leading to off- farm income generation options but the lack of proper sustenance support, institutional requirements for up scaling and out scaling and related constraints hindered farmer to farmer extension, institutionalization of such innovations and their blending with the modern scientific knowledge for the benefit of farming community at large. To enable farm produce to be competitive, innovative farming practices within the framework of commercial agricultural production for long term improvement and sustainability is important. The innovations led by farmers have neither been institutionalized for their horizontal and vertical expansion nor properly recognized. As a result, many technologies developed by innovative farmers have not reached to other farmers. Although, the initiative in the form of protection of propriety rights of the farmer-led innovations by government and non-government bodies have been taken in recent past but at a limited scale. Achieving impacts at the scale can only happen by leveraging the dynamism of private enterprise. institutional mechanism and human resources base in rural ecosystem was found lacking in social processes of group and enterprise management skills along with marketing and communication skills. The capacity building interventions not only helped in changing entrepreneurial competencies but broadened the horizon of the participants to adopt secondary agriculture and launch their own income generating activities. The backward and forward linkages in the form of advisory services, input supply, marketing of the produce, financial backstopping was at a fairer level and the support and convergence of various stakeholders like banks, NGOs, research institution, state line department brought positive impact in the form of initiation of



income generating activities. The price spread analysis of major commercial crops of the project location showed very wicked picture where the producers' share was found even less than one fifth of the consumer rupee in some cases. In order to reduce distressed sale and length of marketing chain the producers were trained and motivated in primary processing and were linked with innovative farmers and already established entrepreneurs for marketing and enhanced profitability. Screening for scalability of farmers' innovations and efforts for their institutionalization implied need for creation of platform for exchange of information and experiences, developing and disseminating theme-based knowledge products and undertake analysis of partner institutions to assess their potential as participants and building capacity of partner institutions. The framework for agri-enterprise development for maximizing farm profitability was found to be the function of entrepreneurial competencies, entrepreneurial climate, and farmers' innovations.

Model for Scaling Farmers' Innovations

With the huge network of Krishi Vigyan Kendras and ATARIs innovations can be tested, verified and institutionalized, social media can be used for farmers to farmer interaction on innovative issues, creation of effective alliance of farmers with a mixture of traditional knowledge, farmers' innovations and scientific knowledge, more institutional arrangements to initiate collective production processes, networking mechanisms of stakeholders and popularizing the identified innovative technologies through documentation, publication, success stories and dissemination in different ecosystems. With the initial experiences several initiatives were taken in the form of experimental interventions like; creation of social media platform through WhatsApp and analysis of content sharing pattern, documentation of innovative farmers' success stories in the publication form, inclusion of few innovative farmers in IARI outreach programme to facilitate transfer of technologies, devoting separate session in Pusa Krishi Vigyan Mela for innovative farmers, linking farmers with public sector seed production corporation and so on. The systematic analysis of the content shared the social media platform showed that most of the content shared was knowledge intensive with a mix of personal farming experiences. WhatsApp being the potential source for socialization and internalization promoted the creation of social wealth in the form of discussion forums of Innovative farmers for learning exchange. The extension mechanism for purposeful farmer to farmer learning exchange has been created which in turn is a step towards innovative farmer led extension delivery mechanism. The experiences of explorations and action interventions showed that human resources base in rural ecosystem was found lacking in social processes of group and enterprise management skills along with marketing and communication skills. The capacity building interventions not only helped in changing entrepreneurial competencies but broadened the horizon of the participants to launch their own income generating activities. The backward and forward linkages in the form of advisory services, input supply, marketing of the produce, financial backstopping was at a fairer level and the support and convergence of various stakeholders like banks, NGOs, research institution, state line department brought positive impact in the form of initiation of income generating activities. As per social learning framework strategy proposed by Noguera et al (2016), pro-environmental values and intentions with time as a determinant factor in the social learning process play role while trying to change values and attitudes through dissemination of innovations.

Some of the actionable points aroused include; Establishing and maintaining a database (including physical library) of available technologies, innovations and all sponsored/ unsponsored reports and publications; Establishing and maintaining a meta-database of agricultural information and means for facilitating it to act as a platform for exchange of information and experiences; Developing and disseminating theme-based knowledge products (posters, radio and TV messages, pamphlets, etc.); Publishing lessons learnt (Print as well as electronic) from development and adoption of innovation activities; Undertake an analysis of partner institutions to assess their potential as participants in maximizing farm profits as primary information centers; Building capacity of partner institutions (both human and infrastructure) to enable them become functional primary information centers as well as active partner; Developing of institutional policies and quality assurance protocols; and facilitating a strong network of Innovative Farmers for the purposes of learning exchanges and up scaling and out scaling their innovations.

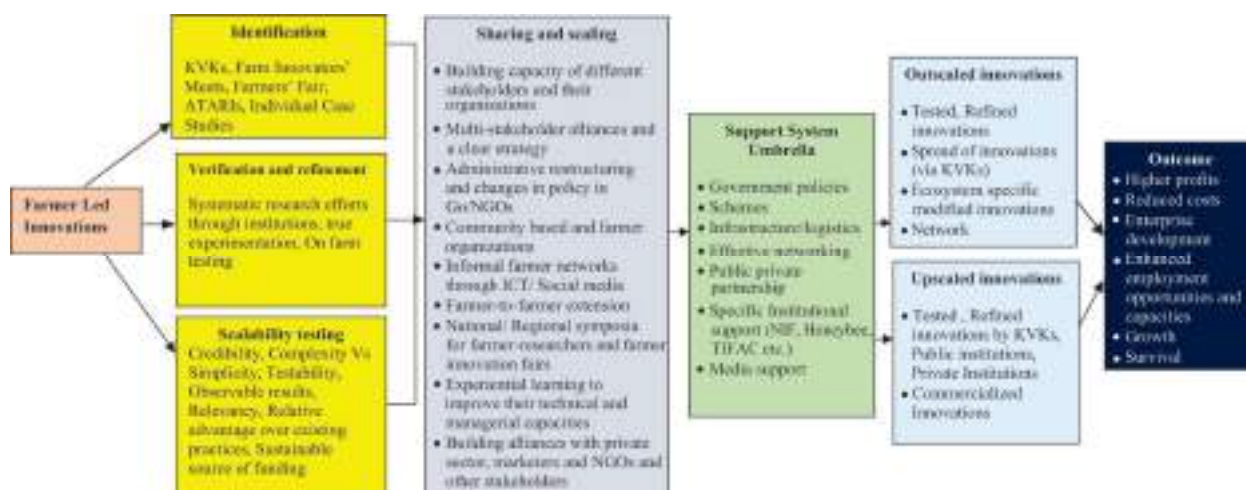


Figure 3. Model for Scaling Farmers' Innovations

The farmer led innovations are driven by a range of interlinked factors: economic factors (the inability to afford external inputs or grow enough food to be food secure), environmental factors (the need to adapt to climate fluctuations or restore infertile soils which can not be rested due to small landholdings), social factors (migration, HIV /AIDS, and scarce labour availability), cultural factors (need to use certain plants for ritual and other purposes), and political factors (availability of subsidized fertilizers and seeds as a form of political patronage by a neo- patrimonial state). In the farm sector, determinants of entrepreneurial success turnover and annual income play the major role in enterprise development. The model of agricultural science and technology as a centralized activity, undertaken by experts and diffused to farmers, has been challenged by collaborative research and innovation approaches in which farmers, scientists, and engineers can learn together about the nature of the problems being faced and the potential of different solution pathways. Hence, the model to scale the farmers' innovation (Figure 2) may act as a guiding tool.

A skilled workforce is always necessary to continue fast-paced growth and pull millions out of poverty. There was a need of 129.79 million skilled workforce by 2022 in 24 key sectors like agriculture, food processing, handloom etc. But only 4.69% were undergoing formal skill training (NSSO, 2011-2012). Agriculture sector alone required the 24.8 million in 2022 (National Policy on Skill Development and Entrepreneurship, 2015). In agriculture sector only 18.5% of workforce is skilled, of which 0.5% have formal technical education (IAMR, 2013). The innovations led by farmers have neither been institutionalized for their horizontal and vertical expansion nor properly recognized. As a result, many technologies developed by innovative farmers have not reached to other farmers. FLIs having additional advantage over conventional innovations to tackle second generations' problems require different set of capacities on the part of farm innovators to scale their innovations in addition to be innovative, learning institutes for which are yet to be come into existence. (Nain et al, 2018; Nain et al.,2019). Although, the initiative in the form of protection of propriety rights of the farmer-led innovations by government and non-government bodies have been taken in recent past but at a limited scale.

This initiative was intended to enhance awareness of the innovative capacities of the farmers, to identify farmer-led innovations having potential to be adopted for larger impact and to share the experiences of farmers-led innovations in the field of agriculture and allied sector. It was highlighted that identification of innovative farmers is not an end in itself, but how these farmers can be supported in improving their works and help them ensure sustainable livelihood and how best the spirit of innovativeness among the smallholder farmers can be cultivated. It was stressed that there is great need for developing a closer network of all innovative farmers among themselves and also with the researchers. Innovative ways to increase production, improve organisation, or reduce dependence on external inputs, farmer innovations were found having significant potential to improve the quality of life for farming families in Malawi and reduce their impact on the environment. The farmer led innovations are driven by a range of interlinked factors: economic factors (the inability to afford external inputs or grow enough food to be food secure),



environmental factors (the need to adapt to climate fluctuations or restore infertile soils which cannot be rested due to small landholdings), social factors (migration, HIV /AIDS, and scarce labour availability), cultural factors (need to use certain plants for ritual and other purposes), and political factors (availability of subsidized fertilizers and seeds as a form of political patronage by a neo- patrimonial state) (FAO, 2012). In the farm sector, determinants of entrepreneurial success turnover (.019) and annual income plays major role in enterprise development (Kobba et al., 2020). Hence the conceptual model proposed to scale the farmers' innovation (Figure 3) may act as a guiding tool.

Conclusion

Farm Innovators could have effectively become consultants and entrepreneurs leading to off- farm income generation options but the lack of proper sustenance support, institutional requirements for up scaling and out scaling and related constraints hindered farmer to farmer extension, institutionalization of such innovations and their blending with the modern scientific knowledge for the benefit of farming community at large. Institutional mechanism and human mobilization for networking and resource optimization, collectivization, technologies and methodologies of secondary agriculture are the keys for maximizing farm income. Human resources base in rural ecosystem in general is lacking in social processes of group and enterprise management skills along with marketing and communication skills. The capacity building interventions not only have the potential for changing entrepreneurial competencies but broadening the horizon of the participants to launch their own income generating activities.

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Application of AI through satellite based extension strategy for INM on soil fertility status in Arecanut crop in Southern Karnataka

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ABSTRACT

The global population is expected to surpass 9 billion by 2050, resulting in a substantial rise in food demand and agricultural consumption. Agriculture, being one of the most dependent sectors for human survival, is currently confronted with multiple challenges, including diminishing natural resources and a growing shortage of agricultural labour. In this context, the adoption of advanced technologies such as drones, remote sensing and satellite-based monitoring agricultural operations offers promising solutions to overcome these constraints. Digital agriculture has emerged as a comprehensive approach that integrates principles and tools from information science, environmental science, computer and software engineering, systems science, geographic information systems (GIS), global positioning systems (GPS), remote sensing and virtual satellite imaging. This multidisciplinary integration enables better synchronization of soil characteristics, climatic conditions and environmental factors with agricultural practices, thereby improving farm-level decision-making (Schuster, 2017).

At present, the world population exceeds 7 billion and is projected to reach approximately 9.6 billion by 2050 (Wang, 2011). By 2030, nearly 5 billion people are expected to belong to the middle-income group with improved disposable income for food, yet an estimated 4.5 billion individuals may continue to face food insecurity. Meeting the nutritional needs of this expanding population requires a dramatic increase in agricultural output, potentially doubling production within a limited timeframe, which presents a significant global challenge. Addressing this challenge necessitates the widespread adoption of modern and advanced technologies, particularly the integration of big data and digital tools across all stages of the agricultural production cycle (Van and Woodard, 2017). In the coming years, digital agriculture is anticipated to play a pivotal role in meeting the growing food demands and enhancing farm productivity.

Agricultural extension, as a dynamic and evolving discipline, is undergoing significant transformation driven by rapid technological advancements, changing farmer needs and the global emphasis on sustainable agriculture. Digitalization has become a powerful enabler of modern extension activities, offering substantial benefits across the agricultural sector. Tools such as mobile-based platforms, web-based applications, artificial intelligence (AI), the Internet of Things (IoT), blockchain technologies and other ICT solutions have modernized traditional extension models by enhancing accessibility, operational efficiency, data-driven decision-making and stakeholder collaboration. Mobile applications, SMS-based advisory services and e-learning platforms are increasingly utilized to provide timely, location-specific recommendations to farmers, resulting in productivity gains of 20–30%. Furthermore, AI-powered advisory systems and IoT-enabled monitoring tools can improve decision-making accuracy by up to 40%, while blockchain technology enhances data security, transparency and trust (N. Krishna Priya *et al.*, 2025).

The implementation of digital tools also facilitates the automation of routine tasks, reduces administrative burdens and streamlines extension processes, allowing extension professionals to focus more on delivering high-impact services. Digital platforms enable wider outreach through multiple communication channels, including social media, websites and mobile applications, thereby improving the effectiveness of information dissemination. Additionally, digital technologies support rapid and accurate information exchange, enabling extension services to deliver real-time updates, research insights and actionable recommendations to farmers. Technologies such as sensors and data analytics further enable precision agriculture by optimizing the use of critical inputs such as water, fertilizers and pesticides based on real-time field data, ultimately enhancing productivity and sustainability. Moreover, digital tools support effective monitoring and evaluation of extension programs, helping assess the impact of interventions and refine strategies for improved outcomes.



The present paper explains a digital application that enables the assessment of soil fertility status through satellite-based as an extension strategy to wide spread the INM technologies through ICT tools. The extension approaches used by the company 'Karyon Organics' has been highlighted by interpreting remotely sensed data, the application provides spatial and temporal insights into soil nutrient conditions across agricultural fields. Based on this analysis, appropriate integrated nutrient management strategies can be formulated and implemented in a site-specific manner. Such data-driven nutrient planning helps optimize the use of organic and inorganic inputs, improves nutrient use efficiency and supports sustainable soil health management. Consequently, this approach contributes to enhanced crop productivity, increase in yield, income and improved decision-making for farmers and agricultural stakeholders towards agricultural sustainability.

Introduction

Agriculture is one of the world's oldest and most significant industries. Food and work demand are increasing as the world's population grows. Traditional farming methods are not sufficient to meet food demands and provide employment for billions of people worldwide, prompting the development of new automated methods (Javaid *et al.*, 2023). The rapid growth of the global population is expected to increase food demand by about 70% by the middle of this century. Meeting this demand is challenging due to limited natural resources, climate change and increasing pressure on water and land. Efficient water management and sustainable land-use practices are therefore essential. Artificial Intelligence (AI) provides effective technological solutions to address these challenges in agriculture. AI applications support improved crop yield and quality by optimizing the use of resources such as water, soil and inputs. Technologies including satellite-based land-use analysis, sensor-driven monitoring and predictive models for crop disease detection are increasingly being adopted worldwide. As a result, AI based extension strategies is becoming a key driver of innovation and investment in the agri-technology sector.

Artificial intelligence

Artificial intelligence (AI) is an interdisciplinary area of research focused on replicating human intelligence in machines through the simulation of cognitive functions such as learning, reasoning and problem-solving. In recent years, researchers and extension professionals have increasingly adopted AI technologies to address key challenges in agricultural production (Holzinger *et al.*, 2023). AI supports farmers in improving productivity by enabling the selection of suitable crop varieties, optimizing fertilizer and soil management practices, enhancing pest and disease control, estimating crop productivity and forecasting commodity prices (Redhu *et al.*, 2022).

Advanced AI techniques, including deep learning, machine learning, robotics, image processing, artificial neural networks, wireless sensor networks (WSN) and Internet of Things (IoT) systems, are being widely applied to agricultural problem-solving (Mushtaque, 2024). These technologies facilitate data-driven decision-making by continuously monitoring field-level parameters such as weather conditions, temperature, soil properties and water usage in real time (Kumar *et al.*, 2022).

Application of AI in agriculture

- 1. Machine Learning and Predictive Analytics:** Machine learning models process large datasets obtained from sources such as weather data, soil analysis and crop health records to predict future trends. Predictive analytics supports decision-making related to crop planning, nutrient management and harvesting schedules.
- 2. Computer Vision and Image Recognition:** Computer vision techniques enable the analysis of visual data for agricultural purposes. These technologies are widely used to assess crop health, identify pests and diseases and evaluate soil conditions using images captured by cameras, drones or satellites.
- 3. Robotics and Automation:** Robotic and automated systems are used to carry out repetitive and labor-intensive agricultural operations, including planting, weeding and harvesting. These systems improve operational efficiency, precision and overall productivity while reducing dependence on manual labor.
- 4. Internet of Things (IoT) and Sensors:** IoT devices and sensor networks collect real-time field data such as soil moisture, temperature and humidity. This information supports precision agriculture by enabling continuous monitoring and remote management of farm conditions.
- 5. Crop Monitoring and Management:** AI-enabled drones and satellites equipped with multispectral sensors collect real-time information on crop condition, growth stages and soil characteristics. Machine



learning techniques analyze these data to detect patterns and predict potential problems such as pest attacks or nutrient deficiencies. Early identification supports timely management practices, reducing yield losses and improving crop quality.

6. **Predictive Analytics:** AI-based models integrate historical weather records, soil data and past crop performance to forecast future agricultural trends. These predictions assist farmers in planning operations by estimating optimal planting and harvesting periods, potential pest outbreaks and expected yield levels.
7. **Automated Machinery:** AI-guided autonomous equipment, including tractors and harvesters, improves operational efficiency in farming systems. These machines perform tasks such as sowing, weeding and harvesting with high accuracy, lowering labor requirements and minimizing human errors. AI systems adapt operations based on factors such as field conditions, terrain and crop type.
8. **Soil Health Monitoring:** AI applications evaluate soil samples to assess nutrient availability and other essential soil properties. This information is used to design site-specific fertilization strategies, reducing excessive fertilizer application and improving soil health. Targeted nutrient management supports sustainable and resource-efficient farming practices.
9. **Pest and Disease Control:** AI-driven image analysis tools identify early symptoms of pest infestations and plant diseases using images captured by drones or field-based sensors. These systems enable precise diagnosis and recommend targeted control measures, decreasing dependence on broad-spectrum pesticides and supporting environmentally sustainable agriculture.

AI in Agricultural Extension

Agricultural extension has historically been central to promoting sustainable farming practices, enabling knowledge transfer and fostering rural development. However, the modern agricultural sector faces increasingly complex challenges, including food security, efficient resource utilization and climate change adaptation, which necessitate more innovative approaches. In this regard, artificial intelligence (AI) has emerged as a powerful tool with the potential to transform agricultural extension services. As efforts intensify toward achieving the Sustainable Development Goals, examining the integration of AI into agricultural extension systems has become increasingly important.

Traditionally, agricultural extension has depended largely on human expertise and face-to-face interactions to deliver information, training and advisory support to farmers. While effective these approaches are often constrained by limitations related to scale, accessibility, and timeliness. AI through machine learning, data analytics and automation offers opportunities to enhance extension services by leveraging large datasets, advanced algorithms and intelligent decision-support systems (Smith *et al.*, 2020). The integration of AI into agricultural extension presents numerous advantages. AI-driven technologies can process extensive data sources, generate real-time recommendations and support informed decision-making at the farm level. Additionally, AI enables the delivery of tailored advice that reflects the diverse needs and conditions of farming communities. Predictive models powered by AI can forecast pest and disease outbreaks, improve crop management strategies and promote more efficient use of limited resources, thereby advancing agricultural sustainability (Jha *et al.*, 2019).

Based on this background the present paper aims to explore how Indian extension professionals such as scientists, agricultural officers, consultants, field agents and corporate R&D representatives are leveraging AI-based tools in extension teaching and services. These professionals act as vital conduits, connecting farmers with essential knowledge and technologies that can significantly improve agricultural practices.

To understand the practical application of AI-driven satellite imagery in field-level decision-making and Integrated Nutrient Management (INM), a case study as an extension strategy was conducted using the crop nutrition and management package recommended by Karyon Organics. The study focused on how satellite-based data, including crop vigor assessment, spatial variability analysis and temporal crop monitoring, can be utilized to guide nutrient scheduling, optimize input use and support timely corrective measures. By integrating satellite insights with on-ground recommendations, the case study demonstrates improved nutrient efficiency, targeted interventions and informed management decisions. The field observations and results are discussed below.

Case study



Karyon Organics effect on soil management in Arecanut

Karyon Organic has emerged as one of the leading manufacturers and promoters of organic manures in Indian market with an inspiration to come on international platform as well soon. The vision is to protect the natural soil and environment in its entity in order to produce nutritious crop through their quality manufacturing and marketing appreciated techniques in an accelerated manner together with education program for farming community so as to get the maximum yield and income.

Core focus

1. Soil Revitalization: Uses organic formulations to boost microbial activity and fertility
2. Nutrient Dense crops- Aims to address nutrient deficiencies in crops caused by modern farming

Karyon Organics offers a range of organic products, including specific solutions for arecanut (betelnut) farming like Orycane and Oniton, which are bio-fertilizers designed to improve root health, vegetative growth and soil fertility for plantation crops like areca. While they have fertilizers for general agriculture (like Boss, Lamion, Foliton), their focus is on "Healthy Farming" using natural inputs to boost yields and reduce reliance on chemicals, expanding into nutraceuticals and personal care too.

Karyon Organics supports arecanut cultivation through a systematic application of bio-organic formulations designed to optimize soil health, enhance plant immunity and boost yield quality. Their approach centers on replacing or supplementing chemical inputs with nutrient-dense bio-molecules to improve the yield potentials.

Product Support for Arecanut

The company utilizes several key products to address different stages of arecanut growth:

Soil Fertility and Root Development:

- **BOSS (Bio Organic Soil Solution):** This nutrient-rich solution improves soil structure and fertility, promoting robust root development and overall plant health.
- **Orycane:** Developed with advanced technology, this formulation induces macro and microbial activities in the soil. In arecanut, it helps increase "white roots," maintains nitrogen levels and stimulates the decomposition of organic debris to maintain a healthy C:N ratio.

Plant Protection and Immunity:

- **Nature Rapidon:** An organic formulation rich in minerals like potash that strengthens the plant's resistance against biotic and abiotic stresses, including fungal attacks common in humid arecanut plantations.
- **Nature Folisaf:** A liquid bio-formulation designed for foliar health. It is particularly effective for managing pests like thrips and mites that can damage arecanut leaves and flowers.
- **Nature Beecare:** Used as part of an integrated pest and disease management strategy to maintain biological balance.

Growth and Yield Enhancement:

- **Germiton and Foliton:** These products support vegetative growth and can be used to improve the availability of nutrients during critical flowering and fruit-setting stages.
- **Oniton:** Although often cited for root/tuber crops, its ability to induce microbial activity and healthy root development makes it a versatile tool for enhancing long-term plantation health.

Extension strategies followed for successful implementation

Karyon Organics supports agricultural recommendations by integrating satellite-based remote sensing data with soil and crop management models. This technology allows for precise, data-driven decisions that replace traditional practices.

- **Data Collection:** The process begins with gathering multispectral or high-resolution images from earth observation satellites, which provide macro-level data over vast areas.
- **Feature Extraction:** Relevant spectral, spatial and temporal data are extracted from the raw images. This often involves using various vegetation indices (like the Normalized Difference Vegetation Index - NDVI) to estimate crop biomass, health, and water stress.
- **Data Integration:** The satellite data is unified with other data sources, such as:
 - Ground-level data from soil sensors (for nutrient levels, moisture).
 - Real-time weather forecasts and historical climate models.
 - On-the-field farm management app data.



- **AI-Powered Analysis:** Machine learning and deep learning algorithms process this integrated data. The AI models are trained on past data to identify patterns, detect subtle changes in crop conditions (like color shifts indicating stress), predict potential diseases or pest outbreaks, and forecast yields.
- **Recommendation Generation:** Based on the analysis, the system generates customized recommendations for farmers. These can include:
 - Optimal timing for fertilization or irrigation.
 - Identification of appropriate crop varieties for specific soil profiles.
 - Targeted interventions for pest and disease management.
 - Crop rotation techniques to improve soil nutrient value.
- **Delivery to Farmers:** The insights and recommendations are delivered to farmers, likely through a user-friendly platform or mobile application, enabling them to make data-driven decisions to optimize resource use and improve yield.

Satellite images and AI-based recommendations were explained using data from a farmer's arecanut field belonging to ShriVishwanathPatil of Nettiki village, Sorbataluk, Karnataka. One acre of the field was selected for observation. The satellite images helped in understanding crop condition and nutrient status, while the recommendations guided field-level management practices. The observations made during the study and the results obtained from the selected plot are presented in the table below.

Table 1: Details of Yield, Cost of Cultivation and Income in Arecanut Plot before and after the package recommendation

Sl.No.	Particulars	AvgYield (Qtls)	AvgExpenditure/year (Rs.)	AvgIncome/year (Rs.)	AvgNet Income/year (Rs.)	BC Ratio
1	Benchmark year(2022-23)	10-11	1,00,000	4,18000	3,18000	1:4.1
2	Demonstration year(2023-24,2024-25)	20-21	2,00,000	10,50000	8,50000	1:5

Case study of VishwanathPatil from Nittaki village, Sorbataluk is a small farmer of 4 acres is fully dependent on agriculture. Inorder to increase his income he has adopted all innovative methods under the guidance of Karyon Organics and followed all the packages recommended by the company including major and minor nutrients both organic and inorganic. The yield income and expenditure before and after is presented is table 1.

As indicated in the table the yield per acre was 10-11 Quintal of dryarecanut by investing Rs 1 to 1.5 lakhs and earning net income of 3 to 3.5 lakhs before using the package of Karyon Organic(benchmarkyear). After adopting all the package recommendation of Karyon Organics company the yield was boosted to 20-21 Quintals per acre in the same land by investing 2 to 2.5 lakhs of expenditure and getting the net income of 5,32000Rs(demonstration year). The cost benefit ratio workout to be for check plot 1:4.1 and for treated plot was 1:5.

The same package of Karyon Organics was followed for other commercial crops like ginger, banana and sugarcane. The yield difference was also seen 2 to 3 times increase after adopting Karyon organic packages.

Conclusion

The adoption of AI-based applications has significantly improved farmers' income patterns by effectively utilizing research advancements and satellite-based technologies through remote sensing. Crop management package recommendations can be delivered to farmers in the shortest possible time through digital platforms such as mobile applications, text messages, videos and digital reports. This approach reduces the need for frequent physical visits by extension scientists for advisory services, while enabling timely and accurate guidance. Moreover, the use of AI allows technical advisory services to reach a larger number of unreached farmers simultaneously, thereby enhancing the overall efficiency and impact of extension services even in the unreached remote areas.

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Digital Media for Agri-Entrepreneurship towards *Atmanirbhar Bharat*

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ABSTRACT

The vision of *Atmanirbhar Bharat* (Self-Reliant India) emphasizes inclusive economic growth driven by innovation, entrepreneurship, and digital empowerment. In this situation, youth and rural communities can actively engage in agri-entrepreneurial activities thanks to digital media and instruments. The quick growth of internet access, smartphone adoption, and social media usage in rural India has created new opportunities for agri-entrepreneurship. The patterns in rural internet expansion, the significance of digital media in starting businesses focused on agriculture, and the obstacles to digital adoption are all examined in this lead paper.

Keywords: Digital Media, Agri-Entrepreneurship, Smart Farming, *Atmanirbhar Bharat*

Background

India still remains predominantly rural, with farming and related sectors employing a substantial portion of the population. Nonetheless, obstacles like divided land ownership, market inefficiencies, restricted financial access, and information disparities have historically hindered rural entrepreneurship. The *Atmanirbhar Bharat* initiative of the Indian Government aims for a self-sufficient economy fuelled by local innovation, value enhancement, and entrepreneurship, especially among young people and rural areas.

Agricultural extension is evolving into an **agri-enterprise** model to assist farmers in moving from subsistence farming to lucrative agribusinesses. This contemporary method combines entrepreneurial concepts with conventional extension services such as training and technical guidance. Digital media and digital technologies have become significant catalysts in this change. The combination of low-cost smartphones, improved internet access in rural areas, digital platforms, and social media has significantly changed the way information is obtained, businesses are established, and markets are accessed. Digital media provides rural youth with unique chances to escape geographical isolation, obtain real-time information, create brands, and engage directly with consumers and stakeholders.

Smartphone Ownership Among Farmers in India

The ownership of smartphones among farmers has significantly risen, especially among the younger demographic of farmers. Smartphones are currently commonly utilized for:

- Accessing agri-advisory services
- Digital payments and banking
- Online marketing and networking
- Participating in training and capacity-building programs

This trend forms the backbone of digital rural entrepreneurship.



Using Digital Tools for Agri-Entrepreneurship

The incorporation of digital tools has become crucial, not just optional, for sustainable agri-entrepreneurship for the following reasons:

Information Access and Knowledge Empowerment

Digital platforms offer farmers and agricultural entrepreneurs up-to-date information on weather, crop tips, pest control, pricing, and government programs, facilitating informed choices.

Market Linkages

Digital tools for market linkages diminish reliance on intermediaries by facilitating direct market access, clear price discovery, and enhanced negotiation power for producers.

Youth Engagement in Agriculture

Digital media makes agriculture more attractive to rural youth by integrating technology, innovation, and entrepreneurship, thereby addressing rural unemployment and migration.

Major Digital Tools Used for Agri-Entrepreneurship in India

Some of the key digital tools and platforms supporting agri-entrepreneurship include:

- Mobile Applications: AgriApp, BharatAgri, Granular, mKisan, Kisan Suvidha etc.
- E-NAM (National Agriculture Market): Online trading and price transparency
- Digital Payment Systems: UPI, mobile wallets for seamless transactions
- Decision Support Systems: Crop advisory and pest forecasting tools
- E-commerce Platforms: Amazon Kisan, Flipkart Samarth, BigBasket sourcing models
- GIS and Remote Sensing Tools: For crop monitoring and precision agriculture

Using Digital Tools to Launch Agriculture-Oriented Enterprises

Digital tools support various stages of enterprise development such as:

- *Idea Generation and Validation*
- *Input Procurement*
- *Production and Advisory Services*
- *Marketing and Branding*

Essential Digital Expansion Technologies and Platforms

Multiple digital technologies are being employed to enhance agri-enterprise:

- **Mobile Apps and Web Platforms:** Provide cohesive services ranging from weather reports to information on government programs.
- **SMS and Interactive Voice Response (IVR):** These fundamental phone technologies are essential for connecting with farmers in regions with low digital literacy or restricted internet access, delivering urgent information and enabling recorded inquiries.
- **Social Media:** Services such as Facebook and WhatsApp are very popular due to their personal connections and ability to build communities, facilitating group discussions and sharing information among extension workers and farmers.



- **Artificial Intelligence and Data Platforms:** Projects utilize AI and data platforms to establish an integrated ecosystem, linking different stakeholders to deliver thorough, data-informed services to farmers.

Digital Start-Ups in Entrepreneurship and Smart Agriculture

Digital entrepreneurship in agriculture encompasses advancements like:

- Smart irrigation and precision farming
- Crop monitoring using drones
- Diagnostics for pests and diseases powered by AI
- Online marketplaces and transportation services

Utilizing Social Media and Blogs for Agricultural Businesses

Social media sites like Facebook, YouTube, WhatsApp, Instagram, and blogs are more frequently utilized for:

- *Disseminating successful experiences and effective strategies*
- *Marketing farm products directly*
- *Informing consumers regarding product quality and sourcing transparency*
- *Establishing confidence and brand recognition*

Blogs, specifically, assist agri-entrepreneurs in building thought leadership and a sustainable digital footprint (Digitalagrihub.org, Samunnati etc.).

Obstacles to Utilizing Digital Solutions for Rural Entrepreneurship

Even with advancements, numerous obstacles persist:

- *Inability to use digital technology and absence of technical abilities*
- *Weak internet access in rural locations*
- *Restrictions due to language differences and insufficient regional content*
- *Significant upfront expense of cutting-edge technologies*
- *Lack of trust in digital platforms*

Role of Digital Media in Achieving Atmanirbhar Bharat

Digital media empowers rural youth by fostering innovation, self-employment, local value addition, and market integration. By strengthening agri-entrepreneurship, reducing post-harvest losses, and enhancing income opportunities, digital tools directly contribute to the economic self-reliance and inclusive growth envisioned under *Atmanirbhar Bharat*.

Conclusion

Digital media and digital tools have emerged as game-changers for youth and rural entrepreneurship in India. When effectively integrated with agriculture and allied sectors, they enhance productivity, market access, innovation, and income generation. While challenges persist, focused capacity building, supportive policies, and inclusive digital infrastructure can unlock the full potential of rural digital entrepreneurship. By fostering agri-enterprises through digital tools, agricultural extension services help build a more resilient, profitable, and sustainable agricultural sector. Empowering rural youth through digital media is not only essential for transforming Indian agriculture but also central to realizing the vision of *Atmanirbhar Bharat*.



Digital Tools for Seed Production and Quality Testing to Ensure Seed Supply Chain

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AI and ML revolutionize sustainable seed production by optimizing field management, and ensuring quality, leading to higher yields with fewer inputs through applications like predictive analytics for genetic traits, computer vision for quality checks, and data-driven decisions for precise irrigation and pest control, ultimately boosting efficiency and reducing environmental impact. These technologies accelerate development of resilient crops, optimize resource use, and provide non-destructive seed quality assessments, supporting food security and sustainable agriculture. This study explores the potential and applications of ML and AI methodologies to enhance various facets of seed-related processes. From seed viability assessment to crop yield prediction, using advanced algorithms enable a more precise and efficient understanding of seed characteristics. The applications of digitals such as ML and AI in seed production and quality testing are many.

1. Enhancing seed quality assessment Seed quality assessment is a critical aspect of seed science, influencing crop establishment, vigor, and yield potential. Traditionally, assessing seed quality involved labor-intensive and subjective methods. However, this process has been revolutionized with the advent of machine learning algorithms. By analyzing vast datasets encompassing genetic information, environmental parameters and phenotypic traits, AI can accurately predict seed quality parameters such as germination rate, vigor and disease resistance. This data-driven approach in seed science plays a crucial role in modern plant breeding. By using advanced technologies like genomics, bioinformatics, and data analytics, scientists can identify genetic markers linked to desirable traits such as disease resistance, drought tolerance, higher yields, and improved nutritional quality.
2. Accelerating breeding programs Breeding new crop varieties with desired traits is a time consuming process traditionally reliant on trial and error. However, machine learning and artificial intelligence techniques have expedited this process significantly. Additionally, AI-driven breeding programs optimize hybridization and genome editing techniques, enhancing traits such as yield, stress tolerance, and nutritional content. By leveraging AI, seed scientists can develop resilient crop varieties adapted to changing climatic conditions and evolving market demands more rapidly than ever before.
3. Precision agriculture and seed placement Precision agriculture relies on data-driven decision making to optimize resource use and maximize crop productivity. AI plays a pivotal role by integrating data from various sources, including satellite imagery, drones and IoT sensors.
4. By analyzing spatial variability in soil properties, climate conditions and crop health indicators, AI generates precise seeding maps and recommends optimal seed placement strategies. Additionally, AI-powered machinery enables precise seed placement and planting density adjustments, ensuring uniform crop establishment and maximizing yield potential. This precision enhances resource efficiency, minimizes input costs, and mitigates environmental impact, promoting sustainable agricultural practices. Predictive analytics powered by AI optimizes seed production, distribution, and inventory management. This results in a more streamlined supply chain, reducing costs and ensuring a consistent and reliable supply of seeds to farmers. The digital tools will improve the efficiency, accuracy, traceability, and resource management from field to lab, ultimately enhancing seed quality and crop yields while reducing waste.



Digital innovations through Startups impacting farming

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A startup venture could be defined as, a new business that is in the initial stages of operation, beginning to grow and is typically financed by an individual or small group of individuals. It is a young entrepreneurial, scalable business model built on technology and innovation wherein the founders develop a product or service for which they foresee demand through disruption of existing or by creating entirely new markets. Startups are nothing but an idea that manifests into a commercial undertaking.

India, the 3rd fastest growing centre for technological start-ups (CNBC, 2019). India became third in start-up ecosystem race and it is trying to get better its ease of doing business rank, in 2019 it was 77 and now in 2020 as per "World Bank's Ease of Doing Business Report 2020" it is improved by 14 ranks and stand on 63rd rank among 190 countries (World Bank, 2020).

Digital technologies are transforming agriculture by making farming more efficient, sustainable, and resilient. The integration of tools such as sensors, satellites, drones, artificial intelligence (AI), and data analytics has enabled farmers to make informed, data-driven decisions. Precision agriculture, for example, allows farmers to monitor soil health, moisture levels, and crop conditions in real time, leading to optimized use of water, fertilizers, and pesticides. This not only reduces input costs but also minimizes environmental impact.

Technologies like Geographic Information Systems (GIS) and remote sensing help in early detection of pests, diseases, and nutrient deficiencies, allowing timely interventions and reducing crop losses. Smart machinery and automation, including GPS-enabled tractors and robotic harvesters, improve operational efficiency and address labor shortages. In addition, digital platforms and mobile applications provide farmers with access to weather forecasts, market prices, and advisory services, empowering them to plan better and improve profitability.

Digital technologies also strengthen supply chains by improving traceability, reducing post-harvest losses, and connecting farmers directly with buyers. Overall, digitalization in agriculture enhances productivity, supports climate-smart farming practices, and plays a crucial role in ensuring food security for a growing global population.

Startup ecosystem:

Start up ecosystem at institutional level play an important role. The essential features of the ecosystem includes mentorship, makers lab/workshop, simulative events like Ideathon, financial support etc.(Fig 1)

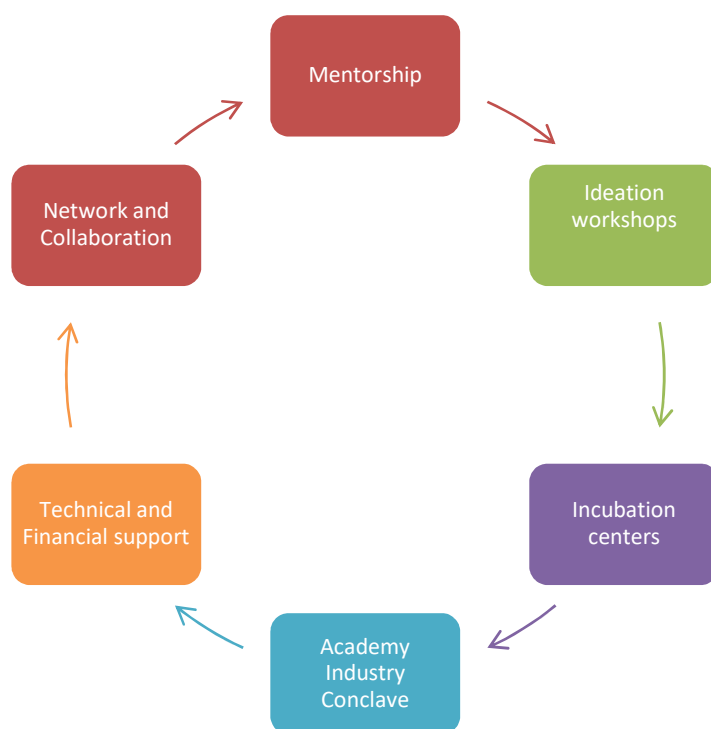


Fig 1 Elements of Start up ecosystem

The process of startup development follow different stages like ideation, validation, prototype development and standardization and commercialization (Fig 2)

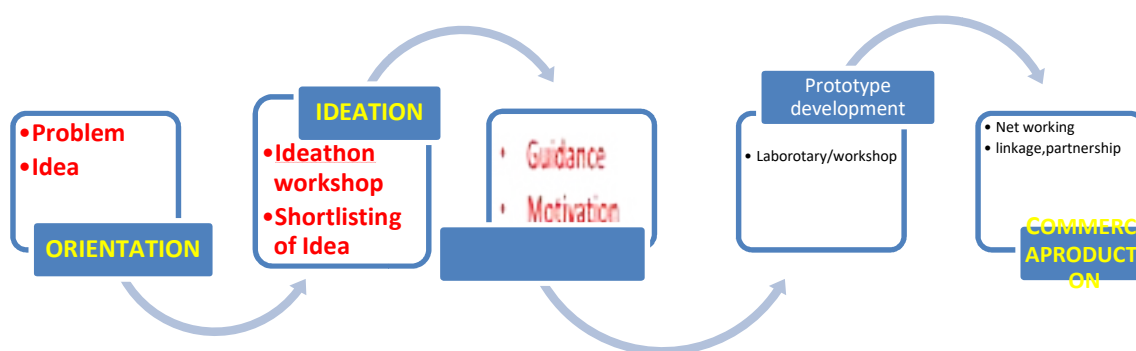


Fig 2: Process of startup development

RKVY–Krishik Agri-Business Incubator- University ofAgricultural Sciences, Dharwad

KRISHIK Agri Business Incubator is funded under the project Innovations and Agri entrepreneurship development programme of Rastriy Krishi Vikas Yojane.(RKVY). The project was launched in 2018-19 and UAS Dharwad was recognized as Knowledge partner to guide four ABI's. Krishik ABI has completed 11 cohorts and supported 136 start ups since 2018-19.This includes 25 women led startups and 4 student startups.The startups have developed innovative solutions to farmers problem in six focused areas namely waste to wealth, farm machineries, IOT and precision agriculture, food processing and value addition,Sustainable agriculture and crop production technologies. The startups have developed innovative solutions in digital technologies.



Some of the digital technology driven startups are listed below

1. Smart Sampark LLP

Smart Sampark LLP is revolutionizing farmer support services through an innovative IoT-based intelligent answering system designed specifically for Kisan Call Centres. By integrating a user-friendly ChatBox, the platform enables farmers to receive quick, accurate, and systematic answers to their agricultural queries in real time, reducing dependency on manual call handling and improving overall efficiency.

Founded by Mr. Aryan Karchi, this startup has already positively impacted 30 farmers while creating 4 direct jobs, laying a strong foundation for scalable, technology-driven extension services in Indian agriculture.

2. Fala Tech Pvt Ltd

Fala Tech Pvt Ltd offers a comprehensive farming assistance system tailored for polyhouse cultivation. This AI-enabled IoT solution seamlessly integrates hardware, software, and expert services to optimize climate control, irrigation, nutrient management, and overall productivity in protected farming environments.

Led by Mr. Padmaraj Pattanashetti, Fala has generated ₹40 lakhs in cumulative revenue and supported 35 farmers while creating 6 employment opportunities, demonstrating strong commercial potential in precision farming technology.

3. Nefty Technologies Pvt Ltd

Nefty Technologies Pvt Ltd has developed a specialized e-commerce platform focused on authentication and traceability of the premium GI-tagged Nanjangud Rasabale banana. By ensuring product authenticity from farm to consumer, the platform builds trust, protects the unique identity of this premium variety, and helps farmers secure better market prices.

Founded by Ms. Kavya S, this initiative has already benefitted 10 farmers and generated 6 jobs, contributing to the preservation and promotion of geographical indication products.

4. Sampark Bindu Solutions Pvt Ltd

Sampark Bindu Solutions Pvt Ltd provides a powerful Big Data-based decision-making platform combined with a free e-marketplace that directly connects agricultural buyers and sellers. The solution empowers farmers with data-driven insights while eliminating middlemen and enabling transparent, efficient transactions.

Led by Mr. G. Sadananda Murthy, the startup has positively impacted 3 farmers and created 3 jobs in its early phase, with strong potential for scaling across rural markets.

5. Agrikart Organics Pvt Ltd

Agrikart Organics Pvt Ltd is building trust in the organic ecosystem through a dedicated platform for authenticity and traceability of organic products. It also provides free technical services and advisory support to organic farmers, helping them improve practices and access better markets.

Founded by Mr. Rakesh Sindagi, the startup has achieved impressive ₹77 lakhs in cumulative revenue, benefitted 220 farmers across 4 states and 16 districts, and generated 7 employment opportunities.

6. Nexenstial LLP

Nexenstial LLP operates an efficient online B2B platform that connects livestock suppliers (shepherds, poultry owners, and cattle breeders) with vendors, abattoirs, and meat aggregators. The



solution streamlines transactions, improves price discovery, and enhances supply chain efficiency in the meat and livestock sector.

Led by Mr. Gurusiddheshwar Hiremath, the platform has recorded the highest revenue of ₹120 lakhs among the cohort, positively impacted 500 stakeholders, and created 3 jobs.

7. Pravinya Infotech

Pravinya Infotech is developing a smart computer vision-based application that enables rapid and accurate quality assessment and grading of seeds. This technology helps farmers, seed companies, and certification agencies ensure high-quality planting material and reduce losses due to poor seed quality.

Founded by Dr. Prakashgoud Patil, the startup is in its early development stage with promising potential to become a key quality assurance tool in Indian seed systems.

8. Grape Master

Grape Master is a leading real-time online advisory platform that empowers grape growers by solving daily field problems through its dedicated mobile application. Farmers receive expert guidance on pest management, nutrient application, irrigation scheduling, and other critical decisions, helping improve yield and quality.

Led by Mr. Sunil Genuji Shinde, this startup has made the most significant social impact benefitting an impressive 70,000 farmers, generating ₹50 lakhs in revenue, and creating 12 jobs across 2 states and 15 districts.

9. e-Agricraft Livlink Pvt Ltd

e-Agricraft Livlink Pvt Ltd is transforming the livestock trading ecosystem with a modern digital platform that offers on-site veterinary services, transparent price discovery, and efficient transaction processes. The solution empowers both farmers and traders with accessible, sustainable, and trustworthy livestock marketing.

Founded by Dr. Geeta T in the recent 2024–25 cohort, the startup is positioned to address critical gaps in livestock supply chains and create value for millions of animal rearers across India.

10. AREKA Karmik Pvt Ltd

AREKA Karmik Pvt Ltd bridges the critical skill gap in areca nut cultivation by connecting skilled agricultural workers directly with areca farmers through a dedicated platform. This initiative enhances farm productivity, ensures timely operations, and provides reliable livelihood opportunities for skilled rural workforce. Led by Jayachandra T. R., the startup has already generated ₹5 lakhs in revenue, supported 100 farmers across 7 districts, and created 4 jobs in its early phase.

Most of the startups explore digital media to support farming community and generate revenue. In coming days, farmers would be empowered through information, market, monsoon and other information support.



Uav Lidar and Sar Applications in Sustainable Forestry and Agriculture

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ABSTRACT

The study was carried out in Uttara Kannada district to assess land use land cover classes and to assess forest biomass using drone based LiDAR and SAR data. There are ten permanent plots were established each of one hectare in dry, moist and semi-evergreen forest. The trees permanent plots were numbered and enumerated for biomass estimation. Drone based LiDAR data was collected over the dry, moist and semi-evergreen forest. The LiDAR data was processed and the number of stems found in LiDAR data as indicated in DGN implies that the number of actual marked trees enumerated in dry and moist deciduous forest are more or less same as with LiDAR data. Where as in semi evergreen forest the number of tree counts are very less in LiDAR data compared to actual number of trees as the LiDAR pulses are not penetrate the crown in semi-evergreen forest. The regression analysis for field estimated AGB and the tree height and diameter from LiDAR data was used to establish the model. The tree height from LiDAR data was tried for for 50th, 75th and 95th percentile height in all the three forest types. In dry deciduous forest regression equation was established with 95th height percentile which was correlating much better as indicated by with R² value of 0.95 and the equation is $Y=0.980X+0.021$. Where Y is AGB tons/ha and X is 95th percentile tree height from LiDAR in meter and the RMSE error is 0.18 t/ha. Regression equation for Moist deciduous forest with 95th percentile height is $Y=0.825X+0.226$ with RMSE error of 0.13 t/ha. The equation for semi-evergreen forest is $Y= 0.6437X+0.9292$. with RMSE error of 0.40 t/ha.

SAR (Synthetic aperture radar) L band was used to classify the land use and land cover using SAR backscatter. The fully polarimetric L-band quad-pol (HH, HV, VV & VH) SAR data of ALOS-2 PALSAR-2 was used and established Multiple Linear Regression (MLR) model for forest aboveground biomass of the study area. The Multiple Linear Regression (MLR) analysis indicated that the combination of HH and HV polarization for forest AGB retrieval shows a good correlation with field and predicted biomass with R² values of 0.86 tonne.

Key words: SAR, LiDAR, Boimass, Forest, LULC, MLR, Percentile and backscatter.

Introduction:

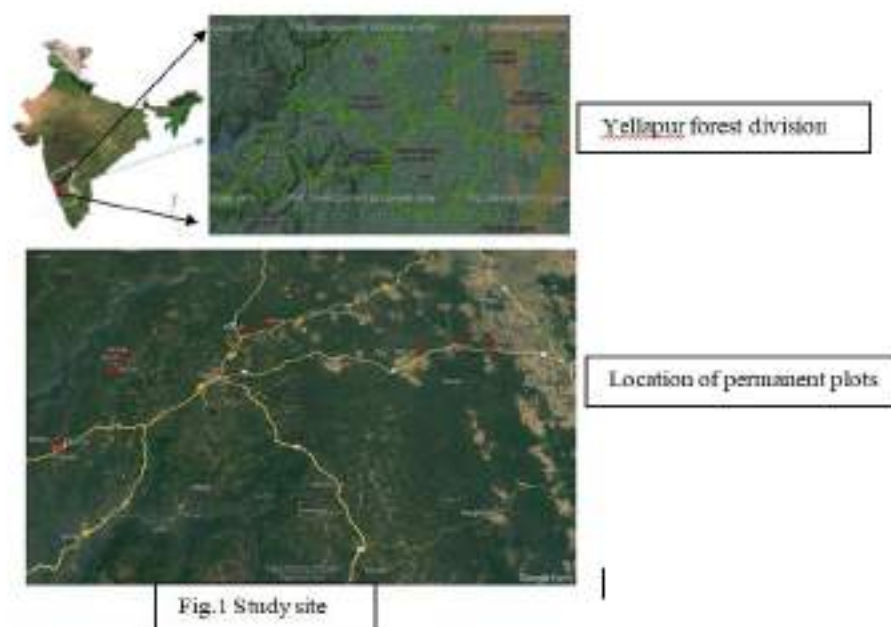
Forest plays a vital role in regulating climate through carbon sequestration in its biomass (Iqbal *et al.*, 2014). Forest Aboveground Biomass (AGB) reflects the health and environmental conditions of a forest ecosystem (Sinha *et al.* ., 2015). Tropical forests are pivotal in this regard as they sequester and store relatively large amounts of carbon compared to other forests (Nesha *et al.*, 2020). The forest is the major sink of carbon storage and it becomes the source due to anthropogenic activities leading to the degradation of forest which further leads to global warming (Zhu *et al.*, 2020). The accurate estimation of forest biomass is most important in estimating carbon storage. The importance of accurately reporting the carbon content



(biomass) of forested lands over time has been acknowledged by several studies (Carreiras *et al.*, 2013;). It plays an irreplaceable role in mitigating global warming caused by the increase in atmospheric carbon dioxide. Forest AGB can be determined from remote sensing techniques UAV LiDAR and SAR data (Suzuki *et al.*, 2013). Recently, there has been growing interest in the use of spaceborne SAR data in estimating AGB of forest vegetation (Otukey, & Emanuel, 2015). SAR sensor transmits a microwave pulse towards the Earth's surface and receives the backscattered signal that is determined by the surface and includes information regarding the land surface structure such as forest characteristics. Microwaves used in SAR remote sensing are not affected by cloud cover, hence SAR data is being widely used in areas where cloud cover exists for most of the period (Suzuki *et al.*, 2013).

Materials and method

The study was carried out in Yellapur forest division having dry deciduous, moist deciduous and semi-evergreen forest. The permanent plots were established in Yellapur forest division, Uttara Kannada district, Karnataka. There are 10 permanent plots, each of one hectare, three plots were laid out in Dry deciduous forest, three plots in Moist deciduous forest and 4 plots in semi-evergreen forest area (Fig.1).



The growth parameters of all the trees were recorded viz., tree diameter at breast height, at base and tree height. The tree volume was estimated for each tree using standard formula. The number of tree species in all 10 plots and occurrence of each species in different permanent plots were recorded. The inventory data over the 10 sampling plots were analysed for vegetation diversity parameters. A few parameters describing biodiversity over the region were generated from the inventory data. These parameters do not represent the overall biodiversity of the district as the inventory plots are confined to Yellapur forest division of Uttara Kannada district, the eastern part of the district and covers primarily tropical dry deciduous, Moist deciduous and semi evergreen forest dominated by teak (*Tectona grandis*) *Terminalia paniculata*, *Myristica malabarica* and *Holigarna arnottiana* tree species.

SAR Satellite Data Used:

The ALOS-2 PALSAR-2 single look complex (SLC) data was acquired on 26-05-2016 in strip map mode. The incidence angle of the quad-pol data was 38.97°. The data used was of 1.1 level which had the



phase information. The L-band data is fully polarized having HH, HV, VH, and VV polarizations. Satellite/Sensor ALOS-2 PALSAR-2 which is Acquired on 26-05-2016 with Range and Azimuth Resolutions 2.86 m and 3.11 m respectively.

Field Data Collection

Drone based LiDAR data was collected for all permanent plots and for SAR data were collected from the entire area using randomly selected sample plots. A total of 30 sample plots were laid out in the study area and the sampling plots of 30 numbers were approximately 0.01 percent of the forest area. Random field sampling plots were done throughout the study area according to accessibility. The Point Centered Quarter (PCQ) method was used to collect the data from the study area. The sample plots were taken in such a way that it represents the different forest density. In the PCQ method, 100 m length was randomly selected with the rope, and tree parameters were measured at starting point and at 25, 50, 75, and 100m length. At each point, there are four quadrates in each quadrate one tree which is near the center was selected and a total of 4 trees one in each quadrate which is near the center point was selected, and its length from the center point was measured with a tape. The layout of the PCQ method is shown in Fig. 2. The PCQ method was used since this method is most suitable in the forest where the trees are randomly grown without proper spacing in a natural forest and the PCQ method is a more precise method for estimating the above-ground biomass (Kumarathunge et al, 2011). The distances of each tree from the center were recorded and tree growth parameters were recorded. The GBH (Girth at Breast Height), and girth at the base of the tree were measured with diameter tape. The height of the trees in the forest was measured with a Ravimultimeter made by Aqua Antiques Nauticals. The location of each sample plot information such as latitude/longitude and altitude were recorded using Garmin e Trex 20x GPS (Huang et al., 2015). In each sample plot, a total of 20 trees were recorded and the sample area was estimated by multiplying the square of the average length of the trees from the center point (Total measured length /20) and the total number of trees (20). The tree volume was estimated using the standard formula given below (Mangla et al., 2016). The aboveground biomass was calculated after multiplying each tree's volume by its specific gravity. The wood density or specific gravity that is represented by dry weight/green volume is the solid wood substance in a given volume of wood (Zobel, 2004).

$$\text{Stem Volume (SV)} = \text{Basal Area (BA)} \times \text{Tree Height} \times \text{Form Factor (FF)}$$

$$\text{Basal Area} = \pi/4 * (\text{DBH})^2$$

$$\text{Forest Aboveground Biomass (AGB)} = \text{Stem Volume (SV)} \times \text{Specific Gravity (SG)}$$

SAR Data Analysis :

The data used for the study was ALOS-2 PALSAR-2, L-band SAR data which is quad pol having all polarizations (HH, HV, VH, and VV). The data of each polarization contains real and imaginary bands (i and q) and intensity bands. These bands were used to create an RGB image. The data is pre-processed

In SNAP software. Complex (SLC) data of ALOS-2 PALSAR-2 was corrected with Range-Doppler Terrain Correction on quad-pol fully polarimetric SAR data for the Orthorectification using Copernicus 30m Global DEM in SNAP V 8.0 toolbox. A refined Lee filter was used to minimize the speckle effect from the SAR data. The image was re-projected to the coordinate system of the study area (WGS_1984_UTM_Zone_43) (Das & Patnaik 2017;). The PALSAR-2 image was used to retrieve HH, HV, VV, and VH polarized backscatter coefficients which are expressed in decibels (dB). The data was calibrated to calculate the backscatter coefficient of the points where field data was collected. The backscatter calibration of SLC data of ALOS-2 PALSAR-2 was performed using Eq. (1) (Peregon&



Yamagata., 2013). The backscatter cross-section of ALOS-2 PALSAR-2 can be obtained by the ensemble averaging or the spatial averaging of pixel values around the target as shown in Eq. (1) (Japan Aerospace Exploration Agency 2016).

$$\sigma^0 = 10 \times \log_{10}(\text{DN}) + \text{CF} \quad (1)$$

The multilinear-linear regression analysis was done to relate the backscatter (σ^0) coefficient of SAR to the corresponding field calculated AGB. This model is used to analyze the relationship between the dependent variable (field measured forest AGB) and the independent variable (SAR backscatter) (Thumaty et al., 2016). This model regresses a correlated variable (AGB) based on one or more independent variables (Zhu et al., 2020). The growth parameters were collected from 30 PCQ sample plots out of which 20 plots of data were used for model generation and the remaining 10 sample plots were used for model validation. The proportion of variance

(R^2) and root mean square error (RMSE) is used to evaluate the model performance (Nizalapur et al., 2010). Eq. (2) is generated by using a common regression equation in which the model parameters were calculated by running the regression analysis between field calculated forest AGB and backscatter coefficients of the SAR data in different polarimetric combinations for the corresponding field plots.

$$Y_{\text{BIOMASS}(t/ha)} = A + (B * \sigma^0_{\text{HH}}) + (C * \sigma^0_{\text{HV}})$$

where A, B, and C are model parameters. The study carried out by Cassol et al., 2019 had derived multiple linear regression models (MLR) equation between a dependent variable (Y) and multiple independent variables (backscatter coefficient). Many previous studies showed the use of the MLR model for estimating forest biomass by using the backscatter coefficient (Zhu et al., 2020; Das & Patnaik 2017).

Statistical Analysis

The regression model is validated by assessing the coefficient of determination (R^2) between the predicted and field-measured forest AGB values. The root mean square error was also calculated to know the relationship between observed and predicted values. The formula to calculate the RMSE is shown in Eq. (3).

$$\text{RMSE} = \sqrt{[\sum (P_i - O_i)^2 / n]} \quad \text{-----} \quad (3)$$

Where $\sum$ is the sum P_i is the predicted value for i^{th} observation in the dataset.

O_i is the observed value for the i^{th} observation in the dataset. n is the number of samples.

Result and discussion:

LiDAR data

The analysis of these parameters indicate dominance of *Tectona grandis*, *Terminalia paniculata*, *Myristica malabarica* and *Holigarna arnottiana* in the studied region. Some of the associated species viz., *Terminalia alata*, *Syzygium laetum*, *Lagerstroemia lanceolata*, *Artocarpus hirsutus* and *Anogeissus latifolia* also showed high importance value index in terms of their abundance and frequency of occurrence in the region. This however, do not represent the species diversity of Uttara kannada district as the sample size for present analysis is restricted to only Yellapur forest division of the UK district, Karnataka. The tree species distributed in the permanent plots are grouped in to different height and diameter classes in all the 10 plots. Total **4783 trees** having **83 species** were recorded in all 10 permanent plots. The tree heights grouped in to different height classes. It shows that 26 percent of trees are falls under 12-15 m height classes followed by



9-12 m class (23%), and 6-9 m class (22%). The least was recorded in 21-24 m height class (2.1%) and > 24 m height class (0.41%).

The distribution of stems in different diameter classes are also grouped in to different diameter classes. It was found that major percent of tree are found in 15-25 cm diameter class (33.8%), followed by 5-15 cm diameter class (30.36%) and 25-35 cm diameter class (21%). The least number of stems were recorded in 55-65 cm diameter class (2%) and > 65 cm diameter class (2%).

The Drone was used to flown over the permanent plots to record the LiDAR data and high resolution RGB images over the permanent plots. The LiDAR data is having high resolution with the accuracy of 2 cm. Millions of LiDAR (Laser) points are received from the target and they are grouped in to different percentile w.r.t. tree height. Starting from 25th 50th , 75th and 95th percentile height. In this technology Laser light is sends from a transmitter, which then reflects off from the objects.

The LiDAR data on tree stems (DGN) and Digital surface model (DSM) , ortho data and tree height model were recorded from drone based LiDAR data. The number of stems found in Lidar data as indicated in DGN implies that the number of trees enumerated in the field in dry and moist deciduous forest are more or less same and even the numbers are higher in LiDAR data than actual marked trees. Where as in semi evergreen forest the number of tree counts are very less compared to actual trees enumerated due to thick coverage of tree crown. The LiDAR pulses not penetrate the crown hence the number of tree counts are less in semi-evergreen forest as indicated from permanent plots of semi-evergreen forest.

Regression model for AGB estimation from LiDAR data:

The regression analysis for field estimated AGB and the tree height from LiDAR data was used to establish the model. The diameter from LiDAR is not correlating for establishing the model hence the tree heights from LiDAR data was tried for different percentile height in all the three forest types. In dry deciduous forest regression equation was established for 50th, 75th and 95th percentile height among them 95th height percentile was correlating much better for both AGB and AGC. Based on 95th percentile height AGB was predicted with the field observed AGB it was found good correlation with R^2 value of 0.95 and the regression model developed was $Y=0.980X+0.021$ (Fig.2). Where Y is AGB tons/ha and X is 95th percentile tree height from LiDAR in meter and the RMSE error is 0.8 t/ha.

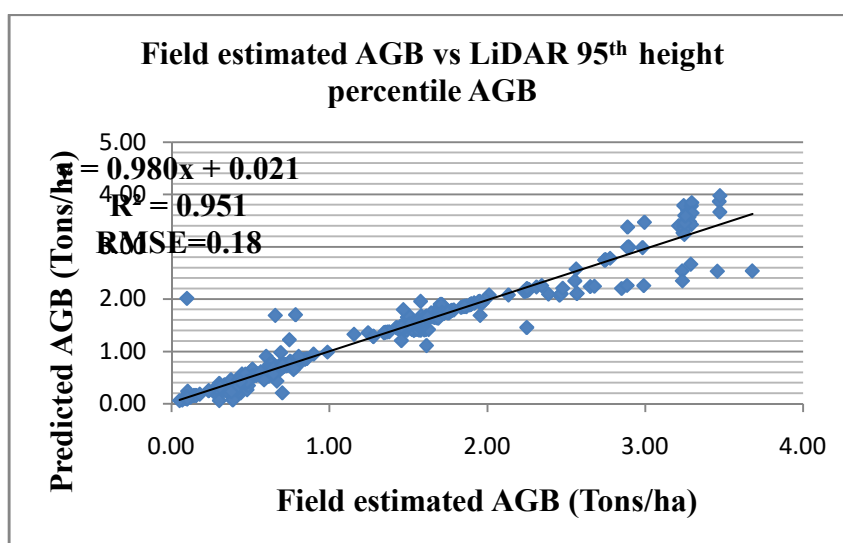


Fig.2 LiDAR data model for estimating biomass from dry deciduous forest



In Moist deciduous forest also regression model equation w.r.t field estimated AGB and different height percentile from LiDAR data was tried for 25th, 50th, 75th and 95th among them good correlation was found with 95th height percentile. The field estimated AGB and predicted AGB based on 95th percentile height was correlated and it was found that the correlation coefficient was (R^2) 0.86 with RMSE error of 0.13. The model equation for moist deciduous forest developed was $Y=0.825X+0.226$ (Fig.3). Where Y is AGB tons/ha and X is 95th percentile tree height from LiDAR in meter.

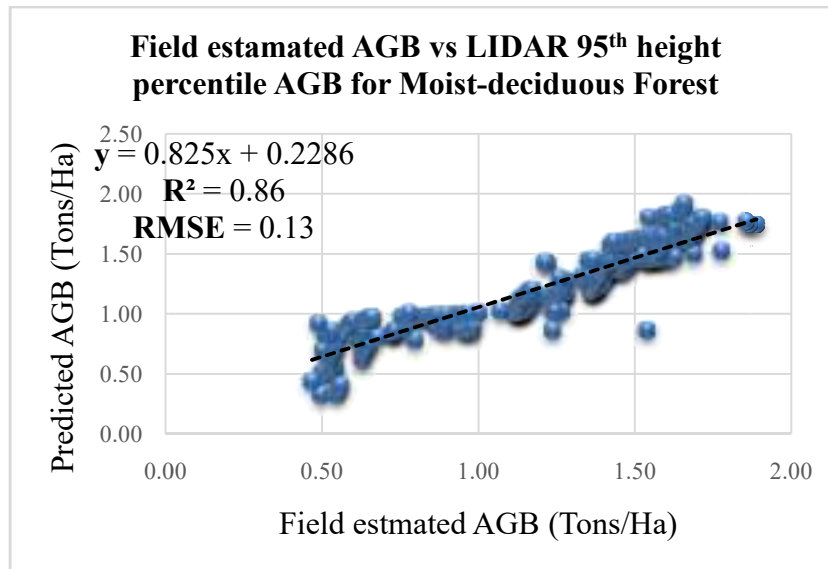


Fig.3 LiDAR data model for estimating biomass from moist deciduous forest

In Semi-evergreen forest also regression model equation w.r.t field estimated AGB and different height percentile from LiDAR data was tried for 50th, 75th and 95th among them good correlation was found with 50th height percentile. The field estimated AGB and predicted AGB based on 50th percentile height was correlated and it was found that the correlation coefficient was (R^2) 0.57 with RMSE error of 0.4 t/ha. The equation for semi-evergreen forest was $Y= 0.6437X+0.9292$ (Fig.4). where Y is AGB tons/ha and X is 50th percentile tree height from LiDAR in meter.

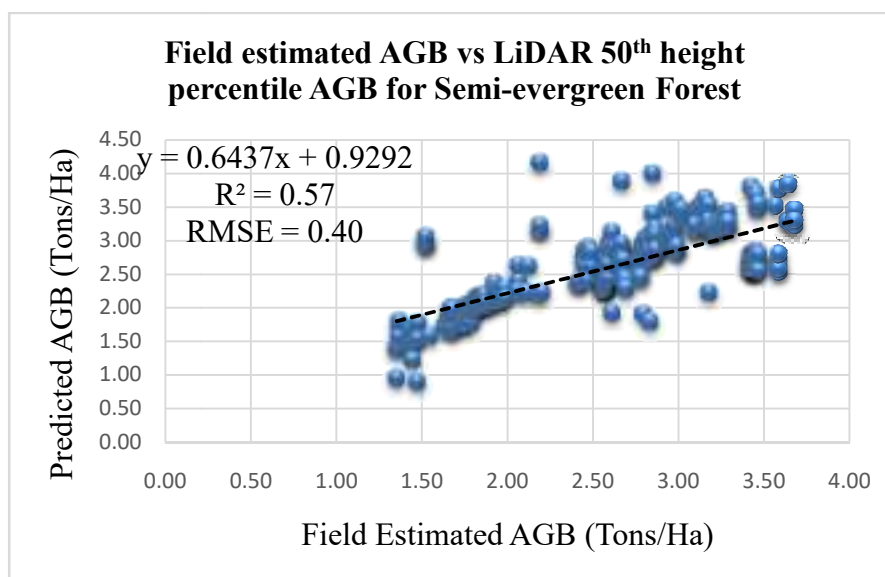


Fig.4 LiDAR data model for estimating biomass from Semi-evergreen forest



SAR data:

The aboveground biomass (AGB) of sampled plots was estimated in tones per hectare based on the sample plot biomass, Forest stem biomass of sample plots varies from 16.11 m³/ha to 1235.79m³ /ha. The higher values are from the plots of dense forests having higher DBH and height. The sampled area included dense forest, moderately dense forest, and sparse forest and hence the variation in biomass has occurred. Forest AGB of each sample plot in tones per hectare was varying from 12.88 t/ha to 1000.98 t/ha due to variations in the specific gravity of different species. Since the PCQ method was followed randomly there was a chance of getting a uncertainty in field-measured forest parameters, hence there may be difference in AGB of forest patches. The backscatter of the L-band in different Polarization from different sample plots was used to predict the biomass. The backscatter image of HH, HV, VH and VV is shown in fig.5..

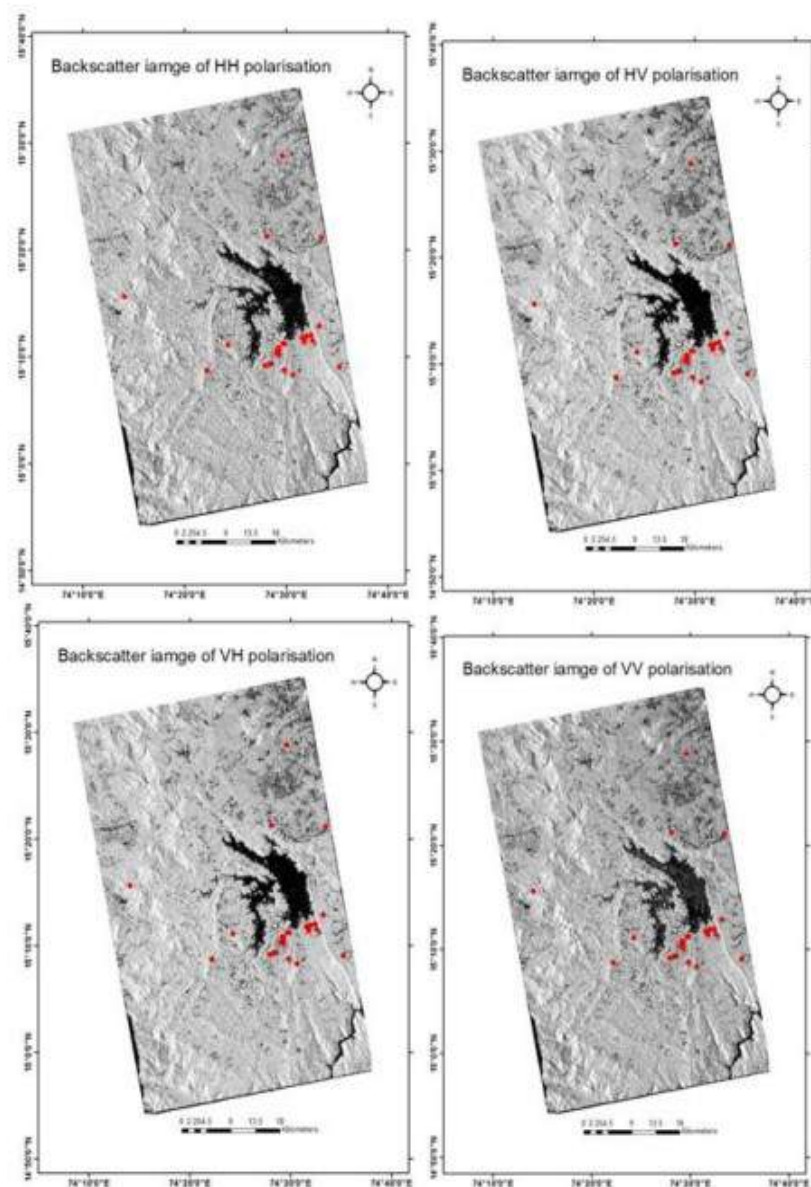


Figure 5. backscatter image of HH, HV, VH and VV



The regression model for different polarisation is shown in fig.6

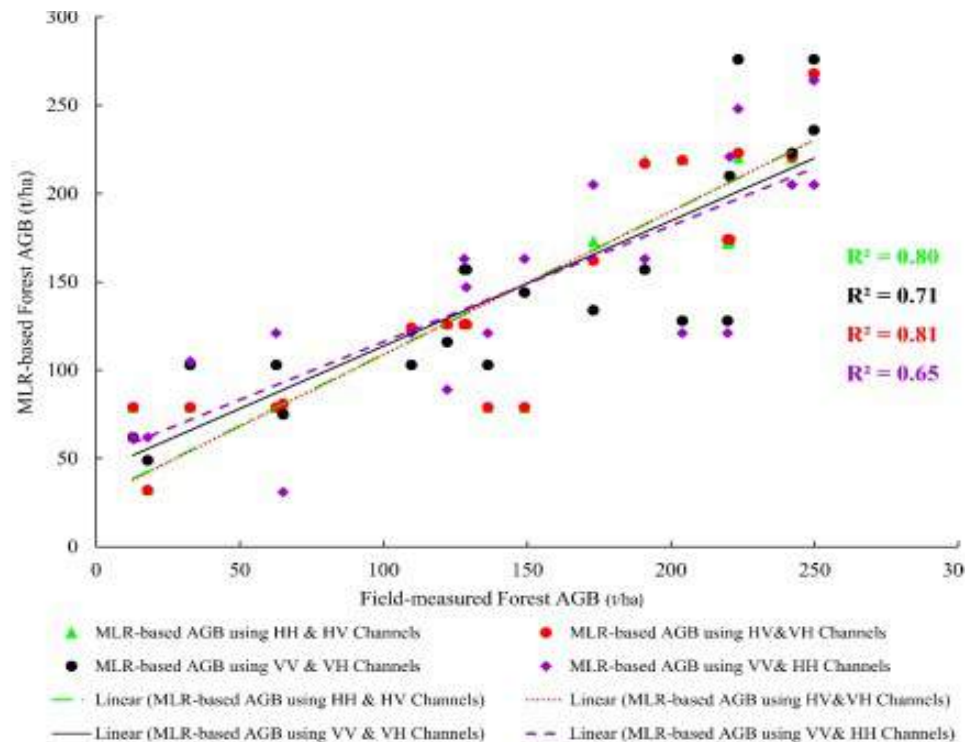


Fig 6. Regression model for different polarisation

Conclusion:

The regression for field estimated AGB and the tree height from LiDAR data was used to establish the model. The tree heights from LiDAR data was tried for 50th, 75th and 95th percentile height percentile in all the three forest types. Among them 95th height percentile was correlating much better for both AGB and AGC. Among different forest LiDAR data gave good correlation in dry deciduous forest as compared to moist and semi evergreen forest. The regression model developed was $Y=0.980X+0.021$ having R^2 value of 0.95 and and the RMSE error was 0.8 t/ha.

The result shown that polarimetric L- band space borne SAR data in the MLR indicated good correlation between field-measured forest AGB and MLR model-based predicted forest AGB for 20 plots that were used in the model training. The validation of the modeling approach was performed with the 10 remaining plots that were not used in the model training and it was observed that the highest coefficient of determination with the lowest RMSE was obtained with HH & HV polarimetric combination.

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Enhancing Food Safety and Nutritional Needs: Role of Digital Technologies

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ABSTRACT

Food safety and nutrition are fundamental to human health, economic productivity and sustainable development. Globally, an estimated 600 million, almost 1 in 10 people in the world fall ill after eating contaminated food and 4,20,000 peoples die every year. At the same time, nearly 3 billion people cannot afford a healthy diet and over 820 million people remain undernourished worldwide (WHO, 2023). Digital technologies have emerged as powerful enablers in addressing these challenges by improving food production efficiency, ensuring safety and quality, enhancing traceability and strengthening nutrition planning and awareness. This paper discusses the role of digital technologies in enhancing food safety and meeting nutritional needs, supported by global and national statistics, while highlighting challenges and policy implications.

Keywords: Food safety, nutrition security, digital technologies, ICT, blockchain, precision agriculture, smart food systems

I. Introduction

Food systems today face unprecedented challenges due to population growth, climate change, urbanization and changing dietary patterns. By 2050 the world's population will reach 9.1 billion, 34 percent higher than today. Nearly all of this population increase will occur in developing countries. Urbanization will continue at an accelerated pace and about 70 percent of the world's population will be urban (compared to 49 percent today). Income levels will be many multiples of what they are now. In order to feed this larger, more urban and richer population, food production must increase by 70 percent. Annual cereal production will need to rise to about 3 billion tonnes from 2.1 billion today and annual meat production will need to rise by over 200 million tonnes to reach 470 million tonnes (FAO, 2022).

It is estimated that the foodborne disease burden in India will rise from 100 million to 170 million in 2030, largely due to contamination, improper handling and lack of traceability (FSSAI, 2022). Simultaneously, 35.50 per cent of children under five are stunted, 32.10 per cent are underweight and 57.00 per cent of women aged 15–49 suffer from anemia (NFHS-5, 2019–21). These alarming figures highlight the urgent need for technology driven, data-based interventions.

Digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), blockchain, big data analytics, mobile applications, and GIS offer transformative solutions to enhance food safety and nutritional outcomes across the entire food value chain.

II. Global and National Food Safety & Nutrition Challenges (Data Perspective)

- One in ten people globally fall ill every year due to unsafe food (WHO, 2023).
- Food contamination and spoilage cause nearly 14.00 per cent post-harvest losses globally, valued at over USD 400 billion annually (FAO, 2021).



- In India, post-harvest losses range between 6.00–18.00 per cent, particularly in fruits, vegetables, meat and fish (ICAR, 2020).
- 45 million children worldwide suffer from wasting (too thin for height), while 149 million are stunted (too short for age) (UNICEF, 2023).
- Micronutrient deficiencies, often called “hidden hunger,” affect more than 2.00 billion people globally (FAO, 2022).

These statistics indicate that food availability alone is insufficient, ensuring food safety and nutritional quality is equally critical.

III. Role of Digital Technologies in Enhancing Food Safety

a. Precision Agriculture and Input Optimization

Precision agriculture technologies such as GPS-enabled machinery, sensors, drones and AI-based decision support systems reduce excessive use of fertilizers and pesticides by 20.00 to 30.00 per cent, thereby lowering chemical residues in food and environmental contamination (World Bank, 2021). Smart spraying and soil-testing apps help farmers apply inputs based on real-time field data, improving food safety at the source.

b. Digital Traceability and Blockchain Systems

Blockchain based traceability systems enable end-to-end tracking of food products. Studies show that blockchain can reduce food fraud by up to 50.00 per cent and cut trace-back time from days to seconds during contamination outbreaks (OECD, 2020). QR-code-based traceability increases consumer confidence and accountability in food supply chains.

c. IoT-Based Storage and Cold Chain Monitoring

Temperature abuse during storage and transport is responsible for nearly 30.00 per cent of food spoilage in perishables (FAO, 2021). IoT sensors and smart cold chain systems continuously monitor temperature and humidity, reducing spoilage losses by 15.00–25.00 per cent and improving food safety compliance.

d. Digital Food Safety Surveillance

AI-driven food safety surveillance systems analyse large datasets to predict contamination risks and disease outbreaks. Countries using digital food inspection tools have reported 20–40.00 per cent improvement in regulatory efficiency (WHO, 2022).

IV. Role of Digital Technologies in Improving Nutritional Security

a. Nutrition Sensitive Digital Advisory Services

Mobile-based nutrition advisory platforms provide farmers and households with information on nutrient-dense crops, biofortified varieties, and balanced diets. Digital advisories have been shown to increase adoption of nutrition-sensitive crops by 25.00–30.00 per cent (FAO, 2021).

b. Big Data and GIS for Nutrition Planning

GIS-based mapping and big data analytics help identify malnutrition hotspots and dietary gaps. In India, digital dashboards under POSHAN Abhiyaan have improved monitoring efficiency and beneficiary coverage by over 20.00 per cent (NITI Aayog, 2022).

c. Digital Monitoring of Public Nutrition Programs

Digital tools used in schemes like ICDS and Mid-Day Meal Programme reduce leakages and improve transparency. E-monitoring systems have resulted in 15.00 to 25.00 per cent reduction in operational inefficiencies (MoWCD, 2021).



d. Consumer Awareness and Behaviour Change

Digital media platforms significantly influence dietary behaviour. Studies indicate that nutrition awareness campaigns through mobile and social media increase healthy food choices by 18.00 to 22.00 per cent among urban and semi-urban populations (UNICEF, 2022).

V. Digital Technologies Across the Food Value Chain

Digital interventions strengthen all stages of the food system:

- **Production:** Precision farming, climate advisory apps (yield increase: 10.00 to 20.00 per cent)
- **Post-harvest:** Smart storage and logistics (loss reduction: 15.00 to 30.00 per cent)
- **Processing:** Automation and digital quality control
- **Marketing:** E-NAM and digital marketplaces (price realization increase: 10.00 to 15.00 per cent)
- **Consumption:** Nutrition apps, smart labelling, diet-tracking tools

This integrated digital ecosystem enhances both food safety and nutritional outcomes.

VI. Challenges in Digital Adoption

Despite proven benefits, adoption remains uneven due to:

- Rural digital divide (only 37.00 per cent rural internet penetration in India) (TRAI, 2023)
- Low digital literacy among smallholders
- High initial investment costs
- Data privacy and cybersecurity concerns
- Fragmented institutional coordination

VII. Conclusion

Digital technologies have the potential to revolutionize food safety and nutrition by making food systems more transparent, efficient and resilient. Evidence based data clearly show that digital tools can reduce food losses, improve safety compliance, enhance nutritional awareness and support targeted interventions. However, inclusive access, supportive policies, and people-centric implementation are essential to ensure that digital transformation leads to sustainable food and nutrition security for all.

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Digital Extension: Progress and Way Ahead

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India's agricultural extension is rapidly transitioning from conventional, often resource-intensive and geographically limited methods, to advanced digitally-enabled, data-driven services. This profound shift leverages technologies like Artificial Intelligence for predictive analytics, Internet of Things for real-time farm monitoring, robust mobile platforms for direct farmer communication, and satellite data for crop health assessment and yield forecasting. Given the immense scale of India's agricultural sector, supporting millions of farmers and contributing significantly to the national GDP, this digital transformation is critical for enhancing productivity, ensuring food security, and promoting sustainability. Key stakeholders including government bodies, innovative tech providers, farmers themselves, and Farmer Producer Organizations (FPOs) are actively involved in co-creating this ecosystem. This document explores breakthrough innovations and proposes a strategic framework for building inclusive, sustainable, and market-linked digital infrastructure, directly contributing to national goals like achieving sustainable food systems and strengthening the 'Atmanirbhar Bharat' (self-reliant India) vision. By addressing existing challenges such as information asymmetry and access, digital extension unlocks significant opportunities for innovation and positions India as a global leader in agricultural technology.

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Executive Summary

Digital extension represents a transformative shift in agricultural advisory services, leveraging technologies such as AI, IoT, blockchain, and mobile platforms to deliver real-time, personalized information to farmers. In India, where agriculture employs over 40% of the workforce and contributes significantly to GDP, digital extension is pivotal for achieving sustainable food systems and the vision of Atmanirbhar Bharat (Self-Reliant India). This paper reviews the state-of-the-art (SOTA) advances, highlighting government initiatives like the Digital Agriculture Mission (DAM) and AgriStack, which aim to create digital identities for 11 crore farmers by 2026-27.



AI-Powered Advisories

Personalized crop management recommendations using artificial intelligence



IoT Precision Farming

Real-time monitoring through connected sensors and devices



Supply Chain Transparency

Blockchain technology ensuring traceability and trust

Key technologies include AI-powered advisories, IoT for precision farming, and blockchain for supply chain transparency, with platforms like Farmonaut's JEEVN AI reaching 70% of farmers by 2026.

Progress has been marked by initiatives such as Kisan e-Mitra and Namo Drone Didi, enhancing farmer incomes and efficiency. However, challenges like digital illiteracy, infrastructure gaps, and small landholdings persist. The way ahead involves scaling AI integration, policy reforms, and public-private partnerships to boost productivity by **20-25%** and foster inclusive growth. This aligns with Atmanirbhar Bharat by reducing import dependencies and empowering smallholders for sustainable, resilient food systems.

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Digital Extension: Transforming Indian Agriculture

Critical Challenges

Indian agriculture faces complex challenges: climate variability, resource scarcity, yield stagnation, fragmented landholdings, volatile markets, and knowledge-action gaps.

Traditional extension systems struggle with limited reach, timeliness, and personalization, hindering their effectiveness against these challenges.



Always-On Access

24x7 availability of advisory services allows farmers to access critical information precisely when needed.



Hyper-Local Precision

Village-level and plot-specific recommendations considering micro-climates, soil, and local pest dynamics.



Farmer-Specific Advisory

Tailored guidance based on individual farmer profiles, crop stages, and resource availability.



Interactive Engagement

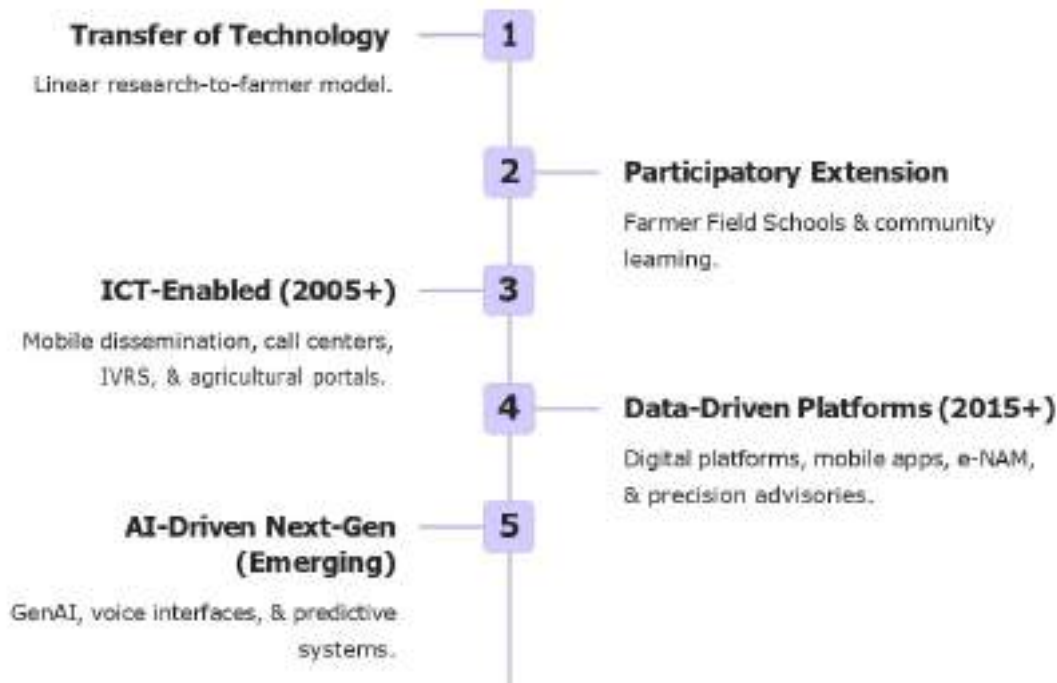
Two-way communication enabling continuous feedback and adaptive learning systems.

Digital extension fundamentally reimagines agricultural advisory services, making them scalable, measurable, and outcome-oriented. This supports India's vision for sustainable food systems and Atmanirbhar Bharat, creating self-reliant, technology-enabled agriculture that balances productivity with sustainability.

"Digital extension is central to achieving sustainable food systems and Atmanirbhar Bharat—combining productivity, resilience, and environmental sustainability through technology-enabled, farmer-first agriculture."



Evolution and Current State: India's Digital Extension Journey



Key Advancements

Digital Public Infrastructure (DPI)

India's agriculture Digital Public Infrastructure (DPI) stack enables verified farmer identities, integrated land records, and consent-based data exchange, supporting scalable services for credit, insurance, and market access.

Voice-Based Accessibility

Voice-based systems like IVRS, multilingual call centers, and chatbots reduce adoption barriers, critical for inclusive digital extension across all farmer segments.



Remote Sensing

Satellite data enables crop monitoring, stress detection, and yield estimation.



IoT Precision Ag

Sensor networks monitor soil and microclimates for precise irrigation.



Drone Services

UAVs facilitate field scouting, crop imaging, and precision spraying.



Market-Linked Extension

Integrates price insights, grading, and logistics to improve selling.

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The current landscape shows multi-dimensional progress, from mobile advisories to remote sensing and IoT-enabled precision agriculture, integrating drone technology and crucial market linkages.

Next-Generation Technologies and Strategic Framework

State-of-the-Art Technologies Reshaping Extension

1

AI/ML Agricultural Advisory

AI/ML provides image-based pest detection, yield prediction, and optimized irrigation, shifting advisories from rule-based to continuously learning systems.

2

Generative AI Transformation

GenAI offers conversational advisory in local languages, simplifying complex guidance and personalizing responses, democratizing expert knowledge for farmers.

3

Digital Twins for Simulation

Digital farm replicas simulate climate impact, irrigation stress, and crop profitability, supporting district-level planning and climate adaptation.

4

Prescriptive Decision Systems

Prescriptive systems advise farmers on optimal actions like spraying days, nutrient plans, and harvest schedules based on market demand.



Critical Gaps and Strategic Interventions

The Four Pillars of Next-Generation Extension

Precision

Plot-level specificity using geo-tagged data and micro-climate monitoring.

Personalization

Individualized advice based on farmer profiles, crop stage, and resources.

Prediction

Early warnings for pests, weather, and market price fluctuations.

Prescription

Actionable plans with clear steps and expected outcomes.

Critical Gaps Requiring Strategic Intervention

Trust & Adoption

- Farmers trust human advisors more.
- Misinformation & conflicting advice.
- Weak feedback limits improvement.

Data Fragmentation

- Siloed datasets.
- Inconsistent land records.
- Limited data integration.

Inclusion Challenges

- Women farmers digitally invisible.
- Elderly face adoption barriers.
- Remote regions lack connectivity.

❑ **Critical Gap: Advisory Quality Assurance** – India lacks standardized validation and accountability for digital advisories. A National Digital Advisory Quality Framework is essential.

Addressing these gaps requires coordinated action in technology, capacity building, and inclusive design. Extension staff need digital literacy and advisory interpretation skills, with women-led extension crucial for inclusive transformation.

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Strategic Roadmap: Global Leadership in Agri-Tech

Every farmer should have access to trusted, localized, real-time, actionable digital advisory

India's agricultural extension future is **Hybrid Extension 2.0**, merging digital tools for scale with human workers for trust and context. This model leverages FPOs for aggregation and peer learning, reinforcing digital advisories through KVKs, ATMA programs, FPO leaders, and Krishi Sakhis.

Extension-as-a-Service (EaaS)



Priority Policy Recommendations

01	02	03
National Digital Advisory Quality Framework (NDAQF)	Open Advisory Standards	Consent-Based Data Governance
Certify advisory models, validate protocols, and establish grievance systems.	Develop interoperable protocols for seamless data exchange.	Implement transparent data usage, benefit-sharing, and privacy-by-design systems.
04	05	
KVK Digital Hub Transformation	Women-Led Digital Extension	
Equip KVKs with AI advisory studios and local content creation.	Scale Krishi Sakhi networks and position SHGs as agri-tech intermediaries.	

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Technology Investments s Results Framework

Technology Investment Priorities (3-5 Years)

Voice-First AI Assistants

Regional language agricultural intelligence via natural conversation.

Real-Time Stress Dashboards

Satellite and weather-integrated crop monitoring for immediate action.

Integrated Decision Engines

Comprehensive farm management combining soil, crop, and climate data.

Results Framework: Outcome-Driven Metrics

Digital extension success must be measured by farmer livelihood improvements and agricultural sustainability, not just activity metrics.

25%

Practice Adoption

Target increase in recommended practice.

15%

Yield Improvement

Measurable productivity gains per hectare.

20%

Input Reduction

Decreased fertilizer, pesticide, and water usage.

30%

Loss Reduction

Minimized crop losses via timely interventions.

Digital extension is foundational for India's sustainable agriculture. The next generation must empower farmers with timely decisions, reduce risk, and enable resilience. India's unique advantages—scale, diversity, strong institutions, innovation, and digital public infrastructure— can create a global benchmark for sustainable food systems and Atmanirbhar Bharat.

This roadmap offers a framework for advancing digital extension. By unifying digital infrastructure with community trust, AI personalization with local languages, and outcome-based governance with capacity building, India can lead in agricultural extension. This ensures technology empowers smallholder farmers, enhances food security, promotes sustainability, and drives inclusive growth.

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Theme I : Oral
Intelligent technologies in Digital
extension for Next generation
Agriculture – progress and possibilities





T-1 O-1: Digital concerns in application of digital tools- achievements and action points

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India continues to push forward as a digitally empowered nation at an astonishing pace as digital technologies have contributed significantly towards the socio economic transformation and the rapid integration of digital tools has created very much new opportunities towards information access and have potential to transform livelihoods but the adoption is greatly influenced by gender disparities as women have less access to digital tools such as mobile advisory app, ICT based extension services, e-commerce platforms, remote sensing etc. even though women hold a significant position in workforce. Gender concerns in the application of digital technology include the gender digital divide where women have less access to digital literacy. Social norms and patriarchal decision making restrict women's mobility limiting their opportunities to access digital services. Additionally biases embedded in digital design content, overlook women's role in value chain. Our gender digital divide needs to be tackled because as per the national family health survey only one in three women in India have never used the internet while the rural India faces even more pronounced divide. The correlation between the gender equality index and the digital economy and society index shows that societies with greater equality between men and women also perform better in the area of digital economy. Despite persistent gender gaps several positive outcomes have emerged from digital initiatives as digital platform help to bridge gap between women farmers and extension services. A combination of inclusive policy frameworks, user centered technology design and sustained capacity building is required to empower women users. A gender sensitive approach is required to ensure that digital transformation becomes a path for equitable development and sustainable agricultural growth. Several action points have been undertaken for gender inclusive digital transformation like training through KVK, local capacity building which ensure that digital future is socially just and equitable.

Keywords: digital concerns, digital divide, women, gender gaps, action points.



T-1 O-2: Smart Fields, Resilient Futures: Digital Technology for Climate-Smart Agriculture

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Digital technologies are revolutionizing agriculture by enabling climate-smart practices that enhance productivity, resilience, and sustainability. Globally, over 70% of farmers using digital tools report improved decision-making and yields. Farms that leverage IoT, remote sensing, and precision agriculture have recorded 15–20% higher yields and 20–30% savings in water and fertilizers. In India, digital advisory services, mobile-based finance, and market platforms are reaching millions of farmers, with World Bank-supported CSA initiatives benefiting 4.7 million farmers, helping reduce emissions and increase productivity. Precision irrigation, drone-based monitoring, and AI-powered crop prediction tools are also increasingly adopted, reducing crop losses and improving resource management. Digital platforms enable farmers to access real-time weather alerts, market prices, and input recommendations, reducing uncertainty and financial risk. Despite these gains, adoption remains uneven, particularly among smallholders with limited connectivity, low digital literacy, or financial constraints. Policy support, public–private partnerships, and targeted investments in rural infrastructure are essential to scale these innovations. Scaling climate-smart agriculture requires bridging the digital divide, investing in farmer training, and expanding access to AI-based advisories, satellite monitoring, IoT sensors, and digital finance tools paving the way for resilient, resource-efficient, and sustainable agricultural systems worldwide. With sustained efforts, digital technology can transform farming into a profitable, climate-resilient, and environmentally sustainable enterprise for millions of smallholders.

Keywords: climate-smart agriculture, digital agriculture, precision farming, IOT sensors, remote sensing, sustainable farming.



T-1 O-3: Smart Farming for Future Farmers of India

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Globally, agriculture is a major source of food. Recently, possible negative consequences on global agriculture have been made worse by climate change and unpredictability. Global population growth and sudden weather changes have put tremendous strain on agricultural food items for sustainable and high-quality food production. One employment that is essential to surviving in our planet is farming. It meets all of a person's necessities to survive in this planet. However, as technology advances with the creation of the Internet of Things, automation (smarter technologies) is taking the place of conventional approaches, leading to a broad improvement in the fields. Recent technical developments, such as data communication and the use of electronic gadgets, have significantly altered the working environment in agriculture. These changes require updated data from production systems, markets, and production agents in order to provide decision-making information for production as well as for the associated strategic and management problems. Smart farming (SF), which is based on the integration of ICTs into the machinery, equipment and sensors of agricultural production systems, produces an abundance of data and information due to the increasing automation of the process. Improved technology-based farming methods are taking the place of traditional farming methods in the current era. Even if these innovative technologies are highly effective, scientists and researchers must continue to pay close attention to them in order to improve their application and output. In order to integrate and assess different agricultural data for decision-making, smart farming depends on data transmission and data concentration in remote storage systems.

Key words: smart farming, consequences, smart and innovative technology based farming



T-1 O-4: Role of Chatbots for Next Generation Agricultural Extension Services in India

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Chatbots in agricultural extension are AI-powered conversational tools that deliver farm-related information and advisory services to farmers through text or voice interfaces, usually via mobile phones, messaging apps, or websites; among them, rule-based chatbots are the simplest type, as they operate on predefined rules and decision trees to provide fixed responses based on specific user inputs. In the Indian context, where access to extension officers is often limited, chatbots help bridge the information gap by providing timely, localized, and easy-to-understand guidance. They can answer questions on crops, soils, weather, pest and disease management, fertilizer use, government schemes, and market prices. By operating in local languages and being available 24/7, chatbots complement traditional extension systems and support small and marginal farmers who may have limited access to experts.

The advantages of using chatbots in agricultural extension include faster information delivery, reduced cost of extension services, scalability to reach millions of farmers, and personalization based on location and crop data. They also reduce dependency on physical visits and help farmers make quick decisions during critical stages of crop production. In India, several successful examples exist: Kisan e-Mitra (Rajasthan) provides information on government schemes; IFFCO KisanChatbot offers advisory on crops, weather, and markets; Microsoft's AI-powered chatbot in collaboration with ICAR and state governments supports sowing decisions; and BharatAgri and AgroStar use chatbot-based advisory to guide farmers on best practices. These successful examples show how chatbots are strengthening agricultural extension by making expert knowledge more accessible, efficient, and farmer-friendly.

Keywords: IoT, Chatbot



T-1 O-5: Perception of Dairy farmers towards Private Extension Services using Machine Learning

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Dairy farming is an important pillar of rural economy which contributes significantly to household food and nutritional security. In developing countries like India, it has become increasingly important to provide dairy farmers with quality extension services to sustain sectoral growth. While public and cooperative extension systems have traditionally played a major role in dairy development, the entry of private extension service providers has introduced new advisory channels offering specialized technical guidance and timely input delivery. In this context, the present research was conducted in Anand dist. of Gujarat among 300 dairy farmers to assess their perceptions toward private extension services. Alongside standard statistical methods, advanced Machine learning techniques were deployed to uncover both linear and non-linear relationships and to determine which factors have most strongly influenced farmer's perceptions. Also, each model's performance was evaluated using MAE, RMSE, RAE and RRSE along with accuracy and precision of model to identify the most reliable model for future related research.

T-1 O-6: Utilization Pattern of ICT Tools by Farm Youth in Coimbatore District of Tamil Nadu

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Information and Communication Technologies (ICTs) are increasingly recognized as essential tools for strengthening agricultural extension systems by enhancing information access, decision-making, and youth participation in agriculture. The present study examined the utilization pattern of ICT tools by farm youth in Coimbatore district of Tamil Nadu using an ex-post facto research design. A total of 120 farm youth were selected through proportionate random sampling from 12 villages across four blocks of the district, and data were collected using a structured interview schedule. The findings revealed that most respondents belonged to the 26–30 years age group, were diploma holders, owned small landholdings (2.5–5 acres), and had more than eight years of farming experience, with a medium level of ICT utilization. Correlation analysis showed that extension agency contact, innovativeness, achievement motivation, decision-making ability, and scientific orientation had a positive and significant association with ICT utilization at the one per cent level of probability, while age, education, and farming experience were significant at the five per cent level. Other variables exhibited non-significant relationships. The study emphasizes the need for targeted extension interventions and capacity-building programmes to enhance effective ICT utilization among farm youth.

Key words: ICT tools, utilization, farm youth, age, risk orientation



T-1 O-7: Temporal LULC Transformations and the Recognition of Rural Livelihood Loss in India

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Rural Land Use and Land Cover (LULC) change has emerged as both a driver and an outcome of rural livelihood transformation across developing regions, particularly in agrarian economies like India. Over the past five decades, rapid conversion of agricultural land, forests and common property resources into built-up, industrial and infrastructural uses has fundamentally altered rural production systems and ecosystem services. This review synthesizes literature and case studies spanning 1970–2025 to trace spatial and temporal patterns of LULC transitions and their socioeconomic consequences. It further explores how geospatial technologies such as Remote sensing, GIS-based modeling and high-resolution satellite imagery have allowed researchers, policymakers and local communities to visualize, quantify and validate the loss of livelihood assets at household and landscape scales. The analysis reveals that declining cultivable area, forest fragmentation, wetland shrinkage and groundwater depletion are closely linked to reduced agricultural income, food insecurity and forced livelihood diversification. Studies from Karnataka, West Bengal, and Tamil Nadu demonstrate that multi-temporal satellite data coupled with socio-economic surveys enable detection of livelihood displacement, identification of affected households and monitoring of adaptation responses such as migration and non farm employment. The integration of spatial datasets with livelihood vulnerability and resilience indices offers powerful insights into the social dimensions of land change.

Key-words: land use land cover change, rural livelihoods, livelihood loss assessment, digital technologies in agriculture



T-1 O-8: Application of Information and Communication Technology (ICT) tools in agriculture

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The application of Information and Communication Technology (ICT) tools in agriculture has emerged as a transformative approach to improving productivity, sustainability, and decision-making in the farming sector. ICT tools such as mobile phones, internet platforms, geographic information systems (GIS), remote sensing, precision agriculture technologies, and agricultural management software enable farmers to access timely and accurate information related to weather forecasts, soil health, crop management, pest and disease control, and market prices. These tools help reduce uncertainties in farming operations and support data-driven decisions, leading to efficient resource utilization and increased crop yields. ICT-based advisory services and mobile applications play a crucial role in bridging the information gap between agricultural research institutions and farmers, especially in rural and remote areas. Digital platforms facilitate knowledge sharing, farmer training, and real-time communication with experts, thereby enhancing farmers' technical skills and awareness of modern farming practices. Furthermore, ICT tools contribute to supply chain management by improving market linkages, reducing post-harvest losses, and ensuring better price realization for farmers. The integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics has further strengthened agricultural systems by enabling precision farming, automated monitoring, and predictive analysis. These innovations support climate-smart agriculture and promote sustainable farming practices. Despite challenges such as limited digital literacy, infrastructure constraints, and affordability issues, the application of ICT tools in agriculture holds immense potential to modernize the sector, improve farmers' livelihoods, and ensure food security. Continued investment, capacity building, and supportive policies are essential to maximize the benefits of ICT in agriculture.

Key Words: information and communication technology, ict tools, internet of things, farmers' livelihoods, capacity building



T-1 O-9: Harnessing Intelligent Digital Extension Tools for Next Generation Agriculture: A Review of Progress and Future Possibilities

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Intelligent digital technologies are rapidly transforming agricultural extension by enabling timely, localized, and data-driven advisory services for farmers. Recent advances in mobile-based advisory platforms, artificial intelligence (AI), machine learning (ML), remote sensing, and Internet of Things (IoT) have created new opportunities to overcome limitations of conventional extension such as poor reach, low agent-to-farmer ratio, and information asymmetry. This paper presents an original synthesis of literature and field-based observations on the adoption and effectiveness of intelligent technologies in digital extension, with a focus on smallholder farming systems in developing regions. It examines how decision support systems, AI-driven chatbots, mobile apps, and sensor-based advisory tools contribute to improved crop management, efficient resource use, and climate-resilient practices. The study systematically analyses documented cases where intelligent digital tools were integrated into extension programmes, highlighting changes in farmers' knowledge, adoption behaviour, and income. It also explores the role of vernacular language interfaces, interactive multimedia, and personalized advisories in increasing accessibility for marginal and less-literate farmers. Further, the paper identifies critical success factors such as user-centric design, reliability of recommendations, institutional support, and digital literacy. Key challenges including data quality, infrastructure gaps, affordability, and trust in digital advisories are discussed to provide a realistic picture of current progress. Based on the review, the paper proposes a framework for next generation digital extension that combines AI-powered analytics, real-time field data, and participatory feedback loops to deliver context-specific, scalable advisory services. The analysis suggests that intelligent technologies, when aligned with local needs and supported by robust extension institutions, hold substantial potential to accelerate agricultural productivity, sustainability, and livelihood security for the next generation of farmers.

Key Words: digital extension, artificial intelligence, machine learning, internet of things, sensor-based advisory tools



T-1 O-10: Farmers friendly Apps: Paving the Way as Game Changer for Transforming Traditional and Sustainable Agriculture into Commercial Agriculture

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Indian agriculture is witnessing vast changes in traditional and sustainable agriculture into a commercial activity. Agricultural extension is now focussing on low-cost technologies, high production technologies, value-addition through processing, quality, price competitiveness, marketing and use of information technology in agriculture. The pressure of changing role and additional responsibility on public extension will add to it while lot of existing problems like wide ratio between extension workers and farmers, inadequate infrastructure and finance. Hence, the existing gap is expected to enlarge. In this context, digital technologies are playing as a major tool for agricultural extension. During early 2000's, Government initiatives like KARS and mKisan laid the groundwork for digital agri-services. During 2010's, apps like *KisanSuvidha* and e-NAM emerged, offering weather updates, market prices and other information. Recently, Krishi-e, Plantix, and AgriCentral apps gained popularity, providing personalized advice and market access. In 2015, agriculture technology was boosted by Digital India Initiative. During 2020, PMFBY app was launched for crop insurance. These farmers- friendly apps have paved as a game changer for the farmers. With the help of these apps, farmers are getting timely advice on crop management, weather and pest control. Farmers are making better decisions by increasing real time market prices, weather forecasts and expert opinions. Farmers are saving cost with optimized fertilizer/pesticide use and getting higher income by selling their produce at better prices with market insights. These apps are very convenient due to quick access of information and services from anywhere anytime. These apps have empowered farmers by making informed decisions with data-driven insights and increasing efficiency by saving time and resources with targeted advice.

Keyword: mobile apps, commercial agriculture, m-agriculture



T-1 O-11: Application of Artificial Intelligence (AI) for Enhancing Sugarcane Productivity

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The Artificial Intelligence (AI) system collects data from satellite imagery, weather forecasts, soil sensors, and farm inputs to provide farmers with customised recommendations. Artificial intelligence software for Agriculture, the technology allows farmers to monitor real-time conditions on their farms with just a few clicks. By optimising irrigation schedules and detecting early signs of pests and diseases, AI helps farmers take preventive action rather than relying on excessive pesticide use. Artificial intelligence software is being developed by many countries to support decision-making by sugar mill operators. It will provide predictive decision support by working with current operators and sugar mill systems. This may help in improving sugar productivity and quality, reduction of production costs, increasing equipment utilization and improving the decision making process undertaken by factory staff within the sugar mill crystallization stage and fugal operational areas.

Computer vision technology may be applied in detection of insect pest, diseases and nutrient deficiency, varietal identification, field survey, crop maturity identification and application of harvest scheduling, field management, identifying areas where crops require water, fertilizer or pesticides. Remote sensing techniques along with hyper spectral imaging and 3-D laser scanning are essential to build crop metrics across thousands of acres. By producing precise 3-D maps for early soil analysis, drones can play a role in planning. Robots are capable of harvesting crops at a much faster pace and higher volume than human workers. With a huge space still untouched in agriculture for the intrusion of automatic response systems, there is a vast opportunity for the extension personal to leverage emerging technology of catboats for assisting farmers with the answers to all their queries and giving relevant advice and real-time recommendations to their specific farm related problems for enhancing sugarcane productivity.

Key words: artificial intelligence, soil sensors, remote sensing techniques, 3-D maps



T-1 O-12: Intelligent Digital Extension Ecosystems: Integrating Artificial Intelligence and Neuro-Responsive Interfaces for Sustainable Agriculture

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Globally, agricultural extension systems are undergoing rapid transformation due to advances in intelligent digital technologies. The integration of artificial intelligence-enabled advisory platforms, data-driven decision support tools, and interactive human-machine communication interfaces is reshaping agricultural knowledge generation, dissemination, and adoption. These digital innovations are increasingly recognised as key contributors to achieving the Sustainable Development Goals (SDGs), particularly in the areas of food security, climate resilience, and sustainable agricultural development. In India, where agriculture sustains a large and diverse population vulnerable to climatic uncertainty, intelligent digital extension systems present significant opportunities for inclusive and climate-smart growth. Recent developments in artificial intelligence, neuroscience-inspired computing, and adaptive digital interfaces are enabling a transition from conventional information-centric extension models to behaviour-responsive and user-focused systems. The integration of brain-computer interface concepts within smart digital extension frameworks offers new possibilities for understanding user attention, cognitive engagement, and decision-making processes, thereby supporting the design of responsive and farmer-oriented advisory platforms. Technologies such as electroencephalography and brain-computer interfaces provide insights into cognitive responses that can enhance message framing, learning effectiveness, and technology uptake through neuro-linguistic approaches. Intelligent digital extension applications span personalised advisory services and adaptive communication strategies tailored to diverse farming contexts. Collectively, these approaches demonstrate the potential to strengthen farmer participation, accelerate technology adoption, and enhance adaptive capacity under changing climatic conditions. The advancement of inclusive extension ecosystems is essential for promoting climate-smart agriculture and sustainable rural livelihoods.

Keywords: brain-computer interface, climate-smart agriculture, human-machine interaction, neuro-linguistic communication



T-1 O-13: Next-Generation Agriculture with a focus on soil fertility management in Moradabad District of Uttar Pradesh.

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The rapid evolution of intelligent technologies is transforming agricultural extension services worldwide, offering unprecedented opportunities for sustainable and precision farming. In the context of Moradabad District, where agriculture plays a central role in rural livelihoods, digital extension tools are becoming instrumental in enhancing soil fertility management and boosting crop productivity. This study explores the integration of advanced technologies—such as remote sensing, geographic information systems (GIS), Internet of Things (IOT) sensors, mobile advisory platforms, and machine learning models to support data-driven decision-making for soil nutrient assessment and targeted interventions. Intelligent soil sensors coupled with IOT networks enable real-time monitoring of key soil parameters (e.g., pH, moisture, organic carbon, nitrogen, phosphorus, and potassium), while GIS mapping facilitates spatial analysis of soil fertility variations across the district's diverse agro-ecological zones. Mobile-based digital extension platforms further empower farmers with localized fertilizer recommendations, alerts on nutrient deficiencies, and customized crop management advisories. Machine learning algorithms analyze historical and real-time soil data to predict future nutrient trends and recommend optimal soil amendment strategies, minimizing input costs and environmental impacts. The adoption of digital soil health cards and decision support systems enhances the precision of soil fertility evaluations and strengthens linkages between farmers, extension agents, and agronomic experts. Preliminary findings indicate that farmers using intelligent digital tools in Moradabad experience improved soil nutrient balance, reduced chemical overuse, and higher crop yields compared to traditional practices.

This paper underscores the potential of intelligent technologies to revolutionize soil fertility management within digital extension frameworks. Challenges such as digital literacy, infrastructure constraints, and data privacy are discussed, alongside policy recommendations to scale these innovations across Moradabad and similar agro-regions. The study concludes that integrating intelligent digital systems into agricultural extension not only enhances soil health monitoring and nutrient management but also fosters resilient, knowledge-driven farming systems for the next generation of Indian agriculture.

Keywords: Introduction, methodology, or soil fertility management.



T-1 O-14: Strengthening Extension Services through Internet of Things (IoT)

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Agriculture remains a pivotal sector of India's economy, yet predominantly traditional practices continue to constrain productivity and sustainability. The integration of the Internet of Things (IoT) in agriculture presents a paradigm shift toward data-driven, precision farming systems that improve resource utilization, reduce costs, and strengthen resilience to climate variability. IoT enables real-time monitoring of soil moisture, weather parameters, crop health, and water management through sensor networks, wireless communication, and cloud-based analytics. In India, an estimated 180,000 farms deployed IoT devices in 2024 for soil and crop monitoring, and precision agriculture adoption is rising rapidly with water optimization and climate monitoring as major use cases. IoT-based systems are being coupled with AI for advanced forecasting, and hybrid connectivity models like LPWAN and 5G are enhancing coverage and efficiency in remote rural areas. Globally, the agriculture IoT market is projected to reach USD 60.12 billion by 2032, driven by precision farming solutions, on-premise deployments, and cellular connectivity. Despite significant opportunities, barriers such as high implementation costs, limited digital literacy, and infrastructure challenges persist. Strengthening policy support, farmer training, and affordable technology solutions will accelerate IoT adoption, driving productivity and sustainability in Indian agriculture.

Keywords: Internet of Things (IoT) in Agriculture, Precision Agriculture, Smart Farming Systems, Data-driven Decision Support



T-1 O-15: Digital Agriculture: Opportunities, Challenges and Strategies

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The agriculture sector is experiencing a paradigm shift, driven by the integration of advanced digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), drones, and big data analytics to boost productivity, reduce input costs, and streamline farm-to-market linkages. India's digital revolution has significantly transformed governance and service delivery in recent years by creating digital identities, secured payments and transactions. This progress has paved the way for a thriving digital ecosystem across various sectors, including finance, healthcare, education, and retail, positioning India as a leader in citizen-centric digital solutions. For transformation of the Agriculture Sector, the Union Cabinet Committee, chaired by Prime Minister Narendra Modi approved the 'Digital Agriculture Mission' with a substantial financial outlay of Rs. 2,817 Crore for the benefit of farming community. The digital tools are exposing new opportunities in agriculture for enhanced productivity, climate resilience, resource optimization & cost savings, efficient input procurement, personalized recommendations, precision farming, and data-driven decision making allowing agriculture to address critical challenges like climate change, food security, and sustainable resource management. The digital tools help empowering smallholder farmers and to bridge the gap between small-scale farmers and technology, enhancing their productivity and livelihoods security. In the new era of digital agriculture, great opportunities to the farmers adapt to climate change, focus on optimizing water and nutrient use for sustainable farming. However, some challenges in the development, promotion and adoption of digital technology in the agricultural sector includes: limited digital literacy among smallholder farmers, poor internet connectivity in rural areas, high cost digital tools and technology, fragmented land holdings, lack of infrastructure, limited access to financial support, data privacy, diverse agro-climatic conditions and resistance to change. Hence, there is an urgent need to develop strategies for making digital tools accessible to smallholder farmers and addressing challenges such as digital literacy, language barriers, high cost of digital tools, infrastructure limitations and data privacy to promote digital agriculture making agriculture smarter, sustainable, and more rewarding for millions of farmers across the country.



T-1 O-16: Prospects and Challenges of Agri- Startups in Andhra Pradesh

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Agri-startups hold immense potential to transform agriculture into a more sustainable, efficient and profitable sector. Agritech-startups have a lot of potential to help rural Indians to improve their livelihoods. Any policies and programmes aimed to promote the development of agri-startups should be based on the current level of performance of the agri-startups. In this context the need for an instrument to measure the opportunities available for agri-startups and factors contributing for their success, which might serve as the foundation for the various entrepreneurship development activities. This study was conducted to know the prospects and challenges of agri-startups in Chittoor and Nellore districts of Andhra Pradesh. Random sampling procedure was used to select the agri-startups. From each district eight startups were selected thus making a total of sixteen for this study. Index developed by Akshitha(2022) was used for the study to measure prospects and challenges. Major prospects were availability of raw material, self-employment opportunities, government support programmes/schemes, modernisation of farming and increased demand for quality food. The major challenges faced by the agri-startups were weak supply chain management, less access to timely information, inability of organisations to identify training needs of agripreneurs, delayed loan sanctioning procedure, changing customer preferences and fear of failure because of more risk and uncertainties. Majority of agri-startups were found to have medium level of prospects. To overcome the challenges and to increase the prospects government should ease the policies and procedures and more funds should be allocated towards entrepreneurship.

Key words: Agri-startups, agripreneurs, prospects and challenges.



T-1 O-17: Integrating Digital Twin into Agricultural Extension: For future extension services

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In the era of modern agriculture, extension systems and their advisory services face substantial bottlenecks, such as high farmer-to-extension worker ratios and lack of unification of ICT solutions on single platform. This review paper explores the integration of Digital Twin (DT) technology for real-time virtual representation of physical assets as a transformative solution for agricultural extension. Unlike traditional static models, a DT creates a continuous synchronization between the physical farm and its digital counterpart, enabling predictive analysis and individualized farm management. The framework of DT comprises an architecture comprising physical entities, virtual models and a data-driven service layer. By leveraging IoT sensors, remote sensing and 5G connectivity, the DT captures high-resolution data on soil health, crop growth and livestock behavior. This data is processed through artificial intelligence and machine learning to perform "what-if" simulations, allowing farmers and extension personnel to test management interventions in a virtual environment before physical implementation. This proactive approach mitigates risks associated with nutrient management, irrigation scheduling, pest outbreaks etc. From an extension perspective, DTs address the "data abundance but actionable guidance scarcity" dilemma. Several studies revealed that technology empowers extension workers with remote monitoring capabilities and evidence-based decision support systems, facilitating the transition from generic regional advisories to farm-specific, precision-guided interventions. From the available reviews it can be concluded that while challenges in interoperability and digital literacy persist, the integration of DTs represents a paradigm shift toward a more resilient, transparent and resource-efficient agricultural extension ecosystem.

Keywords: Digital Twin, Agricultural Extension, Internet of Things (IoT), Predictive Simulation, Decision Support Systems.



T-1 O-18: Intelligent Technologies in Digital Extension for Next Generation Agriculture: Progress, Possibilities and Pathways towards Sustainability and Atmanirbhar Bharat

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The rapid integration of intelligent technologies into agricultural extension systems is redefining the scope, reach and effectiveness of knowledge dissemination in next generation agriculture. Digital extension, supported by artificial intelligence (AI), machine learning, Internet of Things (IoT), big data analytics, remote sensing and decision support systems, has emerged as a powerful mechanism to address the complex challenges of climate variability, resource degradation, market uncertainties and labour shortages. Significant progress has been made in deploying mobile-based advisory services, AI-powered chatbots, satellite-based crop monitoring, precision nutrient and water management tools, and weather-based agro-advisories, enabling real-time, location-specific and need-based recommendations to farmers. Despite notable progress, challenges such as digital divide, limited digital literacy, infrastructure gaps and data governance issues persist. The paper examines progress, opportunities and future pathways of intelligent digital extension in strengthening sustainable food systems and advancing the vision of Atmanirbhar Bharat.

Keywords: Digital Extension, Intelligent Technologies, Next Generation Agriculture, Sustainable Food Systems, Atmanirbhar Bharat





Theme I : Poster
Intelligent technologies in Digital
extension for Next generation
Agriculture – progress and possibilities





T-1 P-1: From Awareness to Impact: Exploring the Role of ICT in Enhancing Agricultural Decision-Making

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The use of Information and Communication Technology (ICT) among people in India is increasing rapidly, so it is essential to assess how it is transforming the agricultural sector. This study explores the role of Information and Communication Technologies (ICT) in improving agricultural decision-making. For the present study, a descriptive research design was adopted. A total of 120 farmers from the Solan district of Himachal Pradesh were interviewed using a structured interview schedule. A multistage random sampling technique was used, under which six farmers were randomly selected from each gram panchayat during 2024-2025. The results of the study revealed that most farmers had awareness of common ICT tools like radio, television, mobile phones, and WhatsApp. However, awareness of specialized agricultural ICT tools, including mobile applications, expert systems, and information kiosks, was very limited. Half of the farmers had medium ICT knowledge. ICTs were primarily used for accessing weather information, pest and disease management, and market updates. However, their use in technically advanced areas such as soil testing remained minimal. Findings demonstrate a high level of adoption of general ICT tools among farmers, indicating their growing relevance in agricultural information exchange. However, the limited utilization of specialized ICT tools restricts advanced decision-making support. Insufficient engagement with technically complex tools leads to existing capacity and knowledge gaps. To enhance the adoption of advanced ICT tools in agriculture, strengthened digital literacy and targeted strategic interventions are essential.

Keywords: Information and communication technology, Effectiveness, knowledge, ICT Tools



T-1 P-2: Intelligent Digital Technologies in Livestock Health Management: Opportunities and Challenges for Veterinary Extension

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Intelligent digital technologies are emerging as important tools for strengthening livestock health management through veterinary extension systems. In India, livestock production is predominantly carried out by smallholder and marginal farmers, where timely access to veterinary services and reliable animal health information remains a major constraint. The integration of intelligent digital tools into veterinary extension offers scope to address limitations related to inadequate manpower, delayed disease detection and weak outreach of scientific advisories at the field level. Digital interventions including mobile-based advisory services, tele-veterinary platforms, artificial intelligence-assisted disease forecasting models, sensor-enabled animal health monitoring and GIS-based disease surveillance systems have shown potential to improve the efficiency and effectiveness of extension delivery. These technologies facilitate real-time disease reporting, early warning of health risks, and dissemination of location-specific advisories for preventive and curative animal health management. Improved access to digital veterinary services supports informed decision-making by livestock farmers, enhances adoption of scientific health practices, reduces disease-related losses and contributes to improved productivity and sustainability of livestock enterprises. However, the adoption and effective utilization of intelligent digital technologies in veterinary extension are constrained by several factors. These include limited digital literacy among livestock farmers, inadequate internet connectivity in rural areas, unequal access to digital devices, gender-related disparities, data privacy and security concerns, and insufficient capacity building of extension functionaries. Furthermore, the effectiveness of digital extension interventions depends on their integration with existing extension mechanisms and their adaptability to local socio-economic and agro-climatic conditions. A farmer-centric, inclusive, and capacity-building approach is essential to ensure that intelligent digital technologies complement conventional veterinary extension methods and contribute to sustainable livestock health management in line with the objectives of Atmanirbhar Bharat.

Keywords: Intelligent digital technologies, livestock health management, veterinary extension, digital advisory services, sustainability, Atmanirbhar Bharat



T-1 P-3: Transforming Agricultural Extension through Intelligent Digital Technologies: Evidence from Indian Case Studies.

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Intelligent digital technologies are reshaping agricultural extension in India by enabling timely, localized and data-driven services that complement traditional face-to-face advisory systems. Published Indian case compilations on “digital agriculture in action” document how tools such as mobile-based agro-advisory platforms, satellite and sensor-driven crop monitoring, AI-enabled decision support, and digital value-chain solutions have begun to bridge longstanding information and market gaps for smallholders. These initiatives span e-extension services delivering weather-based and crop-specific advisories, remote sensing-supported crop health assessment, and start-up led digital platforms linking farmers with input, finance and output markets. This review-based paper synthesizes Indian experiences with intelligent technologies in digital extension, focusing on documented cases from government programmes, research institutions and private agritech ventures. Evidence from these case studies shows that mobile and app-based advisories, interactive voice response systems and AI-assisted tools have improved farmers’ access to timely recommendations on sowing windows, nutrient and water management, and pest–disease control, often leading to better risk management and input use efficiency. At the same time, case studies highlight that sustained impact depends on localized content, vernacular interfaces, trust-building through field institutions and mechanisms for continuous farmer feedback. The review also identifies critical challenges visible across Indian cases: uneven digital infrastructure, gaps in digital literacy, limited interoperability between platforms, and concerns around data governance and long-term financial sustainability of digital services. Emerging national initiatives on AI in agriculture, AgriStack/IDEA, and playbooks for scaling AI-based solutions indicate strong policy interest in mainstreaming intelligent digital extension, while emphasizing the need for robust ecosystems and partnerships. Overall, the Indian case evidence suggests that intelligent technologies, when farmer-centric and institutionally embedded, offer substantial possibilities for next generation agriculture by strengthening last-mile extension, enhancing resilience and improving livelihoods of smallholders.

Key Words: Agricultural Extension, e-extension, Intelligent Digital Technologies, AI-enabled decision support, digital value-chain solutions



T-1 P-4: Digital platforms for Agricultural Extension

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Digital platforms for agricultural extension play a pivotal role in transforming the agricultural landscape by bridging information gaps, enhancing productivity and improving livelihoods. This chapter explores the various digital platforms available in agricultural extension, classification of digital platforms with its descriptions, types of digital platforms, Benefits of digitalization in agricultural extension, challenges for digital platforms for agricultural information, information about different websites, web portals, Mobile applications use for getting agricultural information by farmers, Strengths, Weakness, Opportunities and Challenges for digital platforms and successful cases of digital platforms used for agricultural extension. These platforms offer personalized advisory services, timely information on weather forecasts and market prices and access to training and resources, empowering farmers to make informed decisions and adopt best practices. Through mobile applications, web portals, SMS, IVR, social media and IoT technologies, digital platforms ensure the inclusivity and scalability of agricultural extension services, reaching farmers in remote and marginalized areas. While challenges such as digital literacy and internet connectivity persist, the benefits of digitalization in agriculture are undeniable, driving sustainability, resilience, and socio-economic development in rural communities worldwide.

Keywords: Digital platforms, Agricultural extension, Digitalization, Social media, m-Krishi, Agricultural QR codes



T-1 P-5: Learnings from Traditional and Digital Extension Advisory Services

POLASA BHUVANASRI

There remains hardly any dimension in agriculture that is untouched by Digital technology. Marking a significant rise in the evolution of farming practices, aligning with global goals for sustainable development and inclusive growth. This study explores the transformative potential of traditional and digital technologies in agriculture, drawing insights from Extension Advisory Services (EAS) and field-based learnings across India, particularly in Haryana through a Focus Group Discussion conducted at Saina Nehwal Institute of Agriculture Technology, Training and Education (SNIATTE) with a group of 58 farmers from different districts of Haryana revealed both the benefits and limitations of digital agriculture. With the increasing challenges in reaching small and marginal farmers, digital tools have emerged as pivotal in ensuring accessibility, efficiency, and transparency in extension services. Study traces the paradigm shift from traditional labor-intensive farming to mechanization, precision agriculture, and now Agriculture 4.0 characterized by data-driven practices, Artificial Intelligence for real-time advisory services. Government-led initiatives such as AgriStack, e-Kharid, and the Digital Agriculture Mission efforts to create a farmer-centric digital ecosystem. Additionally, organizations like ICAR, MANAGE, and CCS HAU various ICT and non-ICT interventions including mobile apps, digital kiosks, e-Mausam platforms, and personalized advisory services revealed the extensive outreach digital-technology to farming community. Digital Green's AI chatbot and Kisan Samridhhi Market Portal highlight scalable and inclusive models of digital extension.

KEYWORDS: Digital agriculture, Digital Literacy, Artificial Intelligence, Machine Learning



T-1 P-6: Empowering Next-Generation Indian Agriculture through Intelligent Digital Technologies: Pathways, Progress, and Possibilities for Sustainable Transformation

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Agriculture in India is rapidly transitioning toward a digitally intelligent ecosystem driven by data, connectivity, and innovation. The integration of Artificial Intelligence (AI), the Internet of Things (IoT), machine learning, and digital extension systems is revolutionizing how farmers receive, interpret, and utilize agricultural information. Intelligent digital technologies are improving precision agriculture, enhancing climate resilience, and fostering sustainable food systems — aligning with India's vision of *Atmanirbhar Bharat* (self-reliant nation). Indian agricultural institutions such as the **Indian Council of Agricultural Research (ICAR)**, **ICRISAT**, and **NAARM**, alongside agri-tech start-ups, are at the forefront of this transformation. Initiatives like **Digital Green**, **iSAT (ICRISAT Smart Agro-Tech)**, and **KisanSarathi** demonstrate the effective use of AI-based decision support systems and digital advisory tools to reach millions of smallholder farmers. These platforms integrate real-time data on weather, soil health, and market prices to deliver localized agro-advisories, improving on-farm decision-making and reducing input waste (Kumar et al., 2024; Wani et al., 2019).

A review of recent developments (Beerge et al., 2025; Singh & Kour, 2025) highlights that IoT-enabled soil sensors, mobile learning applications, and satellite-driven monitoring systems have improved yield efficiency by 20–30% while enhancing sustainability. Moreover, blockchain-based traceability systems and machine learning models for predictive analytics are transforming supply chains and food safety management. Despite these advancements, barriers persist in digital literacy, rural connectivity, and data governance, particularly among women and smallholder farmers. For India to fully realize the potential of intelligent agriculture, it must focus on **inclusive digitization**, policy-driven data integration, and capacity-building programs at the grassroots level. Integrating indigenous knowledge systems with AI models can ensure culturally adaptive and region-specific solutions. Ultimately, intelligent technologies will not only modernize Indian agriculture but also create an ecosystem of empowered, informed, and resilient farmers contributing to sustainable national development.

Keywords: Digital Agriculture, Artificial Intelligence, Precision Farming, Internet of Things (IoT), Digital Extension, Sustainable Food Systems, Atmanirbhar Bharat, Climate-Smart Agriculture, Smart Advisory Systems, AgriTech Innovation.



T-1 P-7: Cybercrime in Society 5.0

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Society 5.0 represents a visionary transition toward a human-centric civilization that balances economic advancement with the resolution of social problems by highly integrating cyberspace and physical space. However, this deep convergence of the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) introduces unprecedented vulnerabilities that expand the horizon of cybercrime. This paper explores the evolving landscape of digital threats within this "Super Smart Society," where the distinction between virtual and physical harm increasingly blurs. As critical infrastructure, healthcare systems, and autonomous transportation become fully digitized, the impact of cyberattacks shifts from data theft to direct threats against physical safety and societal stability. The study examines how traditional criminal activities are being augmented by sophisticated AI-driven social engineering, deepfakes, and automated ransomware, complicating the task of attribution and enforcement. Furthermore, it addresses the paradox of Society 5.0: while technology is used to enhance human well-being, the same tools provide cyber-adversaries with advanced means to exploit systemic interconnectedness. By analyzing current legal frameworks and technological safeguards, the paper argues for a paradigm shift in cybersecurity—moving from reactive defense to proactive, resilient ecosystems. It concludes that safeguarding Society 5.0 requires a multi-stakeholder approach involving international policy alignment, ethical AI governance, and a fundamental redesign of digital trust. Only through such integrated security measures can the promise of a seamless, technology-enhanced society be realized without succumbing to the escalating sophistication of modern cyber-criminality.

Keywords: Society 5.0, Cybercrime, Artificial Intelligence, IoT Security, Digital Transformation, Cyber-Physical Systems, Data Privacy, Cybersecurity Governance.



T-1 P-8: Digital extension for Next generation Agriculture

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The rapid advancement of digital technologies is redefining agricultural extension systems, giving rise to a new paradigm known as digital extension, which integrates intelligent technologies to support next-generation agriculture. Traditional extension approaches often face limitations in reaching large and diverse farming communities, delivering timely information, and responding effectively to emerging challenges such as climate change, labour shortages, and resource constraints. In this context, intelligent technologies such as Artificial Intelligence (AI), Internet of Things (IoT), drones, robotics, expert systems, and data analytics are transforming extension services into more responsive, precise, and farmer-centric systems.

This digitalization explores the role of intelligent technologies in strengthening digital extension mechanisms to enhance agricultural productivity, sustainability, and resilience. AI-enabled advisory systems provide real-time, location-specific recommendations on crop management, pest and disease control, soil health, and weather forecasting. IoT-based sensor networks and remote sensing technologies support continuous farm monitoring, enabling extension personnel and farmers to make evidence-based decisions. The integration of drones and robotics in digital extension further improves outreach by enabling rapid field diagnostics, precision input application, and automated farm operations. Showcasing greenhouse farming, smart irrigation, and AI-assisted crop management demonstrate that intelligent digital extension systems significantly reduce labour dependency, optimize input use, and improve farm profitability. These technologies also enhance two-way communication between farmers and extension agencies, fostering participatory learning and faster technology dissemination.

However, the transition toward intelligent digital extension faces challenges such as limited digital literacy among farmers, high initial investment costs, inadequate rural connectivity, and concerns regarding employment displacement. Addressing these issues requires supportive policies, capacity-building initiatives, and strong public-private partnerships.

Keywords: Digital Extension, Intelligent Technologies, Artificial Intelligence in Agriculture, Internet of Things (IoT), Precision Agriculture, Smart Farming, Sustainable Agriculture.



T-1 P-9: Intelligent technologies and sustainable food system Robotics in Agriculture

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The combined effects of rapid population growth, rising living standards so does the demand for agricultural goods, declining cultivable land, increasing climate variability and shortages of skilled agricultural labour necessitate a fundamental transformation in agricultural practices. To address these issues, agriculture sector requires transformative solutions, with adoption of precision agriculture emerging as a key approach through the integration of advanced technologies such as robotics and automation in agricultural system. Robotics in agriculture has emerged as a promising solution to address labour shortages, enhance precision farming and reduce drudgery in farm operations. Emphasis is given for utilizing autonomous agricultural robots in seeding, nutrient management, weed control, pesticide spraying, harvesting and milking operations. Robotic interventions significantly improve operational efficiency and precision in agricultural systems by improving seeding accuracy, optimizing water and chemical use and enhanced weed management efficiency while reducing labour dependency, production costs and environmental impact, thereby resulting in higher crop yields and labour productivity. Technologies such as agricultural drones, autonomous field robots and automated milking systems have demonstrated higher productivity, uniform input application and better crop and animal performance compared to conventional methods. Despite their advantages, challenges such as high initial investment, technical complexity, data ownership, adaptability to diverse farming systems and limited accessibility for smallholder farmers remain critical concerns, especially in developing countries. Nevertheless, with continuous advancements in artificial intelligence, sensors and machine vision, agricultural robotics holds immense potential to transform traditional farming into a more efficient, precise and sustainable system. The adoption of robotics is expected to play a crucial role in achieving future food security, environmental sustainability and the vision of Agriculture 5.0.

Keywords: Autonomous robots, Precision agriculture, Robotics in agriculture, Sustainability, Agriculture 5.0.



T-1 P-10: Challenges and Emerging Innovations in Digital Extension Services for Sustainable Agriculture in India

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In the current context of Indian agriculture, the effective dissemination of information and technology has emerged as a critical component of extension and advisory services. Digital extension and education have emerged as transformative approaches for knowledge dissemination, capacity building, and lifelong learning across diverse sectors, particularly in Agriculture and Rural community development. This paper discusses about the challenges in digital extension services faced by farmers. The major constraints faced by farmers in digital extension services are Limited digital literacy, Lack of real-time interaction and Poor engagement in digital services. Additionally Poor internet connectivity, Low trust in digital advisory services, Language barriers, Lack of context specific information, High cost of devices and data are also prevailing as barriers for using digital extension services by farming community. The study further highlights that Government and Extension agencies should implement emerging approaches, including the application of gamification in digital extension and educational initiatives, as well as the integration of advanced technologies such as Virtual Reality and Augmented Reality in agriculture. These innovations are presented as effective tools for strengthening digital extension and education systems, thereby supporting the country's efforts to achieve sustainable agriculture.

Key words: Digital extension and education, digital illiteracy, digital engagement, gamification, virtual reality, augmented reality.



Theme II : Oral

Digital extension and education to empower farmers for Atmanirbhar Bharat-challenges and opportunities





T-2 O-1: Rythu Nestham Live Video Conference – A trailblazing Digital Expert System to reach the unreachable

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We are in the twenty first century, which is the century of miracles. With the rapid progress in the Social media, information flow has increased enormously, however effective communication with more reliable information to the farmers in real time is a great concern. Many ICT based projects have been initiated in the country to reduce the gap between Scientists, Farmers and Extension Officers at field level but a comprehensive model to address the problem is a dream reality. In this context, to accelerate the reach of agricultural technologies to the farmer's door steps, Professor Jayashankar Telangana Agricultural University and Dept. of Agriculture, Telangana State jointly started a novel ICT based initiative "**Rythu Nestham live video conference**" during 2024 connecting Rythu vedikas [Farmers training centre] across Telangana State involving experts (Agri/Horti/Veterinary), line department officials and farmers to provide relevant and real time solutions to field problems and build confidence of farmers in expert system on a project mode. The main objectives of novel initiative are to serve as a **Digital Expert System** for Scientists-Extension Functionaries -Farmers live interaction at RythuVedikas and Field level there by resolving problems in real time and to build the capacities of Extension Functionaries in utilizing Digital Platform to reach the unreachable. The electronic wing of the PJTAU serves as the nodal agency for the programme and take up the responsibilities of identification of relevant, need based topics, subject experts and acts as the technical backstopping for the entire programme. The electronic wing connects all the rythu vedikas located at clusters of villages where the farmers will sit together and participates in the live programme on webex platform. So far, the platform has served to connect the about 18.00 lakh farmers and Dept. officials at 1597 Rythu Vedikas across Telangana with 77 episodes of Live interactions, where need based advisories were given by Scientists of Agri / Horti / Veterinary along with officers from Marketing, Bankers on Agriculture, Horticulture, Animal husbandry topics based on prevailing weather conditions. The model can serve to be a necessity as an alternative to the existing extension models by bridging the gap between the farmer and the extension personnel/Researcher with real time and precise agro based advisory.

Keywords: Information flow, Digital Expert system, Video conference, Real time, Rythu vedikas, Rythu Nestham.



T-2 O-2: Digital Extension and Education for Agricultural Innovation and Farmer Empowerment in India: Challenges and Opportunities

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Digital extension and education represent a significant paradigm shift in the way agricultural innovation is developed and disseminated in India. The country now hosts over 885 million active internet users, including ~400 million rural users, creating vast opportunities for technology-enabled advisory dissemination. Government-led platforms such as mKisan, which reaches 8.9 crore farm families through mobile advisories, and Kisan Call Centres operating in more than 20 languages, demonstrate the scalability of digital public extension. National Agriculture Market, integrating 1,389 mandis and connecting 1.77 crore farmers, has adequately strengthened the market transparency and inter-state trade efficiency. Evidence from field-based ICT models, including Digital Green's community video approach, highlights significantly higher adoption of recommended practices compared to conventional extension system.

India faces persistent challenges including unequal digital access, variable smartphone ownership, low digital literacy, gender gaps, and limited localization of advisory content. Institutional constraints such as fragmentation of digital platforms, inconsistent advisory quality, and inadequate capacity of frontline extension personnel also restrict impact. Conversely, emerging opportunities—integration of AI-enabled decision-support, remote sensing-based crop monitoring, hyper-local weather advisories, and the rapid growth of agri-tech startups—have the potential to reshape India's extension landscape.

The current paper focuses on current digital extension initiatives, analyses structural and socio-economic barriers, and proposes an integrated hybrid-extension model combining ICT tools with human facilitation through KVKs, FPOs, and grassroots institutions. It is recommended that digital extension, if supported by robust digital infrastructure, inclusive design, strong monitoring frameworks, and farmer-centric pedagogies, has immense potential to accelerate agricultural innovation and empowerment of farmers.

Keywords: Digital Extension, AI Advisory Systems, Farmer Empowerment, Agri- Digital Literacy, Agricultural Innovation.



T-2 O-3: Impact of Digital Farm School on empowerment of dryland farmers of SLS & SBS regions of Andhra Pradesh

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Krishi Vigyan Kendra, Kandukur has been engaging in frontline extension under the administrative control of ICAR-NIRCA, Rajahmundry for the last 12 years. It has jurisdiction of 28 southern mandals of Prakasam district of Andhra Pradesh covering Southern Light Soils (SLS) & Southern Black Soils (SBS) regions. More than 70% of the cultivable area is under dryland farming in this region where there are more uncertainties of whether conditions, rainfall, temperature, available moisture, occurrence of pests and diseases. Under these circumstances timely availability of need-based location specific information to farmers is need of the hour to acclimatize or ameliorate the uncertainties intime to reap good returns. By keeping this in view and limited available resources KVK has started new concept called Digital Farm School comprises of different innovative ICT tools viz Mobile apps (crop suraksha & FCV tobacco), Chatbot on chemical compatibility, Multilocation tele and video conferences, YouTube live programmes, Knowledge on wheels, Phone in live programmes, Short video bytes, WhatsApp groups, QR codes for all demo units of KVK, e-posters, zoom conferences and need based short message services through Kisan Sarathi portal. As a result of making use of these tools there has been improvement of knowledge levels of farmer users from 45.6% to 83.4% on Good Agricultural practices, IPM, INM, IDM, latest varieties and enhancement of diagnostic skills from medium (32.8%) to high (69.8%). Further due to use of these ICT tools there was enhancement of adoption of latest technologies from 54.2% to 76.3% in crops like tobacco, chilli, blackgram, paddy, groundnut, chickpea, redgram and also drastic reduction of communication gap from 42.3% to 8.4% which shows farmers were clearly understood the content and concept that were made available through different ICT tools developed by KVK. In addition to this due to use of these ICT tools and adoption of recommended practices there has been reduction in cost of production Rs.14350/ha in chilli, Rs.11430/ha in tobacco, Rs.9480/ha in paddy, Rs.9780/ha in groundnut, Rs.8350/ha in redgram, Rs.6750/ha in chickpea, Rs.8940/ha in cotton. Due to adoption of these ICT tools average productivity of different crops were enhanced up to 8.2% and net income of farmers was enhanced by 11.2%. As per the analysis of effect on perceived attributes of farmers on these innovative tools it was found that 65.8% expressed that they were relatively advantages, 74.3% expressed that they were compatible, 83.4% expressed that they were trailable easily and 67.9% expressed that they were satisfied with these innovative tools offered by ICAR-NIRCA-Krishi Vigyan Kendra, Kandukur.



T-2 O-4: Sugarcane Farmers in Kushinagar, Uttar Pradesh: Assessment of ICT Tool Utilization and Advantages

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Information and communication technology (ICT) is rapidly reshaping modern agriculture by improving efficiency, decision-making, and productivity. This study explores the extent of ICT adoption among sugarcane farmers in Deoria (District) Sugarcane Committee's Jaura Bazar Center "A," of Kushinagar, Uttar Pradesh, and identifies the benefits and strategies needed to strengthen digital agriculture in the sugarcane sector. A random sampling method is used to select the villages and respondents. Data has been collected through a pre-structured interview schedule from 230 respondents during 2024. The Garrett's ranking method is used to evaluate the ranks given by the respondents. The findings reveal uneven adoption of ICT across farm operations, with websites and mobile applications emerging as the most widely used tools. Farmers identified timely access to critical information—such as weather forecasts, fertilizer recommendations, and sugarcane slip availability—as the most valuable benefit. The study highlights the transformative potential of ICT in sugarcane farming and emphasizes the need for greater awareness, targeted training, and effective integration of digital tools with traditional practices to accelerate adoption and enhance farm performance.

keywords: ICT, Sugarcane Agriculture, Adoption, Benefits, Uttar Pradesh, Garrett's ranking,



T-2 O-5: Capacity Building and Skill Development among Rural Youth: A Study from Central Gujarat

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Capacity building and skill development have become central components in strengthening employability, entrepreneurship and socio-economic empowerment among rural youth. This study assesses the effectiveness, utilization patterns and influencing factors of capacity building programmes in Central Gujarat. A sample of 120 rural youths was selected using simple random sampling. Data were collected through a structured questionnaire and analysed using descriptive statistics, correlation and multiple regression.

Results reveal that 58.33% of respondents exhibited a medium level of skill development, followed by 22.50% with a high level and 19.17% with a low level. Training participation, education, and access to extension services emerged as strong determinants of skill enhancement. Correlation analysis showed significant positive relationships between skill development and educational qualification ($r = 0.331^{**}$), training exposure ($r = 0.412^{**}$) and ICT literacy ($r = 0.287^{*}$). Regression analysis further confirmed that training exposure, motivation level and institutional support were significant predictors ($R^2 = 0.547$).

The study concludes that structured training, practical learning and exposure to ICT tools significantly enhance rural youths' capacity building. Strengthening institutional linkages, developing need-based training modules and improving extension support mechanisms are essential for sustainable rural development.

Keywords: Capacity building, skill development, rural youth, training, regression analysis.



T-2 O-6: Perception of farmers towards CABES an ICT based farm advisory services

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Although India possesses the largest irrigated area and ranks second in arable land, crop productivity remains only 20–40 per cent of the world's highest yield levels. A major contributor to this yield gap is the inadequate extension worker–farmer ratio, which restricts farmers' access to timely and reliable technical information. To address this challenge, the Comprehensive Agribusiness Extension System (CABES) was implemented during 2014–15 as a project-based, ICT-enabled advisory service in both rainfed and irrigated ecosystems. CABES follows a holistic agribusiness approach encompassing crop planning, input procurement, crop production, value addition, and marketing. The present study assessed farmers' perceptions of CABES across 11 dimensions in Navalgund Taluk. All registered CABES farmers constituted the population, from which a random sample received advisory services through Raitha Mitras using tablet-based ICT tools incorporating photographs, videos, animations, graphs, and charts. Each farmer was supported through a unique digital profile. A standardised scale was developed to measure farmers' perception and acceptance of IT-enabled farm advisory services. The findings revealed that 43.25 per cent of the farmers exhibited a medium level of perception and acceptance. Among the dimensions studied, six recorded field applicability indices exceeding 70 per cent, namely field applicability (83.35%), accuracy (78.45%), comprehensiveness of content (75.13%), audio-visual presentation (72.43%), pest and disease management solutions (71.01%), and agricultural input selection (70.58%). The results demonstrate the effectiveness of CABES in delivering integrated, user-friendly extension services through ICT-enabled platforms.

Keywords: Comprehensive Agribusiness Extension System, ICT-enabled advisory services, farmer perception, farm extension, agribusiness approach, crop productivity



T-2 O-7: From Awareness to Impact: Exploring the Role of ICT in Enhancing Agricultural Decision-Making

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The use of Information and Communication Technology (ICT) among people in India is increasing rapidly, so it is essential to assess how it is transforming the agricultural sector. This study explores the role of Information and Communication Technologies (ICT) in improving agricultural decision-making. For the present study, a descriptive research design was adopted. A total of 120 farmers from the Solan district of Himachal Pradesh were interviewed using a structured interview schedule. A multistage random sampling technique was used, under which six farmers were randomly selected from each gram panchayat during 2024-2025. The results of the study revealed that most farmers had awareness of common ICT tools like radio, television, mobile phones, and WhatsApp. However, awareness of specialized agricultural ICT tools, including mobile applications, expert systems, and information kiosks, was very limited. Half of the farmers had medium ICT knowledge. ICTs were primarily used for accessing weather information, pest and disease management, and market updates. However, their use in technically advanced areas such as soil testing remained minimal. Findings demonstrate a high level of adoption of general ICT tools among farmers, indicating their growing relevance in agricultural information exchange. However, the limited utilization of specialized ICT tools restricts advanced decision-making support. Insufficient engagement with technically complex tools leads to existing capacity and knowledge gaps. To enhance the adoption of advanced ICT tools in agriculture, strengthened digital literacy and targeted strategic interventions are essential.

Keywords: Information and communication technology, Effectiveness, knowledge, ICT Tools



T-2 O-8: Beyond Access: Examining the Multidimensional Digital Divide in Indian Agriculture

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The increasing digitalization of agriculture has created new pathways for improving information dissemination, advisory services and farm-level decision-making. Despite these advances, unequal access to and effective use of digital technologies have resulted in a persistent digital divide, particularly among smallholder farmers in developing economies. This study assesses the extent and dimensions of the digital divide among groundnut growers in Banaskantha district of Gujarat, India, focusing on disparities in digital access, skills and usage patterns. The study adopted an *ex-post facto* research design. Primary data were collected from 150 groundnut growers using a structured and pre-tested interview schedule, with respondents selected through a multistage sampling procedure. To capture the multidimensional nature of digital inequality, a digitization index was constructed comprising five dimensions: ICT ownership, ICT accessibility, digital literacy, frequency of ICT use and self-satisfaction with ICT use. Composite scores were calculated and descriptive statistical measures including mean, standard deviation, frequency and percentage analysis were used for interpretation. The results reveal that a majority of groundnut growers (62.67%) exhibit a medium level of digitization, indicating partial inclusion marked by access to basic digital tools but constrained usage capabilities. About 24.00 per cent of the respondents fall under the low digitization category, reflecting continued marginalization driven by limited digital literacy, poor connectivity and infrastructural barriers. Only 13.33 per cent of farmers demonstrate a high level of digitization. Dimension-wise analysis highlights digital literacy and ICT accessibility as the most critical constraints, while relatively high levels of satisfaction with ICT use indicate latent potential for deeper digital engagement. The findings suggest that mere availability of digital technologies does not guarantee meaningful digital inclusion. Targeted capacity-building initiatives, improved rural digital infrastructure and integration of farmer-centric digital tools within extension systems are essential to bridge the digital divide and promote inclusive digital transformation in agriculture.

Keywords: Digital divide; Digital agriculture; Information and Communication Technologies (ICTs); Digital literacy



T-2 O-9: Examining the Relationship Between Farmer Profiles and Performance Outcomes in Soybean Digital Farmer Field Schools

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This study examines the relationship between farmer profiles and performance outcomes among participants and non-participants of Digital Farmer Field Schools (DFFS) in soybean cultivation in Maharashtra, India. Using an ex-post facto research design, data were collected from 150 respondents (75 participants and 75 non-participants) through personal interviews during 2023-2024 across three talukas in Ahilyanagar district. The study analyzed four performance dimensions: knowledge, adoption, productivity, and economic performance in relation to farmer profile characteristics. Results revealed distinct patterns between groups. For DFFS participants, scientific orientation, social media viewing behavior, and techno-savviness emerged as strong predictors across all performance dimensions, showing highly significant positive relationships at the 0.01 level. Education, land holding, annual income, and cosmopolitanism demonstrated significant relationships at the 0.05 level. Non-participant farmers showed fewer significant relationships, with only scientific orientation consistently demonstrating strong associations with knowledge and adoption levels. Notably, demographic factors such as age and gender showed no significant relationship with performance dimensions in both groups, suggesting DFFS programs can be equally effective across diverse demographic segments. The findings underscore the importance of digital literacy and technological engagement in modern agriculture. The significant impact of social media viewing behavior and techno-savviness on participant farmers' performance highlights the need for targeted interventions to enhance digital skills among farming communities. The study recommends prioritizing digital literacy training, leveraging social media platforms for agricultural extension, and ensuring DFFS program accessibility regardless of demographic characteristics to achieve sustainable and productive soybean cultivation systems in Maharashtra.

Keywords: Digital Farmer Field School (DFFS), soybean cultivation, farmer profile, knowledge adoption, productivity, economic performance, scientific orientation, techno-savviness, social media viewing behaviour.



T-2 O-10: Impact of KVK YouTube Channel in Transfer of Agricultural Technologies

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COVID-19 pandemic was very tough period throughout the world. Every sector was near about stopped and lifestyle of every human being was disturbed. Agriculture sector was also affected due to lockdown. Extension activities for transfer of technology were badly affected due to this unexpected situation in the society. Farmers and Scientists from KVK were can't able to go anywhere to organize different extension activities. Due this lockdown farmers were demanding for advices on various agricultural works and asked to do something for transfer of authentic and scientific information to them. So in this situation KVK, Chhatrapati Sambhajnagar-1 decided to do something for farmers for transfer of authentic and scientific agricultural technology. KVK, Chhatrapati Sambhajnagar-1 uploaded more than 213 videos on various agricultural technologies on YouTube. This was found very useful for farmers. As such feedbacks from farmers were received in comment section, by personal visit and through telephonic communication. Due to this farmer not only from Chhatrapati Sambhajnagar but also from throughout Maharashtra are taking advantages of this activity. From only 15 subscribers in 2020 today we have reached more than 17200 subscribers. We have more than 779767 views, more than 50615 hours our channel was watched by the viewers. Also more than Rs.15860/- revenue generated to KVK, Chhatrapati Sambhajnagar-1. As per our observation, our official YouTube channel is the Highest Subscribers Channel among all KVK YouTube channels in Maharashtra and may be in India. So many farmers were visited to KVK, Chhatrapati Sambhajnagar-1 for getting more information about various technologies explained on our YouTube channel and also to purchase bio inputs like bio fertilizers, bio pesticides produced at of our KVK by seeing video on our YouTube channel. So, during our work we found that YouTube is very effective media for transfer of agricultural technology among the farmers. There is need to make effective use of various digital media for welfare of farmers and every extension institute needs to work on this. There is scope for more up gradation and up skilling for more effective video & content creation and for that we are planning to establish digital lab at our KVK level.

Keywords : KVK, Youtube, Digital Agriculture, digital tools, mass media, transfer of technology



T-2 O-11: E-Learning Modules (ELM) on Indigenous Technical Knowledge (ITK): A Pathway for Digitalisation of Traditional Wisdom for Sustainable Farming

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Indigenous Technical Knowledge (ITK) represents a rich repository of location-specific, time-tested and environmentally sound farming practices developed by farming communities over generations. Despite its proven relevance for sustainable agriculture, much of this knowledge remains undocumented, fragmented and vulnerable to erosion due to rapid modernisation and generational shifts. The present paper explores the potential of e-learning modules as an innovative extension approach for systematic digitalisation, preservation and dissemination of ITK to promote sustainable farming systems. The study conceptualises a framework for developing interactive, multilingual e-learning modules integrating traditional practices related to crop production, soil and water conservation, pest and disease management, and climate resilience. Emphasis is placed on participatory documentation involving progressive farmers, local elders and extension professionals to ensure authenticity and contextual relevance. The modules are designed to incorporate audio-visual demonstrations, local narratives, validation notes and scientific rationales to enhance credibility and learner engagement. The study highlights the role of digital platforms in bridging generational gaps, expanding outreach to youth and women farmers, and strengthening farmer-to-farmer learning networks. E-learning-based ITK dissemination offers flexibility, scalability and cost-effectiveness while supporting ecological sustainability, input reduction and climate adaptation. The approach also complements formal extension systems by integrating indigenous wisdom with modern scientific knowledge. The study concludes that digitally enabled ITK e-learning modules can serve as a powerful extension tool for conserving traditional knowledge, enhancing adoption of sustainable practices and advancing inclusive agricultural development. Policy support, institutional collaboration and validation mechanisms are essential for mainstreaming ITK through digital extension initiatives.

Keywords: Indigenous Technical Knowledge, E-learning, Digital Extension, Sustainable Agriculture, Knowledge Preservation, ITK Digitalisation



T-2 O-12: Advancing Millet-Based Farmer Producer Organizations through Digital Extension Models of ICAR–IIMR

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Millets were recognized as climate-resilient and nutrition-rich crops with significant potential to strengthen sustainable food systems and contribute to the achievement of Sustainable Development Goals. However, millet-based production systems continue to face persistent challenges such as fragmented value chains, limited access to quality seed, inadequate technical guidance, weak market linkages, lack of effective price support mechanisms (including MSP for small millets), low adoption of improved technologies, and minimal value addition. Farmer Producer Organizations (FPOs) have emerged as effective institutional platforms to address these constraints by aggregating farmers, enhancing scale efficiencies, and enabling market-oriented interventions. Millet FPOs promoted by the ICAR–Indian Institute of Millets Research have played a significant role in strengthening the millet ecosystem across Andhra Pradesh, Telangana, and Karnataka by collectively addressing production, post-harvest, and marketing challenges. To improve market access and price realization for millet produce, ICAR–IIMR introduced an innovative and inclusive marketing intervention, Girijana Bazar – Market on Wheels. This initiative provides a dedicated platform for millet FPOs to directly market millet grains and value-added products in urban and semi-urban areas, thereby reducing dependence on intermediaries. This initiative has demonstrated encouraging economic outcomes, with average daily sales of around **Rs. 4,500/-**, as the Girijana Bazar operates across **various public and institutional locations**, expanding market reach and consumer access. The model has enabled participating FPOs to achieve an average profit margin of about **25 percent**, thereby improving their financial sustainability. The Girijana Bazar initiative illustrates how FPO-led, market-oriented innovations can convert millet production into stable income streams, strengthen institutional viability, and create inclusive livelihood opportunities, while simultaneously promoting the consumption of nutritious millet-based foods.

Keywords: Farmer Producer Organizations (FPOs); ICAR–IIMR; Tribal Farmers; Girijana Bazar; Market on Wheels; Market Access



T-2 O-13: Digital Extension Services: Key of Farmers Success

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A significant number of farmers lack access to reliable and up-to-date information concerning extreme climate events like droughts, storms, floods, and other natural disasters. Digital agricultural extension utilizes various digital tools and services to efficiently deliver information. Extension workers commonly employ methods such as Short Message Service (SMS), Interactive Voice Response (IVR), interactive radio, and low-cost videos to rapidly reach a large number of farmers. These digital extension services offer timely reminders, alerts, weather forecasts, and best practices, empowering farmers to improve their productivity. The conventional approach to extension, involving face-to-face information sharing is both costly and time-consuming, often lacking significant value for the farming community. Nevertheless, the utilization of digital technology offers opportunities to expand the scope of extension services. Providing accurate information is crucial for enabling farmers to make well-informed decisions and unlock their full potential. Throughout each stage of the cropping cycle, it is essential for information providers to establish strong connections with farmers. Hence, digital technologies facilitate the creation of farmers' networks and ensure continuous communication with service and advisory providers. Some Digital Extension Services include Traditional Information Technology such as radio, television, and print media collectively form this communication medium and Modern Information Technology; this encompasses the internet, portals, mobile devices, community radio, video, digital photography, and call centres.



T-2 O-14: Content Analysis of Misinformation and Fake News in the Agriculture Sector

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Digital platforms have emerged as an important source of agricultural information for the farmers. However, alongside authentic information, misinformation and fake news related to agriculture have increasingly circulated online; posing risks to farm decision-making, input use, and market behavior etc. This study examines the patterns, themes and characteristics of agriculture-related fake news circulating through online platforms using a systematic content analysis approach. Keywords related to agricultural misinformation and fake news were searched, and relevant items were identified from fact-checking portals and verified sources documenting false claims. Each item was coded based on platform of circulation, type of content (text, image, video, audio or multimedia), thematic focus (crop practices, pesticides, weather, seeds, subsidies, markets, food safety, etc.), emotional tone, inferred intent, potential harm, and language etc. Agency responsible for fact-checking, including government bodies, independent fact-checkers, and news organizations or academic institutions was also coded. The study highlights the dominance of visually engaging formats such as videos and images in spreading misinformation, as well as the prominent use of social media and messaging platforms as distribution channels. The study contributes insights into the existing fact-checking ecosystem in the agriculture sector.

Keywords: Fake News, Misinformation, Information Literacy, and Social Media.



T-2 O-15: Reorienting Custom Hiring Centres for the Next-Generation Farmers: Pathways for Sustainable Food Systems and Atmanirbhar Bharat

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Indian agriculture is at a critical crossroads, confronted by persistent challenges such as stagnating productivity, fragmented landholdings, rural youth migration, and growing environmental and climatic stress. These challenges have heightened the need for affordable and efficient mechanisation, particularly for small and marginal farmers who dominate the agrarian landscape. In this context, Custom Hiring Centres (CHCs) were introduced under various government initiatives, including the Sub-Mission on Agricultural Mechanization (SMAM), to provide farm machinery and equipment on a pay-per-use basis, thereby lowering ownership barriers and improving access to mechanisation. CHCs have contributed significantly to enhancing operational efficiency, reducing drudgery, and addressing seasonal labour shortages in agriculture. However, their impact remains constrained by a predominantly conventional and equipment-centric approach. The existing CHC model has not adequately evolved to address emerging demands driven by rapid technological advancements, digitalisation, climate variability, and the growing emphasis on sustainable food systems. Limited adoption of precision agriculture tools, weak digital integration, financial constraints, and inadequate engagement of rural youth further restrict the transformative potential of CHCs. Against the backdrop of national priorities such as sustainable agricultural development and *Atmanirbhar Bharat* (self-reliant India), there is a compelling need to reorient Custom Hiring Centres beyond their traditional role. Reimagined CHCs can function as integrated service hubs that provide access not only to machinery but also to digital platforms, climate-smart technologies, data-driven advisory services, and skill development opportunities. Such a transition can promote resource-efficient farming practices, enhance climate resilience, and create viable entrepreneurial pathways for next-generation farmers. This paper analyses the current framework of Custom Hiring Centres in India, identifies key technological, institutional, and sustainability-related challenges, and proposes strategic interventions for their reorientation. It argues that transforming CHCs into digitally enabled, youth-centric, and sustainability-oriented platforms can strengthen India's agricultural self-reliance, improve inclusivity for smallholders, and support the transition towards resilient and sustainable food systems.



T-2 O-16: Development of a Scale to Measures Attitude towards Digital Technologies in Agriculture in Muzaffarpur District of Bihar, India

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The integration of digital technologies has become an essential component of modern agricultural practices across the globe. Tools such as mobile apps, AI-based advisory systems, remote sensing, GPS-enabled devices, and digital platforms now enable farmers to access real-time information, improve the efficient use of resources, and expand their access to market. The goal of this study was to develop a standardized scale to evaluate the attitude of farmers in Bihar regarding the use of digital technologies in agriculture. The research utilized the well-established Likert summated rating method (Likert, 1932), which is appropriate for evaluating psychological constructs like attitude (Thurstone, 1946). The research was conducted in Patsara and Tepri villages in Bandra block, involving a sample of 120 farmers (60 from each location). Initially, 65 attitude statements were compiled based on existing literature and expert opinions, addressing five elements of the Digital Competency Framework-Information, Communication, Problem Solving, Continuous Learning, and Technology Adoption. The relevance of these statements was assessed by 35 judges in the field of agricultural extension, retaining those with a Relevancy Weight. With the growing emphasis on digital transformation in agriculture, understanding farmers' attitudes towards digital technologies is essential for successful implementation and policy planning. The standardized attitude scale created in this study is specifically aimed at farmers in Bihar and provides a scientifically validated instrument for evaluating their attitude and willingness to adopt digital tools in agriculture. Developed through careful and systematic procedures that included expert validation, item analysis, and reliability testing, this scale achieved a high Cronbach's Alpha of approximately 0.91, signifying excellent internal consistency. Researchers, policymakers, and extension professionals can utilize this tool to carry out baseline surveys and make well-informed choices that promote the adoption of digital technologies in agricultural practices. Due to its strength and relevance in the context of agricultural digitalization, this scale promises broader use in similar agro-ecological environments.

Keywords: Attitude scale, reliability, validity, digital technologies, Likert scale.



T-2 O-17: Role of Artificial Intelligence (AI) in Dissemination and Adoption of Natural and Sustainable Farming Practices by Farmers

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Artificial intelligence (AI) plays a crucial role in the dissemination and adoption of natural and sustainable farming practices by providing farmers with data-driven insights, real-time advisory services, and precision management tools. This approach helps optimize resource use, reduce chemical inputs, and improve overall farm resilience. AI powers platforms and mobile applications that serve as virtual agricultural advisors, offering instant, personalized information to a wide audience of farmers, including those in remote areas. These tools translate complex agricultural content into local languages, overcoming literacy and language barriers.

By analyzing data from sensors, drones, and satellites, AI systems can provide precise recommendations for water management, nutrient application, and pest control. AI uses image recognition and machine learning to detect early signs of crop diseases and pest infestations (e.g., the Plantix app). This allows for timely intervention with natural or biological controls, reducing the need for broad-spectrum chemical pesticides and herbicides. AI models analyze historical weather patterns and climate data to provide accurate forecasts and recommend climate-resilient crop varieties and planting schedules. This helps farmers adapt to changing environmental conditions, minimize crop loss due to extreme weather events, and improve food security. By processing vast amounts of data and providing actionable insights, AI empowers farmers to make more informed and strategic decisions, rather than relying solely on traditional methods or intuition.

AI supports educational initiatives and training programs, helping farmers and extension workers stay updated on the latest sustainable and natural farming techniques. While the benefits are significant, challenges such as high implementation costs, a lack of technical expertise, and limited digital infrastructure in rural areas need to be addressed to ensure equitable access and widespread adoption of these technologies.

Key words: Artificial intelligence, dissemination, adoption, natural farming and sustainable farming



T-2 O-18: Yield gap analysis of oilseed crops through Cluster Frontline Demonstrations in Bihar and Jharkhand

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Cluster Front Line Demonstration (CFLD) on Oilseeds is a flagship initiative of Government of India under National Food Security Mission to enhance oilseed production and productivity. ICAR has taken key initiative to conduct nationwide Cluster Front Line Demonstrations since October 2015 at farmers field to establish production potential of oilseeds through a wide network of Krishi Vigyan Kendras with the financial assistance of Department of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, GOI. The programme emphasizes package demonstration of improved oilseed varieties and other technological inputs on the basis of technology gap assessment to fill the gap between farmers practice and latest technology to maximize the yield and farmers income under real farming situation to bridge yield and technology gaps. The present study assessed the performances of soybean, mustard, linseed, niger and safflower with area 18054 ha involving 48453 demonstrations across Bihar and Jharkhand. 2964 demonstrations were conducted in 980 ha in soybean, 5158 demonstrations were conducted in 1987 ha in niger, 165 demonstrations were conducted in 60 ha in safflower, 36028 demonstrations were conducted in 13746 ha for mustard and 4138 demonstrations for linseed in 1281 ha area. Results indicated that adoption of the demonstrated technologies under CFLDs led to a significant enhancement in grain yield across all oilseed crops, with yields of 14.44 q/ha in soybean over farmers practice (10.73 q/ha), 5.37 q/ha in niger over farmers practice (3.9 q/ha), 6.18 q/ha in safflower over farmers practice (3.83 q/ha), 13.48 q/ha in mustard over farmers practice (9.51 q/ha) and 9.16 q/ha in linseed over farmers practice (6.68 q/ha). The net profit difference was recorded Rs. 72982 with a BCR of 2.90 in soybean, Rs. 30014 with a BCR of 2.79 in niger, Rs. 15019 with a BCR of 2.11 in safflower, Rs. 46134 with a BCR of 2.54 in mustard and Rs. 29450 with a BCR of 2.34 in linseed. The technology gap 10.92 q/ha, extension gap 3.71 q/ha and technology index 43.06 was observed in soybean, the technology gap 0.88 q/ha, extension gap 1.47 q/ha and technology index 14.08 was observed in niger, the technology gap 11.22 q/ha, extension gap 2.35 q/ha and technology index 64.48 was observed in safflower, the technology gap 5.04 q/ha, extension gap 3.97 q/ha and technology index 31.92 was observed in mustard and the technology gap 4.43 q/ha, extension gap 2.48 q/ha and technology index 32.60 was observed in linseed.

Keywords: CFLD, yield gap, technology gap, technology index, yield enhancement



T-2 O-19: Attitude, accessibility and utility pattern of ICTs apparatus by employees of South Gujarat for exploring agricultural information

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ICTs apparatus and applications offer excellent possibilities for strengthening the linkage between research, extension and client system. Further, the ratio of extension agent to farmer can bridge by ICTs apparatus. In present study, the well established institutions and private stakeholders of south Gujarat were identified who are exploring the agricultural information to the farming community. The personnel engaged in welfare activities of those firms were identified. Among them, 200 employees were randomly selected for study. Structured schedules were developed for measuring accessibility and utility Pattern of ICTs apparatus. Majority (72.00 per cent) of the respondents had more favourable attitude towards ICTs apparatus followed by 26.50 and 1.50 per cent of them had favourable and less favourable attitude towards ICTs apparatus respectively. Utility pattern of employees was measured in terms of extent of utilization, purpose of utilization and duration of utilization of ICTs apparatus. In case of extent of utilization, 12.00 and 39.50 percent of the respondents were used radio and digital camera 10 times in a month, while 59.00, 32.00, 96.00, 65.50, 67.00, 57.00, 62.00 and 73.50 percent of them were using television, telephone, mobile, computer, internet, e-mail, search engine and Social media 10 times in a day respectively. Further, 35.00 percent were using agricultural portals 10 times in a week, and 13.00 percent were used video conferencing 10 times in a month and week. All the respondents (100.00 percent) were utilizing ICTs apparatus for retrieving knowledge/information and speedy communication followed by 98.50 percent for e-mailing, 95.50 percent for storing information, 83.00 percent for training and entertainment, 79.50 percent for know more about market situation, 77.00 percent for research and extension activity, 75.00 percent for networking with other organization, 74.50 percent for transfer of technology and 74.00 percent for data collection and analysis. In case of duration of utilization, 11.00, 68.50, 12.00 and 38.00 percent of the respondents were using radio, e-mail, video conferencing and digital camera up to 3 hours per week respectively while, 36.00 and 34.50 percent of them were using telephone and agricultural portals for 3.1 to 6 hours per week. Further, 65.50, 80.00, 67.50, 66.50, 69.50 and 72.50 percent were using television, mobile, computer, internet, web based search engine and social media for more than 6 hours per week respectively. Majority (77.00 per cent) of the respondents possessed moderate to higher level of accessibility of ICTs apparatus.

Key Words: Attitude, Accessibility, Utility pattern and ICTs apparatus



T-2 O-20: Empowerment of Stakeholders for Scaling-Up: Digital Technologies for Agricultural Extension

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The role of digital technologies in transforming agricultural extension services is increasingly recognized as essential for addressing the challenges faced by farmers in rural areas. In India, where factors such as low income, illiteracy, and marginal land holdings hinder the adoption of modern farming practices, the integration of Information and Communication Technologies (ICT) offers a promising solution. However, several challenges—such as connectivity issues, digital illiteracy, and concerns over data privacy—persist, limiting the widespread adoption of digital tools. This paper explores the opportunities and challenges of empowering farmers through digital extension services. It highlights the importance of addressing the digital divide, improving access to ICT tools, and overcoming barriers like gender and socioeconomic disparities. It also emphasizes the need for enhanced technical support and training for both farmers and extension officers to ensure effective utilization of ICT tools. The paper concludes by advocating for collaborative efforts between governments, private sectors, and NGOs to create an inclusive digital ecosystem, ensuring equitable access to agricultural extension services. Bridging these gaps will empower farmers, enabling them to embrace technology, improve productivity, and achieve sustainable agricultural development.

Keywords: Digital Extension, Agricultural Technology, ICT in Agriculture, Rural Development, Farmer Empowerment, Agricultural Productivity, Digital Literacy.

T-2 O-21: Unlocking Agricultural Excellence: Evaluating the Impact of Krishi Vigyan Kendra Gwalior's Subject-Specific Training Program

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This study was conducted in Krishi Vigyan Kendra, Gwalior District Madhya Pradesh, 209 KVK trainees were sampled from a pool of participants, including farmers, farm women, and rural youth, who had attended KVK Gwalior's training programs over the past three years. The primary objective was to assess the perceived utility of these training programs across various thematic areas. Using a cumulative analysis, the study found that a majority of respondents (57.42%) rated KVK training programs as having a medium extent of perceived utility. Additionally, 23.44% of respondents considered these courses to have a high extent of utility, while fewer than one-fifth (19.14%) categorized the training as having a low extent of utility. These results offer valuable insights into the effectiveness of KVK training initiatives in Gwalior District, Madhya Pradesh. The findings underscore the importance of program customization to better meet the diverse needs of trainees, highlighting the potential for enhancing the impact of agricultural training programs.

Keywords: Krishi Vigyan Kendra; Training effectiveness; Trainee; Teaching; Perception, Thematic area Utility Assessment



T-2 O-22: Role and Impact of KVK Activities in the Adopted Villages of Dangs

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KrishiVigyan Kendra (KVK), as a Farm Science Center, plays a vital role in transferring the latest agricultural technologies to farmers and promoting rural development through on-farm testing, training programs, frontline demonstrations, and extension activities. This study assessed the impact of KVK interventions in adopted villages of Dang district, Gujarat. A total of 200 farmers were surveyed, comprising 100 respondents before adoption and the same 100 after adoption, selected from 10 villages across Waghai, Ahwa, and Subir talukas using purposive and random sampling methods. The findings indicated a significant increase in farmers' knowledge on crop production, horticulture, animal husbandry, plant protection, income-generating activities, and home science. The average knowledge gap decreased to 18.99%, reflecting a 34.78% improvement. KVK's training and extension activities contributed to enhanced production, productivity, income, and overall economic status of farmers. Socio-economic variable such as landholding, social participation, extension involvement, information-seeking behavior, animal possession, scientific orientation, risk orientation, and economic orientation significantly influenced knowledge acquisition and technology adoption. The study suggests that KVK should consider these variables while planning training and extension programs to further strengthen adoption and rural development outcomes.



T-2 O-23: A Study of Awareness, Level of Adoption & Challenges Related to Artificial Intelligence (AI) Among Farmers in Palghar District, Maharashtra

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Artificial Intelligence (AI) has emerged as a transformative tool in modern agriculture by supporting decision-making, improving productivity, and reducing risks. However, its successful implementation depends largely on farmer's awareness and adoption. So, the present study aimed to assess the level of awareness, adoption, and challenges related to AI-based agricultural technologies among farmers in Palghar district of Maharashtra. The primary data were collected from 100 farmers using offline interview and online survey. Collected data were analyzed using SPSS Software and applied statistical tools like frequency, percentage, mean scores, and Chi-square test. The results revealed that a majority of respondent belonged to the middle-age group and had secondary & graduation levels of education (60%). Findings indicate that out of 100 respondent 91% farmers have smart-phones but only 68% of farmers were aware of Artificial Intelligence. However, a significant proportion (32%) still lacked awareness. Only 44% used the internet regularly for agricultural purposes, but only 17% use AI content regularly. 36% farmers showed a positive perception towards AI technologies for getting update about weather for timely decision-making, followed by 22% farmers used to increase knowledge regarding new techniques of crop cultivation. Chi-square analysis revealed a significant association between education level and awareness of AI technologies. Farmers with higher education were more aware of AI-based tools, emphasizing the role of education in technology adoption. Major constraints identified were poor internet connectivity, lack of digital literacy, and inadequate awareness. The study highlights the need for location-specific training programs in local language to enhance effective adoption of AI-based technologies among farmers.

Keywords: Artificial Intelligence, Awareness, Adoption, Constraints, digital extension, Sustainable agriculture



T-2 O-24: Optimizing ICT tool for Sustainable Agricultural Development in Wardha District

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KrishiVigyan Kendra's functioning as the primary frontline extension system in India, bridging the gap between agricultural research and field-level adoption. In the era of Agriculture 4.0, the Cyber Extension model has become essential to overcome traditional barriers such as limited extension personnel, geographical isolation and the increasing demand for climate-resilient advisory. Traditional extension methods often fail to provide the real-time, site-specific advisories required for crisis management. Furthermore, the persistent "Digital Divide" among marginal farmers in District Wardha creates an inequity in resource access. This study examines the extent of ICT tool utilization by KVK scientists and its subsequent impact on agricultural productivity and farmer empowerment. The study utilizes a data of farmer-scientist digital interactions. Results indicate a significant shift from one-way information dissemination to multi-channel interactive ecosystems. KVK, Selsura used mobile-based advisory platforms like mKisan, WhatsApp, YouTube-based vernacular training and AI-driven diagnostic apps, which have improved the timeliness of crop variety, pest and disease control, soil health, advance machineries, livestock care and subsidiary occupations alerts by over 40%. The utilization of social media, particularly WhatsApp groups moderated by experts of KVK, Selsura has emerged as the most effective tool for real-time problem diagnosis dissemination of advisories. However, a persistent Digital Divide remains, with only 33–35% of marginal farmers consistently engaging with digital KVK services. It is concluded that the rapid dissemination of information regarding pest and disease control, soil health, crop varieties and advance technologies has directly empowered farmers to move from reactive crisis management to proactive, data-driven decision-making to achieve a truly sustainable food system. By substituting tradition with precision, the ICT-enabled extension model not only secures the farmer's profit margin but also preserves the ecological integrity of the Wardha soil-water ecosystem for future generations.

Key words: ICT, Sustainable Agriculture, Farmers



T-2 O-25: Farmers Attitude Towards the Use of ICT Interventions in Sri Muktsar Sahib District of Punjab

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Agriculture sector is one among the foremost important sector in India. Keeping in view of the demand for agricultural growth, evolutionary changes have been made in transfer of technology to reach the farming community effectively. The technology revolution encompasses new ways of capturing, processing, storing, and displaying information and is capable of increasing productivity and competitiveness through information provision. Effective use of ICT tools in rural areas depends on the preparedness of people through proper knowledge and attitude in using these tools. The Information and Communication Technology (ICT) is one of these solutions and has recently unleashed incredible potential to improve agriculture in developing countries specifically. There in regards, extensive use of information technologies must be promoted to farm level for transfer of technologies. The study was conducted during the year 2024 to assess the attitude of farmers towards information and communication technology tools in two blocks i.e., Muktsar and Gidderbaha of Sri Muktsar Sahib district of Punjab. Pre- structured interview schedule was used for data collection from the farmers and appropriate statistical tools were used to analyze the collected data. Proportionate random sampling was used in the selection of one hundred and twenty (120) farmers as the sample of the study. The outcomes confirmed that a half (50.0%) of the respondents opined that they got timely information regarding the use agricultural inputs through the ICT intervention sand informed that they increased their knowledge on the judicious use of agri-inputs. More than half(54.2%) of the respondents said that the available data through the station may not accurately represent the current weather condition on a farm. Majority of the respondents (78.8%) were happy, satisfied with respect to the response of experts for farmer's queries. Half (50.0%) of the respondents said that they were getting timely information on the demand of product and subsidies available in the market. An appraisal of the content analysis of the statements shows that the majority of the respondents had more favorable attitude towards ICT tools.

Keywords: Agriculture, Attitude, Farmers, ICT, Knowledge.



T-2 O-26: Assessment of problems faced by horticultural farmers using digital tools in Central Zone of Chhattisgarh State

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The purpose of Prime Minister Sri Narendra Modi's Digital India initiative, which was introduced on July 1st, 2015, was to increase technological literacy and connect rural areas to high-speed Internet networks. Digital Infrastructure as a Utility to Every Citizen, Governance & Services on Demand, and Digital Empowerment of Citizens are the three key areas that make up the vision of the Digital India programme, which seeks inclusive growth in the areas of electronic services, products, manufacturing, and job opportunities, among other things. This study was carried out to discover the challenges that Indian Horticultural Farmers faced when adopting digital extension in horticulture and agriculture sector. In Bemetara district of Chhattisgarh state which falls under the Central Zone; the primary data were gathered in 2024-25 using pre-tested schedule related to the problems with horticultural farmers using digital tools. Problems with horticultural farmers using digital tools were found to exist. On the basis of PFI problems faced by farmers; it is observed that Inadequate Government Digital Service Centers & Facilities ranked first followed by Quality of Information, Lack of Awareness towards Benefits of ICT in Agriculture, Lack of knowledge on e-Agriculture, Lack of Training, Expensive to Use, Inadequate ICT Experts, Lower Internet Speed and Apathy towards New to them were ranked second, third, fourth, fifth, sixth, seventh and eighth respectively.

Key Words: Digital Extension, Agriculture/Horticulture Problems, Empowerment and Digital Tools, Training etc.



T-2 O-27: Enhancing Community Nurseries' Income through Digital Outreach: A Pathway to Atmanirbhar Bharat

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Participatory action research was undertaken by ICAR-CAZRI, Jodhpur from 2019-2023 to promote sustainable rural livelihoods through community participatory nurseries. Under the project, a group of ten farmers (men and women) each was formed in two arid villages namely Paladi Ranawata and Dantiwada in Jodhpur district of western Rajasthan. The groups were provided hands-on training at model nursery at CAZRI on layout of nurseries, beds and media preparation, polybag filling, seed collection and storage, seed sowing, raising cuttings and after care of forest, fruits and vegetable seedlings. Thereafter, plant nurseries were constructed at farmers' field in participatory mode in these villages in an area of 8 x 16 m². The quality seedlings of agro-forestry trees (Budded *Prosopis cineraria*, *Tecomella undulata*, *Acacia senegal*, *Azadirachta indica*, *Albizia excelsa*, *Dalbergia sissoo*, *Moringa*), horticulture species (budded *Zizypus sp.* cultivars Gola, Seb and Thai apple; *Cordia myxa*, lemon, pomegranate, papaya) and vegetables (tomato, brinjal, chilly, cauliflower, cabbage, bottlegourd, etc.) were produced from these nurseries. These seedlings were initially sold in the same village and some surplus seedlings were taken to the nearby market for selling, but that consumed extra manpower and time. Therefore, the need for ICT tools for marketing was felt. The groups then started advertising their nurseries through social media platforms viz. facebook, whatsapp and other ICT tools. Marketing through these platforms consistently increased the demand for seedlings. Presently, the nursery gets demands from farmers/ customers from many districts of Rajasthan and nearby states of Gujarat and Haryana. The annual net income of nursery in Paladi Ranawata village increased from Rs. 177210/- in the second year of nursery establishment to Rs. 475024/- in the third year. Similarly, it increased from Rs. 152950/- in the second year to Rs. 186654/- in the third year at Dantiwada nursery. Presently the nursery is expanded in an area of approx 0.4 hectares in both the villages. The marketing of quality planting material through the aid of ICT tools expanded the customer base resulting in higher and sustainable revenues for the nurseries.

Key words: Arid region, Community participation, Digital tool, Marketing, Nursery.



T-2 O-28: Smart Farming Platforms as a source for Knowledge Dissemination in India

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Smart farming, a data-driven approach, integrates traditional knowledge with contemporary technology and practice that aids in agriculture sustainability and long-term viability. The review analyses 20 peer-reviewed articles and 10 institutional reports, supplemented by insights from websites to analyse and understand the smart farming platforms and their relevance in knowledge dissemination process. The entire agricultural processes, from seed selection to harvesting and processing, can be optimized through precision farming and data-driven decision-making. Smart farming platforms like SENSAGRI (Sensor based smart agriculture), RKMP (Rice Knowledge Management Portal) developed by Indian Institute of Rice Research, Hyderabad, etc helps in the streamlining of agricultural farming practices. By their predictive nature, smart farming platforms helps to mitigate the losses in agriculture that occur due to extreme weather conditions and constant changes in climatic conditions. The smart farming platforms aids in successful extension reach in the current scenario of increasing national population and decreasing extension agent-to-farmer ratio. The other major barriers identified include regional disparities, lack of technical expertise, more cost in the adoption of smart farming technologies. Smart farming requires more research, innovations, government initiatives and collaboration among stakeholders to overcome the barriers and in turn realize the full potential of smart farming. Smart farming holds great promise for the future of agricultural sector, by automating and streamlining farming operations and there by supports efficient knowledge dissemination as well as enhances the standard of living for farmers.

Keywords: Agriculture extension, climatic changes, government initiatives, mitigation, RKMP.



T-2 O-29: Drone-Enabled Aerial Seeding: A Digital Innovation for Sustainable Grassland Development and Fodder Security

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Achieving sustainable food systems under the vision of *Atmanirbhar Bharat* requires transformative digital innovations that enable productive use of degraded and underutilised land resources. In India, vast areas of common lands and wastelands remain largely unproductive due to poor soils, undulating terrain, shrub invasion, and limited physical access, which constrains fodder availability and the sustainability of livestock-based food systems. Digital agriculture tools, particularly unmanned aerial vehicles (drones), offer disruptive solutions to overcome these long-standing constraints.

An innovative application of drone technology for aerial sowing of forage seeds on a pilot basis was taken up during the Kharif season of 2021 at the Livestock Breeding Farm, Hessarghatta, Bengaluru, Karnataka. The study covered 50 acres of common land and involved drone-based seeding of region-specific grass and legume species, namely grazing guinea (*Panicum maximum*), *Cenchrus ciliaris* and *Stylosanthes hamata*. A major technological challenge addressed was the ultra-light weight, small size and awned structure of grass seeds, which limit their compatibility with conventional drone seeders.

To overcome this bottleneck, the study developed and tested custom-engineered seed delivery mechanisms, including modified shafts and conveyor systems integrated with a quadcopter agricultural drone. These innovations enabled precise, uniform, and targeted dispersal of forage seeds, minimising wind drift and ensuring effective seed placement without land preparation. The approach allowed rapid coverage of difficult terrain within narrow soil-moisture windows, resulting in good field establishment with significantly reduced labour and time inputs.

The study demonstrates the potential of drone-enabled grassland development as a scalable digital innovation for transforming wastelands into productive assets. Beyond enhancing fodder security, this approach contributes to ecosystem restoration, climate resilience and self-reliant livestock production systems. While challenges related to seed supply chains, pelleting technologies and cost optimisation remain, the innovation provides a strong foundation for integrating digital tools into sustainable food systems in India.



T-2 O-30: Impact of Sustainable Dairy Farming and Livestock Management Training on Gain in Knowledge and Training Satisfaction

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KVK, Bhandara conducted training for Rural Youth on sustainable dairy farming and livestock management in the year 2024-25. It is essential that KVK be able to follow the results of their efforts and understand how the training they imported fit into the complex pattern of socio economic status change in which all farmers participated. Keeping the above facts in view the present study was designed with objectives to Study the impact of training. The impact of the training was assessed by pre and post evaluation testing in terms of improvement in knowledge for different parameters. It was observed that the change knowledge in sustainable dairy farming and livestock management training respondents, pre training mean score was 26.33 and post training mean score was 44.73 observed, percent change in knowledge was observed 69.88. Overall training effectiveness score of the sustainable dairy farming and livestock management training programme worked out to be 93.33 which indicated that the KVK training can be considered to be effective. Overall training satisfaction score of the sustainable dairy farming and livestock management training programme worked out to be 89.23 which indicated that the respondents of sustainable dairy farming and livestock management training more satisfied with respect to the training satisfaction dimensions. It may therefore, be concluded that trainees succeeded in acquiring knowledge after exposure to training and also adopting technologies on scientific dairy farming practices.

Keywords: Dairy farming & livestock Management Training, change in Knowledge, Effectiveness, Satisfaction.



T-2 O-31: Digital Extension Education as a Catalyst to Empower Farmers for Atmanirbhar Bharat

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Digital innovation has emerged as a cornerstone in transforming agricultural extension and education in India, bridging long-standing information gaps and empowering farmers towards sustainable productivity and Atmanirbhar Bharat (self-reliance). This review critically examines the role of digital extension tools—such as mobile-based advisories, artificial intelligence (AI)-enabled decision support systems, digital public infrastructure, and e-learning platforms—in enhancing agricultural knowledge dissemination, farm-level decision-making, market integration, and access to government schemes. Major national initiatives, including the Digital Agriculture Mission, Agri Stack, e-NAM, and farmer-centric ICT platforms, are systematically reviewed to assess their contributions to transparency, efficiency, and inclusiveness in the agricultural ecosystem. India-specific case studies from initiatives such as Digital Green, AI-enabled advisory pilots, Krishi Vigyan Kendras (KVKs), and Farmer Producer Organizations (FPOs) demonstrate tangible impacts on farmer empowerment, income enhancement, and climate resilience. The review further highlights the growing importance of real-time data analytics, remote sensing, geospatial technologies, and participatory digital platforms in enabling precision agriculture, climate-smart practices, and adaptive farm management. These innovations facilitate timely advisories, risk mitigation, and resource optimization at the field level. However, the paper also identifies persistent challenges, including the digital divide, low digital literacy among small and marginal farmers, inadequate rural connectivity, and concerns related to data privacy and governance. Addressing these constraints is critical for ensuring equitable benefits of digital transformation. The review concludes that digital extension and education, when designed to be inclusive, farmer-centric, and scalable, can significantly accelerate agricultural self-reliance and contribute meaningfully to the vision of Atmanirbhar Bharat.

Keywords: Digital extension, ICT in agriculture, Atmanirbhar Bharat, Agri Stack, KVKs, farmer empowerment



T-2 O-32: Educational Technology in Agricultural Extension: Trends, Opportunities, and Challenges

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Educational technology has emerged as a key enabler for strengthening agricultural extension by improving the reach, quality, and effectiveness of capacity-building efforts. Instructional approaches such as programmed instruction, originally developed as structured self-learning systems, are inherently flexible and can be delivered through print, audio-visual, or digital platforms. With the rapid expansion of information and communication technologies, these principles are increasingly embedded in e-learning modules, mobile applications, learning management systems, and digital advisory services. In India, the growing penetration of smartphones among rural households, expansion of internet connectivity, and large-scale initiatives such as mobile-based agro-advisories and online training platforms have significantly enhanced the scope of digital extension. Studies indicate that digitally mediated instructional systems can improve learning efficiency, knowledge retention, and timely access to information for extension personnel and farmers. This paper reviews major trends in the use of educational technology in agricultural extension, highlighting opportunities such as self-paced learning, personalization of content, scalability, and integration with innovation systems. However, challenges including the digital divide, limited instructional design skills among extension professionals, inadequate infrastructure in remote areas, and insufficient emphasis on pedagogically sound content development continue to constrain effectiveness. The paper emphasizes the need to integrate instructional design principles, including programmed learning, with digital technologies to ensure evidence-based, learner-centered, and outcome-oriented extension education.

Keywords: Educational technology, Programmed instruction, Digital extension, Instructional design, E-learning





Theme II : Poster

Digital extension and education to empower farmers for Atmanirbhar Bharat-challenges and opportunities





T-2 P-1: Impact analysis of the adoption of the improved practices of farmers about Crop, Horticulture, Livestock, Silviculture and irrigation before and after IGNP (Indira Gandhi Canal Project) at the Mohangarh tehsil of Jaisalmer in Western Rajasthan

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Different Agri, Livestock and Horti component were taken for the study of. Crops component Bajra, Moong Bean, Moth bean, cluster bean were taken in Kharief and Chickpea, Wheat, Isabgol, Mustard, fennel, Jeera were taken in Rabi. Among Livestock component in large Ruminants Buffalo, Cow, Camel were taken while among small ruminant Sheep, Goat were taken while in horticulture component among vegetables Cachri, Tinda, Onion, Kakri, Loki were taken among fruit component Pomegranate, Date palm, Ber, Maringa, Ker, Sangri were taken and In Jaisalmer most of the farmers are following mono-cropping system either they are following horticulture or they going for crops and livestock or sole crops or sole Horticulture, horticulture and livestock are not common similarly sole livestock is also not common. Adoption level of the farmers is about the Crop-Horti-Livestock-Silviculture and irrigation related has been measured in Mohangarh area of the Jaisalmer. Data has been collected of the 100 farmers before IGNP and after IGNP at Mohangarh tehsil of Jaisalmer (Rajasthan). Rajasthan has been selected because CAZRI is located in here and Jaisalmer is selected because R.R.S. is located in here. Then 100 farmers of Mohangarh have been selected randomly out of total IGNP beneficiaries. Data has been collected in 5 rounds. In single round 20 farmers were chosen for data collection. Data collected were entered in excel sheet and analyzed, and results have been drawn. That in case of crop-horti-livestock-self-reliance and irrigation, adoption level of the farmers is higher in case of after IGNP, and adoption was lower in case of the before IGNP of the same farmers. Higher adoption of all 5 attributes is because of the availability of water from IGNP for irrigation is there which resulted in higher adoption level after IGNP. And before IGNP there was no water available for irrigation is there which resulted in lower adoption of Crop-Horti-Livestock-Silviculture and Irrigation.

Key Words: Measurement, Adoption level, Crop – Horti – Livestock-Silviculture - Irrigation, Arid region, Western Rajasthan.



T-2 P-2: Socio-economic Profile and Constraints of Pineapple Growers in Selected Districts of Manipur

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The study was conducted in three districts of Manipur, namely Imphal-East, Senapati and Kangpokpi district of Manipur during the year 2024. A sample of four hundred and fifty respondents were selected through random sampling for the study. Socio-economic characteristics and identify the major constraints faced by pineapple growers was the main objectives and descriptive research design was used, data were collected through personal interview using a pre-structured interview schedule. The Garrett Ranking Technique was used for the analytical prioritization of constraints. 48.89 per cent of the pineapple growers were of middle aged group (36-55 years old), 39.33 per cent were engaged in agriculture+labour as their occupation, and majority (53.11%) were living in semi-cemented house and 46.89 per cent had a landholding size of 1-2 acres. It was revealed that the major constraint faced by the pineapple growers was price instability, (rank I), with a garrett score of 58.64, sale challenges scored 53.98 (rank II) and limited market access scored 51.69, (rank III). To significantly enhance the profitability and overall economic resilience of pineapple farming in Manipur, it is essential to implement suitable extension approaches along with comprehensive policy support to minimize the constraints of the pineapple growers which will lead to more profitable and uplifting their socio-economic profiles.

Keywords: Pineapple Growers, Socio-economic Profile, Constraints.

T-2 P-3: The Role of Agricultural Extension in Enhancing Farmers' Productivity and Livelihoods: A Review

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Agricultural extension plays a crucial role in promoting agricultural growth, improving farmers' skills, and fostering rural development. This review explores how extension services bridge the gap between research and farmers, facilitate technology adoption, enhance productivity, and contribute to social and economic empowerment. It also highlights challenges faced by extension systems and suggests ways to strengthen their effectiveness in the modern agricultural landscape. Agricultural extension remains a cornerstone of rural transformation. Effective extension systems improve productivity, increase farmers' income, and promote sustainable agriculture. However, strengthening institutional support, embracing technology, and ensuring inclusivity are key to making extension services more impactful

Keywords: Agricultural Extension and Technology



T-2 P-4: Attitude of Farmers towards KisanFarm Pond Scheme

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The study was conducted in Bhilwara district of Rajasthan. 120 respondents were selected for the study. In the study, develop and standardize the reliable and valid scale, to measure attitude of farmers towards Kisan Farm Pond Scheme. An appropriate statistical method 'Scale product method' was used. A panel of 5 judges was requested to assign the score for each selected statement for judgments on three-point continuum viz. agree, undecided and disagree for all the statements. Based on the scale 26 statements were finally selected to constitute attitude of farmers towards Kisan Farm Pond Scheme. From the data it can be revealed that majority 66.67 percent of the farmers had medium level of attitude, followed by high (14.17%) and low level (19.17%). From this, it can be concluded that majority of the farmers had medium level of attitude.

Keywords: Farmers, attitude, kisan farm pond scheme.

T-2 P-5: Assessment of Awareness and Knowledge Gaps on Various Dimensions of Non-Timber Forest Products among Forest Dwellers in Chhattisgarh, India

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Non-Timber Forest Products (NTFPs) are vital for the livelihoods of households in forest-fringed villages of Chhattisgarh. Awareness of various aspects of NTFPs is crucial for their sustainable use, value addition, and market participation. This study assessed the level of awareness, knowledge gaps, and the possession and utilization of digital communication devices among households in these villages. The study was conducted across three agro-climatic zones using an ex-post facto research design. A multistage random sampling technique covered 21 Van Dhan Kendras, with 315 respondents selected. Results indicated that respondents had higher awareness regarding collection practices and government initiatives. However, awareness of storage, processing, value addition, and marketing was relatively low. Knowledge gaps were especially evident in post-harvest management, storage, processing techniques, and market information. Most respondents owned mobile phones and televisions, while radio ownership was limited, and use of these devices for NTFP-related information was minimal. Overall awareness ranged from moderate to high but was uneven across dimensions, highlighting significant extension gaps. The study emphasizes the need for strengthened extension services through targeted training, demonstrations, exposure visits, and capacity-building programs. Leveraging digital communication tools can help bridge knowledge gaps and improve sustainable NTFP-based livelihoods in forest-fringed villages of Chhattisgarh.

Keywords: Non-Timber Forest Products, Awareness, Knowledge Gaps, Forest-Fringed Villages, Digital Communication Devices.



T-2 P-6: Socio-Economic Profile of PM-KISAN Beneficiaries and Constraints in Digital Delivery: A Study of Fatehpur District of Uttar Pradesh

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The Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme is a flagship income support scheme implemented through digital platforms to enhance the socio-economic security of landholding farmers. The study was conducted during 2024–25 in Fatehpur district of Uttar Pradesh to explore the socio-economic profile of PM-KISAN beneficiaries and constraints in the digital delivery of the scheme. A descriptive research design was adopted, and 360 beneficiary farmers were selected using a multistage sampling technique. Data were collected through a pre-tested structured interview schedule, and the Garrett ranking technique was applied to prioritise constraints perceived by the respondents.

The findings suggest that a majority of beneficiaries were middle-aged (51.94%), male (81.39%), with secondary to high school education (51.67%). With respect to economic indicators, over half of the beneficiaries (53.33%) belonged to the medium income category. Ownership of mobile phones (93.89%) and televisions (80.27%) indicated improved access to digital and household amenities. However, more than half of the respondents (53.89%) had no social participation, and the majority reported medium to low levels of extension contact and mass media exposure.

While analysing constraints, findings indicate that insufficient financial assistance was the most severe constraint (Garrett score 70.20), followed by errors in Aadhaar and land records, ineffective grievance redressal mechanisms, and delays in registration approval. Limited knowledge of mobile applications was ranked as a lower constraint but remained a significant barrier for effective utilisation of the scheme.

The study concludes that PM-KISAN has primarily benefited farmers from low to medium socio-economic backgrounds; however, strengthening digital delivery systems could maximise the scheme's impact and ensure inclusive farmer empowerment.

Keywords: Digital extension, PM-KISAN, Farmer empowerment



T-2 P-7: Perception of Farmers towards the Benefits of “Pradhan Bima Yojana” Prayagraj (U.P.)

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Pradhan Mantri Fasal Bima Yojna (PMFBY) is a crop based insurance scheme launched to provide financial support to farmers suffering from crop loss/damage. The present investigation was carried out in two blocks of Prayagraj district of Uttar Pradesh. This was selected through purposive sampling based on higher number of PMFBY beneficiaries. Proportionate random sampling methods were used to select 360 respondents for the Present study. Pre-structured interview schedule were used to collect primary data and appropriate statistical tools were used to draw logical conclusion. The study inferred that majority of the respondents having medium level of socio-economic profile followed by low and high level. It was observed that 54.72 per cent respondents have medium perception followed by 30.28 per cent low perception and only 15.00 percent have high perception towards Pradhan Mantri Fasal Bima Yojana. Education, income, land holding, occupation, risk bearing capacity, mass media exposure and extension contact were found positively associated with the perception of the respondents towards PMFBY.

KeyWords: Perception, PMFBY

T-2 P-8: Empowering farmers through digital initiatives

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Empowering farmers through digital technologies are pivotal for sustainable agriculture, livelihood security, and inclusive growth, addressing climate variability, market fluctuations, and information gaps. Initiatives like Kisan Suvidha, Farmer Mobile App, e-NAM, PM-KISAN, and Kisan Sarathi revolutionize extension services by providing real-time advisories, market linkages, and financial support.

These tools provide quality seeds, real-time advice, expert guidance, and direct financial support slashing risks from poor inputs, accelerating better practices, and boosting crop productivity. PM-KISAN alone covers over 140 million farmers, providing ₹6,000 annually through direct benefit transfer, thereby strengthening financial stability and reducing dependence on informal credit sources. Kisan Sarathi's multilingual advisories enhance decision-making and self-reliance, while awareness depends on education, infrastructure, and demographics.

Challenges include poor internet, low digital literacy, and limited awareness in remote areas. Solutions demand stronger infrastructure, training, and localized support. These platforms boost resilience, productivity, and informed choices, ensuring India's sustainable food security.

Key words: Empowering farmers, Digital initiatives, Digital literacy



T-2 P-9: Beyond Traditional Technology Transfer: One-Way to Two-Way Knowledge Exchange

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The shift from transfer of technology to digital knowledge exchange represents moving from a linear, one-way delivery of technical packages (lab-to-land) to a collaborative, two-way interactive process where farmers and researchers co-create solutions using digital tools like AI and social media. Recent advancements demonstrate a transition from basic ICTs to advanced AI and Big Data analytics in agricultural extension, enabling precision agriculture. This approach utilizes large datasets to provide real-time, predictive insights. Key developments include AI-driven advisory systems for improved decision-making, predictive modelling for pest outbreaks and irrigation optimization, and big data integration for smart farming, leading to higher yields and reduced resource usage. India's success in digital extension highlights the impact of mobile-based advisory services, which have led to a measurable increase in farmer's income by 15% through initiatives like mKisan and Kisan Suvidha. While these programs have achieved significant reach and economic returns, with every rupee spent yielding approximately four rupees in increased farm income, infrastructure challenges pose significant barriers to the adoption of advanced digital tools. Key issues include a lack of reliable internet access, particularly in rural areas, poor connectivity, and inconsistent electricity supply, which create a 'digital divide', limiting the effectiveness of these services for low-income farmers. The emergence of 'Hybrid Extension Systems' in agricultural extension, which integrates AI's scalability with the essential human touch. While digital tools enhance efficiency, they often lack the persuasive power needed for farmers to adopt novel practices. Research shows that blended approaches, combining digital aids with local human agents, can boost knowledge dissemination by 40%. Successful examples, like 'Digital Green', illustrate that while AI ensures scientific accuracy, human facilitators provide social trust and contextual relevance, essential for overcoming resistance to change among farmers.

Key words: Digital Knowledge, Digital Divide, Hybrid Extension



T-2 P-10: Empowering Farmers through Digital Extension and Education for Atmanirbhar Bharat: Challenges and Opportunities

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Digital extension and education have emerged as pivotal strategies for empowering farmers in India on the pathway to Atmanirbhar Bharat (self-reliant India), by bridging information gaps, enhancing decision-making, and facilitating access to markets, inputs, and services. The Government of India's Digital Agriculture Mission, launched with an initial outlay of approximately ₹2,817 crore, aims to build a robust digital public infrastructure (DPI) that integrates tools like AgriStack, crop estimation surveys, decision support systems, and farmer digital identities, to deliver timely and targeted agricultural services across the country. This mission not only establishes a unified digital ecosystem but also strengthens extension delivery by leveraging ICT (Information and Communication Technologies) to disseminate weather forecasts, market prices, pest alerts, soil health information, and personalised advisories to farmers, regardless of their location. Despite these advances, India continues to face significant challenges: rural internet penetration and digital literacy remain barriers, with only about 45 % of rural households having internet access, and many small and marginal farmers lacking the skills required to use digital tools effectively, compounded by infrastructure constraints such as unstable connectivity and power supply. Addressing these gaps is critical, particularly considering that nearly 89 % of agricultural households own less than two hectares of land, limiting their capacity to invest in digital technologies at scale. Studies have shown that digital extension interventions enhance productivity and profitability farmers accessing ICT-driven advisories often achieve notable yield improvements and optimisation of input use, thereby contributing to resilient and sustainable agricultural practices. To fully realise the potential of digital extension in empowering farmers for Atmanirbhar Bharat, concerted efforts are needed in policy support, capacity building, inclusive digital literacy programmes, and multi-stakeholder collaboration, ensuring that digital transformation reaches even the most resource-constrained farming communities.

Keywords: Digital Extension; Agricultural Education; Atmanirbhar Bharat; Digital Agriculture Mission; Farmer Empowerment; ICT in Agriculture



T-2 P-11: Socio Economic and Demographic analysis of Vishunpur Village of Gorakhpur District

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This study undertakes a comprehensive socio-economic and demographic analysis of Vishunpur village in Gorakhpur district, Uttar Pradesh, through the application of Participatory Rural Appraisal (PRA) techniques. Organized by Krishi Vigyan Kendra (KVK), Belipur, the study captures a multi-dimensional profile of the village, encompassing landholding patterns, cropping systems, literacy levels, livestock assets, technological penetration, and infrastructural status. The PRA approach enabled active community involvement in identifying key developmental gaps and potential interventions. The findings indicate that despite a strong literacy rate and increasing access to farm mechanization and ICT tools, significant challenges persist in terms of land fragmentation, irrigation facilities, and support for marginalized groups such as Scheduled Castes. The study contributes actionable baseline data to aid policy makers, planners, and development agencies in crafting targeted and inclusive rural development strategies.

Keywords: Participatory Rural Appraisal, Socio-economic analysis, Vishunpur village, Agricultural productivity, Rural development, Krishi Vigyan Kendra, Livelihood, Infrastructure, ICT, Demographic study



T-2 P-12: Adoption of Natural Farming Practices in Chickpea Crop among the Tribal Farmers

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Natural farming is a chemical-free farming method that aligns with ecological principles, working in harmony with nature. Key practices include using Jeevamrit and Beejamrit. Other techniques involve mulching (Achhadana), intercropping and using local seeds. Natural bio-pesticides such as Neemastra, Agniastara and Bramhastra are effectively used for pest control. These methods help improve soil fertility and reduce dependency on chemical inputs. The present study was conducted during 2024-25 in twelve selected villages from three blocks namely Barwani, Niwali and Pati in Barwani district of Madhya Pradesh. A total of 120 respondents were chosen for the research, selecting ten farmers from each village through a simple random sampling method. Data collection was done using a structured personal interview schedule. The findings revealed that a majority(56.67%) of the respondents had a medium level of adoption, followed by(26.67%) with low and (16.66%) with high adoption levels. The adoption of natural farming practices showed significant positive correlations with factors such as education, landholding size, income, extension participation, access to information sources and knowledge levels. The study concluded that enhancing education and targeted extension interventions can further promote the adoption of natural farming among tribal farmers, leading to improved sustainability in chickpea cultivation.



T-2 P-13: Mushroom Lady of Bihar towards Atmanirbhar Bharat

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Bina Devi's inspiring journey from poverty to posterity in Tikari village, Bihar. Demonstrates the transformative power of agricultural innovation and community leadership. Initially struggling on ₹ 30,000-40,000 annually through traditional farming, Bina Devi transformed her life when Bihar Agricultural University introduced mushroom cultivation to her village in 2013. Starting with just ten mushroom bags due to lack of space in her home, she used the space under her bed, she applied the training skills she received with remarkable dedication and creativity. Within year, her annually income grew from ₹50,000-60,000per mushroom cycle to over ₹5-6 lakh combining mushroom farming, with other agricultural activities. Beyond personal success, having educated more than 70,000 farmers and women across multiple districts. She established 12 mushroom grower with 142 members predominantly women connected to Self-Help Groups under JEEVIKA.

In recognition of her outstanding contribution to women-led rural development, she was conferred the prestigious Nari Shakti 8th March,2020 On the occasion of International women's Day by Shri Ram Nath Kovind, Hon'ble President of India. Following this honor, she become widely famous as the "Mushroom Lady of Bihar"(Mushroom Mahila) for empowering more than 1,500 rural women across 105 villages in Munger district through mushroom cultivation.

During the COVID-19 pandemic, she trained returning migrant workers in mushroom cultivation at quarantine centres, providing crucial livelihood support during. Looking ahead, she plans to develop value-added mushroom products like mushroom biscuits, pickles, and dried powder and other related products for both local and online markets. Her remarkable story exemplified how knowledge transfer, determination, and community engagement can create sustainable rural livelihoods, empowerment women farmers.



T-2 P-14: Application of Silage technology for Sustainable Dairy Food Systems Under Field Conditions

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Seasonal scarcity of green fodder is a major constraint affecting sustainable dairy production, particularly in tribal regions. Silage making is an intelligent fodder conservation technology that enables efficient utilization of surplus green fodder, ensures year-round feed availability and improves productivity of dairy animals. Thus, a Frontline Demonstration (FLD) was conducted to evaluate the impact of silage on milk yield, milk quality and economics of buffalo production under field conditions. A silage bag was distributed to 20 buffalo farmers for green fodder conservation, and the feeding trial was conducted for a period of 60 days. Milk yield was recorded at 10-day intervals and compared with pre-demonstration values. The results revealed that average milk yield increased from 6.9 litres/day before silage feeding to 8.1 litres/day after 60 days, showing an overall increase of 16.74 per cent. Progressive improvement in milk yield was observed throughout the experimental period, indicating better nutrient availability and palatability of silage. In addition, milk quality parameters showed improvement, with fat percentage increasing from 6.9 to 8.1 per cent, leading to enhanced fat yield and FCM, which increased from 1.44 to 1.61 kg. Economic analysis demonstrated the profitability of silage feeding. The gross cost of feeding under demonstration was Rs. 288.70, while the gross return increased to Rs. 400.40, resulting in a net return of Rs. 111.70 and a benefit-cost ratio (BCR) of 1.39, compared to a BCR of 1.25 under farmers' practice. Improvement in milk fat content also resulted in a higher milk price realization at the dairy level. The study clearly indicates that adoption of silage technology using silage bags is a viable, cost-effective and sustainable approach for addressing green fodder scarcity and enhancing milk productivity in buffaloes. The demonstrated technology has strong potential for large-scale adoption among small and marginal farmers in tribal and fodder-deficit regions.

Keywords: Silage technology, Frontline demonstration, Milk yield, Economic analysis



T-2 P-15: Farmers' Perception of Fertilizer Use: Insights for Sustainable Food Systems and Digital Extension

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The imbalanced use of chemical fertilizers has become a critical challenge affecting soil health, environmental sustainability, and human well-being, thereby posing a serious threat to sustainable food systems. Farmers' perception of these effects plays an important role in shaping fertilizer use behaviour and the adoption of sustainable nutrient management practices. In this context, the present study studied the perception of farmers regarding the consequences of imbalanced fertilizer use on human health and the environment in Telangana state. The study was conducted using a multistage sampling technique across six districts representing major field crops, namely paddy, cotton, maize, red gram, soybean, and Bengal gram. From twelve mandals and thirty-six villages, a total of 360 farmers were selected through random sampling. Data were collected using a structured perception schedule and analysed using descriptive statistics and non-parametric tests. The results revealed that less than half of the farmers had a medium level of perception regarding the consequences of imbalanced fertilizer use, followed by low to very low and high to very high levels of perception. Crop-wise analysis indicated that medium perception levels predominated across all crops studied. Paddy farmers recorded the highest mean perception score, while red gram farmers recorded the lowest. However, the Kruskal–Wallis test showed no significant difference in perception levels among farmer groups, indicating a uniform perception pattern across crops. Farmers exhibited relatively higher awareness of issues such as soil nutrient buildup, harm to beneficial soil organisms, and increased pest and disease susceptibility, whereas perception was notably low regarding soil salinity, soil acidity, and the long-term economic costs of soil remediation. The findings point to critical gaps in farmers' understanding of the long-term environmental and health consequences of fertilizer misuse. Addressing these gaps through intelligent digital technologies, such as mobile-based advisories, decision support systems, soil health information platforms, and data-driven nutrient management tools, is essential for strengthening farmer awareness and promoting sustainable food systems.

Keywords: Imbalanced Fertilizer Use, Digital extension, Nutrient management, Environmental impact, Human health



T-2 P-16: Digital extension and education to empower farmers for Atmanirbhar Bharat-challenges and opportunities

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Digital extension and education have emerged as critical instruments for empowering farmers and strengthening agricultural self-reliance under the Atmanirbhar Bharat initiative in India. The concept of Atmanirbhar Bharat encompasses a vision of socio-economic empowerment through indigenous growth and innovation. In this context, digital education emerges as a pivotal tool for realizing this vision (Kusum Lata). The integration of information and communication technologies into agricultural extension systems has transformed traditional knowledge dissemination by enabling timely, location-specific, and cost-effective advisory services to farmers (FAO, 2019). ICTs in enhancing agricultural extension services in India. Agriculture remains the backbone of India's rural economy, and effective extension services are essential for improving farmers' productivity, skills, and knowledge (Sharma *et al.*, 2025). Digital platforms such as mobile advisory services, e-NAM, Kisan Call Centres and decision-support systems have enhanced farmers access to market information, weather forecasts, and best management practices (Meera *et al.*, 2018). Education through digital extension contributes to capacity building by improving farmers' technical knowledge, decision-making ability, and adoption of improved agricultural technologies (Aker, 2017). Despite these advancements, several challenges constrain the effectiveness of digital extension, including the digital divide, low digital literacy, inadequate rural connectivity, and limited institutional capacity. However, significant opportunities exist to strengthen digital extension through convergence of public and private stakeholders, use of artificial intelligence, big data analytics, and community based digital learning models (NITI Aayog, 2021). Farmer Producer Organizations (FPOs) and digital start-ups can play a vital role in bridging information gaps and promoting inclusive digital education (Singh *et al.*, 2022). Thus, digital extension and education hold immense potential to empower farmers, improve productivity, and achieve the vision of Atmanirbhar Bharat through sustainable and inclusive agricultural development (Sharma & Patel, 2020).

Keywords: Digital Extension, Agricultural Education, Farmer Empowerment, Atmanirbhar Bharat, Digital Agriculture, Farmer Producer Organizations (FPOs), Inclusive Development.



T-2 P-17: Constraints in Fertilizer Management among Major Field Crop Growers in Telangana and Strategies for Improvement

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Fertilizers are one of the important inputs for increasing productivity of crops. Recent studies shown wide discrepancies in fertilizer usage. Hence, it becomes necessary to address these issues. Objectives of the study were to identify the constraints in fertilizer management and to develop the suitable strategies to overcome these constraints. Telangana was purposively selected. Six major field crops, paddy, cotton, maize, red gram, soybean and Bengal gram were purposively selected based on maximum area under cultivation. One district was randomly selected for each crop among the cultivating districts. From each district, two mandals, three villages and ten farmers per village were randomly selected among the cultivating mandals, villages and farmers, respectively. Thus, a total of six districts, twelve mandals, thirty six villages and three sixty farmers were selected. Henry Garrett's ranking method was adopted. Results revealed that major constraints were high cost of fertilizers and manures, lack of knowledge on 4R's of fertilizer application, unavailability of manures, timely unavailability of labour and lack of conviction about benefits of fertilizers other than N & P. Fertilizer management can be improved by addressing economic, technical, logistical and psychological barriers through subsidies, credit access, infrastructure and awareness programs.

Key words: Barriers, Manures, NPK, Garrett ranking, Soil health and Suggestions



T-2 P-18: Digital Extension and Education as Catalysts for Enhancing Knowledge and Adoption of Scientific Spices Cultivation Practices

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Digital extension and education have become crucial tools for empowering farmers by enhancing their scientific knowledge and promoting the adoption of improved agricultural practices, essential for realizing Atmanirbhar Bharat. Integrating digital communication tools with traditional extension systems strengthens knowledge dissemination, farmer–scientist linkages and informed decision-making across the spice production value chain. This study was conducted in Chhattisgarh during 2020–21, evaluated the impact of digital-supported extension education on farmers’ knowledge and adoption of scientific spice cultivation practices. A pre–post research design covered 160 spice growers who participated in four capacity-building programmes organized by the Centre of Excellence on Medicinal and Aromatic Plants and Non-Timber Forest Produce, IGKV, Raipur. The interventions combined interpersonal methods with digital communication, educational materials, and continuous advisory support. Findings revealed high adoption for key production practices: field preparation (96.73%), seed/rhizome treatment (91.41%), time of sowing (87.71%), method of sowing (81.06%) and irrigation management (78.60%). Moderate adoption was observed for nutrient management (66.62%), weed management (70.45%), pest management (62.32%), disease management (64.55%), processing (69.53%), marketing (67.22%) and storage (69.95%). Adoption of recommended varieties (62.47%) was comparatively lower. Post-harvest practices reached 72.58%, reflecting increased awareness of value-chain practices. Overall, 74% of respondents were in the medium adoption group, 18% low, and 8% high, highlighting the impact of sustained participation and interaction with extension personnel. The study emphasizes strengthening digital extension through financial support, promotion of low-cost, location-specific technologies, and need-based training to boost adoption. These findings reaffirm the transformative role of digital extension and education in empowering farmers and promoting sustainable spice-based agriculture.



T-2 P-19: Financial Literacy through Digital Extension

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Financial literacy is a crucial component of inclusive and sustainable economic development, particularly in a rapidly digitizing economy like India. In recent years, the expansion of digital financial services such as mobile banking, Unified Payments Interface (UPI), neobanks, e-wallets and government digital initiatives has transformed the way individuals access and manage financial resources. This study examines the concept of financial literacy through digital extension focusing on how digital tools and communication platforms are being used to enhance financial awareness and skills among diverse population groups, especially rural communities, women, youth, and other underserved sections. The study reviews traditional financial education approaches and highlights their limitations in terms of reach, cost, and inclusivity. It further explores the evolution of digital financial services in India, emphasizing key policy initiatives such as Digital India, JAM Trinity, PMJDY, and the rapid growth of UPI-based digital payments. Through an extensive review of national and international research studies, identifies major dimensions of financial literacy including budgeting, savings, digital payments, credit management, investments, insurance, consumer protection, and analyzes how digital extension methods contribute to each of these aspects. Evidence from empirical studies and case examples indicates that digital extension tools such as mobile apps, IVR/SMS services, social media content and neobanks significantly improve financial knowledge when combined with practical, task-based learning. However, challenges such as digital divide, cyber security risks, low digital skills, and trust issues remain significant barriers. The study concludes that digital extension acts as a powerful catalyst for scalable and inclusive financial literacy in India and emphasizes the need for guided digital education, localized content, and institutional support.

Keywords: Financial literacy, Digital extension, UPI, FinTech, Financial inclusion, India, Neobanks , Digital payments , Mobile banking , E-wallets



T-2 P-20: Study the Profile of the Brinjal Growers

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Farmers are using excessive amount of pesticides in a wrong manner with disproportionate dosage, which leads to high cost of cultivation as well as ecological imbalance. The present study was carried out in Akola district of Vidarbha region in Maharashtra State. The results revealed that the majority of the respondents were facing the constraints like lack of knowledge and lack of interest in using preventive measures while handling of pesticide i.e. mask wearing, followed by (98.67%) were unawareness about the toxicity level of pesticide. It was followed by (96.67%) respondent were unaware about safe disposal of residual pesticide bottle, it was seen that for spraying operation 94.67 per cent no skilled labour was available. The 93.33 per cent had lack of knowledge about recommended dose of pesticide.

Keywords: Brinjal, Profile, Maharashtra.



T-2 P-21: Digital Transformation in Agriculture: Pathways to Empower Farmers making India Self-Reliant

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The future of agriculture in India lies in embracing digital transformation, which can significantly enhance the efficiency, sustainability, and resilience of farming systems. The vision of Atmanirbhar Bharat (Self-Reliant India) is intricately linked to empowering farmers through digital technologies that offer solutions for better productivity, resource management, and market access. Digital transformation in agriculture involves the adoption of innovations such as precision farming, IoT-based monitoring systems, data analytics, mobile applications, and e-commerce platforms, all of which have the potential to revolutionize the way farmers operate. Through digital technologies, farmers gain access to real-time information on weather forecasts, soil health, crop management practices, and pest control, enabling them to make informed decisions and reduce dependency on traditional, often inefficient methods. Moreover, digital platforms facilitate direct market linkages, reducing the role of intermediaries, and ensuring better prices for farmers' produce. Furthermore, digital extension services enhance knowledge dissemination, providing farmers with timely guidance and expert advice. Despite the promising potential, the path to widespread digital adoption faces several challenges, including digital illiteracy, lack of internet infrastructure, and limited access to affordable technology, especially in rural areas. Overcoming these barriers requires targeted efforts in digital literacy, improving internet connectivity, and creating affordable tech solutions tailored to the needs of farmers. This abstract explores the transformative role of digital technologies in agriculture, their contribution to empowering farmers, and how they can help achieve the goals of Atmanirbhar Bharat by fostering a self-reliant agricultural sector.

Keywords: Digital Transformation, Atmanirbhar Bharat, Farmer Empowerment, Sustainable Agriculture and E-commerce Platforms.



T-2 P-22: Impact of Soil Health Cards on Fertilizer Use Efficiency and Input Costs among Small and Marginal Farmers

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The Soil Health Card (SHC) Scheme, launched by the Government of India, aims to provide farmers with scientifically based soil nutrient information and customized fertilizer recommendations to promote balanced nutrient application, improve fertilizer use efficiency, reduce input costs, and enhance agricultural sustainability. This study investigates the impact of Soil Health Cards on fertilizer use efficiency and input costs among small and marginal farmers, focusing on changes in fertilizer consumption patterns, cost savings, and nutrient use efficiency after adopting SHC-based recommendations. Empirical evidence from national studies shows that following SHC guidance has led to a significant reduction in chemical fertilizer use about 8–10% overall alongside a shift toward balanced application that improves nutrient use efficiency and crop productivity. Further research indicates that adoption of SHC-based fertilizer recommendations can lead to measurable reductions in production costs, particularly through savings on nitrogenous fertilizers, resulting in lower cost of cultivation for crops such as rice, pulses, and oilseeds. Farmers who apply fertilizers according to soil nutrient status not only reduce unnecessary expenditure on excessive fertilizer use but also benefit from improved efficiency in nutrient uptake, promoting more profitable and sustainable farming operations. Findings from regional studies highlight that SHC adoption enhances input efficiency by reducing over-application of certain nutrients while encouraging balanced fertilizer use, which is particularly beneficial for small and marginal farmers with limited financial resources.

This research underscores the importance of soil testing and advisory services in enabling smallholder farmers to optimize fertilizer use, decrease input costs, and ultimately improve net returns, thereby contributing to more resilient agricultural livelihoods.

Keyword: Soil health card, Fertilizer, Crop productivity



T-2 P-23: Impact of Digital platform on farmers' knowledge, decision making and productivity

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The emergence and widespread adoption of digital technologies have fundamentally transformed the framework of agricultural extension services, enhancing their efficiency, reach and long-term sustainability. The growing use of tools such as smartphones, internet-based platforms, data analytics systems and sensor-driven devices has marked the beginning of a modernized phase in agricultural advisory services. These innovations have facilitated real-time communication, supported evidence-based decision-making and provided farmers with access to extensive and up-to-date agricultural knowledge repositories. The integration of digital platforms has broadened the reach of agronomic knowledge and strengthened farmers' capacity to adopt informed and timely management practices. Through digital extension services, farmers gain timely access to information on crop management, weather, pest and disease alerts, fertilizer use and sustainable practices increasing their technical knowledge and ecological knowledge. By reducing the digital divide, ICT-enabled extension services helps to ensure more equitable access to agricultural information, ultimately improving productivity and promoting sustainability. Digital tools play a key role in closing information gaps, thereby enhancing farm efficiency, profitability, and long-term resilience. The inclusion of local language interfaces allows farmers from diverse linguistic backgrounds to easily comprehend and utilize the guidance offered, significantly increasing the usability and overall impact of these platforms. Tailoring agricultural information to specific regions addresses various farming practices and challenges, enhancing relevance and adoption, also empower the farmers with actionable insights that supports sustainable agricultural development. In conclusion, a digital platform substantially enhances farmers' knowledge, their decision making and boost productivity & sustainable practices but realizing their full potential requires improving digital literacy, infrastructure, and inclusive access.

Keywords: Digital agriculture, digital platforms, digital extension services, ecological technology adoption, farmer's decision-making, ICT-based extension, knowledge dissemination



T-2 P-24: Utilization Pattern and Profile Characteristics of Farmers Using Digital Communication Technologies in Agriculture in Punjab

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The study was undertaken to examine the utilization patterns and profile characteristics of farmers in relation to the use of Digital Communication Technologies (DCTs) in agriculture across Punjab. Research was conducted in Ludhiana and Sri Muktsar Sahib districts, representing the central and south-western agro-climatic zones of the state. An ex-post-facto research design was employed, with 180 respondents randomly selected from twelve villages. Only farmers actively engaged in agricultural operations and possessing smartphones with internet connectivity were included. Data were collected using a pre-tested structured interview schedule and analysed with appropriate statistical tools.

Findings revealed that the majority of respondents were in the middle age group (59.00%) and had educational qualifications up to the senior secondary level (45.33%). Most farmers possessed small to medium landholdings (62.44%) and had 10–15 years of farming experience (62.78%). Regarding DCT utilization, Information shared through WhatsApp groups, YouTube channels, and SMS-based weather forecast advisories or use of mobile applications were the most frequently accessed platforms, primarily for crop cultivation practices, pest and disease management, market price information, and weather forecasts. Furthermore, most respondents demonstrated medium levels of digital awareness (65.56%), extension contact (66.11%), innovativeness (60.56%), scientific orientation (58.89%), and risk bearing capacity (53.33%). However, the awareness regarding eNAM portals, Decision support systems, E-commerce platforms were found to be low. These results highlight significant potential for strengthening digital extension interventions to enhance agricultural communication and decision-making among farmers in Punjab.

Keywords: Digital Communication Technologies (DCTs); mobile applications; weather forecast advisories; WhatsApp; YouTube; utilization patterns; profile characteristics; digital awareness; innovativeness; scientific orientation; market information etc.



T-2 P-25: A Comparative Economic Analysis of Solar and Electric Irrigation Pumps under PM-KUSUM

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Reliable and affordable energy for irrigation is critical for enhancing agricultural productivity and sustainability in India. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme was introduced to promote solar-powered irrigation as an alternative to conventional electric and diesel pumps. This study undertakes a comparative assessment of the economic performance and perceived impacts of solar and electric water pumps under the PM-KUSUM scheme in Hanumangarh district of Rajasthan. A multistage sampling design was adopted, covering 180 farmers from twelve villages, including beneficiaries and non-beneficiaries of the scheme. Economic viability was evaluated using payback period (PBP) and benefit–cost ratio (BCR), while perceived impacts were analyzed across technological, social, psychological, environmental, and crop productivity dimensions using a Likert-based scale. The results indicate that solar water pumps exhibit a significantly shorter payback period (2.07 years) compared to electric pumps (5.20 years), reflecting faster recovery of initial investment. The benefit–cost ratio was also higher for solar pumps (2.82) than for electric pumps (1.91), confirming their superior long-term economic viability. Beneficiary farmers reported high levels of agreement regarding environmental sustainability, reduced irrigation costs, improved crop productivity, and enhanced energy security, although moderate perceptions were observed for administrative procedures and time-saving aspects. The study provides location-specific evidence to support policy efforts aimed at strengthening implementation mechanisms, improving service delivery, and accelerating the adoption of solar irrigation technologies in Indian agriculture.

Keywords: PM-KUSUM; Solar water pumps; Economic analysis; Benefit–cost ratio; Payback period



T-2 P-26: Digitalization for empowerment of Farmer Producer Organizations (FPOs)

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Agriculture remains foundational component of Indian economy, providing livelihoods to majority of its population. Yet the sector continues to face long-standing constraints such as low productivity, fragmented landholdings, weak market linkages, and inadequate infrastructure. These challenges disproportionately affect small and marginal farmers, who constitute the bulk of the workforce. In response, Farmer Producer Organizations (FPOs) have gained prominence as an institutional mechanism to promote collective action, improve access to quality inputs, strengthen bargaining power, and enhance market opportunities. The growing integration of digital technologies has further expanded the role of FPOs. Mobile applications, online trading platforms, and data-driven advisory systems now enable real-time information flow, streamlined resource management, and improved profitability. Government initiatives such as National Agriculture Market (eNAM) provides an electronic marketplace for more than 4,300 FPOs and the Pradhan Mantri Formalization of Micro Food Processing Enterprises (PM FME) scheme supports FPOs with credit-linked subsidies and market facilitation. Similarly, the National Policy on FPOs offers structured framework for their establishment, capacity development, and financial support. Public-private partnerships also contribute through technology deployment, training, and co-financing of digital infrastructure. Digital financial tools and services such as mobile wallets, UPI-enabled payments, and blockchain-based credit systems promote transparency and reduce transaction delays. UPI adoption among farmers rose to 43% in early 2024, compared with 18% in 2022, indicating rapid uptake of digital finance within agricultural markets.

Despite these advancements, several barriers persist, including unreliable internet and power supply, limited digital literacy, concerns over data privacy, and socio-cultural resistance to technological change. Overcoming these challenges demands coordinated efforts by government agencies, private companies, and civil society to strengthen infrastructure, build digital capacities, ensure data protection, and deliver context-specific extension services. Such a holistic approach is essential for maximizing the transformative potential of digital technologies in empowering FPOs and smallholder farmers.

Keywords: Farmer Producer Organizations, Agriculture, Farmer, Market linkage



T-2 P-27: Extension and Education through ICT to Empower Farmers towards Atmanirbhar Bharat: Challenges and Opportunities - A Review

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Digital extension and digital education are emerging as critical enablers for empowering farmers in the era of knowledge-driven and technology-intensive agriculture. In India, the vision of Atmanirbhar Bharat emphasizes self-reliance, resilience and sustainability across sectors, with agriculture playing a pivotal role. Digital technologies such as mobile advisory services, e-learning platforms, artificial intelligence, big data analytics, geospatial tools and social media are transforming agricultural extension and education systems by enhancing access to information, improving decision-making and strengthening farmer capacities. Significant progress has been made through initiatives such as mobile-based advisories, online training programmes, digital knowledge repositories and virtual extension platforms, which bridge spatial, temporal and institutional gaps. However, challenges including digital divide, low digital literacy, infrastructural limitations, content localization and institutional preparedness continue to constrain the effectiveness of digital extension and education. This paper critically examines the role of digital extension and education in empowering farmers, analyses challenges and opportunities, and suggests strategic interventions to strengthen farmer-centric digital ecosystems. The study highlights that inclusive, participatory and capacity-oriented digital extension systems are essential for achieving sustainable agricultural development and realizing the goals of Atmanirbhar Bharat.

Keywords: Digital Extension, Digital Education, Farmer Empowerment, Atmanirbhar Bharat, Sustainable Agriculture



T-2 P-28: Knowledge, Attitude and Practice (KAP) of Vegetable Growers on Pesticide Safety: Levels, Drivers and Constraints

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A rigorous synthesis of prior studies indicates that vegetable cultivation is largely undertaken by middle-aged, small and marginal farmers with low to moderate formal education, moderate farming experience, and dependence on informal information sources—especially input dealers. Across contexts, chemical plant protection remains dominated by broad-spectrum insecticides (notably organophosphates and pyrethroids), with frequent over-dosing, unsafe mixing, improper storage and disposal, and limited observance of label instructions, pre-harvest intervals and personal protective equipment (PPE), increasing residue and exposure risks. Most studies report medium-to-low safety knowledge and mixed attitudes: farmers often acknowledge hazards yet continue risky practices due to perceived yield/income loss, limited training exposure and weak extension contact. The literature therefore highlights a persistent knowledge–practice gap shaped by education, training access and the information ecology. Accordingly, an expert-informed strategy is warranted, combining risk communication, hands-on capacity building, affordable PPE, safe storage/disposal infrastructure, and promotion of IPM/GAP, supported by Delphi-based consensus to prioritise locally feasible interventions and monitoring indicators.

Keywords: Vegetable growers; Pesticide safety; Knowledge–attitude–practice; PPE; Delphi technique





Theme III : Oral

Digital tools to ensure sustainable food systems-opportunities and challenges





T-3 O-1: Analysis of Digital Divide in Agricultural Information Dissemination: A Comparative Study of Rural and Urban Ecosystems across Kerala

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Realizing the vision of *Atmanirbhar Bharat* and sustainable food systems necessitates equitable digital empowerment, yet the digital divide remains a critical barrier excluding marginalized farming communities from the benefits of modern agricultural extension. While digital technologies offer transformative global opportunities, their impact varies significantly across local contexts. This study investigates the magnitude and determinants of the digital divide in agricultural information dissemination between rural (Panchayat) and urban (Municipality) ecosystems in Kerala.

Operationalizing the digital divide as disparities in access, skills, and utilization, the study employed a composite *Digitization Index (DI)* comprising five weighted dimensions: ICT ownership, accessibility, digital literacy, frequency, and quality of use. Primary data were collected from 300 farmers across three distinct Agro-Ecological Zones (High Hills, Coastal Plains, and Midland Laterites), equally categorized into rural (n=150) and urban (n=150) groups.

The extent of the divide was analyzed using an independent sample t-test, which confirmed a substantial asymmetry. Urban farmers exhibited a high mean digitization index of 49.83, whereas rural farmers lagged significantly at 34.12, resulting in a digital gap of 15.71 ($t=18.63$, $p<0.001$). To empirically disentangle the drivers of this disparity, a three-fold Blinder-Oaxaca decomposition was performed. The results revealed that endowments (resource differences like income/education) explained only 19.6% of the divide. In contrast, the interaction effect accounted for the largest share (71.2%), indicating a "double disadvantage" where rural farmers not only lack critical assets but also fail to realize returns on the assets they do possess due to ecosystem failures. Specifically, while determinants like ICT awareness and IT savviness showed high potential returns, their interaction effects were strongly negative. These findings imply that advancing digital extension requires shifting focus from mere infrastructure distribution to building supportive rural ecosystems that cultivate high-value digital skills.

Keywords: Digital Divide, Blinder-Oaxaca Decomposition, Digitization Index, Agricultural Information, Rural-Urban Gap.



T-3 O-2: The Role of Artificial Intelligence in Sustainable Agriculture

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With the growing population and rapid urbanization there is immense increase in the demand for food. The pressure on the farmers to meet these demands is increasing while facing various challenges. Currently, the agricultural practices are moving towards use of artificial intelligence over conventional methods to achieve sustainable food production. Agricultural sustainability refers to the ability of agricultural systems to adequately maintain productivity so as to satisfy the demands of current generation without endangering the capacity of next generation to satisfy their needs.

Artificial intelligence (AI) is one of the digital technologies and its use in agriculture is immensely increasing (Ryan et al., 2023). With this, farmers can use inputs more effectively and maximize the agricultural outputs (Vijaykumar et al., 2022). AI tools efficiency and data dependability indicate the agriculture industry's growth and potential (Mathur et al., 2023).

In the field, AI can be used for pest control and it can also save time by spraying the pesticide over crops using drone technology (Javaid et al., 2023). AI and remote sensing can enable large-scale monitoring of soil conditions. This helps assess the soil quality, and its improvement can lead to high crop yields (Mathur et al., 2023). AI can be used to monitor the planting process in real-time and make adjustments ensuring the best possible conditions, like areas with higher nutrient content or better water availability, reducing risk of crop failure (Linaza et al., 2021; Shadrin et al., 2020).

Use of AI in agriculture has its own benefits and challenges. It aids farmers in comprehending and analysing data such as solar radiation, wind speed, temperature and precipitation. The challenges in using AI include lack of response time and accuracy, AI systems are internet based and their application is limited especially in rural or isolated areas (Tanveer et al., 2022). The paper discusses the scope of AI applications for future foods and various challenges to be addressed.



T-3 O-3: Mobile-Based Digital Extension for Goat Farming: An Impact Assessment of the “Goat Guru” App

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The livestock sector plays a critical role in strengthening rural livelihoods and nutritional security in India; however, the effectiveness of conventional extension systems is often constrained by limited manpower and high farmer-to-extension personnel ratios. Mobile-based digital extension platforms offer a scalable and cost-effective solution to bridge this information gap. The present study assessed the impact of the “Goat Guru” mobile application as a digital advisory tool for goat farming in Mirzapur district of Uttar Pradesh, with emphasis on knowledge enhancement and utilization behaviour among farmers. The study was conducted among 80 goat farmers using a before-and-after research design. Primary data were collected through a structured interview schedule and analysed using descriptive and correlational statistical techniques. The findings revealed that a majority of the respondents were middle-aged (66.40%) and male (93.80%), possessing medium levels of education, media exposure, and extension contact. Nearly three-fourths (75.00%) of the respondents perceived the mobile application as moderately effective in meeting their information needs related to goat husbandry practices. A significant improvement in knowledge levels was observed among users, particularly those with stronger extension contact ($r = 0.405$, $p < 0.001$). Further, the effectiveness of the application showed a significant positive association with herd size and income from goat rearing ($r = 0.307$, $p < 0.01$), indicating the influence of economic attributes on ICT adoption. The study underscores the potential of mobile-based digital extension tools in enhancing farmers’ technical knowledge, supporting informed decision-making, and improving productivity in small ruminant farming systems. Strengthening content customization, capacity building, and institutional outreach can further enhance the role of digital advisory services in achieving sustainable food systems and advancing the vision of Atmanirbhar Bharat.

Keywords: Digital extension, ICT, Goat farming, Knowledge gain, Mobile advisory services



T-3 O-4: Digital Technologies, Urban Occupations, and Nutrition Transitions: Evidence from Online Food Purchasing

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Rapid urbanisation and digitalisation are reshaping India's food systems by transforming how households access, purchase, and consume food. Using nationally representative NSS 2022–23 data from 190,261 urban households, this study examines how urban occupation influences online food purchasing (OFP), dietary diversity, internet access, and processed food consumption. A multinomial IPWRA framework is applied to address selection bias and estimate the causal effects of different occupational groups relative to casual labourers. The findings show that self-employed and regular salaried households are significantly more likely to engage in online food purchasing—by 7.8 and 9.4 percentage points, respectively—while the “others” category shows a similar 7.6-point increase. Occupation also strongly predicts dietary diversity: self-employed and salaried households exhibit higher HDDS scores (0.124 and 0.121 units), whereas non-working groups show marginal declines. Digital inclusion mirrors these disparities, with formal workers being 15–17 percentage points more likely to have internet access. Processed food expenditures also rise sharply among higher-income occupational groups, whose spending on both served and packaged processed foods substantially exceeds that of casual labourers. Overall, the study highlights occupation as a major determinant of digital adoption, diet quality, and food environment transitions in urban India, with casual labourers remaining the most disadvantaged.

Keywords: Urban occupation; online food purchasing; dietary diversity; digital access; processed food consumption; IPWRA; NSS; nutrition transition.



T-3 O-5: Social Networking in Agriculture: Relevance in Rural India

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Social networking is becoming an important part of agricultural life in rural India, helping farmers access information quickly and connect with others beyond their immediate village. Studies show that a large majority of farmers (more than 84.00 %) use mobile phones and social media to get agriculture-related information, with platforms like WhatsApp, YouTube, and Facebook among the most frequently used for communication and learning about farming practices, weather, pests, and markets. In rural areas where traditional extension services are often limited, social networks help farmers share real-time insights, photos, and videos, learn from peers and experts, and discuss practical solutions in local language groups. For example, many farmers use WhatsApp groups daily to ask questions and share crop updates, while YouTube is popular for instructional videos on technique and crop care. However, challenges like unequal digital access, varying levels of digital literacy, and occasional misinformation remain, particularly in remote communities. Despite this, the potential of social networking to complement traditional extension systems and bridge information gaps in rural India is significant, especially as smartphone ownership and data access continue to grow.

Key Words: Extension and Advisory Services, Networking, Rural India, Social Media



T-3 O-6: From Information Access to Actionable Intelligence: Challenges and Opportunities in Transitioning to 'Phygital' Extension Models for Indian Smallholders

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The pursuit of Atmanirbhar Bharat within the agricultural sector has catalyzed a shift from traditional knowledge dissemination to a sophisticated digital extension ecosystem. However, for India's 120 million smallholders, the primary challenge remains the transition from passive "information access" to "actionable intelligence" the ability to receive and implement site-specific, real-time data for improved decision-making. This study explores the emergence of the 'Phygital' (Physical + Digital) extension model as a transformative strategy to bridge the existing digital divide. By integrating the human-centric trust of Krishi Vigyan Kendras and Farmer Producer Organizations (FPOs) with advanced technologies like AI-driven diagnostics, AgriStack, and IoT-enabled precision tools, the phygital approach addresses the critical barriers of digital illiteracy and the "trust deficit" found in purely automated systems. A systematic review of current interventions reveals that while structural challenges such as inconsistent rural connectivity and the need for vernacular-based interfaces persist, phygital models significantly enhance technology adoption rates by up to 50% compared to traditional methods. The paper concludes that true farmer empowerment and self-reliance are predicated on a decentralized socio-technical framework where digital tools are localized and facilitated by community-led intermediaries. Ultimately, fostering this hybrid ecosystem is essential for translating high-level policy goals into measurable improvements in crop yields, resource efficiency, and market profitability for the Indian smallholder.

Keywords: Phygital Extension, Actionable Intelligence, Atmanirbhar Bharat, Smallholder Empowerment, AgriStack



T-3 O-7: Does Buying Food Online Improve Dietary Diversity and Nutrient Intake: The case of Indian Households?

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This study investigates whether online food purchasing improves dietary diversity and nutrient intake among Indian households, using nationally representative data from the Household Consumer Expenditure Survey (HCES) 2023–24 covering 190,261 urban households. Although only 6.9% of households report purchasing food online, digital platforms are rapidly reshaping food acquisition patterns. To estimate causal effects while addressing selection bias, the analysis employs an Inverse Probability Weighted Regression Adjustment (IPWRA) approach. Dietary outcomes include the Household Dietary Diversity Score (HDDS), dietary concentration measured by the Herfindahl–Hirschman Index (HHI), daily per capita intake of calories, protein, and fat, and expenditure on served prepared and packaged processed foods. The results indicate that online food purchasing significantly increases dietary diversity and reduces dietary concentration, reflecting more diversified food baskets. Online purchasers also experience modest but significant increases in calorie, protein, and fat intake. However, online purchasing leads to substantially higher spending on processed and ready-to-eat foods, indicating a shift toward convenience-oriented consumption. The findings highlight both nutritional gains and emerging dietary risks associated with digital food markets in India.

Keywords: Online food purchasing; Dietary diversity; Nutrient intake; Processed foods; IPWRA; Household consumption; Digital Access



T-3 O-8: Blockchain Technology for Transparency, Efficiency and Precision in Seed Distribution: A Successful Intervention in Jharkhand

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Ensuring timely, transparent and efficient distribution of quality seed is a critical prerequisite for enhancing agricultural productivity and farmer welfare; however, conventional seed supply systems in many regions continue to suffer from structural inefficiencies, including leakages of subsidized inputs, record manipulation, delays in delivery and limited accountability. In response to these challenges, the Government of Jharkhand launched a pioneering blockchain-based seed distribution system in 2022, becoming the first Indian state to operationalize a production-grade blockchain platform for agricultural input management. The design, implementation and outcomes of this intervention were developed in partnership with SettleMint, wherein all major stakeholders viz. seed producers, state agriculture authorities, distributors, LAMPS, PACS, FPOs, extension personnel and farmers are integrated into a decentralized digital network. The system employs Aadhaar-linked farmer registration and OTP-based authentication to ensure accurate beneficiary identification and prevent duplication, while every transaction from seed allocation to final delivery is immutably recorded, enabling complete traceability, real-time monitoring and automated subsidy settlement through smart contracts. The intervention has produced substantial operational improvements, reducing distribution time from 3–4 weeks to 5–7 days, lowering administrative costs by nearly 30 percent and virtually eliminating transaction errors. Precision targeting has minimized input wastage by 25–30 percent and contributed to a 15–20 percent increase in crop productivity, while also strengthening farmer trust and institutional credibility. To date, more than three lakh farmers, 600 LAMPS/PACS and private distributors, and 160 FPOs have been registered on the platform, with over 30,000 quintals of seed distributed during the recent Kharif season. The Jharkhand experience demonstrates that blockchain technology can fundamentally transform agricultural extension and public service delivery by enhancing transparency, efficiency and precision, offering a scalable and replicable governance model for strengthening agricultural input systems across India.



T-3 O-9: AI Application in diagnostics, decision support and prediction for transforming agricultural landscape

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Indian agriculture is currently at a critical juncture, confronted with persistent challenges including climate variability, fragmented landholdings, degradation of natural resources, increasing pest and disease incidence, and high market volatility. In this complex context, Artificial Intelligence (AI) is emerging as a transformative enabler, offering advanced capabilities for data-driven diagnostics, decision support, and predictive analytics to enhance agricultural productivity, resilience, and sustainability. AI-based diagnostic applications in India are increasingly being deployed for the early detection of crop diseases, pest infestations, nutrient deficiencies, and soil moisture stress through the use of machine learning algorithms, computer vision, remote sensing technologies, and IoT-enabled sensors. These tools facilitate timely and precise interventions, thereby optimizing input use and reducing production costs, particularly under precision agriculture initiatives aligned with national digital agriculture missions. AI-powered predictive analytics are being utilized to forecast crop yields, weather-related risks, irrigation requirements, and price trends, supporting proactive and risk-informed decision-making by farmers, extension systems, and policymakers. Furthermore, AI-driven decision support systems integrate agronomic, climatic, and socio-economic datasets to generate localized and personalized advisories delivered through mobile applications, chatbots, and digital extension platforms such as m-Kisan and various state-level initiatives. These innovations significantly improve access to real-time advisory services for small and marginal farmers, who dominate India's agrarian structure. AI is also reshaping agricultural education and capacity building by enabling personalized learning pathways, virtual simulations, and data-driven training for students, extension personnel, and agri-entrepreneurs. However, the widespread adoption of AI in Indian agriculture remains constrained by uneven digital infrastructure, limited AI literacy, data quality concerns, affordability barriers, and unresolved issues related to data privacy, transparency, and inclusiveness. Addressing these challenges through coordinated investments in infrastructure, human capacity development, farmer-centric AI design, and robust governance frameworks is essential to ensure that AI-driven innovations translate into equitable, resilient, and sustainable agricultural transformation in India.

Keywords: Artificial Intelligence, Decision Support System, Precision Agriculture, Climate-Smart Agriculture and Sustainable Agriculture.



T-3 O-10: RuPS : Rural Participatory Sensing with Rewarding Mechanisms for Crop Disease Monitoring”

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Due to devastating impact of crop diseases, it becomes significantly important to monitor the situation on the farms by collecting real incidences for providing on-time alerts to the farmers. We have proposed a novel Event based Rural Participatory Sensing (RuPS) framework for agricultural crop disease monitoring which rewards farmers using Multi Criteria based Decision Making (MCDM) based rewarding scheme. In our work, we use MCDM schemes by proposing novel benefit and cost attributes for determining performance scores and ranks of participants in rural sensing applications. Presented Multi-Criteria Decision Making based rewarding mechanism by computing Event and GIS based attributes from real data obtained by RuPS application. The proposed TOPSIS-AHP reward mechanism has shown significant distinction between the scores of the participants

Key Words: RuPS: Rural Participatory Sensing

T-3 O-11: Sustainable Agriculture through Natural Farming: Opportunities and Challenges

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Farmer's are playing vital role in Natural Farming practices for sustainable development in Agriculture. In selected research district Samastipur, Darbhanga and Gaya of Bihar farmers are preparing for natural fertilizer to enhance soil fertility for sustainable development. They are using beejamrit for Seed Treatment, For Fertilizer purpose Jeevamrit, Ghan Jeevamrit, Pranamrit, Bakramrit (Solid fertilizer), Gajramrit, Sarvamrit, Uplamrit and as in form of Liquid Insecticide: Neemastra, Lohastra, Agnayastra, Brahmastra, Sarvakitnashi, Dasparniarc and for control of Fungicide Shothastra, Lohastra, Pyajastra, Belastra, Mahuastra, Bhumiasta, Mathastra, Compost chay, Tulastra etc. For Viral Rognashi: Hingastra, Vishastra (Spotted wilt Virus) are practicing farm for sustainability. Amrit, Mungamrit is use as Crop Tonic.

Key Words: Natural farming, Sustainable development, Information dissemination]



T-3 O-12: E-Readiness and Utilization Pattern of ICT Tools of Young Farmers in Birbhum District, West Bengal

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In the present era of digital agriculture, Information and Communication Technology (ICT) is rapidly revolutionizing the way in which farmers access information, make decision and connect themselves in knowledge system. Though, young farmers are often perceived as digitally adapt but their accessibility, preparedness and willingness to use ICT tools for agricultural purposes becomes a critical concern in it's adoption. E-readiness plays a critical role in determining how effectively young farmers harness ICT for agriculture. Keeping this in mind, a study was undertaken with 120 randomly chosen young farmers from six villages across three blocks, namely Bolpur-Sriniketan, Illambazar, and Labpurto analyse the digital preparedness of the rural farming youth and how effectively ICT tools are being used in agriculture. This paper is based on the research conducted at BHU Varanasi on e-readiness & utilisation pattern of ICT tools in West Bengal. The study adopted a structured interview schedule to collect information related to socio-personal, economic, and psychological factors, level of e-readiness, utilization patterns of ICT, and constraints. Statistical tools such as frequency, percentage, correlation, regression analysis, ANOVA and mean score ranking technique revealed that young and marginal farmers tend to have mostly medium-level psychological traits and high e-readiness, though agricultural ICT use remained dimensionally uneven. ICT utilization amongst young farmers, particularly for agriculture purposes, fell into the category of low to medium and was mainly bound by weather forecast and pesticide selection. Education, mass media exposure, innovativeness, scientific orientation, and economic motivation had a significant influence on both e-readiness and ICT utilization. Strong positive relationships were observed between e-readiness and ICT use. Despite the widespread availability of smart phones, the adoption rate of ICT tools was quite low mostly limited by lack of capacity building, digital access, and localized content for agricultural ICT adoption.

Keywords: ICT tools, E-readiness, Digital agriculture,



T-3 O-13: Artificial Intelligence as an Intelligent Digital Tool for Ensuring Sustainable Food Systems: An Analysis of Opportunities and Challenges

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The present study was conducted to examine the role of Artificial Intelligence (AI) in ensuring sustainable food systems, with a particular focus on the opportunities offered and challenges encountered in its adoption across the agri-food sector. The study aimed to assess the potential of AI-based technologies in promoting economic, environmental, and social sustainability, while also identifying key constraints limiting their effective implementation. A descriptive and analytical research design was adopted for the study. Primary data were collected from stakeholders associated with agriculture, food systems, research institutions, agribusiness firms, and allied sectors using a structured and pre-tested questionnaire. The study focused on AI applications such as precision agriculture, crop and yield prediction, pest and disease management, smart irrigation, climate risk assessment, and AI-enabled supply chain and traceability systems. Secondary data were collected from published research articles, reports of international organizations, policy documents, and government publications to supplement the primary findings. The collected data were analyzed using appropriate statistical tools, including frequency distribution, percentage analysis, mean score ranking, and inferential techniques. The results revealed that AI technologies significantly contributed to improved decision-making, optimized use of inputs, enhanced productivity, reduced environmental impact, and strengthened resilience of food systems to climate variability. AI-based solutions were perceived as highly effective in supporting sustainable resource management and food security objectives. However, the study also identified several major challenges in the adoption of AI for sustainable food systems. These included high investment and operational costs, inadequate digital infrastructure, lack of technical expertise, data-related issues, ethical and privacy concerns, and unequal access to advanced technologies. The study concluded that while AI holds immense promise for transforming food systems sustainably, targeted policy support, institutional strengthening, capacity building, and inclusive governance mechanisms are essential to overcome existing challenges and ensure equitable and responsible deployment of AI technologies.

Keywords: Artificial Intelligence; Sustainable food systems; Precision agriculture; Resource efficiency; Digital transformation; Opportunities and challenges



T-3 O-14: Development of Decision Support System Framework for FPO Management

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The Government of India launched the Central Sector Scheme for the *Formation and Promotion of 10,000 Farmer Producer Organizations (FPOs)* in 2020–21 to strengthen small and marginal farmers through collective action. Despite their growing importance, FPOs continue to face management challenges arising from fragmented information systems, limited technological capacity, and weak decision-support mechanisms. In this context, the present study aimed to assess the decision-making needs of FPOs in Arunachal Pradesh and to design a context-specific Decision Support System (DSS) framework for FPO management. A mixed-method research design was adopted, covering four Farmer Producer Companies promoted under CAU, Imphal, with data collected from 88 respondents comprising CEOs, accountants, and farmer members. Decision-making needs were prioritized using the Relative Need Index (RNI), wherein features with scores ≥ 91 were classified as high priority and incorporated into the framework, scores between ≥ 79 and < 91 were treated as moderate priority and deferred for subsequent iterations, and scores < 79 were considered low priority and excluded. Based on high-priority features the proposed framework consists of eight integrated modules covering financial, member, marketing, procurement, crop production, governance, training, and grievance management. The framework was evaluated by information technology experts using selected ISO 9126 quality characteristics, confirming its functionality, usability, efficiency, and portability. The study recommends pilot implementation of the DSS with appropriate alpha and beta testing prior to large-scale deployment to strengthen data-driven decision-making and operational efficiency in FPOs.

Keywords: Decision Support System, Decision-making, FPO, Framework, Software





Theme III : Poster

Digital tools to ensure sustainable food systems-opportunities and challenges





T-3 P-1: Digital Tools for Sustainable Food Systems: Opportunities and Challenges

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The global food system faces unprecedented pressure from population growth, climate change, resource depletion, and the imperative to meet the UN Sustainable Development Goals (SDGs). Digital technologies-such as Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, remote sensing, and Blockchain-offer a transformative pathway toward sustainability. Opportunities are substantial, primarily driven by the ability of these tools to enhance precision and efficiency. Precision agriculture, enabled by sensors and data analytics, optimizes the use of scarce resources like water, fertilizers, and pesticides, thereby reducing environmental impact (e.g., lower greenhouse gas emissions and pollution). Digital tools also improve supply chain management through enhanced traceability, transparency, and real-time monitoring, leading to a significant reduction in food loss and waste. Furthermore, they can provide farmers with crucial, timely information (e.g., weather forecasts, market prices) and foster new, more sustainable business models. However, the widespread adoption and equitable scaling of these tools face significant Challenges. These include a substantial digital divide, characterized by high upfront costs for technology, lack of adequate digital infrastructure (especially in rural and developing regions), and a critical skills gap among farmers and operators. Ethical and governance concerns are also paramount, focusing on issues of data ownership, privacy, security, and the risk of increased market concentration and power imbalances favouring large corporations over smallholder farmers. To fully realize the potential of digitalization for a resilient and sustainable food system, policy interventions are needed to ensure inclusive access, foster digital literacy, and establish robust regulatory frameworks that address data governance and promote equitable benefit distribution.



T-3 P-2: Assessment of CFLDs on Enhancement of Yield and Profitability of Chickpea among the Farmers of West Nimar Region District Barwani, MP

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Pulses are widely cultivated in India especially by small holding farmers. These are low input required crops because of their legume crops ability to assimilate atmospheric nitrogen through its symbiotic association with *Rhizobium* sp.; thus helping in enhancing the soil quality for subsequent cereal crop cultivation. Chickpea crop is best for health and income generation but the production of gram is decreasing day by day because farmers unaware of new technology. Krishi Vigyan Kendra was organized many programme for promotion of pulse crops like- CFLDs /FLDs, OFTs and other extension activities successfully with an objective to demonstrate and popularize the improved agro-technology on farmers' field under varied existing farming situations. Overall chickpea crop is best for health and income generation but the production of chickpea is decreasing day by day because farmers unaware of new technology. KVK was conducted CFLD pulse in 20ha area every year since last four years. All 50 demonstrations in 20 ha area were conducted in 5 different villages and result concluded that increase average yield 19.56 q/ha in demonstration plot as compared to 13.64q/ha in control plot. There was 43.50 per cent increase in yield observed in demonstration plot over farmers' practice. It was observed that potential yield can be achieved by imparting scientific knowledge to the farmers, providing the quality need-based inputs and proper application of inputs. The average of total gross income from grain is Rs 102900/ha. as against only Rs. 72430/- in the farmer practice. Net income obtained under CFLD was only Rs. 62940/ha., and only Rs 36578/ha. in farmer practice respectively. KVK is playing most essential role in dissemination of technology through CFLDs& FLDs.

Key words: Assessment, CFLDs, Enhancement, Yield, Profitability, KVK and Chickpea



T-3 P-3: Impact of Integrated Nutrient Management on Wheat Yield and Soil Health

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Imbalanced fertilization, primarily the excessive reliance on nitrogenous and phosphatic sources without corresponding potassium, micronutrients, or bio-organic inputs, has led to significant yield gaps in global wheat production systems. The present study reports the outcomes of a three-year On-Farm Testing (OFT) programme (2018–2021) conducted to evaluate the performance of Integrated Nutrient Management (INM) in wheat (*Triticum aestivum* L.) under farmers' field conditions. The technological intervention (T2) comprised soil-test-based application of N, P, K, and Zn in conjunction with a microbial consortium of *Azotobacter*, Phosphorus Solubilizing Bacteria (PSB), and Potassium Solubilizing Bacteria (KSB), and was compared with prevailing Farmer's Practice (T1). The results revealed that T2 consistently outperformed T1 across all growth and yield parameters, recording a maximum grain yield of 51.50 q ha⁻¹ along with the highest benefit–cost ratio (1:2.74). In addition to yield enhancement, INM significantly improved soil health, particularly soil organic carbon, which increased from 0.47% to 0.52% over the study period. The findings underscore the technical and economic superiority of INM and highlight its potential for sustaining wheat productivity while restoring soil fertility under intensive cropping systems.

Keywords: Integrated Nutrient Management, Soil health, On-Farm Testing, Wheat Productivity.



T-3 P-4: Internet of Things (IoT) for Transforming Agricultural Extension and Sustainable Food Systems

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The Internet of Things is a technology to strengthen agricultural extension systems and promote sustainable food systems. The integration of IoT with agricultural extension is reshaping how knowledge, inputs, and services are delivered to farmers and how food systems are monitored and governed in the context of climate change, resource scarcity, and food security concerns. IoT architectures based on distributed sensor networks, cloud platforms, and application-layer decision support systems enable real-time monitoring of soil, water, crops, livestock, climate variables, and supply chains. These systems support precision management across the agricultural cycle, from land preparation to harvesting, storage, and logistics. At the field level, IoT-enabled applications such as smart irrigation, fertilizer optimization, pest and disease surveillance, and microclimate monitoring have demonstrated the capacity to increase productivity, improve input-use efficiency, and reduce environmental pressures, contributing to climate-smart agriculture. Continuous data streams generated by IoT technologies significantly expand the information base of agricultural extension services. Advisory systems are shifting from generic recommendations to site-specific, sensor-informed, and predictive guidance. This transition redefines the role of extension professionals, positioning them as data interpreters and knowledge brokers within digitally enabled innovation systems. Beyond the farm gate, IoT strengthens food systems by enabling traceability, cold-chain monitoring, quality assurance, and reduction of post-harvest losses, linking farm-level management with broader goals of nutrition, food safety, market transparency, and climate resilience. Despite its potential, adoption of IoT-driven extension is constrained by high initial investment costs, connectivity gaps, interoperability issues, data ownership and privacy concerns, and limited digital skills among farmers and extension personnel. Addressing these challenges requires inclusive business models, enabling regulatory frameworks, investments in rural digital infrastructure, and collaboration among farmers, extension institutions, technology providers, and policymakers. Overall, when embedded within extension systems and supported by governance, IoT can serve as a lever for building sustainable food systems.

Keywords: Internet of Things, Agricultural Extension, Precision Agriculture, Sustainable Food Systems, Climate-Resilient Agriculture



T-3 P-5: Recycling Hope: From Waste Bins to Business Wins

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Historically, waste management evolved from ancient Greek practices of decentralised burial to the crisis-driven industrial systems of the 19th century, which introduced centralised collection to combat urban filth and disease. For decades, the global standard remained a linear "take-make-waste" model, in which materials were extracted, used and discarded in massive, environmentally damaging landfills. However, in 2025, waste handling has undergone a radical transformation into a tech-centric industry. Global waste generation is approaching nearly 4 billion metric tons, forcing a transition from simple disposal to sophisticated resource recovery. Modern facilities now utilise AI-powered sorting robots, IoT sensors for real-time bin monitoring and blockchain-based traceability to ensure that every discarded item is accounted for in a digital supply chain.

Looking ahead, the future of waste lies in a fully realised circular economy. By 2030, we anticipate the term "waste" will be obsolete, replaced by "secondary raw materials," which are processed through advanced chemical recycling and enzymatic hydrolysis, enabling the breakdown of complex plastics indefinitely. This evolution has turned the humble waste bin into a profitable business frontier. Today's entrepreneurs are achieving "business wins" by launching urban mining ventures to recover precious metals from e-waste, developing waste-to-energy plants that power entire neighbourhoods and pioneering "Product-as-a-Service" models that eliminate ownership to ensure products return for recycling. By treating environmental stewardship as a core profit driver rather than a regulatory burden, 2025 businesses are proving that the most sustainable path is also the most economically resilient.

Key Words: Recycling, waste management, business, sustainability





Theme IV : Oral

Opportunities and advanced in digital extension and education –Global and local experiences





T-4 O-1: Evaluation of the Effectiveness of Agricultural Extension Advisory Services in Improving Farmers' Income: Review

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Agricultural extension advisory services play a crucial role in improving farmers' knowledge, skills, and decision-making capacities, thereby contributing to higher agricultural productivity and increased income levels. The present study, **"Evaluation of the Effectiveness of Agricultural Extension Advisory Services in Improving Farmers' Income,"** examines the extent to which these services have influenced the socio-economic conditions of farmers. The study was conducted in selected rural areas using a mixed-method research design comprising structured interviews, focus group discussions, and secondary data analysis. Key parameters assessed included farmers' access to extension services, frequency of advisory interactions, adoption of improved agricultural practices, and resulting changes in farm productivity and income. The findings indicate that regular exposure to extension advisories significantly enhanced farmers' awareness and adoption of modern agricultural technologies such as improved seed varieties, balanced fertilizer application, and integrated pest management practices. Consequently, participants reported notable increases in crop yields and household income. Despite these positive outcomes, several challenges were identified, including inadequate field visits by extension personnel, limited digital literacy among farmers, and insufficient feedback mechanisms. The study concludes that strengthening extension systems through capacity-building initiatives, ICT-enabled advisory platforms, and participatory approaches can further improve service effectiveness and support sustainable income growth for farming communities.

Keywords: Agricultural extension, advisory services, farmers' income, technology adoption, ICT, rural development.



T-4 O-2: Comparative Assessment of Mobile Diagnostic Tools for Capacity Building of Plant Health Advisors in Bihar

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The integration of mobile-based diagnostic applications into agricultural extension is reshaping plant health advisory systems, particularly in smallholder-dominated regions like Bihar. This study evaluates the efficacy of digital capacity building by comparing three prominent diagnostic tools, BAU Sabour's *e-Nirog*, *Plantix*, and *Plantora*, among 124 extension functionaries from KVKs, ATMA units, and the State Agriculture Department. The objective was to determine how app usability and targeted training influence disease diagnosis accuracy and advisory efficiency. Employing a mixed-method framework, data were collected via pre- and post-training assessments, field observations, and diagnostic logs. Results indicate that digital familiarity directly correlates with diagnostic precision. A comparative analysis revealed distinct strengths: *Plantix* demonstrated superior ease of use and rapid image detection; *Plantora* excelled in generating structured advisories, while *e-Nirog* offered the highest relevance for region-specific crop systems in Bihar. Despite these strengths, initial user challenges regarding image capture protocols and probability interpretation were noted. However, structured interventions, including hands-on training and workflow integration significantly mitigated these issues. Post-training evaluations showed that over 70% of participants reported enhanced competence in delivering app-supported advisories. The study concludes that while digital tools are powerful assets, structured capacity building is essential to standardize their use. Empowering extension personnel with these technologies is critical for minimizing diagnostic delays and promoting eco-friendly, long-term disease management in the region.

Keywords: Digital Extension, Plant Health Advisors, e-Nirog, Bihar.



T-4 O-3: Digitalization Journey of Agricultural Extension: Evolution from early ICT initiatives to AI-driven technologies

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Over the years, the transition of agricultural extension has revolutionized how farmers cultivate their fields. The early flagship initiatives focused on basic centralized knowledge delivery and two-way interaction, providing generalized solutions to farmers. The shift came in the form of mobile phones, which provided solutions to farmers at their doorstep, easing access to information and advisory services. Although it was a huge success in terms of reach, it encountered issues that were eventually and partially resolved by the successful implementation of various infrastructure under the Digital India initiative. Initiatives such as the electronic National Agricultural Market, Pradhan Mantri Gramin Digital Saksharta Abhiyan, Common Service Centres, and Aadhaar-linked Direct Benefit Transfer of PM-KISAN, among others, have not only increased the farmer income but also contributed to digital literacy. However, the obsolete reactive approach has paved the way for predictive AI-driven technologies encompassing Machine Learning and Big Data analytics that capture the essence of precision agriculture. Kisan e-Mitra, National Pest Surveillance System, along with the components of the Digital Agriculture Mission, has laid the foundation for the future of Indian agriculture. The key trend has been moving from advising on what to do to predicting what will happen and guiding accordingly. The amalgamation of state-of-the-art technologies and cooperative endeavours of all interconnected stakeholders can successfully establish the foundational infrastructure—providing digital identity, market access, financial transfer, and connectivity—leading to tangible results, including increased digital penetration and measurable economic empowerment for rural households. The future of extension lies not only in informing farmers but also in engaging, empowering, and co-creating solutions with stakeholders as equal partners in the agriculture innovation process.

Keywords: Artificial intelligence, Digital literacy, Information Communication Technology, Machine learning, Knowledge dissemination, Predictive Approach



T-4 O-4: Effectiveness of mobile based digital farm advisories in dissemination of information: A study in North Karnataka

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Mobile based digital farm advisories are revolutionizing the way agricultural information is delivered to farmers by providing timely, location-specific information. Digital advisories have become a powerful tool for technology transfer to the farming community with increased digital literacy. The effectiveness of these advisories becomes a prime importance. The present study was conducted during the year 2024 with 180 farmers using various mobile based digital farm advisories in Belgaum, Haveri and Gadag districts of North Karnataka. The effectiveness was measured using 7 dimensions. Radar chart was used to represent the normalized values of different dimensions which depicts that relevance of technical content and need/problem based information dimensions contribute the most to the effectiveness of the advisories. Relational analysis through regression was done and it was found that innovative proneness was found significant at 1% level whereas, farming experience, accessibility to digital farm advisories and social media utilization were found to be positively significant at 5% level with effectiveness. The R² value was found to be 0.56 indicating 56 per cent of the variance in the dependent variable i.e., effectiveness of mobile based digital farm advisories was due to the explained independent variables. Hence these factors to be considered while improving the effective use of the information disseminated through these digital farm advisories.

Keywords: Mobile based digital farm advisory, effectiveness, ICT, Farmer's information needs



T-4 O-5: Utilisation of ICT tools for Acquiring and Disseminating Agricultural Information by Extension Personnel of Andhra Pradesh and Assam.

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Information and communication technology tools are the wide spread technology for acquiring and disseminating any information required by the people throughout time series. India has made remarkable progress to start effective using of ICT tools for agricultural services. Therefore, the present study was conducted to explore the extent of use of ICT tools by the extension personnel in two states i.e., Andhra Pradesh and Assam. A sample of 240 extension personnel was selected as respondents, 120 from each state following random sampling technique. Data were collected through Google forms. Utilisation level of ICTs was measured considering five aspects i.e., awareness, knowledge, duration of use, acquiring knowledge and disseminating knowledge. Statistical tools like frequency, percentage, mean, standard deviation, t-test, correlation and regression were used. Findings revealed that overall utilization pattern of ICT tools by the two state extension personnel showed nearly equal percentage in medium category i.e., 69.16 and 66.66 per cent respectively. The awareness level (40.00% and 54.16%), knowledge level (65.83% and 60.00%), equal per cent (68.33%) of the respondents were medium duration of use of ICT tools, acquiring knowledge (68.33% and 60.83%) and disseminating knowledge (60.83% and 51.66%) by the Andhra Pradesh and Assam state extension personnel respectively. There is a significant difference between two states in utilization pattern. Positive and significant relationship was found between education, length of service, possession of ICT tools, duration of use of ICT tools, training undergone and perception with their utilization pattern of ICT tools.

Keywords: Agricultural extension, Agricultural information, Extension personnel, Information and Communication Technology tools, Utilisation,



T-4 O-6: Role of WhatsApp in Transfer of Agricultural Technology

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As regards to role of WhatsApp in transfer of agricultural technology it was observed that Out of total 120 respondents more than half of the respondents (50.83 %) had reported moderately important role of WhatsApp in transfer of agricultural technology, followed by highly important (33.34 %) and less important (15.83 %) role of WhatsApp in transfer of agricultural technology. The important constraints reported by majority of respondents regarding use of WhatsApp were farmers faced constraint of **poor** internet connectivity, messages authenticity, language problem, lack of time to check messages, Suggestions given by the farmers about constraints regarding use of WhatsApp were poor network problem should be resolved, while the other suggestions were, training must be arranged for proper use of smartphone and WhatsApp.

Farmers viewed WhatsApp as a 'easy' communication app that solved problems using audio-visuals and provided an on-time response during a crisis in their agriculture activities, according to the findings. Distractions and exposure to uncontrolled communications or material were two of the most serious problems that resulted from the use of WhatsApp. Regardless of its drawbacks, social media has proven to be a significant tool for pluralistic extension, bringing all participants in the Agriculture Information System together and making them shareholders in development.

T-4 O-7: Advancements through Machine Learning (ML) in Extension Research: A review

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The conventional survey-centric approach in extension research has undergone a significant shift over the past few decades due to rapid advancements in AI technologies. Machine learning techniques such as clustering of data, ensemble learning, sentiment analysis and predictive modeling are increasingly being used worldwide to improve sampling accuracy, detect response bias and automate data cleaning. These models are transforming the design and way of analysis by natural-language interpretation of open-ended responses and preprocessing of large data sets. Various research studies report the growing use of ML for respondent classification, anomaly detection and simulation of survey populations to test instrument reliability. This review paper discusses latest research on how this particular technology is reshaping digital survey methodology, highlighting emerging opportunities for accuracy and efficiency and identifying gaps that need further investigation.



T-4 O-8: Digital Pathways to Empower Farm Communities: Integrating Innovation in Extension and Education for Sustainable Food Systems

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The rapid evolution of digital technologies has catalysed transformative changes in agricultural extension and education systems worldwide. From precision advisory services powered by mobile apps to remote sensing-based crop monitoring and AI-driven decision support tools, digital platforms are redefining how knowledge is shared, adopted, and scaled for sustainable food systems. This paradigm shift holds significant promise for achieving Atmanirbhar Bharat by empowering farmers with real-time information, enhancing productivity, reducing risk, and enabling market linkages.

Globally, countries are harnessing digital solutions to bridge the extension gap and democratize access to scientific know-how. In the Netherlands, data analytics platforms support climate-smart cropping decisions; in Kenya, interactive voice response (IVR) systems deliver localized agro-advisories to smallholder farmers; and in Japan, AI-enabled disease diagnostics via smartphone applications are accelerating early disease detection and prevention. These examples illustrate how digital agriculture strengthens resilience, inclusivity, and sustainability.

Closer to the grassroots, Krishi Vigyan Kendra (KVK), Badnapur, Dist. Jalna has operationalized digital extension tools to complement traditional field-based activities. During the 2024-25 crop seasons, KVK, Badnapur successfully integrated WhatsApp groups, YouTube instructional videos, weather alerts, pest and disease forecasts, and market information to over 3,500 farmers (35% of whom are women).

In addition, KVK Badnapur conducted digital literacy camps for farming communities, enabling farmers to utilize government platforms like eNAM, PM-KISAN, and Soil Health Card portals independently.

However, despite the successes, challenges persist - digital infrastructure gaps, language preferences, and varied levels of digital literacy continue to constrain full adoption in remote hamlets.

This paper advocates for scalable, farmer-centric digital pathways that promote knowledge equity and contribute to the vision of a digitally inclusive and self-reliant agricultural sector in India.



T-4 O-9: Impact of Comprehensive Agribusiness Extension Services (CABES): ICT enabled farm advisory service

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Agriculture remains a central pillar of the Indian economy, supporting the livelihoods of millions while contributing significantly to national food security and economic stability. With increasing demand for food grains, the agriculture sector must achieve an annual growth rate of nearly 4 per cent, alongside a 2 per cent growth in food grain production. In this context, information and communication technology (ICT)-enabled extension services have emerged as a promising approach to enhance farm productivity and farmers' income. The present study evaluates the effectiveness of the **Comprehensive Agribusiness Extension Services (CABES)**, an ICT-enabled farm advisory service, and examines its impact and scalability. The study was conducted in Navalgund Taluk, where all farmers registered under CABES constituted the population. A randomly selected sample of farmers received extension services through **Raitha Mitras**, who used tablet-based ICT tools containing crop-specific information in the form of photographs, videos, animations, graphs, and charts. Each farmer was registered with a unique digital profile. The findings revealed that 60.00 per cent of farmers participated in group meetings, 46.50 per cent attended demonstrations, 42.50 per cent took part in campaigns, 38.50 per cent attended training programmes, and 26.75 per cent participated in field visits to progressive farmers. Additionally, all farmers accessed the e-SAP application and received information related to agricultural inputs. Printed advisories were received by 28.50 per cent of farmers, 27.00 per cent viewed video-based advisories, and 26.25 per cent received soil health cards. The study highlights the effectiveness of CABES in improving access to timely agricultural information and underscores its potential for wider scalability in strengthening ICT-based agricultural extension systems.

Keywords: Agriculture extension, ICT-enabled advisory services, CABES, Farm productivity, Farmers' income, Raitha Mitras



T-4 O-10: Digital Empowerment and Financial Resilience Assessing the Impact of PMFBY on Farmers of Prayagraj District for an Atmanirbhar Krishi

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Climate variability and increasing production risks have intensified the need for effective risk management mechanisms in Indian agriculture. The Pradhan Mantri Fasal Bima Yojana (PMFBY) was introduced to enhance farmers' financial resilience through crop insurance supported by digital platforms for enrolment, yield assessment, and claim settlement. This study, conducted in the Prayagraj district of Uttar Pradesh, assesses the impact of PMFBY on digital empowerment and financial resilience among 180 beneficiary and 180 non-beneficiary farmers. Primary data were collected through a semi-structured interview schedule and analyzed using correlation coefficients and ranking techniques. The socio-economic profiling revealed that the majority of respondents were middle-aged (36 to 50 years), male-dominated (87.22%), and primarily marginal to small-scale farmers. Findings indicated a medium level of knowledge regarding PMFBY among 62.78% of beneficiaries, with the highest awareness focused on crop insurance apps. However, critical gaps persist, as the least known aspects included the specific benefits provided by the government. Attitude levels were also found to be medium (64.44%), with a strong belief that the scheme protects against financial risks. Correlation analysis showed that education, farming experience, land holding, and mass media exposure were significantly and positively related to both knowledge and attitude levels. The impact analysis demonstrated that beneficiary farmers spent 5.58% more on cultivation than non-beneficiaries, primarily due to higher investments in labour and fertilizers encouraged by the insurance safety net. This resulted in an additional net income of 4.65% for insured farmers, who achieved an average yield of 47.18 q/ha compared to 44.90 q/ha for non-insured farmers. Despite these benefits, major constraints identified included corruption in claim settlements and lack of proper publicity. Respondents strongly suggested organizing more trainings and utilizing youth farmers for grassroots communication. The study concludes that while PMFBY has strengthened financial resilience, its full potential as a tool for Atmanirbhar Krishi requires addressing systemic integrity issues and enhancing last-mile digital extension education.

Keywords: Pradhan Mantri Fasal Bima Yojana (PMFBY), Digital Empowerment, Financial Resilience of Farmers, Crop Insurance, Atmanirbhar Krishi



T-4 O-11: Digital Literacy as 21st Century Competency among Students Enrolled in Undergraduate Agricultural Programmes: An Empirical Study

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The increasing significance of 21st century skills has brought digital literacy to the forefront of higher education especially in areas like agriculture where the application of technology is becoming crucial. With the growing integration of digital extension systems, artificial intelligence-based advisory services, precision farming systems, and data-driven decision-making systems into the sphere of agriculture, access, interpretation, and application of digital information is no longer optional but essential for students and professionals working in the field. Strengthening digital literacy in agricultural higher education is a step that will empower the future extension personnel to bridge the knowledge gap, provide context specific and inclusive advisory services, promote sustainable and climate smart agricultural practices and support innovation, entrepreneurship and the larger vision of Atmanirbhar Bharat. The present study adopted an evaluation-based approach to assess digital literacy among students enrolled in undergraduate agriculture programmes, using primary data collected through a self-structured assessment tool administered to students enrolled in agriculture programmes at Banaras Hindu University (BHU). According to the findings, the students were found to have an moderate level of digital literacy, reflecting a basic level of familiarity with digital resources. Such familiarity appeared to be comparatively consistent across different institutional factors, and no statistically significant differences were observed in overall digital literacy. Although the difference across course years appeared marginally higher when the mean scores of senior students were considered, the difference was not statistically significant. The findings emphasized the critical importance of purposeful instructional design and framed experiential learning to strengthen digital literacy among agriculture students, consequently enhancing their readiness to navigate effectively amid technology-driven agricultural environments.



T-4 O-12: Usage Pattern of ICT Tools in Agricultural University

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The research was carried out in 2021-22 at the CCS Haryana Agricultural University (CCSHAU), Hisar to determine the usage pattern of ICT tools by the faculty of the university. Four colleges of the university i.e. College of Agriculture, College of Agricultural Engineering and Technologies, College of Basic Sciences and Humanities, and College of Home Science were selected purposively for collection of data. Further, 25 faculty members were selected randomly from each selected college. Thus, a total of 100 faculty members were selected for the study. Data was collected with the help of well-structured questionnaire. Study concluded that majority of respondents use ICTs for collection of course materials (98.00%) and online classes (98.00%). While, ICT tools also used for research purposes i.e., articles/policy paper etc. and submission of articles to journal/magazines used 94.00 and 93.00 per cent, respectively. Study also concluded that majority of the respondents used ICT tools for teaching and research, while utilization of ICT tools was quite low in extension activities as compare to others.

Key words: Progress, Teaching, Research and Extension



T-4 O-13: On-farm Demonstrations of Agricultural Drones for Precision Spraying in Western Rajasthan: Performance and Insights

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This study is based on the on-farm demonstrations of application of agri-drones conducted by ICAR-Central Arid Zone Research Institute, Jodhpur (Rajasthan). A total of 339 demonstrations were organized during 2023-24 (Rabi) and 2024-25 (Kharif and Rabi) covering 513 hectares in a farmer-participatory mode across 25 villages in Jodhpur district. The application of 15 kg capacity drones was demonstrated for precision spraying of nutrients and pesticides across diverse arable crops (cumin, mustard, fenugreek, fennel, isabgol, wheat, barley, cotton, castor), vegetables (onion, garlic, chilies, cabbage, cauliflower, sweet potato) and horticulture crops (ber and pomegranate). Findings revealed that some farmers were aware of this technology, though these demonstrations were the first of their kind in these villages. Drone-based spraying demonstrated high efficiency, covering one hectare in 20-25 minutes compared to 3-3.7 hours using tractor-mounted sprayers and 10-12 hours using battery operated sprayers. The cost of drone-based spraying was Rs. 1,235/ha compared to Rs. 1,730/ha under conventional ground application methods (tractor-mounted sprayers or manual laborers). Drone pilots reported the absence of deep integration of topography and area maps into automated flight plans as a constraint, reducing their operational efficiency. Farmers reported that the drones with additional agricultural tasks (sowing seeds, fertilizer application, monitoring crop health) will be useful for small grain crops sown in the region. Undulating topography, high wind velocity, high temperatures and existing farming systems with naturally scattered agroforestry trees are the challenges specific to this region. Yet, the demonstrations showcased the significant potential of drones for resource-use efficiency and operational ease in farming operations in the region.

Government has initiated programmes to address scarcity of certified drone pilots while high initial cost of drones can be offset through rental services/ custom-hiring centers. Research on understanding the scale and nature of drone application, the knowledge and skill gaps and the potential risks with special reference to arid regions is needed for developing a strong policy framework for promotion of this potential technology.

Key Words: Agricultural drone, Arid region, On-farm demonstration, Precision agriculture, Resource-use efficiency.



T-4 O-14: Significance of ICT tools as Information Sources for farmers livelihood

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The present study was conducted in eastern Uttar Pradesh to assess the importance of Information and Communication Technology (ICT) tools as perceived information sources for farmers' livelihood. A total of 175 farmers were selected from five districts namely Chandauli, Varanasi, Mirzapur, Sonbhadra and Ghazipur. The respondents were registered farmers of five selected Krishi Vigyan Kendras (KVKs) and were users of various ICT tools. The introduction of ICT in the agricultural sector has brought significant changes in the conventional extension system by enabling timely, need-based and cost-effective dissemination of information. Social media has emerged as an important platform in farming due to its ability to connect farmers with agribusiness stakeholders across large geographical areas. The findings revealed that mass media sources such as television, radio and mobile phones were the most preferred ICT tools for accessing agricultural information. Agriculture Extension Officers and KVK personnel were contacted by 70 per cent and 43 per cent of the respondents, respectively, highlighting their significant role in disseminating weather and advisory information. The study emphasizes the growing relevance of ICT tools in strengthening agricultural extension services and improving farmers' access to reliable information.

Keywords: ICT, internet, mobile phone, social media, radio, information dissemination.



T-4 O-15: Role of Podcasts as Catalysts for Agricultural Information Dissemination

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In the evolving landscape of agricultural communication, digital media platforms have redefined how information is created, shared, and accessed by farming communities. Among these, podcasts have emerged as an innovative and accessible tool for agricultural information dissemination. This paper explores the growing significance of podcasts as an extension communication medium and their potential to strengthen knowledge sharing between researchers, extension professionals, and farmers.

Podcasts blend the advantages of radio broadcasting with interactive, on-demand accessibility, allowing users to consume information anytime and anywhere. For farmers with limited time or literacy barriers, podcasts provide an engaging means of learning through local language storytelling, expert interviews, and experience-sharing episodes. Unlike traditional extension tools, podcasts can cater to diverse topics—from crop management and livestock care to market trends and government schemes—thus broadening outreach and impact.

The study draws upon existing research, case studies from agricultural universities, and emerging podcast initiatives in India and abroad. It examines factors influencing adoption, such as smartphone penetration, internet connectivity, and content relevance. The analysis also highlights challenges including digital literacy gaps, infrastructural limitations, and the need for locally contextualized and credible content.

Findings suggest that podcasts can complement traditional extension methods by enhancing participatory communication and continuous learning among rural audiences. Integrating podcasting into extension programs could empower farmers with timely, need-based, and personalized information delivery. The paper concludes that institutional support, content co-creation with stakeholders, and systematic evaluation of podcast outreach are critical for making this medium a sustainable component of modern agricultural extension systems.

Keywords: Agricultural communication, digital extension, podcasting, information dissemination, farmer education



T-4 O-16: Use of Digital Extension Tools for Technology Dissemination in Soybean: Social Media to Digital Platforms - Experiences of ICAR-NSRI

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With the developments in digital technologies, the ICAR-National Soybean Research Institute has started using digital tools and social media platforms for dissemination of soybean production technologies. In addition to the Expert Groups on WhatsApp and Telegram, the institute has shifted its focus on content generation in the form of videos, shorts and reels on specific and precise information to upload on YouTube, Instagram and Facebook for dissemination of information to soybean stakeholders. The major thrust was given on promotion of improved soybean production technologies and also as feedback mechanisms among the clients. The “Soybean Gyan” app recently launched by the Institute has also facilitated the multilingual interactive feature through which farmers of different soybean growing states can not only access and share the information but also communicate his feedback and issues to the scientists. The digital tools developed by the institute like expert systems for identification of varieties, damage due to insect-pests and diseases has revolutionized the traditional process of technology transfer to a new, modern, up to date with the new digital era making the process of technology dissemination offering solution for an efficient, effective, interactive and time bound way. The AI empowered mobile application “Soybean Gyan” developed by ICAR-NSRI having a knowledge base on soybean can be accessed, retrieved and used even without internet connectivity after it is properly downloaded and installed on the smartphone. The other six social media tools of the institute are useful for receiving the feedback of the soybean stakeholders and are equally useful for technology dissemination for increasing the soybean yield levels through use of improved agronomic practices and latest technology recommendations.



T-4 O-17: Changing Scenario of Agriculture Extension Service in India

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Agricultural extension in India has undergone substantial transformation in response to evolving socio-economic conditions, climatic uncertainties, technological advancements, and changing farmer needs. Traditionally dominated by a top-down Transfer of Technology (ToT) approach, extension systems primarily focused on disseminating research-generated innovations with limited farmer participation. Over time, challenges such as climate variability, market volatility, labour scarcity due to rural youth migration, and inadequacies in public extension capacity necessitated a reorientation of extension services. This review paper systematically examines the changing scenario of agricultural extension services in India, tracing its evolution from traditional and transitional phases to the contemporary, technology-enabled and farmer-centred era. Based on a systematic review of secondary literature, the study synthesizes evidence from peer-reviewed journals, policy documents, and reports of national and international organizations. This paper highlights major institutional, technological, methodological, and communication-related changes shaping modern extension systems. It is showing a clear shift towards pluralistic extension involving public agencies, private sector actors, NGOs, Farmer Producer Organizations (FPOs), and agri-tech startups. The integration of information and communication technologies (ICTs), artificial intelligence, and digital platforms has significantly enhanced the speed, reach, and personalization of advisory services. Participatory approaches, climate-smart extension, market-led advisories, and entrepreneurship-oriented support have broadened the purpose of extension beyond technology dissemination to holistic livelihood enhancement. Overall, the transformation of agricultural extension has contributed to faster information delivery, improved farm-level decision-making, greater youth engagement, enhanced farmer participation, strengthened climate resilience, promotion of agri-preneurship, and improved transparency and accountability. The paper concludes that while modern extension systems offer significant opportunities, sustained investments in institutional capacity, digital literacy, and inclusive governance are essential to ensure equitable and effective extension service delivery in India.

Key Words: Extension system transformation, Pluralistic extension, Digital advisory services, Market-led extension, Youth engagement, Technology-enabled extension.



T-4 O-18: E-Readiness of Field Extension Functionaries for Digital Agricultural Extension in Chhattisgarh

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The study was conducted to examine the e-readiness of the field functionaries towards digital extension in Chhattisgarh. A proportionate stratified random sampling method was adopted to select 305 Rural Agricultural Extension Officers (RAEOs) representing all the three agro-climatic zones of the state. E-readiness was assessed through three major components, namely; access to information and communication technologies, infrastructure readiness, and personal readiness. The findings revealed that a majority (63.94 %) of the RAEOs exhibited a medium level of e-readiness. Access to ICTs was found to be moderate, as reflected by a higher proportion of neutral responses regarding access to ICT facilities without dependence on personal devices (52.79 %) and availability of sufficient data limits or internet packages (52.13 %). Infrastructure readiness was also at a moderate level due to neutral responses related to internet connectivity (44.26 %), power supply (42.95 per cent), and availability of power backup systems (43.61 per cent). Similarly, personal readiness was moderate, as a substantial proportion of respondents expressed neutrality regarding conducting online trainings (44.26 %), updating ICT skills (45.57 %), creating digital content (43.61 %), and independently troubleshooting technical problems (42.62 %), except 39.34 per cent of the respondents were agreed with confidence in using digital tools. The study concludes that although field extension functionaries in Chhattisgarh are gradually adopting digital approaches, their current level of e-readiness is not sufficient to fully harness the potential of digital agricultural extension. Therefore, there is a need to strengthen ICT access, improve infrastructural facilities, and enhance personal digital competencies through systematic capacity-building programmes and supportive policies to promote effective and sustainable digital extension services in the state.



T-4 O-19: Transforming Agricultural Extension through Intelligent and Smart Technologies: Experiences and Lessons from SAUs and KVKs

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Agricultural extension systems in India are undergoing rapid transformation due to the integration of intelligent and smart technologies. Agricultural extension services have traditionally relied on human-mediated communication to disseminate knowledge and best practices to farmers. However, rapid advancements in intelligent technologies such as artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and mobile computing are transforming extension delivery into a scalable, data-driven, and adaptive ecosystem. State Agricultural Universities (SAUs) and Krishi Vigyan Kendras (KVKs) play a pivotal role in this digital transition by adopting information and communication technologies (ICTs), artificial intelligence (AI), mobile advisory platforms, decision support systems, and data-driven tools. This review paper synthesizes research findings, institutional reports, and documented experiences related to the application of intelligent technologies in agricultural extension, with a specific focus on SAUs and KVKs in India. The review highlights key technological interventions, institutional experiences, impacts on extension delivery, and challenges in adoption. Evidence suggests that digital and intelligent extension approaches enhance outreach, timeliness, and relevance of advisories while improving farmer decision-making and technology adoption. However, infrastructural limitations, digital literacy gaps, data interoperability issues, and capacity constraints remain major bottlenecks. The paper concludes by identifying lessons learned and proposing future directions for strengthening intelligent digital extension systems through policy support, capacity building, and inclusive technology design.

Keywords: Smart agriculture, digital extension, intelligent technologies, SAUs, KVKs, ICT in agriculture, AI, IoT, decision support systems



T-4 O-20: e-Crop as a Digital Extension Intervention: Evidence from Crop Insurance Linkages in Bapatla District of Andhra Pradesh

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The Government of Andhra Pradesh introduced the e-Crop (Electronic Crop Booking) system as a digital extension intervention aimed at improving the accuracy of crop enumeration, enhancing transparency in scheme implementation, and strengthening the delivery of crop insurance. The present study evaluates the performance of the e-Crop system in Bapatla district with specific emphasis on (i) trends in crop coverage under e-Crop and (ii) the role of extension facilitation in strengthening crop insurance delivery. Both primary data and secondary data were utilised. Primary data were collected during 2023–24 from 60 extension professionals using a structured and pre-tested questionnaire. Secondary data on crop-wise area registered under e-Crop for paddy, maize, and pulses were collected for the period 2019–20 to 2022–23 from official records. Analytical tools such as compound annual growth rate, Pearson's correlation, Garrett ranking, and construction of an Extension Effectiveness Index (EEI) were employed. The findings revealed a consistent increase in e-Crop registration across major crops, accompanied by a corresponding improvement in crop insurance coverage. Correlation analysis indicated a positive and significant relationship between extension facilitation and insurance effectiveness, underscoring the pivotal role of extension personnel in operationalising digital platforms. The EEI showed that 86.67 per cent of extension professionals perceived medium to high effectiveness of e-Crop implementation. Poor internet connectivity and increased workload were identified as the major constraints affecting system performance. The study concludes that e-Crop has emerged as an effective digital extension mechanism for strengthening crop insurance delivery; however, investments in digital infrastructure and continuous capacity building of extension personnel are essential to sustain and scale its impact.

Keywords: e-Crop, Digital extension, Crop insurance, Extension Effectiveness Index, Andhra Pradesh



T-4 O-21: Extent of utilization of Information and Communication Technology (ICT) by the farmers of Nagaland

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The study was conducted during the year 2025–26 with the objective of examining the extent of utilization of Information and Communication Technologies (ICTs) by farmers in Nagaland. A multistage random sampling technique along with a descriptive research design was adopted. The districts of Chümoukedima, Wokha, Mokokchung, Peren, and Phek were selected purposively for the study. From each selected district, two blocks were chosen using a simple random sampling procedure, resulting in a total of ten blocks. Further, two villages were randomly selected from each block, making a total of twenty villages. From the selected villages, 20 farmers from each block were randomly selected, constituting a total sample size of 200 respondents. The findings revealed that a majority of the respondents (91.50%) were aware of social media platforms such as WhatsApp and Facebook used for agricultural networking, followed by SMS-based services providing agricultural tips and weather updates (66.50%). Overall, 64.50 per cent of the respondents exhibited a medium level of awareness regarding ICT and its applications. In terms of accessibility, the majority of the respondents had access to smartphones (94.00%), followed by radio (82.00%), with 79.50 per cent falling under the medium level of ICT accessibility. Regarding utilization, the majority of respondents frequently used YouTube (72.50%), occasionally used cameras (65.50%), and rarely used advanced tools such as drones and GIS (100%). Overall, most of the respondents (79.50%) belonged to the medium category of ICT usage in farming practices, followed by the low usage category (19.50%).

Keywords: Information and Communication Technologies, Utilization, Farmers, Nagaland



T-4 O-22: Rice Cultivation Challenges During Kharif and Summer Seasons in Sakti District of Chhattisgarh: A Digital Technology Perspective Towards Sustainable Food Systems

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The present study examines the problems and constraints faced by rice growers during kharif and summer rice cultivation in Sakti district of Chhattisgarh, with special emphasis on exploring the potential role of digital technologies in achieving sustainable food systems. The study was conducted in Sakti, Dabhara, Malkharoda and Jaijaipur blocks of the district. Primary data were collected through personal interviews using a structured questionnaire from 128 rice growers who cultivated rice in both seasons, randomly selected from 16 villages across four blocks during the agricultural year 2024–25.

The findings revealed that rice growers encountered multiple production and marketing constraints in both seasons, adversely affecting productivity, profitability and sustainability of rice-based food systems. During the kharif season, the major constraint reported was the high cost of transplanting (83.59%), followed by severe incidence of stem borer and sheath blight disease (73.43%), indicating significant pest and disease pressure. Additionally, severe weed infestation in dry broadcasted rice was reported by 60.93 per cent of the respondents. These production-related constraints highlight the need for timely digital agro-advisories, pest and disease forecasting systems, and labour-saving technologies to enhance resource-use efficiency and environmental sustainability.

In the summer season, the most serious constraints were the absence of bonus for summer rice (72.65%) and lack of government procurement facilities (68.75%). Low market price (63.28%) and poor market facilities (56.25%) further limited farmers' income, threatening economic sustainability. The findings emphasize the importance of digital market platforms, price information systems, and e-governance initiatives to strengthen market access, ensure remunerative prices and promote sustainable food systems. Overall, the study underscores that integrating digital technologies with rice cultivation and marketing can play a crucial role in addressing farmers' constraints and improving the sustainability of rice-based food systems in the region.

Keywords: Problems, Constraints, Kharif, Summer, Rice, Sustainability, Digital



T-4 O-23: Impact of Agro Advisory Services of District Agro Meteorological Units (DAMU) of KVKs in Eastern and Southern dry zones of Karnataka

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Uncertain weather and changing climate conditions have become a daily challenge for farmers, especially in rain-fed regions where crop success depends heavily on timely rainfall and favourable weather. In Southern Karnataka, frequent fluctuations in rainfall, temperature and extreme weather events often lead to yield losses, higher input costs and risky farm decisions. To support farmers in managing these challenges, District Agro-Meteorological Units (DAMUs) were established at Krishi Vigyan Kendras to provide location-specific weather forecasts and agro-advisories. The present study examined the impact of DAMU agro-advisory services on farmers' awareness, adoption behaviour, farm operations and economic benefits in Tumkur, Ramanagara, Mandya and Chamarajanagara districts of Karnataka, where DAMUs have been functioning since 2019–20. An ex-post facto and exploratory research design was followed and 120 farmers who were regular recipients of DAMU advisories were selected through purposive sampling. Primary data were collected using a pre-tested structured interview schedule and analysed using descriptive statistics such as frequency and percentage. The findings showed that the four DAMUs together reached 95,441 farmers through digital platforms including WhatsApp, Facebook and the Meghdoot application. Most respondents were middle-aged, small and marginal farmers with moderate to higher educational status. More than three fourth of farmers (86.67%) were aware of climate change, and KVKDAMU units emerged as the principal source of agrometeorological information for 96.67 per cent of the respondents. Adoption of DAMU advisories was very high (98.33%), and an equal proportion perceived the advisories as useful. The advisories notably influenced key farming operations, especially harvesting, spraying and irrigation scheduling, enabling farmers to align field activities with prevailing and forecasted weather conditions. Farmers reported tangible economic benefits from advisory adoption, ranging from ₹5,000 to more than ₹20,000 per season. Overall, the findings clearly demonstrate that DAMU-based agro-advisory services play a significant role in strengthening farm-level decision-making, reducing weather-related risks and improving farm income in Southern Karnataka, thereby contributing to climate-resilient agricultural practices.



T-4 O-24: Boosting Digital Skills to Promote Youth Engagement in Overall Agriculture: Evidence from Ludhiana District

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Digital literacy stands as a key driver for boosting youth participation in diverse agricultural activities amid Punjab's pressing issues like residue burning, nutrient management, and mechanization needs. In Ludhiana district, central to rice-wheat and broader cropping systems, rural youth aged 18-35 increasingly avoid farming despite high smartphone use (85%). Drawing from the DigComp 2.1 framework, this study examines digital competencies' role in enhancing engagement across crop production, soil health practices, and market linkages. Objectives focused on measuring skills in core domains—information literacy, communication, safety, and problem-solving—and their ties to farming involvement. It also identified predictors through analysis and suggested KVK strategies for Ludhiana's varied agri-scenario, impacting productivity and sustainability. A cross-sectional survey of 200 youth from five blocks used a reliable 21-item scale (Cronbach's $\alpha=0.82$), with multistage sampling from key farming areas. Methods combined descriptives, correlations, chi-square, and regression under the Technology Acceptance Model for tool usability evaluation. Key data showed basic digital literacy overall (mean= 3.15 ± 0.84), moderate engagement (52.5%), strong correlation ($r=0.62$, $p<0.01$), and predictive skills explaining 47% variance ($R^2=0.47$). These insights highlight skill gaps stalling youth in Punjab agriculture. KVK training could lift adoption of practices by 30-40%, cutting pollution and raising yields. Integrating digital modules in extension will spur innovative, resilient farming among Ludhiana youth.

Keywords: Digital skills, youth agriculture, DigComp model, Punjab farming, sustainability



T-4 O-25: Assessment of Weather Based Agromet Advisories Bulletin Under District Agro-Met Unit (Damu) Using ICT Tools and Social Media in Tribal Gadchiroli District of Maharashtra

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District Agro-Met Unit (DAMU) play a vital role in strengthening farming communities by providing real-time, weather-based advisories aimed at improving crop productivity, profitability, and risk management. Study was undertaken by KVK, Sonapur-Gadchiroli in Paddy crop during kharif season 2021-24 in villages of Gadchiroli district to know the effectiveness and usefulness of AAS and quantify the economic benefits.

The study revealed that in Paddy crop the yield 45.87 q/ha, gross monetary returns Rs 100914/ha, total cost of cultivation Rs.51445/ha, net monetary returns Rs.49469/ha and B: C ratio 1:1.96 % in case of AAS farmers and yield 37.75 q/ha, gross monetary returns Rs.83050/ha, total cost of cultivation Rs.71450 Rs./ha, net monetary returns Rs.11600/ha and B: C ratio 1:1.16, respectively in case of non-AAS. On the basis of net monetary returns, the farmer who have adopted the Agromet Advisories in their day to day operation have more monetary return Rs.37,869/ha. than Non AAS Farmer and Rs. 20005 /ha less cost of cultivation than Non AAS Farmer which means due to use of ICT tools and social media farmers have more profit Rs.57,874/ha than Non AAS Farmers in Paddy crop. Thus, the application of AAS based on medium range weather forecast through ICT tools and social media platform are more useful for enhancing the more income and socio-economic status of farm families in tribal Gadchiroli District.

Keywords: AAS, DAMU, ICT Tools, Social media, Weather and Agro-met bulletins.



T-4 O-26: Bridging Skill Gaps: Digital Competency and Employability of Agricultural Youth for Sustainable and Smart Agriculture

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The transformation of agriculture towards sustainable and smart systems has intensified the demand for a digitally competent workforce, particularly among agricultural youth. Despite the growing adoption of intelligent technologies, a significant skill gap persists between the competencies acquired through formal agricultural education and those required by the evolving agricultural labor market. The present paper aims to examine the role of digital competencies in bridging skill gaps and enhancing the employability of agricultural youth in the context of sustainable and smart agriculture. Digital competencies such as digital literacy, use of mobile and web-based advisory platforms, data-driven decision making, precision agriculture tools, and climate-smart technologies are increasingly essential for employment in public extension services, agri-startups, agribusiness firms, and sustainable farming enterprises. The paper highlights how inadequate exposure to digital tools, limited experiential learning, and insufficient industry linkage contribute to employability challenges among agricultural youth. Further, the study emphasizes the importance of competency-based education, digital skill training, and extension-oriented capacity building programs to improve professional readiness and adaptability. Strengthening digital competencies not only enhances employability but also supports effective knowledge transfer, innovation adoption, and sustainable agricultural development. The paper concludes that addressing digital skill gaps among agricultural youth is crucial for promoting smart agriculture and achieving long-term sustainability in the agricultural sector.

Keywords: Digital competency, Employability, Agricultural youth, Smart agriculture, Sustainable agriculture

T-4 O-27: Use of Digital Platforms in Agricultural Extension Education: A Study at Krishi Vigyan Kendra, Durgapur

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Digital platforms are emerging as powerful tools for enhancing the effectiveness of agricultural extension education by ensuring timely information flow and strengthening farmer–scientist linkages. The present study examines the adoption and utilization of digital technologies for extension education and service delivery at Krishi Vigyan Kendra (KVK), Durgapur, Maharashtra. The KVK has developed an extensive digital network comprising 151 WhatsApp groups that connect 31,641 farmers, facilitating real-time dissemination of crop production advisories, pest and disease management practices, weather-based alerts, and information on government schemes. Additionally, a dedicated Facebook page is used to broaden outreach through dissemination of improved agricultural technologies, training programmes, and farmer success stories. The results indicate that digital platforms significantly enhance communication efficiency, widen outreach, and promote active farmer participation in extension activities. The study highlights that integration of digital platforms with conventional extension approaches can substantially strengthen last-mile delivery of agricultural innovations and improve the overall effectiveness of extension services.

Keywords: Agricultural extension education; Digital platforms; Information and communication technology; Krishi Vigyan Kendra; WhatsApp groups



T-4 O-28: Understanding the Impact of Educational Gamification on Student Learning Outcomes

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As digital technologies reshape the pedagogical landscape, educators face the increasing challenge of engaging students who are accustomed to interactive, on-demand content. This study examines educational gamification, where the integration of game design elements such as points, badges and leader boards into non-game contexts serves as a strategic solution to enhance student learning and academic performance. Grounded in psychological frameworks like self-determination theory (SDT) and flow theory (FT), the study analyses how satisfying innate needs for autonomy, competence and relatedness drives deeper cognitive processing and sustained engagement. Gamified approaches encourage meaningful feedback loops, dynamic goal-setting, and adaptive challenges that evolve as learners progress, ensuring a balance between success and motivation. The integration of analytics-driven insights enables educators to track engagement patterns and personalize learning paths, bridging the gap between playful learning and academic rigor. A synthesis of empirical evidence reveals that gamified learning environments significantly outperform traditional methods in key metrics. Comparative data indicates that well-implemented gamification can boost academic achievement by approximately 15% and substantially increase retention rates and class participation. However, the research highlights that success is highly dependent on design execution. However, outcomes depend on Superficial "pointsification" often leads to a short-term novelty effect, whereas learner-centric designs that balance challenge with skill effectively mitigate disengagement. Furthermore, the analysis addresses critical challenges, including the potential for anxiety in hyper-competitive settings and the necessity of ethical, inclusive design. Looking ahead, the study identifies a shift toward "Gamification 3.0," where AI-driven personalization and immersive technologies such as Augmented Reality and Virtual Reality adapt narratives and challenges to individual learner profiles. Ultimately, gamification must evolve from a system of extrinsic rewards to a sophisticated pedagogical instrument that fosters intrinsic motivation and lifelong learning habits.

Keywords: Gamification, Pedagogy, Learning, Instructional Designs, Academic Achievement, Student Engagement, Educational Technology.



T-4 O-29: Attitudinal Assessment on AI-Driven Tools in Agricultural Education: A Student Perspective

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The rapid advancement of Artificial Intelligence (AI) under the Fourth Industrial Revolution has reshaped educational landscapes, with significant implications for agricultural education. This study assessed the attitudes of B.Sc. (Hons.) Agriculture students at Vignan Institute of Agriculture and Technology, Andhra Pradesh, towards AI-driven tools, focusing on perceived academics, learning, and personality development. Using a proportionate stratified random sample of 180 students from a population of 443, data were collected via a teacher-made, five-point Likert scale. Results indicated that 41.11% of respondents exhibited high attitudes towards AI tools, 38.33% showed medium attitudes, and 20.55% reported low attitudes (Mean = 3.07, SD = 0.25), reflecting a generally favourable disposition with low variability. High Z-scores were observed for self-directed learning, real-time advisory capabilities, and diagnostic functions, highlighting AI's potential to enhance engagement, independent learning, and field-based competencies. Conversely, concerns emerged regarding overreliance on AI, reduced human interaction, and potential creativity decline, indicating the need for a balanced, human-centric integration strategy. The findings underscore AI's promise as a complementary pedagogical tool in agricultural education, while emphasising targeted training, blended learning approaches, and capacity building to maximise benefits and mitigate limitations.

Keywords: Artificial Intelligence, Agricultural Education, Attitude, Learning



T-4 O-30: Extent and Level of Social Media Involvement among Agricultural Extension Professionals

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In India, the use of digital tools has increased rapidly in agricultural extension, and social media has become an important support system for information sharing and advisory services. The present study aimed to assess the extent and level of involvement of agricultural extension professionals in different social media platforms. An ex-post facto research design was followed, and data were collected from extension professionals using a structured and pre-tested questionnaire. The level of involvement was measured using an involvement index based on frequency of use, time spent, and type of activities performed on social media platforms. The results showed that most of the respondents had a medium level of involvement in social media, followed by low and high levels. Among the platforms, WhatsApp was the most commonly used, followed by YouTube and Facebook. These platforms were mainly used for sharing agricultural information, providing timely advisories, spreading awareness about government schemes, and maintaining communication with farmers and fellow extension staff. Lower involvement was observed in platforms that require advanced technical skills and regular content creation. The study indicates that social media has strong potential to support agricultural extension activities in India. It also suggests that regular training and institutional support are needed to improve the effective use of social media by extension professionals for better outreach and service delivery.

Key Words: Agricultural extension, social media, extension professionals, ICT tools, digital communication.



T-4 O-31: Digital Extension Services: A Study on the Efficacy of WhatsApp among Lac Growers

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Information technologies are regarded as mediating channels and a vehicle bringing changes. Social media tools such as Whatsapp offer new form of dissemination of farm information. In this backdrop it is important to study the effective use of social media such as Whatsapp in bridging technology gap. This study examined the effectiveness of Whatsapp using primary data collected from sixty Lac growers in Saraikela-Kharsawan district of Jharkhand state. Two set of lac growers belongs to small production system were selected randomly counting fifty in each considering homogeneity in age, education and exposure to information tools. Lac cultivation technology was provided respectively through Training and Whatsapp messages (both text and voice) among selected lac growers. Data were collected through personal interview on pre-tested interview schedule and also through FGDs. Perceived effectiveness; extent of utilization of technology and their applicability were calculated with the help of various descriptive analyses.

It was observed that technology disseminated through voice messages through group call were utilized more as compared to given through text and training. Whatsapp was found more effective in dissemination of Lac technology as compared to training. Respondents were of opinion that Whatsapp provided them the opportunity to solve problem of Insect pest as they can able to interact with expert very simultaneously. Most of respondents reported that Whatsapp messages were easy, understandable and available on time. It can conclude that Whatsapp was found effective in terms of utilization of advice related to Lac cultivation and influencing the adoption of Lac production technology.

Key Word: Whatsapp, Dissemination of Agriculture Technology, Lac Production Technology



T-4 O-32: Can Whatsapp platform be used as an Agricultural Advisory Tool ? Empirical Evidences from the study of Organic Whatsapp group in Tamil Nadu

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Social Networking sites have been indispensable in the lives of people. Among the Social Networking platforms, Whatsapp is ubiquitous and it's been used by millions of people worldwide. There are sporadic evidences that whatsapp platform is being used for Agricultural Technology Transfer and this mode has potential to remove the long pending time and space constraints. Though, this has huge potential, empirical studies proving the effectiveness of whatsapp has been lacking in Extension Science. This paper attempts to unravel the effectiveness of an organic whatsapp group.

TN-OAIG is the official whatsapp group of Nammazhvar Organic Farming Research Centre of Tamil Nadu Agricultural University with 144 members and this whatsapp group has been taken for the study and sixty prominent farmers from the group who actively participated in the group were selected through deliberate sampling and taken as sample size for the study. Expost facto research design was used for the study. The analysis of the whatsapp since its inception revealed that most of the queries were on pest and disease management and organic input preparation. There were 257 queries with images, 34 messages with videos and 26 audio messages of field problems from the farmers were received and the solutions were given. Among the crops Fruit crops, Vegetable crops and plantation crops were predominantly queried crops with 83, 59 and 55 messages.

Sharing advices to fellow farmers (85%) and utilisation of contacts (72%) were the reasons pointed out by whatsapp users for being in whatsapp group. Sixty Eight percentage of farmers reported that they were checking the group everyday and 61 percentage of farmers were reported to ask queries whenever crop problem arises. Fifty six percentage of users told they used to adopt the information received from whatsapp which is an encouraging finding. The Effectiveness of whatsapp advisory is statistically different among various categories of annual Income and Frequency of checking whatsapp group with significant ANOVA F value. Further there existed agreement among the respondents about the factors influencing effectiveness of whatsapp and marketing pattern with Kendal's W of 0.422 and 0.530 respectively. There existed moderate and significant correlation between Economic benefits of organic farming and networking among fellow farmers (0.431*)

The result of Logistic Regression to predict whether whatsapp can supplement (0 score) or replace (1) revealed that if the economic benefit of the whatsapp message shared is higher, the odds of whatsapp replacing conventional technology delivery by 4.3 times. The multinomial logistic regression to predict the dependent variable of adoption indicated that if the appropriateness of the message is high, the probability of adopting an innovation after consultation with experts increased by 9 times when compared to fully adopting the innovation in Organic Farming



T-4 O-33: Enhancing Community Nurseries' Income through Digital Outreach: A Pathway to Atmanirbhar Bharat

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Participatory action research was undertaken by ICAR-CAZRI, Jodhpur from 2019-2023 to promote sustainable rural livelihoods through community participatory nurseries. Under the project, a group of ten farmers (men and women) each was formed in two arid villages namely Paladi Ranawata and Dantiwada in Jodhpur district of western Rajasthan. The groups were provided hands-on training at model nursery at CAZRI on layout of nurseries, beds and media preparation, polybag filling, seed collection and storage, seed sowing, raising cuttings and after care of forest, fruits and vegetable seedlings. Thereafter, plant nurseries were constructed at farmers' field in participatory mode in these villages in an area of 8 x 16 m². The quality seedlings of agro-forestry trees (Budded *Prosopis cineraria*, *Tecomella undulata*, *Acacia senegal*, *Azadirachta indica*, *Albizia excelsa*, *Dalbergia sissoo*, *Moringa*), horticulture species (budded *Zizypus sp.* cultivars Gola, Seb and Thai apple; *Cordia myxa*, lemon, pomegranate, papaya) and vegetables (tomato, brinjal, chilly, cauliflower, cabbage, bottlegourd, etc.) were produced from these nurseries. These seedlings were initially sold in the same village and some surplus seedlings were taken to the nearby market for selling, but that consumed extra manpower and time. Therefore, the need for ICT tools for marketing was felt. The groups then started advertising their nurseries through social media platforms viz. facebook, whatsapp and other ICT tools. Marketing through these platforms consistently increased the demand for seedlings. Presently, the nursery gets demands from farmers/ customers from many districts of Rajasthan and nearby states of Gujarat and Haryana. The annual net income of nursery in Paladi Ranawata village increased from Rs. 177210/- in the second year of nursery establishment to Rs. 475024/- in the third year. Similarly, it increased from Rs. 152950/- in the second year to Rs. 186654/- in the third year at Dantiwada nursery. Presently the nursery is expanded in an area of approx 0.4 hectares in both the villages. The marketing of quality planting material through the aid of ICT tools expanded the customer base resulting in higher and sustainable revenues for the nurseries.

Key words: Arid region, Community participation, Digital tool, Marketing, Nursery.



T-4 O-34: Utilization of Social Media for Circulation of Information Related to Activities Conducted by KVK, Gondia

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The present paper highlights the effective utilization of social media as a powerful tool for the circulation and dissemination of information related to various activities conducted by Krishi Vigyan Kendra (KVK), Gondia. In the era of digital communication, social media platforms such as WhatsApp, Facebook, YouTube, Instagram and Twitter have emerged as fast, cost-effective and farmer-friendly means for reaching a large number of stakeholders simultaneously. KVK Gondia has strategically adopted these platforms to enhance outreach, improve farmer awareness and ensure timely delivery of need-based agricultural information.

Through social media, KVK Gondia regularly shares advisories and technical messages related to crop production practices, farm mechanization, horticultural crops, crop protection measures, organic and natural farming techniques, and climate-smart agriculture. Information regarding on-farm trials, frontline demonstrations, training programmes, field days and extension activities is also disseminated to farmers, extension personnel and other stakeholders. Visual content such as photographs, short videos, live demonstrations and success stories has significantly improved understanding and adoption of recommended technologies. In addition, social media is effectively used for wider circulation of scientific articles published by KVK scientists in reputed magazines and newspapers. Links and summaries of expert talks delivered through television and radio programmes are also shared, enabling farmers who could not access these media directly to benefit from the information. Feedback received through comments and messages helps scientists understand farmers' problems and provide quick solutions.

Overall, the utilization of social media by KVK Gondia has strengthened the extension-research-farmer linkage, increased technology reach, improved farmer participation and contributed to faster adoption of improved agricultural practices. The study concludes that social media can serve as an effective complementary extension tool for Krishi Vigyan Kendras to achieve inclusive, responsive and technology-driven agricultural development.

Keywords: Social media, circulation, dissemination, information



T-4 O-35: Mapping Farmers' Information Pathways: A Social Network Analysis

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The Indian agricultural extension system continues to face persistent challenges in ensuring timely, effective, and inclusive dissemination of agricultural information, compounded by limited penetration of intensive private extension services. Understanding how farmers seek, access, and exchange information is therefore critical for strengthening communication strategies. Social Network Analysis (SNA) offers a robust analytical framework to examine the structure, intensity, and efficiency of information flows among multiple actors within agricultural systems. The present study investigates the information-seeking patterns of farmers using SNA to identify effective and efficient communication channels that can be further leveraged by the extension system. The study was conducted in Anand and Vadodara districts of Gujarat, where two blocks and two villages from each block were purposively selected. Using random sampling, data were collected from 120 farmers and analysed using UCINET software. The results revealed that farmers accessed 36 information nodes for production-related aspects, while 27 and 23 nodes were identified for protection and marketing information, respectively. The protection information network exhibited higher density (0.553) and transitivity (0.705), along with a lower average geodesic distance (1.450), indicating stronger interconnections and faster information diffusion compared to other networks. The absence of dominance by either public or private actors in the marketing network highlights a critical gap requiring focused intervention. Node-level analysis underscored the central role of input dealers as key information intermediaries, while district-wise comparison showed greater accessibility to agricultural information among farmers in Vadodara than in Anand. The findings underscore the utility of Social Network Analysis in diagnosing structural strengths and gaps within agricultural information systems. The study provides actionable insights for policymakers and extension agencies to redesign communication strategies, strengthen neglected networks, and enhance the overall effectiveness of agricultural information dissemination.

Keywords: Social Network Analysis; Agricultural Extension; Information-Seeking Behaviour; Communication Networks



T-4 O-36: Digitalization in Horticulture for Sustainable Production

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Horticulture contributes significantly to food security, economic growth, employment, nutrition and recreational activities. Commercial horticulture is very diverse, in terms of crops grown, available cultivars, propagation of planting material, growing media, production systems, crop protection and post-harvest management and processing and demands intensive labor input. Consumer demands for an affordable, year-round supply of horticultural produce, in addition to an increased variety and novelty of produce, are expanding. Existing uncertainties resulting from the erratic weather patterns, pests, diseases and other challenges like quality loss, high labour cost make it as a non economical. In order to increase the productivity and profitability there is a need for digital horticulture. Digital horticulture refers to the use of digital technologies to improve the efficiency, quality and productivity of horticultural crops. This includes technologies such as mobile apps, IoT (Internet of things), **Drones & Remote Sensor**, precision irrigation systems, **Robotics & Automation**, Smart greenhouses and GPS-guided machinery, as well as the use of data analytics, Artificial intelligence (AI) and machine learning to make informed decisions about crop management and farm resource allocation. These digital technologies can be used to collect data about soil conditions, crop health, weather patterns and other factors that impact plant growth and yield. The integration of automated procedures in horticulture increases the productivity as well as the quality of the products. These tools can provide various benefits such as increased efficiency, reduced costs, improved crop yields and reduced environmental impact. It also helps farmers make more informed and appropriate decisions about crop management and resource allocation, thus helping to improve production and sustainability by maximizing the production and minimizing waste. The transition to digitalization is a complex process, full of challenges (lack of digital literacy, lack of access to reliable internet, high cost, etc.) and opportunities that require a multifaceted approach. Digital smart interventions would make this sector more technology-driven, productive, input and energy efficient, environment-friendly, complete value-chain development and worldwide development

Keywords: Digital Horticulture, Technology, AI, IoT, Data, Productivity



T-4 O-37: The Role of Krishi Vigyan Kendras (KVKs) in the Dissemination of Drone Technology for Climate-Resilient Agriculture

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Climate change poses a significant threat to global food security, characterized by erratic rainfall, shifting pest dynamics, and increased abiotic stress. In the Indian context, **Krishi Vigyan Kendras (KVKs)** have emerged as the primary institutional catalyst for bridging the gap between advanced aeronautical engineering and grassroots agricultural application. This paper explores the multifaceted role of KVKs in the dissemination of **Unmanned Aerial Vehicles (UAVs)**, or drones, as a tool for climate-smart agriculture.

The research highlights how KVKs facilitate technology adoption through three core mandates: **Frontline Demonstrations (FLDs)**, **Capacity Building**, and **On-Farm Testing (OFT)**. By showcasing the precision of drone-based nutrient and pesticide application, KVKs demonstrate a **20-40% reduction in input wastage** and a significant decrease in water consumption—critical factors for adapting to water-stressed environments. Furthermore, drones equipped with multispectral sensors allow for early detection of climate-induced crop stress, enabling farmers to make data-driven decisions that minimize yield losses.

The study identifies that KVKs are instrumental in overcoming socio-economic barriers such as high initial costs and technical illiteracy. Through initiatives like the **"Namo Drone Didi"** scheme and the establishment of **Custom Hiring Centers (CHCs)**, KVKs provide small and marginal farmers with equitable access to drone services. Training programs for rural youth and Self-Help Groups (SHGs) not only foster technical proficiency but also create a new cadre of "drone entrepreneurs" within the rural economy.

In conclusion, the KVK network serves as the "last-mile" delivery system essential for scaling drone technology. Their role in validating location-specific technology and building local expertise is indispensable for transforming traditional farming into a resilient, high-tech, and climate-adaptive enterprise.

Keywords: Krishi Vigyan Kendra, Drone Technology, Climate Change, Precision Agriculture, Technology Dissemination, Rural Development.



T-4 O-38: Digital Adoption and Socio-Economic Profile of Wheat Growers

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The present study examines the digital adoption practices of wheat growers in relation to their socio-economic profile in Nashik district of Western Maharashtra. With the increasing role of digital technologies in agriculture—such as mobile-based advisories, online market platforms, weather alerts, and crop management applications—understanding farmers' adoption patterns is critical for improving productivity and profitability. A total of 120 wheat growers were surveyed using a structured interview schedule to collect data on socio-economic characteristics including age, education, farming experience, landholding, annual income, and crop area, as well as personal traits such as innovativeness, achievement motivation, and scientific orientation. The study also assessed the use of communication sources (personal, group, and mass media) and the level of digital adoption in farming practices. Results indicated that the majority of farmers were middle-aged, educated, and had medium farming experience, with medium landholding and income levels. Television remained the most widely used source of information, while digital tools such as mobile applications and the internet were moderately utilized. Correlation analysis revealed significant positive relationships between digital adoption and factors such as education, experience, income, landholding, herd size, innovativeness, and scientific orientation, highlighting the role of socio-economic characteristics and personal traits in technology uptake. The findings emphasize the need for targeted digital extension programs, improved accessibility of digital tools, and training initiatives to enhance awareness and adoption among small and marginal wheat growers.

Keywords: Digital adoption, Wheat growers, Socio-economic profile, Communication sources,



T-4 O-39: Intelligent Technologies in Digital Extension for Next-Generation Agriculture: Progress, Possibilities, and Pathways

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Agricultural extension systems across the world are undergoing a paradigm shift driven by rapid advancements in digital and intelligent technologies. Traditional extension approaches, largely dependent on physical contact, linear knowledge transfer, and human intermediaries, are increasingly inadequate to address the complexity of climate variability, market uncertainty, resource degradation, and the diverse information needs of small and marginal farmers. Intelligent digital technologies such as artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), remote sensing, big data analytics, mobile-based advisory platforms, and decision support systems offer unprecedented opportunities to transform agricultural extension into a more responsive, inclusive, and impact-oriented system. This review article critically examines the progress, applications, and future possibilities of intelligent technologies in digital agricultural extension for next-generation agriculture. The paper synthesizes global and Indian experiences on the use of intelligent digital tools in knowledge dissemination, precision advisory, climate-smart agriculture, pest and disease forecasting, market intelligence, and capacity building of farmers and extension personnel. It highlights how these technologies enable real-time, location-specific, and personalized advisories, thereby enhancing productivity, resilience, and sustainability of farming systems. At the same time, the review identifies persistent challenges such as digital divide, data quality issues, algorithmic bias, institutional readiness, policy gaps, and limited digital literacy among farmers. The article emphasizes the need for human-centered and context-sensitive digital extension models that integrate traditional agricultural wisdom with advanced analytics. It argues that intelligent technologies should complement rather than replace human extension agents, fostering hybrid extension systems. The review further proposes strategic pathways for strengthening curriculum redesign, capacity building, public-private partnerships, and ethical governance of digital agriculture. The paper concludes that intelligent digital extension, if inclusively designed and responsibly governed, can play a pivotal role in empowering farmers, strengthening food systems, and realizing the vision of Atmanirbhar Bharat in agriculture.

Keywords: Digital extension, Intelligent technologies, Artificial intelligence, Precision agriculture, Agricultural advisory systems, Next-generation agriculture



T-4 O-40: Demonstration of Agri Drone Technology for Prosperity of Farming Community of Pali District in Rajasthan

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The agriculture sector in our country facing scarcity of working manpower for different farm operations leading to increase in cost of cultivation, decrease in yield and farm income. The traditional way of spraying chemicals, liquid fertilizers and fermented organic manure in agriculture is very labour intensive and poses a health risk to person due to exposure of toxic chemicals to the eyes, lungs, and skin. The use of agri drone technology is an important alternative to manual spray of liquid fertilizers and pesticides. The use of drone helps in achieving the resource optimization by increasing the input use efficiency. The optimum and precise application of input resources will increase in farmers' income. The KVK Pali has conducted demonstrations in 150 ha in various villages of different blocks of Pali district during 2024-25. The present study was conducted to assess impact, prospects, and challenges in adoption of this technology. The result of the study showed that the application of drone technology saves time, labour, water, and chemicals. The study reveals that drones can spray five times faster in comparison to tractor operated power spray as it takes around 10 minutes/ acre (0.4 ha) and it also reduces the input cost. Up to 30 percent reduction in use of nitrogenous fertilizers and pesticides was observed due to automated processes. Furthermore, drones could save up to 92 percent of water usage for spray of liquid fertilizers and agrochemicals. This technology would also attract the young educated people towards farming sector.

The major challenges / constraints were poor internet connectivity, weather dependency, lack of awareness and knowledge, higher cost of drone, limited flight time, frequent technical errors during operations, scarcity of trained pilot, higher battery replacement & maintenance cost, and non-availability of engineer for repairing at local level. Thus, the adoption of agri-drone technology would play a vital role in enhancing agricultural productivity, sustainability, rural employment, farmers' income contributing significantly to achieve the vision of Viksit Krishi and Viksit Bharat 2047.

Key Words: Agri Drone Technology, Liquid fertilizers, Agro Chemicals, Knowledge, Prospects, Constraints



T-4 O-41: Study on Utilization Pattern of Information Communication Technologies Among Grape Growers

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The study was conducted in Vijayapura district of North Karnataka during the year 2020-21. This district was selected purposively as this district is having highest area (12,400 ha) under grape cultivation in Karnataka. Out of ten talukas of the district five talukas were selected based on the highest area under grape cultivation. From each selected taluka three villages were selected based on the highest area under grape cultivation. From each selected village ten grape growers were selected randomly. Thus, the total sample size was 150 grape growers. The important findings of study were that more than one thirds (34.00 %) of the respondents belonged to medium use of ICTs category, followed by 33.33 per cent of the respondents belonged to high use of ICTs category and 32.67 per cent of the grape growers belonged to low use of ICTs category. The study also indicted that socio-economic characteristics like education, farming experience, accessibility to ICT tools, mass media utilization, were found to be positive and highly significant with the utilization pattern of ICTs by the grape growers at 1.00 per cent level of significance and achievement motivation was found to be positive and significant with the utilization pattern of ICTs by the grape growers at 5.00 per cent level of significance.

Further, it could also be observed from the result that the 'F' value (6.517) obtained from the multiple regression analysis was found to be statistically significant at one per cent level indicating that all the independent variables put together contributed significant to the variation in the Utilization pattern of ICTs by grape growers. The coefficient of determination (R^2) was 0.384 which revealed that 38.40 per cent of variation in the Utilization pattern of ICTs by grape growers was explained by all the independent variables selected for the study. Further, it was also inferred that out of the thirteen independent variables only education, farming experience, accessibility to ICT tools, mass media utilization and achievement motivation contributed significantly at 1.00 per cent towards the variation in the Utilization pattern of ICTs by grape growers and extension contact contributed significantly at 5.00 per cent towards the variation in the Utilization pattern of ICTs by grape growers.

Keywords: Utilisation, grape growers, Information Communication Technologies, Agriculture



T-4 O-42: Blending Screens and Soil: Phygital Extension Models for Sustainable Agriculture

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Agricultural extension systems are increasingly adopting phygital models that integrate digital technologies with conventional, face-to-face extension mechanisms to enhance the reach, relevance and effectiveness of advisory services. This paper reviews selected research studies, policy documents, evidence reports and case-based initiatives to examine the conceptual foundations, operational mechanisms and outcomes of phygital agricultural extension models, with a particular focus on India. Phygital extension is defined as an integrated ecosystem that combines physical institutions such as Krishi Vigyan Kendras, Farmer Producer Organisations, self-help groups, non-governmental organisations and frontline extension personnel with digital platforms, applications and media for advisory delivery, learning and market linkages.

The review develops a conceptual framework that distinguishes phygital extension from conventional ICT-based or multi-channel approaches by emphasising deep integration, continuous feedback loops and co-production of locally relevant content. Four broad model types are identified: FPO or cooperative–platform hub-and-spoke models; lead farmer or community animator models supported by digital platforms; public extension and KVK-led systems with digital follow-up; and NGO or CSR-mediated community phygital models. Evidence suggests that embedding digital tools within trusted local institutions improves farmers’ access to information, enhances understanding and relevance of advisories, strengthens collectives, and supports higher adoption of recommended practices, improved resource-use efficiency and better market connectivity.

At the same time, challenges related to digital literacy, infrastructure gaps, institutional coordination, data governance and risks of exclusion for unorganised or digitally disconnected farmers persist. The paper concludes that phygital extension represents a promising and scalable pathway for revitalising agricultural extension, provided it is supported by integrated policies, sustained capacity building and stakeholder convergence, and designed as “phygital by default” to promote inclusive and sustainable agricultural development.

Keywords: Phygital extension, Digital agriculture, ICTs, Sustainable agriculture, Extension systems



T-4 O-43: Utilization of Information Communication Tools by Extension Functionaries for Dissemination of Technologies

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In the era of modernization and globalization, agricultural extension system has undergone sea changes through adoption of advanced technologies necessary for timely dissemination of information to farmers. Information Communication Technologies (ICTs) tools such as mobile phones, computers, internet services, social media platforms, multimedia applications, and digital advisory systems have emerged as powerful means for improving the efficiency and outreach of agricultural extension services. In this background the study has been conducted in the Karnataka state to assess the extent of utilization of ICTs by extension functionaries. The respondents for the study consisted extension functionaries working in governmental development departments and non-governmental organizations (NGOs, FPOs, and Cooperatives). A purposive sampling technique was used to select the respondents. Questionnaire was sent to the respondents in the Google Form to have wide coverage of sample respondents. The survey link was shared with the respondents through email, What'sApp, and other social media platforms. Information was received from 160 respondents of different cadre. Data was analyzed using mean score and respondents were categorized by using index values. The results indicated that more than three fourth of the respondents were using network based technologies with a mean score of 76.97 followed by web based agriculture information portals (mean score 75.84). Only half of the respondents were using software (50.00) in dissemination of agricultural technologies. Majority of the extension functionaries were fall in the category of high (54.00 %) utilization of ICT tools with index value of 0.61-0.80 followed by very high (24.00 %) to medium (20.00 %). Utilization of ICT tools by extension functionaries has significantly strengthened the dissemination of agricultural technologies. There is a need to organize capacity building, strengthen infrastructure, and policy support to further enhance the effective use of ICT tools in agricultural extension.



T-4 O-44: Reaching the Urban Masses: Innovative Horticulture Extension Initiatives

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The Horticulture Extension Education Center (HEEC) at the University of Horticultural Sciences, Campus Bengaluru, has pioneered innovative urban-oriented extension approaches to build capacity and transfer horticulture technologies to urban populations. Recognizing the importance of reaching out to urban communities, HEEC has devised initiatives that disseminate cutting-edge horticultural practices and foster sustainability and community engagement. HEEC's flagship program, summer and winter horticulture camps for kids, creates awareness and educates young minds about horticulture's potential, inspiring the next generation of horticulturists. Hands-on experiences in cutting-edge farms and interactions with progressive farmers help urbanites develop a deeper understanding of sustainable agricultural practices. HEEC facilitates direct marketing linkages, promoting a more equitable food system. The family farmer approach connects urbanites with progressive farmers, eliminating middlemen and ensuring quality products, benefiting both consumers and farmers. HEEC also leverages technology, establishing consumer WhatsApp groups for training, capacity building, and sale of farm produce, disseminating information and fostering informed urban consumers. These initiatives have enabled HEEC to reach a wider audience, transfer technology effectively, and enhance the university's visibility among urban populations. The success of these initiatives testifies to HEEC's commitment to innovation, community engagement, and sustainability, shaping the future of horticulture and promoting a sustainable food system for generations to come. HEEC's efforts will play a crucial role in addressing the challenges of urbanization and promoting sustainable agriculture. By empowering urban communities with knowledge and skills, HEEC is bridging the gap between urban and rural areas, promoting a more inclusive and sustainable food system. As urban populations continue to grow, HEEC's initiatives will have a lasting impact on the future of horticulture and food security. Overall, HEEC's innovative approaches have demonstrated the potential to transform urban horticulture, making it more sustainable, equitable, and accessible to all. As a model for urban extension, HEEC's initiatives can be replicated and scaled up to promote sustainable agriculture and food systems globally.



T-4 O-45: Digital Media Utilization Among Farmers and Agricultural Professionals: Opportunities, Impacts and Challenges- A Review

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The digital transformation of agricultural extension represents a crucial evolution beyond traditional, contact-dependent extension systems. This review analyzes findings from 30 peer-reviewed articles and 7 institutional reports, supplemented by insights from official organizational websites to explore the use of digital media among farmers and agricultural professionals. Digital tools such as SMS and IVR services, mobile apps, web portals, social media and AI-enabled advisory systems have revolutionized agricultural information dissemination, enabling faster, cost-effective, interactive and scalable outreach. The findings indicate that digital media use significantly enhances farmers' knowledge, decision-making, input efficiency, crop productivity and income. Users of mobile-based and agrometeorological advisory services report higher yields, lower cultivation costs, and increased earnings. Platforms like WhatsApp, YouTube, agricultural apps and web portals are popular for real-time advisories, pest and disease identification, market intelligence and peer learning, with farmers' preference for concise, problem-specific, visual content in regional or bilingual formats. For agricultural professionals, digital media improves outreach, advisory speed, documentation, monitoring, training and crisis communication while cutting time and travel costs. Despite these advantages, challenges such as low digital literacy, language barriers, misinformation, poor rural connectivity, siloed platforms and organizational resistance hinder utilization. Emerging trends like AI, machine learning, IoT, satellite data and blockchain suggest a move towards data-driven, personalized services. Ultimately, digital media complements rather than replaces conventional extension, emphasizing the need for better platform integration, digital skills enhancement, localized content and institutional capacity to foster inclusive, sustainable agricultural development.

Keywords: Digital media, agricultural extension, farmers, agricultural professionals, digital advisory services, artificial intelligence, social media.



T-4 O-46: Determinants of Nutritional Literacy among College Students in India

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Nutritional literacy is a critical determinant of healthy dietary behaviour and long-term wellbeing. The present study examines the socio-demographic, educational, and informational determinants of nutritional literacy among college students in India. A cross-sectional survey was conducted among 914 respondents using a structured questionnaire covering socio-demographic characteristics, parental education, regional background, dietary behaviour, and exposure to nutrition-related information. Nutritional literacy was assessed using the validated Nutritional Literacy Scale developed by Liao, Lai, and Chang (2019). Descriptive results indicate relatively strong functional nutritional literacy, moderate interactive literacy, and comparatively weaker critical literacy, particularly in evaluating online nutrition information and identifying credible sources. Independent samples *t*-tests and one-way ANOVA were employed to examine unadjusted group differences, followed by multivariate regression analysis to identify independent predictors of nutritional literacy. While gender, age, income, religion, social group, and academic year did not show significant adjusted effects, regression results reveal that exposure to nutrition-related information at the university level emerged as the strongest predictor of nutritional literacy. Students reporting lower or no exposure demonstrated significantly lower literacy scores. Parental education also exerted a positive and significant influence, with students from graduate- and postgraduate-educated households displaying higher nutritional literacy. Additionally, regional differences persisted, with students from Western India and, marginally, the Northeast exhibiting higher literacy levels. The findings highlight the central role of institutional exposure and family educational background in shaping nutritional literacy, beyond individual socio-economic characteristics. Strengthening university-based nutrition education and integrating critical nutrition literacy into extension and higher education curricula can significantly enhance students' capacity to navigate misinformation and make informed dietary choices. These results offer important implications for designing targeted nutrition education and extension interventions.

Keywords: Nutritional literacy, university students, parental education, nutrition information exposure, India



T-4 O-47: Harnessing Text Mining and Analytics to strengthening Digital Agriculture

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Our success as human race is because of our ability to communicate and share information and that is where the concept of language comes, toughest thing to learn. Today's world, only 21 percent of the available data is present in structured form whereas rest of them has been generated as we speak, as we tweet and as we send messages on WhatsApp, Instagram or various other messaging platforms and majority of this data exists in the textual form which is highly unstructured in nature. In order to produce significant and actionable insights from this text data, it is important to get acquainted with the techniques of text analysis. Human can instantly understand a sentence in their native language, it is quite challenging for a computer to make sense of one. Then the concept of Natural Language Processing (NLP) comes into picture for better understanding of text data. Different text analytics allow us to represent this text quantitatively. This allows analysts to use statistics to summarize the content of the documents, condensing years of reading into minutes of computation. Text analysis quickly sums up entire corpora of text, allowing social scientists to systematically study subject matters encoded in the text. One can use these tools to find out how people feel towards a particular phenomenon on social media (Sentiment Analysis), or understanding the main topics in news articles (Topic analysis). By aggregating results of text analysis and using NLP tools to turn the numbers into easy-to-understand reports and graphics, text analytics can identify patterns, trends and actionable insights that one can use to make data-driven decisions. For this purpose, we have used 2000 tweets on "Farm Bill" & "New Education Policy" and different success stories for Sentiment Analysis. Text clustering and networking purpose "Farm Bill" text data were used. In Topic Analysis was done on a different news article regarding the recent farm bill, collected from "The Hindu". As a result of these analyses combined are like Sentiment Score graph, Zipf's law validation, Text dendrogram, Centrality measures in text network, Beta co-efficient, Gamma co-efficient of Topic modeling and lastly relationship map over farm bill in Thematic analysis.

Keywords: Natural language Processing, Sentiment Analysis, Topic Analysis, Text clustering and Text networking





Theme IV : Poster

Opportunities and advanced in digital extension and education –Global and local experiences





T-4 P-1: Role of E-Governance for Agricultural Stakeholders: A Boon in Disguise

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Karnataka occupies a pioneering position in India's e-governance landscape and is widely recognised as a frontrunner in the adoption of Information and Communication Technology (ICT) for public administration. The establishment of the Department of Personnel and Administrative Reforms (e-Governance) and initiatives such as the Centre for e-Governance and Centre for Smart Governance Directorate of Electronic Delivery of Citizen Services (EDCS) and Karnataka State Remote Sensing Applications Centre (KSRSAC) have played a crucial role in planning and delivering online services to citizens through various platforms. Karnataka delivers a large number of citizen-centric services through platforms such as Bhoomi, Seva Sindhu, Sakala, Grama One and Jana Sevaka, reflecting its leadership in transparent and efficient service delivery. The present study reviews major e-governance initiatives implemented in Karnataka with the objectives of assessing service efficiency, transparency, citizen adoption and key implementation challenges. The methodology is based on a systematic review of secondary data drawn from government reports and empirical research studies conducted across various districts of the state. Findings from earlier studies indicate that e-governance initiatives have significantly reduced service delivery time and transaction costs, improved access to essential services such as land records and certificates, and enhanced transparency in administrative processes. However, notable urban-rural disparities persist in terms of digital infrastructure, service quality and awareness levels. Challenges including connectivity issues, server overload, digital literacy gaps and perceived risk continue to affect sustained usage, particularly among rural citizens. The discussion highlights that service quality, trust in service providers, facilitating conditions and performance expectancy positively influence citizens' attitudes and continuous intention to use e-governance services. In conclusion, Karnataka's e-governance framework demonstrates strong institutional capacity and measurable improvements in public service delivery, while continued infrastructure strengthening, system reliability and capacity building remain essential for ensuring inclusive and sustainable digital governance across the state.

Keywords: E-governance, Karnataka, Digital governance, Service delivery, ICT, Public administration



T-4 P-2: Understanding Farmer Profiles in Digital Farmer Field School Program: Evidence from Maharashtra

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Soybean (*Glycine max* L.) plays a vital role in Maharashtra's agricultural economy, yet productivity remains suboptimal due to persistent resource and knowledge constraints. To address these challenges, the PAANI Foundation launched the Digital ShetiShaala (DSS), a Digital Farmer Field School (DFFS) model, aimed at enhancing soybean cultivation through participatory digital learning. This study compared the socio-economic and personal profiles of 75 participant and 75 non-participant farmers across Ahilyanagar district. Results revealed that most respondents belonged to the middle age group with secondary-level education. However, participants demonstrated stronger scientific orientation, higher techno-savviness, greater social media engagement, and a greater representation of women compared to non-participants. While non-participants tended to own larger landholdings, they showed lower orientation toward innovation and external linkages. The study concludes that DFFS not only strengthens knowledge and inclusivity but also bridges digital gaps, thereby offering a scalable model for agricultural extension in Maharashtra.

Keywords: Soybean, Digital Farmer Field School, Farmer's profile, PAANI Foundation, Ahilyanagar.

T-4 P-3: Constraints and Suggestions of Participant Farmers under the Digital Field Farming School (DFFS) on Soybean in Maharashtra.

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The study explored the constraints faced by farmers and their suggestions for improving the Digital Field Farming School (DFFS) programme. Results indicated that poor internet connectivity (78.67%) and insufficient digital competence (74.67%) were the most critical challenges. Other issues included unavailability of yellow and blue sticky traps (57.33%), limited neem seed access for neem ark preparation (53.33%), unsuitable session timing (49.33%), and lack of practical orientation (42.67%). Additionally, 38.77 per cent reported unavailability of Android devices, while 30.67 per cent faced difficulty obtaining *Metarhizium anisopliae* biopesticide. To enhance DFFS implementation, participants suggested flexible scheduling (76.00%), more practical orientation (60.00%), and increased expert interaction and demonstrations (54.67%). Strengthening rural digital infrastructure (49.33%) and subsidizing Android devices (38.67%) were also emphasized. The findings underscore the importance of digital literacy, local resource availability, and adaptive scheduling for strengthening digital agricultural extension initiatives.

Keywords: DFFS, Digital Agriculture, Farmer Constraints, Extension Education, Rural Connectivity



T-4 P-4: Leveraging Digital Technologies for Agricultural Extension: Opportunities and Challenges

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Digital technologies are playing an increasingly important role in transforming agricultural extension and education by making advisory services more accessible, timely, and relevant to farmers' needs. This review explores both global and local experiences with digital extension, highlighting recent advances such as mobile-based advisory services, artificial intelligence (AI) applications, big data driven decision tools, social media platforms, and virtual learning environments. At the global level, these technologies support rapid dissemination of weather information, pest and disease warnings, market updates, and farm management advice which helps farmers make better-informed production decisions and improve productivity.

In local and smallholder farming contexts, digital tools have strengthened learning opportunities, encouraged interaction between farmers and experts, and improved the reach of extension services in remote and underserved areas. However, several constraints continue to limit widespread and equitable adoption, including poor digital infrastructure, low levels of digital literacy, gender-related disparities in access to technology, high costs of devices and internet connectivity, and concerns related to data security and privacy. Digital solutions are most effective when combined with traditional face-to-face extension and supported by strong institutional arrangements. Building digital skills, ensuring inclusive access, and encouraging partnerships between public and private actors are critical for long-term sustainability. Overall, digital extension and education hold strong potential to strengthen agricultural knowledge systems and improve resilience, provided that innovations are designed to match local conditions and farmers' capacities.



T-4 P-5: Barriers to Effective Two-Way Communication in Agricultural Extension

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Agricultural extension serves as the vital bridge between scientific research and field application, yet the transition from a traditional "top-down" delivery system to a participatory, **two-way communication model** remains fraught with challenges. This abstract examines the multi-dimensional barriers—structural, socio-cultural, and technical—that impede the reciprocal flow of information between extension agents and farmers, ultimately hindering agricultural productivity. **Structural barriers** often stem from rigid institutional hierarchies where services are viewed as unidirectional pipelines, leaving little room for farmer feedback or the integration of indigenous knowledge. **Socio-cultural factors**, including high illiteracy rates, language disparities, and deeply ingrained traditional beliefs, create a "perceptual gap" that prevents farmers from articulating their needs or fully trusting external advice. Furthermore, **technical and infrastructural constraints**, such as limited access to Information and Communication Technologies (ICTs) and poor physical infrastructure, restrict real-time interaction in developing regions. Economic limitations, including the high cost of data and inadequate funding for personnel, further stifle engagement quality. The study concludes that effective two-way communication requires a paradigm shift toward a **dialogic approach**, necessitating policy interventions that prioritize farmer-led agendas, the recruitment of culturally competent agents, and the strategic deployment of user-friendly digital tools to ensure innovations are both scientifically sound and locally sustainable.

Keywords: Agricultural Extension, Two-Way Communication, Participatory Development, Information Asymmetry, Socio-cultural Barriers, Knowledge Transfer, Rural Infrastructure.



T-4 P-6: Role of Digital Competencies in Improving Employability of Agricultural Graduates under Smart Extension Systems

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The rapid integration of digital technologies into agricultural extension systems has significantly transformed the nature of professional roles and skill requirements for agricultural graduates. In this context, digital competencies have emerged as a critical determinant of employability under smart extension systems. The present paper examines the role of digital competencies—comprising digital literacy, data handling skills, use of mobile-based advisory services, decision support systems, and communication through digital platforms in enhancing the employability of agricultural graduates. The study emphasizes how smart extension systems, supported by intelligent technologies such as ICT tools, mobile applications, artificial intelligence, and precision agriculture platforms, demand a workforce equipped with advanced digital skills. Lack of adequate digital competencies among graduates often results in a skill gap, limiting their employment opportunities in public extension services, agri-startups, private agribusiness firms, and climate-smart advisory services. The paper highlights the need for integrating digital competency-based training into agricultural education curricula to align academic outcomes with labor market requirements. Further, the paper discusses the role of extension education institutions in capacity building, continuous skill upgradation, and experiential learning to improve graduates' adaptability and professional readiness. Strengthening digital competencies not only enhances individual employability but also contributes to effective knowledge dissemination, farmer empowerment, and sustainable agricultural development. The study concludes that fostering digital competencies among agricultural graduates is essential for strengthening smart extension systems and supporting the broader goal of Atmanirbhar Bharat.

Keywords: Digital competencies, Employability, Agricultural graduates, Smart extension systems, Digital extension



T-4 P-7: Sustainable Weed Management in Sugarcane: Problems and Opportunities

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Competition by weeds during the growing season of the crop for soil moisture, mineral constituents, sunlight, and space along with unhealthy nutrient management practices is the major constraint in enhancing the crop productivity. Besides, reducing the crop yield directly, heavy infestation of weeds interfere with crop harvest and elevate farm production costs through energy spent in controlling them. A weed which escapes the control measures and produces seed at maturity, further multiplies weed control problems by acting as a source of seed bank replenishment and re-infestation in the subsequent years. In sugarcane, the reduction in cane yield due to weeds ranged from 40 – 67 %, the highest being in those areas where farmers are not familiar to improved weed management technologies. Weed control is most critical early in the season prior to the sugarcane canopy closure over the row middles. Wide spacing in between sugarcane rows allows wide range of weed flora to grow profusely. The kind of weed species and the duration of its infestation have a major impact on stalk size, number of millable canes and finally the cane and sugar yields. Further, it severely reduces not only the tonnage, but also its quality besides hindering in the various field operations and harbouring insect-pests and disease. The nature of weed problem in sugarcane cultivation is quite different from other field crops because of inherent capacity of slow initial crop growth and heavy input requirements. The intensity and diversity of weed flora in sugarcane is dependent on the planting season. Owing to heavy nutrient application and frequent irrigation favours emergence of more flush of weed flora in the same growing season. There are several perennial weeds causing immensely losses in plant and ratoon cane crop in the tropical and subtropical regions of the country as well as the world. These weeds are so damaging that the losses can be experienced as high as 90% of the total crop yield in various part of the world. Although weeds are a challenge in the current sugarcane production system in India, there are many opportunities exist for developing sustainable and effective weed management programmes for main and ratoon crop. A huge quantity of trashes ranging from 12-15 tons/ha) can be effectively utilized as a component of IWM practices besides improving the resource use efficiency. In sugarcane, weeds are generally controlled with manual and cultural manipulations. Now-a-days timely availability of labour is a problem. So, the herbicide uses for weed control in sugarcane is considered to be economical and thus becoming increasingly popular. Hence, providing a weed free environment is absolutely essential to realize the full potential of new varieties and to make the best use of key production factors like nutrients, moisture and other natural resources. There are several weed management techniques which may be started much before planting as a preventive measure and may continue in the standing field crop by way of physical, mechanical, and chemical methods of weed management to improve the cane yield and farmer income.

The integration of AI and robotics is revolutionizing weed control in sugarcane farming, offering more precise, efficient, and sustainable solutions compared to traditional methods. These technologies leverage advanced algorithms and data analysis to optimize weed management strategies. By integrating AI into sugarcane farming practices, Indian farmers can achieve higher yields, lower production costs, and improved resource management- all of which are crucial for sustaining the rising demand driven by increased domestic sugar consumption and the expanding Ethanol Blended Petrol (EBP) Programme.

Key words: Artificial intelligence, robotics, weed, biofuel, sugar



T-4 P-8: Digital Extension and Farmer Education in India: Pathways to Sustainable Food Systems and Atmanirbhar Bharat

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Under the concept of Atmanirbhar Bharat, digital extension and farmer education have come to be essential elements in changing Indian agriculture to be sustainable and self-reliant. Quick advances in information and communication technologies (ICTs), including mobile-based advisory services, digital learning platforms, artificial intelligence-enabled decision support systems and e-extension networks, have considerably extended agricultural range, efficiency and effectiveness. Services for enlargement. These digital initiatives help farmers to make educated decisions and so increase income and production by enabling timely dissemination of crop management, climate advisories, input usage, market intelligence and risk reduction information. With an eye on their contribution to sustainable food systems and farmer empowerment, this review article critically analyzes the part digital extension and farmer education play in India. It emphasizes significant digital projects and platforms including mobile agricultural applications, online capacity-building programmes, e-NAM and Kisan Call Centres, even evaluating their effects on small and marginalized farmers. Furthermore, examined in the report are major problems including limited digital literacy, the digital divide, inadequate infrastructure and concerns of accessibility and inclusiveness, especially among women and resource-poor farmers. Digital extension offers great chances to improve farmer education, build resilience to climate variation, encourage effective resource usage and support innovation in agriculture notwithstanding these limitations. To maximise the possibilities of digital expansion in reaching sustainable food systems and the objectives of Atmanirbhar Bharat, the review recommends strategic interventions including better digital infrastructure, capacity building, inclusive design of digital tools and supportive policy frameworks.

Keywords: Digital Extension, Farmer Education, Atmanirbhar Bharat, e-Extension Services, Sustainable Food Systems, Information and Communication Technologies (ICTs) in agriculture, e-Extension Services,



T-4 P-9: Impact of Farmer FIRST Programme on Income Enhancement in Palwal District, Haryana

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The Farmer FIRST Programme (FFP) implemented by ICAR–IARI, New Delhi in Palwal district, Haryana, has demonstrated measurable socio-economic and technological impacts through participatory interventions. Covering 93.2 hectares across four clusters—Amarpur, Dadhota, Katesra, and Kulena—the project benefitted over 760 farm families through integrated modules encompassing crops, horticulture, livestock, natural resource management, and rural enterprises.

In crop-based interventions, improved wheat varieties (HD 3226, HD 3086, HDCSW 18) yielded 53.25 q/ha, achieving 8% gain over local checks and net returns of ₹98,929/ha (B:C = 3.10). Short-duration basmati varieties (PB 1509, PB 1885) increased yield by 8–12% and reduced irrigation by 15 days, with returns up to ₹1.15 lakh/ha (B:C = 3.07). Summer mungbean (Pusa Vishal, Pusa 1641) recorded 15.6% yield gain (10.75 q/ha) and enhanced annual household income by ₹20,000–25,000. Horticultural diversification promoted nutritional and economic security. Bottle gourd (Pusa Santushti) produced 176.2 q/ha, generating ₹1.16 lakh/ha (B:C = 3.03), while carrot (Pusa Rudhira) yielded 197 q/ha with ₹1.15 lakh net returns (B:C = 2.93). Marigold (Pusa Narangi Gaiinda) demonstrated 125 q/ha yield, earning ₹1.25 lakh/ha (B:C = 3.2). Nutritional kitchen gardens, covering 4.1 ha and 410 women, ensured year-round vegetable supply with B:C ratios of 2.2–2.9, fostering 85% adoption post-training.

In livestock interventions, health and feeding camps led to a 10–15% rise in milk yield, linking farmers with schemes like Pashu Kisan Credit Card and Mini Dairy. Protected cultivation demonstrated cucumber yields of 648 kg/100 m² (B:C = 3.19) and capsicum yields of 565 kg/100 m² (B:C = 3.11). Button mushroom enterprises produced 4,530 kg across 8 units, realizing net profit of ₹3.18 lakh, with per-unit returns of ₹39,818 (B:C = 2.77). Farmer-led seed production under buy-back arrangements yielded B:C ratios of 3.2–3.3, while natural farming models attained ₹4.16 lakh/acre gross and ₹1.82 lakh net income. Through 16 Farmer–Scientist Interfaces and convergence with NABARD, ICAR–NDRI, and local NGOs, the project strengthened knowledge networks and trust among stakeholders. The outcomes illustrate that participatory extension, integrating science, local innovation, and entrepreneurship, can effectively enhance productivity, income, and resilience while promoting gender-inclusive and environmentally sustainable livelihoods.

Keywords: Farmer FIRST Programme, participatory extension, livelihood diversification, agripreneurship, women empowerment, crop productivity, Palwal



T-4 P-10: Mahavistar (MahaVISTAAR-AI): An AI-Based Digital Platform for Agricultural Extension Services

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The increasing complexity of agriculture due to climate variability, market fluctuations, and rising input costs demands innovative and technology-based extension approaches. The Mahavistar (MahaVISTAAR-AI) mobile application, introduced by the Government of Maharashtra, serves as a digital solution to bridge the information gap between farmers and agricultural advisory services. The application utilizes artificial intelligence to deliver timely, location-specific, and need-based recommendations covering crop management, pest and disease control, fertilizer scheduling, weather advisories, market price information, and government support programs.

A key strength of the Mahavistar app lies in its farmer-friendly design and multilingual interface, which enables users to access expert guidance in their local language. By integrating real-time data with scientific agricultural practices, the platform supports informed decision-making at various stages of crop production. The app reduces reliance on traditional extension mechanisms and promotes efficient use of resources, thereby lowering production risks and enhancing farm sustainability.

Overall, Mahavistar represents a progressive shift towards digital agricultural extension, offering scalable and inclusive advisory services. Its effective adoption can contribute significantly to improved productivity, income stability, and technological empowerment of farmers in Maharashtra.

Keywords: Digital Extension, Mahavistar App, Artificial Intelligence in Agriculture, Farmer Advisory System, Smart Farming



T-4 P-11: Impact of MPKV Released Wheat Variety Phule Samadhan and its Implications for Digital Agricultural Extension

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The present study conducted to assess the impact of the Mahatma Phule Krishi Vidyapeeth, Rahuri released wheat variety Phule Samadhan on wheat growers in Nashik district of Western Maharashtra, with a special focus on yield, income, and socio-economic characteristics of the wheat growers, along with the role of digital agricultural extension in enhancing adoption and productivity.

The study was conducted using an ex-post facto research design, and data were collected from 140 wheat growers (70 Phule Samadhan wheat variety growers and 70 other wheat variety growers) through personal interviews using a structured interview schedule.

Results revealed that a majority of Phule Samadhan growers belonged to the middle age group, had secondary to higher secondary education, had medium farming experience, marginal landholdings, and medium annual income. The findings indicated that Phule Samadhan wheat variety resulted in higher yield and income compared to other varieties.

Correlation analysis showed a significant positive relationship between impact and variables such as farming experience, landholding, area under wheat, crop productivity, and market orientation. Major constraints faced by the farmers included lack of technical knowledge, seed unavailability, labor scarcity, and irrigation-related issues. The study highlights the potential of digital agricultural extension services, including mobile-based advisories, digital information of seed distribution, digital weather-based alerts, and market information services to solve these constraints and enhance the impact of improved wheat varieties. The findings show the importance of integrating digital tools with conventional extension systems to facilitate timely decision-making, resource optimization, and income enhancement for small and marginal farmers.

Keywords: Phule Samadhan, Wheat, Impact assessment, Digital extension, Yield, Income, Adoption



T-4 P-12: Towards Inclusive and Demand-Driven Agricultural Extension - The Role of Digital Technologies

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Rapid advancements in digital technologies have transformed agricultural extension and education systems worldwide, creating new opportunities for efficient, inclusive, and demand-driven knowledge dissemination. Digital extension platforms such as mobile applications, SMS and voice-based advisory services, social media, e-learning modules, artificial intelligence (AI), Internet of Things (IoT), and data analytics have enabled timely, location-specific, and personalized information delivery to farmers. These tools support informed decision-making related to crop management, weather forecasting, pest and disease control, market access, and climate-smart agricultural practices, thereby enhancing productivity, income, and resilience. Global experiences demonstrate that digitally enabled extension systems can scale rapidly and effectively when supported by participatory approaches, localized content, and peer-to-peer learning. Successful initiatives highlight the role of digital ecosystems in strengthening farmer engagement and improving extension outreach. At the local level, especially in developing countries, institutional support from governments, agricultural universities, extension agencies, and public-private partnerships have been instrumental in building digital capacity at the grassroots. Integration of digital tools within existing extension frameworks has improved accessibility and responsiveness of advisory services. Despite these advancements, several challenges persist, including the digital divide, inadequate ICT infrastructure, limited digital literacy, language barriers, and concerns related to data privacy and inclusiveness. Addressing these constraints requires targeted investments in digital infrastructure, farmer-centric platform design, capacity building of extension personnel and users, and supportive policy environments. A resilient digital extension and education system must incorporate continuous feedback mechanisms, user participation, and context-specific adaptation. Leveraging global innovations while aligning them with local realities is essential for realizing the full potential of digital extension in promoting sustainable agriculture, food security, and rural transformation.

Keywords: Digital extension, ICTs, e-extension, artificial intelligence, mobile advisory systems



T-4 P-13: Digital Extension and Education for Empowering Farmers towards Atmanirbhar Bharat: A Review

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Empowering farmers through knowledge, skills, and institutional support is central to achieving the vision of Atmanirbhar Bharat in agriculture. Agricultural extension and education systems play a pivotal role in this process; however, conventional extension approaches are increasingly inadequate in addressing the complex challenges faced by farmers, including climate variability, market instability, declining profitability, and limited access to timely information. Digital extension and education have emerged as transformative mechanisms to overcome these constraints by enabling wider outreach, inclusivity, and real-time advisory services. This review paper critically examines the role of digital extension and education in empowering farmers and strengthening agricultural self-reliance in India. The review synthesizes peer-reviewed literature, policy documents, and empirical studies related to digital agricultural extension, farmer education, and technology-mediated advisory systems. It highlights the contribution of digital tools such as mobile-based advisories, e-learning platforms, social media, decision support systems, and data-driven extension models in enhancing farmers' access to information, improving decision-making capacity, and fostering market participation. Special emphasis is given to Indian initiatives and grassroots innovations that align digital extension with local contexts and farmer needs. The review identifies that digital extension has significantly improved the reach and efficiency of extension services, particularly among small and marginal farmers, youth, and farmer producer organizations (FPOs). Digital education platforms support continuous learning, peer-to-peer knowledge exchange, and capacity building beyond geographical and institutional boundaries. However, challenges such as digital divide, limited digital literacy, language barriers, and institutional readiness continue to hinder equitable outcomes. The paper argues that digital extension should be viewed not merely as a technological intervention but as a socio-educational process requiring human facilitation, participatory design, and supportive policy frameworks. The review concludes that inclusive, human-centered, and context-sensitive digital extension and education systems are essential for farmer empowerment and for realizing Atmanirbhar Bharat in agriculture. Strategic investments in capacity building, curriculum reform, and institutional convergence can strengthen the transformative potential of digital extension.

Keywords: Digital extension, Farmer empowerment, Agricultural education, Atmanirbhar Bharat, ICTs in agriculture



T-4 P-14: Strengthening Coastal Agriculture in WestCoast through Soil Science–Based Extension Services

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The west coast of India, encompassing the coastal districts of Maharashtra (Palghar, Thane, Raigad, Ratnagiri, and Sindhudurg) and the state of Goa, represents a unique agro-ecological region dominated by lateritic, acidic, and well-drained soils that constrain agricultural productivity. Analysis of soil test data from coastal Maharashtra and Goa indicated soil pH ranging from 4.5 to 6.5, electrical conductivity between 0.05 and 0.40 dS m⁻¹, and organic carbon content of 0.40–1.50%. Available nitrogen (150–350 kg ha⁻¹) and phosphorus (5–25 kg ha⁻¹) were predominantly low to medium, while potassium varied from 80 to 350 kg ha⁻¹. Micronutrient assessment revealed widespread deficiencies of boron (0.2–0.6 mg kg⁻¹) and zinc (0.4–1.2 mg kg⁻¹), whereas iron (10–45 mg kg⁻¹), manganese (5–30 mg kg⁻¹), and copper (0.3–2.0 mg kg⁻¹) were largely adequate. To address these soil fertility constraints, soil science–based extension interventions were implemented by ICAR–Krishi Vigyan Kendra, North Goa and ICAR–Central Coastal Agricultural Research Institute (CCARI), Goa, in collaboration with Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The interventions focused on soil-testing–based nutrient advisories, liming to correct soil acidity, integrated nutrient management, and site-specific micronutrient application. Extension activities covered 242 villages in North Goa and 161 in South Goa, resulting in the distribution of 9,058 Soil Health Cards with crop-specific fertilizer recommendations. To strengthen digital outreach, an Android-based mobile application, *Fertilizer Calculator Goa*, was developed to provide soil-test–based fertilizer guidance for major crops. Farmer awareness was further enhanced through soil health campaigns, training sessions, exhibitions, diagnostic field visits, and mass outreach via print and digital media. The study demonstrates that integrating soil-test–based advisories with digital tools and multi-channel extension approaches improves soil fertility management, optimizes nutrient-use efficiency, and supports the sustainable intensification of coastal agriculture in the Konkan region.

Keywords: Coastal agriculture; Soil testing; Extension services; Nutrient management; Konkan region



T-4 P-15: Usage Pattern of Websites by Post-Graduate students – A Study

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In the digital era, websites serve as vital platforms for academic pursuits in agricultural education, providing swift access to scholarly articles, databases and repositories. Postgraduate students depend on them for literature reviews, data analysis and knowledge dissemination, revolutionizing traditional research practices. The present study examines the pattern of website usage, purposes, influencing factors and challenges faced by postgraduate students of the University of Agricultural Sciences, Dharwad, in accessing online academic resources. A descriptive research design was adopted and primary data was collected from 52 postgraduate students using a structured questionnaire. Frequencies and percentages were employed for data analysis. The findings reveal that academic websites such as Google Scholar (98 %), ResearchGate (94 %), and Springer (44 %) are the most frequently used platforms for research-related activities. Google with 83 per cent usage emerged as the dominant search engine, while laptops (50 %) were identified as the primary device used for accessing online resources. Postgraduate students mainly utilized websites for accessing research articles and journals, locating theses, supplementing lecture materials, and staying updated with recent research developments. Peer groups, particularly seniors and friends, played a significant role in introducing students to useful academic websites. Despite high self-reported confidence in search proficiency, students encountered key constraints like restricted access to full-text articles, download limitations, information overload and challenges in assessing online information quality. These barriers reveal deficiencies in institutional access and underscore the necessity for robust digital support frameworks. The study advocates bolstering institutional subscriptions to academic databases, intensifying digital literacy programs, and amplifying faculty and library guidance to optimize students' utilization of online scholarly resources.

Keywords: Postgraduate students, academic websites, digital resources, information-seeking behaviour, agricultural education



T-4 P-16: Smart Hydroponics technology

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According to the Food and Agriculture Organization of the United Nations, the global population is projected to reach nine billion by 2050, with nearly 75% residing in urban areas. This rapid urbanization, combined with challenges such as climate change, water scarcity, and soil degradation, will intensify pressure on global food systems. As arable land continues to shrink, innovative food production methods become essential. Hydroponics cultivating plants in nutrient-enriched water instead of soil offers a practical solution to these constraints. By delivering nutrients directly to plant roots, hydroponic systems significantly reduce water consumption and eliminate dependence on soil quality. The integration of hydroponics with smart farming technologies represents a promising advancement in sustainable agriculture. Smart farming employs the Internet of Things (IoT), sensors, and automated control systems to continuously track and manage environmental parameters such as nutrient levels, plant health, and system conditions. This data-driven approach enables precise and real-time adjustments, ensuring optimal growing conditions throughout the year, independent of external climate variations. As a result, crop yields increase, growth cycles accelerate, and resource use becomes more efficient. Additionally, smart hydroponic systems reduce reliance on chemical inputs by enabling environmentally friendly pest control and decreasing overall waste. Remote monitoring capabilities allow users to oversee water levels, pH balance, temperature, and nutrient solution conditions via the internet. Since temperature fluctuations can affect pH and nutrient uptake, the system incorporates scheduled temperature assessment to maintain stability. Continuous monitoring of electrical conductivity (EC) and pH is achieved through specialized sensors, while fuzzy logic controllers automatically regulate pumps to adjust nutrient concentration and pH levels for optimal plant development.

Overall, the combination of hydroponics and intelligent automation has the potential to transform agriculture by enabling decentralized food production, strengthening food security, and fostering more resilient, resource-efficient farming systems.

Keywords: Hydroponics, IoT, Sensors, Smart farming, Food security



T-4 P-17: Applications of Drone Technology in Agriculture: A Review

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Sustainable agriculture faces increasing challenges due to climate variability, labour shortages, rising input costs, and the need for efficient resource management. In this context, drones or Unmanned Aerial Vehicles (UAVs) have emerged as an important technological component of sustainable agricultural systems. UAVs provide new opportunities to meet the productivity demands of a growing population while promoting environmentally friendly farming practices. This study is based on a review of 15 research articles collected from Google Scholar and other scientific literature sources. The objective of this paper is to critically review existing literature to gain a deeper understanding of technological advancements in drone systems, their multiple applications in agriculture, and the limitations or challenges associated with their adoption. The review highlights various applications of drone technology in sustainable agriculture, including crop monitoring, precision application of agrochemicals, irrigation management, crop health assessment, plant nutrition management, and pest and disease surveillance. Integration of drone technology with recent advances in data analytics has significantly contributed to optimizing resource use efficiency, reducing production costs, and enhancing socio-economic sustainability in farming systems. The study reports several challenges that hinder the widespread adoption of drones in agriculture that includes constraints such as regulatory restrictions, high initial investment costs, lack of technical knowledge and operational skills among farmers, and technical limitations under diverse environmental conditions. Based on the studies it can be concluded that drones have the potential to revolutionize traditional agricultural practices and improve the socio-economic viability of farming. There is the need for targeted research, supportive policy frameworks, capacity-building and custom hiring service initiatives to promote the effective adoption of drone technology in agriculture.

Keywords: Drone technology, Unmanned Aerial Vehicles (UAVs), Sustainable agriculture, Precision farming



T-4 P-18: Impact analysis of Cluster frontline demonstrations (CFLD) pulses on yield enhancement of Chickpea (*Cicer arietinum* L.) in the district of Narsinghpur, Madhya Pradesh

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The study was carried out by Krishi Vigyan Narsinghpur district of Madhya Pradesh to know the yield gaps between improved package and practices under cluster front line demonstration (CFLD pulses) and farmer's practice (FP) of Chickpea (*Cicer arietinum* L.) crop variety JG-36 under rain fed condition. Cluster Front Line Demonstration on Chickpea were conducted on farmer's fields during Rabi season of two sequential years i.e. 2019-20 and 2020-21 under National Food Security Mission (NFSM), Govt. of India to demonstrate the impact of enriched agro-techniques on production and economic benefits under rainfed conditions. CFLD's were conducted in 30 ha and 20 ha area for two years with active involvement of 125 farmers and scientific staff of KVK. According to analysis of data the highest grain yield was obtained in demonstrated plots with an average of 13.72 q/ha as compared to local check with an average of 8.17 q/ha. An average mean of extension gap, technology gap and technology index were calculated as 5.61 q/ha, 6.36q/ha, 31.75 percent, respectively. Adoption of improved package of practices in Chickpea cultivation recorded average higher B:C ratio (3.07) as compared to Farmers Practice (1.93) during the period of study. Thus, the productivity of Chickpea could be increased with the adoption of recommended improved package of practices. The study resulted in satisfying the farming community for higher productivity and returns.

Keywords: Chickpea, front line demonstration, technology gap, impact, yield, technology index



T-4 P-19: Extension Strategies in the Changing Scenario of Indian Agriculture

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Indian agriculture has undergone significant transformation over the past several decades, driven by technological advancements, policy interventions, and evolving socio-economic conditions. Agricultural extension has played a pivotal role in disseminating production-oriented technologies; however, the changing agricultural scenario necessitates a paradigm shift towards market-led, demand-driven, and sustainability-focused extension strategies. This examines the evolution of agricultural extension across different time periods, highlighting its transition from centralized, top-down approaches to more participatory, ICT-enabled, and holistic systems. The study emphasizes emerging agricultural directions and proposes strategic actions such as dissemination of financial information, cost-reduction training, market linkage development, capacity building, strengthening research–extension–farmer linkages, and adoption of farming system approaches. New concepts and initiatives in extension, including multi-agency involvement and digital interventions, are discussed as essential tools for addressing contemporary challenges. Major challenges faced by agricultural extension services include the vast geographical spread of India, diversity of crops and allied activities, limited financial capacity of farmers, inadequate demonstrations, and neglect of indigenous technical knowledge. It also identifies constraints faced by farmers under both public and private extension systems, such as lack of timely inputs, insufficient access to information, weak institutional support, and exploitation by intermediaries. Empirical insights from selected research studies on organic farming, fodder production, and climate change awareness further strengthen the discussion on future extension strategies. concluding that need-based, area-specific, and innovation-driven extension interventions are crucial for enhancing farmers' income, productivity, and sustainability. A strong national policy framework and a multi-extension agency approach are identified as key future thrusts to ensure inclusive agricultural development and global competitiveness.

Keywords: Agricultural Extension, Market-led Extension, Extension Strategies, Sustainable Agriculture, Farmer Empowerment



Theme V : Oral
Digital applications in Start-ups and
entrepreneurship development for
Atmanirbhar Bharat





T-5 O-1: Digital Innovations Driving Agri-Startups: Strengthening Entrepreneurship for Atmanirbhar Bharat

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Digital technologies are reshaping India's startup landscape, accelerating entrepreneurship and strengthening the vision of Atmanirbhar Bharat, especially in the agricultural sector. India now hosts over **100,000 startups**, with more than **3,000 dedicated agri-startups**, marking one of the fastest-growing entrepreneurial segments in the country. Digital tools such as AI-based crop advisory, IoT-driven precision farming, remote sensing, blockchain-enabled supply chains, and smartphone-based market linkages are reducing information gaps and empowering farmers with real-time decisions. Telangana has emerged as one of India's most vibrant agri-innovation hubs, supported by initiatives like **T-Hub**, **RICH**, **WE-Hub**, and state-backed incubation programs that nurture early-stage agri-enterprises. The state contributes significantly to the national agri-startup ecosystem by fostering solutions in seed technology, farm mechanisation, FPO digitalisation, drone-based services, and agri-fintech. Despite this progress, challenges such as uneven digital literacy, limited rural connectivity, and scarcity of early-stage capital still constrain scaling. Strengthening digital infrastructure, building agri-entrepreneur skills, promoting public-private partnerships, and enabling policy support can unlock the full potential of agri-startups to drive rural livelihoods, agribusiness growth, and self-reliance. This work highlights how digital applications act as a catalyst for innovation-led agri-entrepreneurship and how states like Telangana can serve as blueprints for a resilient and technology-driven Atmanirbhar Bharat.

Keywords: Agri-startup ecosystem, Digital agriculture, Entrepreneurship development, Atmanirbhar Bharat, Telangana, Agri-innovation, Precision farming.



T-5 O-2: Assessment of the Effectiveness of the Seed Hub Project in Enhancing Quality Seed Production in Lalitpur District

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To ensure the availability of location-specific high-yielding varieties and quality seeds, pulse seed hub program was sanctioned to Krishi Vigyan Kendra, Lalitpur, Uttar Pradesh in 2016-2017. With the active participation of the farmers via buy back policy, KVK successfully procured 1120.8 quintals of Fieldpea, 281.16 quintals of chickpea, 59.44 quintals of Blackgram, Greengram 51.34 quintals and 19.4 quintals of Lentil during the period of 2018-19 to 2021-22. This resulted in the production of 1532 quintals of seed, covering 2083.5 ha. of land in the district. Buy-back agreements were signed between KVK and the farmers for their participation in the project. Selected farmers received training in good agronomic practices. Over the course of four years, the seed hub program generated a gross profit of INR 6628627.25 and a net profit of INR 3614893 for KVK. Profits from seed sales were reinvested into building additional facilities to enhance the seed production program. The buy-back policy has significantly improved the socio-economic status of the participating farmers compared to traditional cultivation methods.

Keywords: Seed hub, Quality seed, Participatory seed production and Pulses



T-5 O-3: Relational Analysis of Floriculture Growers with their Entrepreneurial Behaviour

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The present study was carried out to know the 'entrepreneurial behaviour of floriculture growers' and 'relationship between personal, socio-economic characteristics of floriculture growers and their entrepreneurial behaviour'. Ex-post-facto research design was used for the present study. Data were collected with the help of pre-structured interview schedule. The collected data was analysed by using statistical tools such as mean, standard deviation, frequency, percentage and correlation. The data revealed that 65.83 per cent of the respondents belonged to medium entrepreneurial behaviour. Whereas 17.50 per cent and 16.67 per cent had low and high level of entrepreneurial behaviour, respectively. Independent variables namely, education, size of land holding, area under polyhouse, annual income, credibility, risk orientation, planning orientation, marketing behaviour and place of market were positive and highly significant relationship with the entrepreneurial behaviour of floriculture growers while age was negative and non-significant relationship with the entrepreneurial behaviour of floriculture growers. Majority of the floriculture growers had medium entrepreneurial behaviour. It is clear indication of the farmer's progressiveness. Therefore, it calls for intensification of educational efforts and policy support to the protected cultivation by the field extension workers of the development departments, NGO's and private organizations. As majority of the respondents had medium innovativeness, still there is lot a need to expose the farmers to new developments in agriculture technologies and motivate them to adopt the new technologies by organizing group discussions, meetings and field trips. The study revealed that certain variable such as education, land holding, annual income, credibility, planning orientation, risk orientation, marketing behaviour found significant relationship with entrepreneurial behaviour. The Government and private organizations should aim at manipulating these variables to their advantage for promoting entrepreneurs in floriculture.

Key words: Floriculture growers, entrepreneurial behaviour, relationship, independent variables, significant



T-5 O-4: Entrepreneurial Preferences of Agricultural Technical School Students: An Assessment of Opportunities for Digital Application

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The present investigation entitled “Entrepreneurial Preferences of Agricultural Technical School Students: An Assessment of Opportunities for Digital Application” was conducted in the Akola and Buldhana districts of Maharashtra using an exploratory research design. A purposive sample of 120 students was selected from four Agricultural Technical Schools (ATS). Primary data were collected through personal interviews using a structured and pre-tested questionnaire and were systematically classified, tabulated and analyzed. The findings revealed that among the selected agri-entrepreneurial activities, Krishi Seva Kendras were perceived as the most preferred enterprise by 52.50 per cent of the respondents, indicating strong interest in input supply and advisory-based services. Custom Hiring Centres were reported as most preferred by 42.50 per cent, while an additional 39.17 per cent expressed preference, reflecting substantial entrepreneurial potential in farm mechanization services. In contrast, Agricultural Clinics recorded comparatively lower preference, with only 27.50 per cent of students reporting them as most preferred and 33.33 per cent categorizing them as not preferred. Similarly, Organic Agriculture was least preferred, with 32.50 per cent indicating it as most preferred and 27.67 per cent reporting it as not preferred, suggesting constraints related to certification complexity, technical know-how, and market access. The preference pattern indicates considerable scope for integrating digital applications in these enterprises. Mobile-based crop diagnostic and tele-advisory services can strengthen Agricultural Clinics, while digital extension platforms, e-input management systems, and advisory dashboards can enhance the effectiveness of Krishi Seva Kendras. Online machinery booking, scheduling and inventory management systems can improve the operational efficiency of Custom Hiring Centres. For Organic Agriculture, digital certification platforms, traceability systems and e-marketing channels can address existing limitations and improve market linkage. Strengthening digital competencies among ATS students can enhance enterprise viability, service delivery, and sustainability. The study underscores the need for digitally driven extension strategies, targeted capacity building, and institutional support to promote technology-enabled agri-entrepreneurship among rural youth.

Keywords: Agricultural Technical School (ATS) students, entrepreneur, agri enterprises, entrepreneurial preferences, Digital application in agriculture.



T-5 O-5: Digital Transformation of Agri-Based Livelihood Systems: Startup-Led Entrepreneurship for Atmanirbhar Bharat

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Agriculture and allied sectors form the backbone of India's rural economy, yet their entrepreneurial potential remains constrained by fragmented value chains, limited market integration, weak information flows, and high transaction costs. Within agri-based livelihood systems, where agriculture and allied activities function as interdependent sources of income, digital transformation has emerged as a critical pathway for enabling startup-led entrepreneurship to address these persistent challenges.

This study presents a conceptual review based on policy documents, startup ecosystem reports and existing academic studies to understand how digital applications are supporting agri-based entrepreneurship. This review examines how existing studies document the role of simple digital tools such as mobile-based services, online platforms, basic data applications, and artificial intelligence in supporting agri-based startups by reducing production, market, and information-related risks, improving decision-making, enabling cost-efficient service delivery and enhancing market access for farmers and rural entrepreneurs. The review further highlights that the scalability of such startups is closely linked to the availability of cost-efficient digital infrastructure, particularly cloud-based systems that support digital platforms, data-driven services, and early-stage business sustainability.

While digital tools create new opportunities, sustainable agri-based entrepreneurship requires targeted extension and policy support beyond technology deployment. Startups scale more effectively when extension systems enable capacity building, local validation, trust-based linkages, and integration into public programmes, alongside strengthening digital skills among rural youth and women. Such coordinated extension and startup policy efforts can translate digital innovation into sustained entrepreneurial outcomes, reinforce domestic value chains which reduce reliance on external intermediaries and contribute to India's goal of a more self-reliant and inclusive rural economy under the Atmanirbhar Bharat vision.

Keywords: Digital transformation, Agri-based livelihoods, Startup-led entrepreneurship, Extension facilitation, Atmanirbhar Bharat



T-5 O-6: Agricultural startups in Western Rajasthan: Opportunities and Challenges for Digital Extension

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Agri-startups in Western Rajasthan have significant opportunities to address the region's unique challenges, such as water scarcity and climate variability. Government initiatives like "Startup India", the Rajasthan Startup Policy and the Digital Agriculture Mission offer support through incentives, funding, and infrastructure development. However, challenges remain, including high initial capital requirements for technology adoption, small land holdings that complicate scalable solutions, inadequate rural internet infrastructure, and a gap in digital literacy among some farmers. Agricultural startups in Western Rajasthan face significant opportunities in digital extension, driven by the need for climate-resilient practices in an arid environment, but they are challenged by the **digital divide, farmers' economic constraints**, and the need for locally relevant solutions.

Digital tools like IoT sensors, precision irrigation control, and data analytics for soil moisture monitoring are crucial in Western Rajasthan's water-scarce environment. Providing Localized and Timely Information, improving Market Linkages and Price Transparency by providing digital platforms which can connect farmers directly with consumers and buyers, eliminating middlemen and ensuring better prices for their produce. E-marketplaces and supply chain technology platforms are major opportunities identified for the state's agritech sector. Leveraging Government Support: Both Central and State governments offer significant support through initiatives like "Startup India," the RKVY-RAFTAAR scheme, and the "Rajasthan Startup Policy 2022". These programs provide financial assistance, training, and incubation support for agri-tech innovations. Digital extension services can bridge the information gap where traditional extension agents are scarce. Mobile phones and social media platforms



T-5 O-7: Scaling Secondary Agriculture through Farmers Producer Companies using Digital Tools and Capacity Building

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Farmer Producer Companies (FPCs) are increasingly expected to move beyond aggregation into secondary agriculture (processing, packaging, branding and multi-channel marketing) to improve farmer incomes and contribute to Atmanirbhar Bharat. Evidence indicates that FPCs diversified into processing, manufacturing and marketing functions perform better than those confined to input supply or basic marketing; mature FPCs typically combine aggregation with primary and secondary processing (milling), packaging, branding and wider market channels. Recent value-chain experiences (e.g., millet-based FPO/FPC initiatives) show that e-commerce marketing through digital platforms such as ONDC and GeM, along with branded product portfolios, can substantially strengthen value addition and producer share in the consumer rupee. However, the transition to secondary agriculture remains constrained by governance and capability gaps (especially in strategic planning, financial management, statutory compliance and effective use of digital platforms like e-NAM) highlighting the need for structured, need-based capacity building. This paper proposes a framework linking digital extension and platform literacy with entrepreneurial orientation and subsequent adoption intensity of secondary agriculture activities. A mixed-method approach is suggested, integrating activity-portfolio mapping and index-based assessment of role performance to generate actionable recommendations for incubators, extension systems and policymakers to scale digital entrepreneurship pathways in FPCs.

Keywords: Capacity building, Digital platforms, Entrepreneurial orientation, Farmer Producer Companies and Secondary agriculture.



T-5 O-8: Scaling up Farmers Innovative Model for Wider Adoption: Case Studies

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Today, farmer-led innovations form a cornerstone of sustainable agricultural transformation, showcasing the ingenuity and resilience of farming communities. Professor Y. P. Singh pioneered systematic scientific inquiry into farmers' indigenous knowledge in India during mid-sixties (1965–1967). Notably, the Honey Bee Network and the National Innovation Foundation (NIF) in India have become global exemplars in this regard (Gupta, 2006; Gupta et al., 2019). Ultimately, wider adoption and upscaling are successful when farmer-led innovations are supported by an enabling ecosystem that integrates scientific validation, policy support, financial mechanisms, community participation, and market opportunities. The present study takes up the farmers' innovations not in exclusivity rather in a holistic approach as Farmers' Innovative Models. The study serves to investigate the mechanism for scaling up the Innovative models for wider adoption among the farming community.

From an inventory of 500 innovative farmers recognized with IARI Innovative and Fellow awards during the last 10 years (2016-2025), a total of 200 innovative farmers were screened at the initial stages based on the potential innovations developed by them. A survey study of the 200 farmer innovators and their innovative models was conducted through a structured questionnaire. In the next phase, five farmers' innovative models were identified and selected for the present study from across the country. These five models represented various regions and agro-ecological situations of the country.

Hi-tech banana cultivation model of Mr. Dhirendrabhai Desai, district Bharuch, Gujarat integrates drip irrigation with tissue culture plants, ensuring uniform growth and optimal water and nutrient use. The system combines Integrated Bio-Nutrient Management (IBNM), green manuring, and bio-composting to improve soil fertility while reducing chemical dependence. **Fish based IFS model developed by Ms. Manju Rani Kashyap, district Ghaziabad, Uttar Pradesh**, is based on waste-to-wealth transformation, alongside recycling enterprise residues resulting in low-cost fish feed, rapidly increasing fish weight, improved yield by 30-40% and reduced maturity by about one month with enhanced product quality and marketability, effectively doubling farmers' income through substantial cost reductions. **Landless Farming Model developed by Mr. Gowhar Ali Lone, district Baramulla, Jammu & Kashmir** offers significant advantages, particularly for small farmers and women, enabling home-based cultivation without the need for land. It maximizes productivity using vertical spaces, generates high returns, and integrates crop-livestock systems sustainably. **Integrated, low-cost and scalable model for mushroom cultivation, spawn production and value-added processing is developed by Anita Kumari.** Her low-cost mushroom growing chamber, built using an iron frame and foggers for humidity regulation, enables successful cultivation of oyster and milky mushrooms, achieving year-round production without expensive machinery. **Low-cost electrical solutions for nutmeg processing, including a Nutmeg/Mace Dryer and a Nutmeg Desheller is developed by Mr. Ranjit Kumar R., district Coimbatore, Tamil Nadu.** These innovations are self-motivated, aimed at reducing labour, improving efficiency, and adding value to nutmeg production. Both of the farmer scale innovations emphasize affordability, simplicity and scalability, enhancing income and streamlining nutmeg processing for smallholders.

The farmers' innovative models under study in different agro ecological situations are scalable, sustainable and economically viable. The models have stood the test of time, proving to be affordable and suitable for small and marginal farmers as well as landless. They have great potential to be replicated in the respective regions for bringing transformation in agriculture, ensuring livelihood security and enhanced income for the larger farming community.

Key Words: Up scaling, Innovative Model, Recycling, Scalability



T-5 O-9: Quantifying support for agripreneurs: a multidimensional scale development and analysis of institutional mechanisms for Atmanirbhar Bharat

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Agricultural entrepreneurship and incubation systems have become integral components of India's efforts to build an Atmanirbhar and inclusive economy. In this context, where agricultural extension, market access, and enterprise development are increasingly supported by digital platforms and information systems, a study was conducted as part of doctoral research to identify the institutional interventions essential for agripreneurship development. This research presents the Institutional Support for Agripreneurship Development Scale (ISAD-S), a multidimensional instrument designed to assess the extent and effectiveness of institutional support for emerging agripreneurs. Addressing the need for standardized assessment tools within an evolving agricultural extension landscape, the ISAD-S was developed through a three-stage process comprising item collection, item selection, and statistical validation. The scale was tested on a diverse sample of 341 participants, undergoing exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to refine its structure and establish its psychometric soundness. The final 24-item scale captures four essential dimensions of agripreneurial support i.e., technical, financial, legal and bureaucratic, and production and marketing which demonstrated high reliability (Cronbach's alpha = 0.829) and strong content validity. Key findings highlighted notable strengths in production and marketing support, particularly in market linkages, product development initiatives, and access to market intelligence (mean score = 3.60). In contrast, financial support, scoring 2.76, emerged as the weakest dimension, underscoring persistent gaps in credit facilitation and funding accessibility. Legal support was effective in building awareness of standards and regulatory procedures, while technical support remained vital for project formulation and implementation. By offering a standardized mechanism to assess institutional support, the ISAD-S provides insights useful for curriculum redesign, capacity-building in extension systems, strengthening incubation and advisory mechanisms, and improving support frameworks for start-ups and FPOs. The tool contributes to fostering resilient agripreneurial ecosystems and supports efforts toward more self-reliant and sustainable agricultural development in alignment with the vision of Atmanirbhar Bharat & Digital Ecosystems.

Keywords: Exploratory Factor Analysis, Agri-entrepreneurship, Digital ecosystems





Theme V : Poster

Digital applications in Start-ups and entrepreneurship development for Atmanirbhar Bharat





T-5 P-1: Startup Environment for Farmer Producer Organization Development in Manipur North East India

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Agriculture in India is marked by the continuous decline in the size of operational holdings with each successive generation. This trend has posed serious challenges to the survivability and profitability of small and marginal farmers, who constitute the largest segment of the farming population. To overcome these challenges, the aggregation of farmers into collective institutions has emerged as a viable and sustainable strategy. Among the different models, the Farmer Producer Company (FPC) has been recognized as one of the most effective institutional forms for enhancing the incomes of small holders through collective action. The Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers' Welfare, Government of India, has identified FPCs—registered under the special provisions of the Companies Act, 1956 (as amended in 2002, and now under the Companies Act, 2013)—as the most appropriate vehicle for farmer aggregation. An FPC combines the spirit of cooperation with the efficiency of a corporate structure, thereby enabling farmers to access investments, technology, inputs, markets, and support services on a much larger and more sustainable scale. Government schemes and policies have played a pivotal role in strengthening Farmer Producer Organizations (FPOs) in Manipur by providing financial assistance, capacity-building support, market linkages, and institutional backing. Initiatives such as the Central Sector Scheme for Formation and Promotion of 10,000 FPOs, MIDH, RKVY, NERAMAC interventions, and state-specific programs have collectively encouraged farmer collectivization, improved access to inputs, and enhanced bargaining power for small and marginal farmers. These schemes also aim to promote value addition, improved governance, improved post-harvest management, and participation in formal markets. However, despite the progress, many FPOs continue to face challenges related to limited awareness of schemes, administrative bottlenecks, financial constraints, infrastructural gaps, and capacity-building needs. Strengthening coordination among implementing agencies, simplifying documentation processes, and enhancing extension support will be crucial for improving the effectiveness of these initiatives. Overall, government support has laid a strong foundation for transforming FPOs into sustainable, market-oriented agribusiness institutions in Manipur. Continued policy attention, targeted interventions, and active participation from farmers and stakeholders will be essential for ensuring that FPOs reach their full potential in empowering rural communities and driving agricultural development in the state.



T-5 P-2: Entrepreneurship Development for Atmanirbhar Bharat”

1. SURENDRA PRATAP SONKAR, 2. PRADEEP KUMAR YADAV, 3. RAJESH CHANDRA VERMA,
4. DURGESH KUMAR MAURYA, 5. PRAKASH CHANDRA, 6. TARUN KUMAR & DEVESH KUMAR

Entrepreneurship development plays a pivotal role in advancing the vision of Atmanirbhar Bharat, which aims to build a self-reliant and globally competitive India. The concept emphasizes nurturing an enabling ecosystem where individuals, particularly youth, women and rural populations, can transform innovative ideas into viable enterprises. This paper highlights the significance of entrepreneurship as a driver of economic growth, employment generation and social transformation. Government initiatives such as Start-Up India, Stand-UpIndia, PMEGP, Atal Innovation Mission and MUDRA Yojana have strengthened institutional support, eased access to credit and promoted innovation-driven enterprises. The emergence of digital platforms, skill development programmes and incubation centres has further enhanced entrepreneurial capacity across diverse sectors including agriculture, manufacturing and services. Despite these advancements, challenges such as limited financial literacy, inadequate market linkages and infrastructural gaps hinder entrepreneurial growth in rural and semi-urban regions. The paper argues that sustained policy support, mentorship networks, technological integration and inclusive capacity-building efforts are essential for empowering potential entrepreneurs. Strengthening entrepreneurship at the grassroots level will not only accelerate economic resilience but also contribute significantly to employment creation, innovation and sustainable development—ultimately advancing the goals of Atmanirbhar Bharat.

Keywords: Entrepreneurship development, Atmanirbhar Bharat, Innovation, Start-upecosystem, Skill development, Economic resilience.



T-5 P-3: Rural Youth under ARYA: Socio-economic Profile and Entrepreneurial Constraints

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Rural youth entrepreneurship has emerged as a critical pathway for strengthening agricultural livelihoods and achieving the vision of Atmanirbhar Bharat. The Attracting and Retaining Youth Agriculture (ARYA) programme aims to promote agripreneurship among rural youth through skill development and enterprise-based interventions. The present study examines the socio-economic profile of beneficiaries and non-beneficiaries and perceived constraints of ARYA beneficiaries. The study was conducted in Kaushambi district of Uttar Pradesh with a total sample of 320 rural youth, comprising 160 beneficiaries and 160 non-beneficiaries. Data were collected using pre-tested structured interview schedule, covering socio-economic aspect along with constraint analysis through Garrett ranking. It was concluded from the study that 41.87 per cent among beneficiaries belongs to medium socio-economic category followed by high category whereas among the non-beneficiaries most of the respondents i.e. 43.12 per cent belongs to low category followed by medium category. The findings also reveals that ARYA beneficiaries were predominantly middle-aged comprising 42.50 per cent, had higher education i.e. 58.75 per cent while non-beneficiaries were largely confined to lower education categories, with 67.50 per cent educated up to primary or secondary level. Although mobile phone ownership exceeded 90.00 per cent in both groups, ownership of advanced farm machinery remained limited, indicating potential for digital support.

Constraints perceived by beneficiaries include poor awareness, skill and attitude towards farming emerged as critical constraints with first ranking in personal constraints. In social constraints, inadequate support for agri-based start-ups ranked first with Garrett ranking of 60.06. Other constraints were high cost of input, low motivation, poor knowledge about topic and high dependence on middlemen.

The findings conclude that digitally enabled advisory, market-information and mentoring systems, coupled with improved convergence of ARYA with financial and input support schemes, can strengthen rural start-ups and agri-preneurship for Atmanirbhar Bharat.

Keywords: Entrepreneurship, ARYA, Rural youth.



T-5 P-4: Okra and Mr. Umesh, Global Face of Prayagraj

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Mr. Umesh Patel, a farmer from Ramaipur village, Prayagraj, Uttar Pradesh, represents a tremendous success in agricultural entrepreneurship and rural development. With a master's degree in Environmental Science and backed by sustainable agricultural knowledge, Mr. Umesh transitioned from traditional farming to cultivating high-value cash crops such as okra, bitter gourd, and chili. His vision expanded beyond individual farming when he recognized the role of middleman who played in capturing agricultural profits. In response, he established a farmer school(pathshala) in 2014 to educate neighbouring farmers about crop diversification, and founded an NGO (Jeevan JyotiSikshaSamiti, Prayagraj)in 1999 that compained social awareness, environmental conservation, and women's empowerment. A pivotal movement came when Mr. Umesh and his NGO collaborated with Sam Higginbottom University of Agriculture Technology and Science(SHUATS) and the Plant Protection Varietyand Farmers Right Act(PPV&FRA) to identify and register domestic crop varieties. Out of the 400 collected seeds, 250 were authenticated as truly domestic, with 32 officially registered as certified varieties, establishing Gangapar Seed Bank in 2017.

Recognizing that individual farmers lacked production scale for international market, Mr. Umesh and his nephew Mr. Munish, a Ph.D. scholar in genetics andplant breeding, conceptualized a Farmer Producer Organization (FPO). The Phulpur Farmer Producer Company Limitedestablished in 2022, now unites approx. 1200 farmers across 350-400 acres of land, producing 12000-14000 quintal okra annually. The FPO successfully exports 700-800 quintals of okra to Dubai at premium prices (8-18 dirham per kilogram) while maintaining local market sales. This model generates annual profits exceeding 25-35 lakh rupees. Mr. Umesh's achievements demonstrate how knowledge, innovation, and collective organization can unlock agricultural export potential and rural prosperity.While he is focusing future expansion in European market and much more.Government should provide proper facilities such as training, demonstration, institutional loan with minimum interest as well as subsidies on the basis of categories so that several farmers may take initiatives, as Mr. Umesh is doing. Intelligent technology, A.I. and digital extension can help a lot for agricultural progress and possibilities and minimize challenges.

Keywords:Okra, Entrepreneurship, FPO, Dubai, NGO.



T-5 P-5: Entrepreneurial Behavior of FPO Members: Insights from Haryana

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India's agricultural sector contributes around 16 per cent to GDP and about 55 per cent of the population is engaged in agriculture. Most Indian farmers are small and marginal, struggling with issues such as limited market access, low bargaining power, and inadequate availability of agricultural inputs. Farmer-Producer organisations have emerged as a key strategy to tackle these challenges by fostering information exchange, profit margins and collective power to bargain in markets. The study entitled "Entrepreneurial behaviour of Farmers toward Farmer Producer Organisations in Haryana" explores the knowledge level, entrepreneurial behaviour, market linkages and constraints faced by the member farmers of FPOs. The research includes ten FPOs selected randomly from two purposively selected districts of Haryana, i.e. Hisar and Jhajjar, with a total of 180 respondents. The findings of the study revealed that 75.00 per cent of the respondents were middle-aged (30-50 years), 50.56 per cent completed senior secondary level of education, 88.80 per cent engaged in agriculture and 78.34 per cent had a medium annual income. The majority of the farmers had a medium level of information-seeking behaviour (71.67%), extension contacts (80.56%), mass media exposure (70.00%), decision-making ability (62.21%), credit orientation (68.88%) and risk-bearing ability (57.77%). The knowledge level was also found medium leveled among 55.56 per cent and 76.66 per cent of respondents in Hisar and Jhajjar, respectively. Age and farming experience were negatively correlated, whereas education, information seeking behaviour, extension contacts, mass media exposure and credit orientation had significant positive correlation with the knowledge level of the farmers. In terms of overall entrepreneurial behaviour, the majority of the respondents in Hisar (62.23%) and Jhajjar (65.66%) districts had a medium level of entrepreneurial behaviour. Age and farming experience were negatively correlated, whereas education, land holding, information seeking behaviour, extension contacts, mass media exposure, trainings undergone, social participation, economic motivation and credit orientation were correlated significantly with entrepreneurial behaviour. Input dealers were the most frequently used source for procurement of inputs; public sector banks were the primary source of credit. The private sector was dominant in storage and processing linkages. APMCs were the dominant market channel for selling the harvest. Limited processing and value addition facilities, High initial investment for setting up an FPO, no guarantee for stable pricing and limited training and demonstrations were the severe constraints faced by the FPO members.

Keywords: Entrepreneurial behaviour, Farmer Producer Organizations, market linkages, constraints



T-5 P-6: Business Models for Scaling Climate Smart Agriculture Technology in Muzaffarpur District of Bihar, India

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Bihar is one of the poorest, most populous states in India. The populations are mainly rural dwellers and are dependent on agriculture production, as a means of subsistence and as revenue. Bihar (or more generally the entire eastern Indo Gangetic Plains of India) is composed of small scale (less than a hectare) and fragmented farm holding with poor access to new technologies. As well as being extremely vulnerable to climate change and frequent climatic aberrations (floods, drought and weather volatility), Bihar is also hindered by natural resource degradation and a lack of knowledge and development opportunities. Introducing climate-smart practices and technologies to male and female farmers and promoting business models with the best upscaling potential can increase the resilience and adaptive potential of agriculture in Muzaffarpur of Bihar state. Farmer's adoption of CSA technologies and practices could be enhanced through the involvement of CSA service providers or entrepreneurial farmers. Indeed, sustainable business models linking farmers and private sector have the potential to benefit all CSA-value chain stakeholders. CSA practices provide both farmers and service providers with the opportunity to better manage risks, to save labor and costs and to increase revenues. To determine the feasibility of this research, a socio-economic survey will be carried out in the Muzaffarpur district of Bihar on 15 different service providers (i.e. small businesses) leasing or providing CSA technologies and machineries. Climate Change, Agriculture and Food Security (CCAFS) research project will identify existing and potential business models that can support scaling-up and scaling-out of CSA practices and technologies in Bihar. These business models will be assessed using the business model canvas as it presents the global strategy to a well-established business. It details all parts of the company, showing revenues, costs, preconditions and partnerships required but it also underlines potential risks and benefits of the business for all stakeholders. Templates of the canvas business model will be incorporated into the analysis. It will allow us to evaluate current and potential effects of the adoption of business models promoting CSA practices and technologies, on both service providers (SPs) and customers (male and female farmers). This project "Business models for scaling Climate Smart Agriculture in Bihar, India" is part of the CRA project "Recommendation domains incentives and institutions for equitable local adaptation planning at sub-national level and scaling up CSA practices in wheat and maize systems".

Keywords: Climate change, smart agriculture, custom hiring centre and farm mechanization



T-5 P-7: Factors influencing Farmers Perception of Agri-Tech Startup– Farmer Producer Organizations (FPO) Integration for Improved Extension Advisory Services

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The integration of Agri-Tech Startups with Farmer Producer Organizations (FPOs) has emerged as a promising approach to enhance Extension Advisory Services and support smallholder farmers in India. This study explores the factors influencing farmers' perception of such integration in Telangana and Chhattisgarh, two states with contrasting agro-economic and digital adoption contexts. A total of 300 farmers from ten purposively selected FPOs (five per state) were surveyed during 2022-2024, and 21 socio-personal, economic, behavioral, communicational, and institutional variables were analyzed using correlation, multiple regression, and stepwise regression techniques. In the overall pooled analysis, correlation analysis revealed that 4 variables were significant at the 0.05 level are age, Information seeking behaviour, Farmers empowerment and training received. Further, 12 variables showed significance at the 0.01 level are education, annual income, extension contact, innovativeness, risk orientation, mobile inclination, FPO membership, attitude of farmers towards FPO, Cosmopolitaness, Social participation and satisfaction level of farmers towards FPO. Notably, experience, landholding, economic orientation, management orientation and credit acquisition remained non-significant, suggesting that integration potential is less dependent on resource capacity and more on adaptive behavior, technology inclination, and trust in FPO mechanisms. Multiple regression models explained 67.7% of perception variation in Telangana, 59.7% in Chhattisgarh, and 63.0% overall, indicating substantial explanatory power of the selected variables. Stepwise regression identified ten key predictors: age, annual income, innovativeness, mobile inclination, FPO membership, cosmopolitaness, social participation, participation in FPO activities, satisfaction, and empowerment. Among these, satisfaction emerged as the strongest predictor, highlighting the role of positive prior experiences and trust in fostering favorable perceptions. The findings underline the importance of enhancing satisfaction, encouraging digital adoption, and strengthening empowerment to promote positive perceptions and wider acceptance of Agri-Tech–FPO integration in agricultural advisory systems. The findings provide a comprehensive understanding of how farmers perceive the potential of Agri-Tech-FPO collaborations in enhancing agricultural advisory systems, highlighting dimensions that can guide targeted interventions, training, and policy measures to strengthen digital agriculture initiatives in diverse regional contexts.

Key words: Factors, Agri-Tech Startup, FPO, Integration, Perception, Extension Advisory Services



T-5 P-8: Digital Disruption and Rural Innovation: The Role of Agri-Tech Start-ups in Building an Atmanirbhar Bharat

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India's agricultural economy is undergoing a dynamic digital transformation driven by the rapid growth of agri-tech start-ups, digital entrepreneurship, and policy reforms aimed at fostering *Atmanirbhar Bharat* — a self-reliant nation. The integration of Artificial Intelligence (AI), Internet of Things (IoT), blockchain, and cloud-based decision platforms is reshaping how farmers, agribusinesses, and rural entrepreneurs engage with markets and information systems. Digital applications are enabling data-driven decision-making, value-chain efficiency, and financial inclusion across India's rural landscape. Over the past decade, over **1,500 agri-tech start-ups** have emerged in India (NASSCOM, 2024), focusing on precision farming, digital marketplaces, supply chain analytics, and agri-fintech solutions. Platforms such as **DeHaat**, **AgNext**, **Ninjacart**, and **Stellapps** exemplify how technology-driven entrepreneurship is solving critical challenges in post-harvest management, input optimization, and traceability. Meanwhile, ICAR and ICRISAT have developed digital innovation hubs and incubation centers, fostering young entrepreneurs through capacity-building programs such as **Agri Innovate India**, **NAARM's ABI**, and **ICRISAT's Agribusiness Incubator (ABI)**. These initiatives demonstrate the synergy between digital technologies, start-up innovation, and policy frameworks (Kumar et al., 2024; Wani et al., 2023).

Despite strong growth, challenges remain in scaling rural innovations due to infrastructure gaps, limited digital literacy, and access to venture funding. Furthermore, many early-stage agri-entrepreneurs face difficulties in integrating advanced analytics and AI tools due to high costs and fragmented data ecosystems. Addressing these barriers requires collaborative efforts between government, research institutions, and private investors to create sustainable and inclusive entrepreneurial ecosystems. The future of digital entrepreneurship in agriculture lies in **co-innovation models**—where technology, finance, and policy intersect to create resilient agri-value chains. By promoting digital start-ups, women-led enterprises, and rural innovation hubs, India can unlock vast employment opportunities while enhancing food security and export competitiveness. Digital entrepreneurship is not merely an economic tool—it is the foundation of a technologically empowered, self-reliant rural India.

Keywords: Digital Entrepreneurship, Agri-Tech Start-ups, Atmanirbhar Bharat, Agri-Innovation, ICT in Agriculture, Digital Transformation, Rural Development, Incubation Ecosystems, Smart Farming, Agri-Business.



T-5 P-9: Impact of ARYA Project on Entrepreneurship Development in Navsari district of South Gujarat

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Entrepreneurship-led agricultural development is increasingly recognized as a sustainable pathway for enhancing farm income, employment generation and rural livelihood security. The Attracting and Retaining Youth in Agriculture (ARYA) project implemented by KrishiVigyan Kendra (KVK), Navsari aimed to promote agri-based enterprises among rural youth and farmers through capacity building, value addition and market-oriented interventions. The present study evaluates the impact of ARYA interventions during 2019–2026, focusing on mango processing, mango nursery and grafting, fish farming and fish value addition enterprises. Primary data were collected from training records, beneficiary case studies and enterprise-level economic analyses. Descriptive statistics and benefit–cost analysis were employed to assess income enhancement and enterprise viability. Results indicated substantial improvement in technical skills, quality compliance, adoption of scientific tools and profitability. Women participation exceeded 55 per cent, reflecting strong inclusiveness of the interventions. Mango grafting and processing enterprises recorded the highest net returns, while fish farming in village ponds showed benefit–cost ratios above 3.0. The study concludes that KVK-led ARYA interventions effectively transform traditional farming into profitable agri-entrepreneurship and recommends upscaling similar models across tribal and coastal regions.

Keywords: ARYA project, Agri-entrepreneurship, KVK interventions, Value addition, Rural youth, Income enhancement



T-5 P-10: Challenges and Policy Suggestions for Strengthening Secondary Agriculture Adoption by Rural Youth

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Secondary agricultural practices have gained prominence as a viable livelihood diversification pathway in climate-vulnerable smallholder farming systems. Despite their potential to enhance income stability and farm resilience, the adoption of secondary agriculture among rural youth remains limited. This study aims to identify the key constraints hindering rural youth from engaging in secondary agricultural practices and to propose context-specific suggestions to promote their wider adoption. This study was conducted in Kheda district, Gujarat with 120 respondents through a semi-structured interview schedule using ex-post facto research design and examined economic, institutional, technical, and socio-personal barriers influencing adoption decisions. The findings revealed that major constraints include limited access to credit, inadequate technical knowledge and training, poor market linkages and lack of awareness on institutional support. Based on these findings, the study proposes a set of actionable suggestions, including improved access to youth-friendly credit schemes, targeted capacity-building and skill development programs, strengthening extension and advisory services, and the development of market infrastructure and value-chain linkages. The study concludes that addressing these constraints through coordinated institutional and policy support can significantly enhance rural youth participation in secondary agriculture, thereby contributing to sustainable livelihoods and resilience in smallholder farming systems.

Keywords: Secondary agriculture practices, Constraints, Suggestions



T-5 P-11: Youth Entrepreneurship: Young Founders Shaping India's Startup Future

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India stands at a pivotal economic juncture, leveraging its massive demographic dividend where over 65% of the population is under the age of 35 to transition from a nation of job seekers to one of job creators. This study explores the dynamic landscape of youth entrepreneurship in India, analysing its critical role as a primary engine for economic resilience and innovation. The study examines the exponential growth of the Indian startup ecosystem, now the third-largest globally, driven by the digital revolution, supportive government frameworks like Startup India and a significant cultural shift that is beginning to destigmatize entrepreneurial failure. The analysis highlights key sectoral trends, particularly the rise of Agri-tech, Fin-tech and social innovation, which are democratizing opportunities beyond traditional metropolitan hubs. Through a review of secondary data and case studies ranging from urban tech ventures to rural grassroots innovations supported by centres like the Agri Business Incubation Centre (ABIC) the research identifies critical drivers of success. However, it also addresses persistent challenges that hinder scalability, including access to early-stage capital, regulatory complexities and the skills gap in underserved regions. The narrative is also expanding to embrace "grassroots entrepreneurship," where rural youth and women leverage technology to build sustainable, community-centric ventures. Maximizing this potential requires a strategic shift toward decentralized investment in Tier-2 and Tier-3 cities, institutionalized mentorship and experiential learning models. The discourse also examines the rise of grassroots and women entrepreneurship, where rural youth are increasingly leveraging digital platforms, local resources, and sustainable technologies to build community-centric enterprises that merge profit with social purpose. Ultimately, the future of India's economic trajectory depends on empowering this diverse wave of young founders to drive inclusive and sustainable growth.

Keywords: Entrepreneurship, Startup, Agri-tech, Ventures, Grassroots Innovation, Startup India, Economic Resilience, Demographic Dividend



T-5 P-12: Digital Applications in Start-ups and Entrepreneurship Development for Atmanirbhar Bharat

DHANU RAJ

The "Atmanirbhar Bharat" (Self-Reliant India) mission represents a paradigm shift in India's economic strategy, aiming to transform the nation into a global manufacturing and innovation hub. At the core of this transformation is the integration of digital applications within the startup ecosystem. This paper explores the pivotal role of digital technologies—such as Artificial Intelligence (AI), Blockchain, Internet of Things (IoT), and mobile-first platforms—in fostering entrepreneurship and accelerating the growth of indigenous ventures. Digital applications have democratized access to markets, finance, and mentorship, which were traditionally localized. For startups, the "India Stack," including UPI and Aadhaar-based authentication, has significantly reduced operational costs and improved the ease of doing business. In sectors like Agri-tech, Health-tech, and Fin-tech, home-grown applications are solving uniquely Indian problems while scaling to global standards. These digital tools enable entrepreneurs to optimize supply chains, enhance customer engagement through data analytics, and ensure financial inclusion for the grassroots population. However, the journey toward a digitally self-reliant India faces challenges, including the digital divide in rural areas, cyber security threats, and the need for robust data protection frameworks. This study analyzes government initiatives like the "Atmanirbhar Bharat App Innovation Challenge" which incentivizes local developers to create world-class software solutions. The findings suggest that a robust digital infrastructure, coupled with supportive policy frameworks, is essential for nurturing a vibrant entrepreneurial culture. In conclusion, digital applications act as the primary catalyst for entrepreneurship development in the modern era. By reducing dependency on foreign technology and empowering local innovators, digital transformation is not just a technological upgrade but the bedrock of a self-reliant and economically resilient India.

Keywords: Atmanirbhar Bharat, Digital Transformation, Start-ups, Entrepreneurship Development, Innovation, India Stack.



T-5 P-13: Agritech Startup in India Prospects and Challenges

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In recent years, agritech startups have gained prominence in India as strategic instruments for enhancing agricultural productivity, sustainability, and rural livelihoods. Traditional farming systems in India continue to face issues such as inadequate market access, price fluctuations, limited credit availability, poor storage infrastructure, low mechanization, middlemen exploitation, and the growing impact of climate change. Agritech startups have emerged as a promising solution to bridge these gaps by leveraging digital technologies, data-driven platforms, and modern business models. This seminar explores the concept of agritech startups, their eligibility criteria, and their role in reshaping Indian agriculture. It examines the global and Indian startup ecosystem, highlighting India's position as the third-largest startup hub and the rapid growth of agritech enterprises supported by venture capital, incubators, government initiatives such as Startup India, AIM, NIDHI, and RKVY-RAFTAAR. The prospects of agritech startups include employment generation, supply chain optimization, processing and export enhancement, efficient resource utilization, digital infrastructure development, custom hiring centers, and technology-driven grading and sorting systems. Case studies of successful agritech startups such as Ninjacart and Jai Kisan illustrate innovative business models that strengthen farmer-market linkages and improve access to financial services. Despite their potential, agritech startups face challenges including financial constraints, long gestation periods, technology affordability, regulatory hurdles, lack of mentorship, and uncertain returns on investment. The seminar concludes that strategic support, policy facilitation, and ecosystem strengthening are essential to promote agritech startups as key drivers of sustainable agricultural development and rural prosperity in India.

Keywords: Agritech Startups, Digital Agriculture, Agricultural Innovation, Startup Ecosystem, Farmer Empowerment



T-5 P-14: Role of Agricultural Extension in Enabling Policy Support for Scaling Innovations: A Review

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Agricultural extension has traditionally focused on technology dissemination and capacity building at the field level; however, its role has increasingly expanded to include engagement with policies that enable the scaling of innovations. In recent decades, the agricultural innovation system approach has emphasized the importance of linkages among research, extension, farmers, markets, and policy institutions. This paper presents a review of literature, policy documents, and institutional experiences to examine the evolving role of agricultural extension in policy engagement for scaling agricultural innovations. The review highlights key pathways through which extension contributes to policy processes, including generation of field-level evidence, feedback from farmers, facilitation of multi-stakeholder platforms, and advocacy for enabling institutional and regulatory environments. Evidence from national and international experiences suggests that innovations scale more effectively when extension systems actively interface with policy actors and development programs. However, challenges such as limited policy literacy among extension professionals, weak institutional mechanisms for translating grassroots insights into policy inputs, and inadequate recognition of extension as a policy actor constrain its potential contribution. The paper underscores the need for capacity building in policy engagement, strengthening institutional platforms, and repositioning extension organizations as knowledge brokers within innovation systems. The review provides insights for extension professionals, researchers, and policymakers seeking to enhance the role of extension in innovation-led agricultural development.

keywords: Policy engagement, scaling of innovation, Institutional mechanisms, Multi stakeholder platforms



Theme VI : Oral Gender concerns in application of digital tools – Achievements and Action points





T-6 O-1: Digital Tools and Women in Agriculture: A Gender Responsive Approach

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Women play a crucial role in the agricultural sector and in shaping rural economies. Yet, it is evident that rural women continue to face marginalization due to limited decision-making power, restricted access to economic opportunities, and inadequate exposure to new technologies. Although the discourse on digital agriculture is gaining momentum, its specific implications for women farmers remain insufficiently examined—a gap this paper aims to address. Unprepared farmers, particularly women, may find it challenging to adjust to digital innovations, making a gender-responsive approach essential. Such an approach involves not only integrating gender considerations into agricultural tools but also recognizing and analyzing the often invisible yet indispensable roles women fulfill as homemakers. Numerous studies highlight persistent constraints, including sociocultural norms defining gender roles, lack of information, the prevailing digital divide, and restricted decision-making capacity. The transformative potential of digital tools for the economic empowerment of rural women is significant. Mobile phones, internet connectivity, and digital financial services can substantially improve women's access to critical resources. Using a qualitative methodology, this paper reviews existing literature to explore key questions—most importantly, why efforts should extend beyond merely providing women with digital tools. It argues that society must also acknowledge and critically evaluate women's non-negotiable contributions, not only within the household but also to national income through their often unseen labor.

Keywords: Agriculture, digital tools, gender responsive, home-makers, women



T-6 O-2: Gender Dimensions in the Adoption of Digital Agricultural Technologies in India: Evidence and Way Forward

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The rapid growth of digital agricultural technologies in India has opened up new ways to make farming systems more productive, efficient and resilient. However, the adoption and effective utilization of these technologies remain uneven, particularly from a gender perspective. The paper consolidates current evidence regarding the gender aspects of digital agricultural technology adoption in India, emphasizing women farmers. The findings revealed gender disparities in access to digital devices, usage patterns, decision-making roles and the advantages gained from digital agricultural tools, including mobile-based advisories, agri-applications, digital extension platforms and market information systems, utilizing empirical studies, policy documents and development reports. It was further revealed that although women represent a significant segment of the agricultural workforce, their utilization of digital agricultural technologies is impeded by various interconnected factors, including limited mobile phone ownership, diminished digital literacy, socio-cultural norms, restricted mobility and insufficient access to extension and institutional support. Furthermore, many digital agriculture initiatives in India remain gender-neutral in design, with inadequate consideration of women farmers' specific needs, preferences and contexts. The paper identifies major gaps in the current digital agriculture ecosystem and suggests a way to encourage gender-responsive digital agricultural development in India. The proposed strategies include gender-sensitive technology design, building targeted skills, better integration of digital tools with extension services and getting more women farmers involved in creating and sharing digital solutions. The paper concludes emphasizing the importance of digital interventions to ensure that the benefits of agricultural digitalization contribute meaningfully to women's empowerment and sustainable agricultural development.

Keywords: Digital Agriculture Technology, Digital Extension, Gender, Women Farmers, India.



T-6 O-3: Bridging the Digital Gender Divide: Achievements and Action Points in the Application of Digital Tools

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Digital technologies have emerged as powerful enablers of economic growth, social inclusion, and sustainable development. However, persistent **gender disparities in access to and effective use of digital tools** continue to limit the transformative potential of digitalization. Globally, despite rapid expansion of connectivity, women remain less digitally connected than men. According to the International Telecommunication Union (ITU), in 2022 **69 % of men used the internet compared to 63 % of women**, leaving **over 250 million fewer women online worldwide**. The digital gender divide is particularly pronounced in low- and middle-income countries, where structural inequalities intersect with limited digital infrastructure and socio-cultural constraints. In India, the gap is wider and multidimensional. National and industry reports indicate that **women are about 33 % less likely than men to use mobile internet**, and only **around one-fourth of adult women own smartphones**, compared to over **40 % of men**. While flagship initiatives such as Digital India, digital literacy missions, and mobile-based service delivery platforms have expanded digital outreach, women's participation remains constrained by affordability, lower digital literacy, safety concerns, and restrictive gender norms. Despite these gains, the transition from **digital access to meaningful digital empowerment** remains incomplete. Bridging the digital gender divide therefore requires a shift from gender-neutral digital policies to **gender-responsive digital ecosystems**. Key action points include ensuring affordable and safe connectivity, strengthening digital literacy and confidence among women and girls, promoting gender-sensitive design of digital tools, and embedding gender-disaggregated monitoring within digital development programmes. Addressing these dimensions is critical not only for gender equity but also for inclusive economic growth and achievement of the Sustainable Development Goals.

Keywords: Digital Gender Divide; Digital Inclusion; Gender-Responsive Technology; Digital Literacy; Women's Empowerment; ICT for Development; Policy Action Points



T-6 O-4: OPPORTUNITIES AND ADVANCES THROUGH DIGITAL PROMOTIONAL ACTIVITIES AMONG WOMEN ENTREPRENEURS IN PRAYAGRAJ DISTRICT UTTAR PRADESH: A REVIEW

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The present study was conducted to know the digital promotional activities among women entrepreneurs in Prayagraj District of Uttar Pradesh. The respondents using digital promotion through social media, content marketing, email, and e-commerce to build brands, engage customers directly, and expand reach cost-effectively. They also focus on storytelling and building trust. In the digital age, women also have new challenges and opportunities. Using the newest technology to advertise products or services on the market is very popular now a day's among the women entrepreneurs. Using digital media to draw in and motivate customers is the main objective of digital promotional activities. The growing digital era is responsible for the increase in consumer power. The female entrepreneurs in our digital era are strengthened and revitalized by this piece. It is revealed that social media is essential for empowering female entrepreneurs; yet, obstacles including limited resources, a lack of digital literacy, and erratic platform algorithms need to be addressed. It indicates that mentorship programs, cash grants, digital literacy training, and increased platform transparency can all increase the efficacy of digital promotional activities for women entrepreneur. Government should take proper steps, financial assistant, digital promotions to improve the social and economical condition of women entrepreneur.

Keyword: Digital promotional activities, Digital awareness, Women entrepreneur



T-6 O-5: Use of Social Media by Farm Women in Production and Post-harvest Management of Pulses

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The use of social media by farm women has emerged as a significant factor influencing decision-making in the production and post-harvest management of pulses. With increasing access to smartphones and digital networks in rural areas, farm women are leveraging platforms such as WhatsApp, Facebook, YouTube, and agriculture-specific apps to access critical information on improved cultivation practices, pest and disease management, optimal harvesting times, storage techniques, and market trends. This digital engagement empowers them to share real-time experiences, seek expert advice, and participate in agricultural groups, thereby enhancing their technical knowledge and confidence. The interactive nature of social media facilitates rapid dissemination of innovations, peer learning, and timely problem-solving, leading to improved crop yields, reduced post-harvest losses, and better income opportunities. Furthermore, social media use strengthens women's roles in household and community decision-making by increasing their agency and visibility in agricultural activities.

The study conducted in Raigad district of Maharashtra state in the year 2025-26 revealed that more than fifty per cent (53.34 per cent) of the farm women demonstrated low social media usage scores up to 7. This indicated that the farm women in the study have very limited engagement with social media platforms. One-third (33.33 per cent) farm women exhibited medium social media usage and only 13.33 per cent demonstrated high social media usage. The results concluded that only a tiny fraction of the farm women are active and frequent users of social media. Overall, the integration of social media into rural agrarian contexts need to hold considerable promise for supporting inclusive, gender-responsive agricultural development and sustainable pulses production systems. However, challenges such as digital literacy gaps, network connectivity issues, and socio-cultural barriers persist.

Key words: Social Media, Farm Women, post-harvest, Pulses



T-6 O-6: Gender Concerns in the Application of Digital Tools for Empowering Women Farmers: An Empirical Analysis

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Digital tools such as mobile phones, agricultural applications and online advisory platforms have become increasingly important in improving access to information and services in the agricultural sector. However, the effective utilization of these digital tools by rural women farmers remains constrained due to persistent gender-related barriers. The present study examines the gender concerns in the application of digital tools and their implications for empowering women farmers in agriculture. An ex-post facto research design was adopted, and the study was conducted among 240 rural women farmers in Nalgonda district of Telangana. Data were collected through a structured interview schedule. The major gender concerns were identified and prioritized using the Garrett Ranking Technique.

The findings revealed that limited digital literacy and skills was the most severe constraint faced by women farmers followed by lack of ownership of mobile phones/smartphones and high cost of digital devices and internet services. Language barriers, time constraints due to household responsibilities and limited access to training were ranked as moderate concerns, while socio-cultural restrictions, poor network connectivity, lack of women-centric digital design and limited family support were perceived as relatively less severe.

The study suggests gender-responsive strategies such as strengthening digital literacy programs, improving access and affordability of digital tools, developing women-friendly digital content, and enhancing institutional support. Addressing these gender concerns is crucial for empowering women farmers, bridging the digital gender divide and promoting inclusive and sustainable agricultural development.

Keywords: Digital tools, women farmers, gender concerns, Garrett ranking technique, women empowerment, inclusive agriculture



T-6 O-7: Gender Concerns in Digital Empowerment: An Index-Based Assessment of Aspirational Self-Reliance among Tribal Farm Women in Middle Gujarat

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Tribal farm women represent a vital component of India's rural production system; however, their digital participation, aspirations, and self-reliance potential remain insufficiently documented. This study constructs a standardized Aspiration Index to evaluate the educational, social, political, and occupational aspirations of tribal farm women in Middle Gujarat, incorporating gender concerns in the use of technological and digital tools for data collection and analysis. A random sample of 240 respondents was assessed through structured interviews supported by digital questionnaires. Findings indicate that more than half of the respondents (52.92%) reported medium levels of educational aspirations, reflecting growing interest in learning and technology-supported information access. Political aspirations were comparatively minimal, with nearly 79.58% positioned in very low to low categories. Social aspirations showed relatively higher confidence, with 67.91% placed in moderate to high aspiration ranges. Occupational aspirations were largely low to moderate, pointing toward limitations in skills, digital exposure, and employment choices. The overall Aspiration Index revealed that 65% of tribal farm women hold moderate aspiration levels and 34.17% remain at low levels, with no respondents achieving high aspiration categories. Although digital engagement tools enabled structured assessment, the results clearly highlight existing gender-based gaps in access, usage, and benefits of digital resources. The study stresses that while tribal women are gradually moving toward self-reliance, significant barriers continue to affect their digital inclusion and aspiration growth. Strengthening women-centric digital literacy, improving access to education, skills, and livelihood technologies, and promoting gender-responsive extension programmes are essential to enhance their self-reliance and empowerment.

Keywords: Digital Empowerment, Gender Concerns, Aspiration Index, Tribal Farm Women, Self-Reliance



T-6 O-8: Gendered access to digital tools in sustainable cabbage cultivation: evidence from cabbage farmers in Nagaland

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Digital inclusion is now widely seen as a vital factor in promoting gender equity and sustainable farming in India. However, women farmers continue to face significant barriers in accessing digital tools, ICT-based advisory services, and e-governance platforms due to structural, socio-cultural, and infrastructural constraints. In Nagaland's hill agriculture, cabbage is an emerging crop linked to household food security and income; women provide substantial labour but lack control over smartphones, data services, and formal digital channels, limiting access to sustainable practices like organic nutrient management, integrated pest management and climate-resilient cropping decisions. Focusing on cabbage farmers in selected Nagaland districts, the study examines how gendered socio-economic factors shape digital access. Findings indicate that women play a central role in many sustainable cabbage practices, including use of local seed, on-farm nutrient recycling and labour-intensive intercultural operations, but they have comparatively limited control over digital devices, data costs and participation in online market negotiations. Instances where women's groups access information through shared smartphones or messaging groups show improvements in input planning, pest management and price realization, yet these remain localized achievements. The findings also highlight the potential of gender-responsive digital interventions, including national initiatives such as the Digital India Programme and the MahilaKisanSashaktikaranPariyojana (MKSP), which emphasize women's collectives and self-help groups as platforms for digital inclusion in agriculture. The study concludes that integrating gender-responsive digital strategies into agricultural and rural development policies in Nagaland is essential for advancing SDG 5 on gender equality. Key action points include gender-sensitive digital extension services, women-focused training schedules, strengthening self-help groups, promoting local-language digital content, and supporting collective access to devices and connectivity. Strengthening these measures can enhance both gender equity and the sustainability of cabbage cultivation systems in the region.

Keywords: Gendered access, digital tools, cabbage farming, sustainability, Nagaland



T-6 O-9: Digital Stressors as Emerging Causes of Anxiety in College Youth: A Gender Analysis

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The increasing integration of digital technologies into higher education has significantly transformed academic practices, communication patterns, and social interactions among college youth. While these advancements have enhanced access to information and learning resources, they have simultaneously introduced new forms of psychological stress. The present study examines digital stressors as emerging causes of behavioural anxiety among college youth, with a specific focus on gender-based differences. The research was conducted among 280 male and female respondents drawn from seven universities representing diverse academic disciplines, namely Medical, Law, Engineering, Agriculture, Agricultural Engineering, Horticulture, and Veterinary Sciences in Chhattisgarh. Primary data were collected through a structured questionnaire administered via personal interviews. The study analysed and assessed various forms of anxiety, including academic, social, emotional, and technology-induced anxiety. Special emphasis was placed on identifying digital stressors, such as online academic pressure, excessive screen exposure, digital overload, social media comparison, cyber-expectations related to performance and availability, and unequal access to digital resources. The findings revealed that both male and female students experienced moderate to high levels of anxiety; however, female respondents reported higher anxiety related to social comparison, online evaluation, and digital multitasking, whereas male respondents exhibited relatively higher anxiety associated with performance pressure, competitive online environments, and technological expectations. Disparities in digital access, confidence in technology use, and concerns related to online safety further intensified anxiety, particularly among female students. The study also examined coping mechanisms adopted by college youth, highlighting the growing reliance on digital tools, including educational platforms, mental-health applications, online peer networks, and virtual counselling services. While digital tools have contributed to increased awareness and accessibility of support systems, existing gender concerns and the digital divide limit their optimal utilization. The study concludes with action-oriented recommendations emphasizing the development of gender-sensitive digital interventions, institutional support mechanisms, and inclusive digital policies aimed at reducing anxiety and promoting mental well-being among college youth in higher education.

Keywords: Behavioral anxiety; Digital stressors; Gender differences; College youth; Online academic pressure; Social media comparison; Digital coping mechanisms; Higher education



T-6 O-10: From Access to Agency: Gender-Inclusive Pathways in India's Digital Agricultural Revolution

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The digitalization of Indian agriculture presents transformative potential for enhancing productivity, sustainability, and knowledge dissemination. However, gender disparities in digital access, literacy, and participation continue to limit the equitable benefits of this transformation. Women, who make up nearly 37% of India's agricultural workforce, remain underrepresented in digital initiatives due to sociocultural barriers, limited access to technology, and inadequate gender-responsive policies. Bridging this digital divide is therefore crucial to realizing inclusive agricultural growth and advancing India's vision of *AtmanirbharBharat*. Recent interventions led by ICAR, ICRISAT, NABARD, and Digital Green highlight encouraging progress. Programs such as Digital Green's video-enabled learning, NABARD's e-Shakti initiative, and ICRISAT's Smart Agriculture for Women Empowerment have demonstrated measurable gains in knowledge dissemination, income diversification, and social inclusion. Studies (Khatri et al., 2024; Wani&Padmaja, 2022) reveal that when women are trained as digital extension intermediaries, technology adoption rates in their communities increase significantly. Moreover, integrating mobile-based learning, IoT tools, and AI-driven advisories into women's cooperatives and self-help groups has strengthened both productivity and agency.

Nevertheless, barriers remain. Limited ownership of digital devices, gendered labor norms, and restricted decision-making power hinder full participation. Institutional efforts must therefore move beyond access to build **agency**—empowering women not just as users but as **designers, educators, and innovators** of digital agriculture. Policy frameworks should emphasize gender-sensitive technology design, digital literacy training, and inclusion of women in agri-tech startups and data governance systems. To ensure a sustainable and equitable digital transition, future action points include developing low-cost, multilingual mobile platforms, creating community digital hubs for women, integrating gender metrics into agricultural data systems, and promoting women-led agri-enterprises. A gender-inclusive digital ecosystem is not only a moral imperative but also a strategic necessity for transforming Indian agriculture into a resilient, intelligent, and equitable system.

Keywords: Gender Digital Divide, Women Empowerment, Digital Agriculture, ICT for Development, Inclusive Innovation, Smart Farming, Digital Literacy, Atmanirbhar Bharat, Women in AgriTech, Gender Equity.



T-6 O-11: Gender concerns in application of digital tools in agricultural extension

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Contributing around 16-18% to India's GDP, agriculture and allied activities are vital for ensuring food security for 1.47 billion population, supporting roughly half of the population, and provides raw materials for industries, with recent years showing robust growth and record exports. Indian agriculture is characterized by traditional method of farming, fragmented supply changing and increasingly unpredictable weather patterns. Women constitute a significant majority of India's agricultural workforce, handling from sowing to post-harvest. Use of digital tools in agricultural extension is an urgent critical enabler for revolutionizing farming practices. Digital tools being used in agriculture includes combination of several advanced tools like mobile applications, Internet of Things devices, satellite imagery, artificial intelligence and blockchain-driven platforms. Application of digital tools helps in enhancing productivity of various crops, in addition to ensuring sustainability and improving market access. Digital tools are transforming Indian agriculture, especially for women farmers who are gaining access to valuable information, improving yield and enhancing livelihoods. Digital initiatives like Farmers chat, E-form, Digital Sakhi initiative, RSV mobile application, KisanSuvidha, Bhashini platform and Inclusive design^{etc.}, empowering women farmers by bridging knowledge gaps, improving crop productivity, income, market access and promoting climate-smart practices. Less access to smartphones, internet and digital platforms, cultural restrictions and gender roles and lack of digital literacy are the major issues of concerns, limiting women's ability to use digital tools. There is an urgent need to take necessary action to remove these constraints to enable women farmers to use digital tools in agriculture which will ultimately revolutionize Indian agriculture.



T-6 O-12: Empowerment of Women Farmers in Digital India: Challenges and Opportunities

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In India, agriculture forms the backbone of rural livelihoods, with women playing a significant and indispensable role in agricultural development and allied sectors. Empowering rural women with digital technologies in agriculture can generate substantial indirect benefits by enhancing productivity, efficiency, and sustainability. Digital empowerment refers to the process of strengthening women's capabilities and skills through the use of technology, enabling them to actively contribute to agricultural development and improve their socio-economic status. The Government of India has launched several initiatives aimed at empowering women, including *Digital India*, *PMGDISHA*, *Skill India Digital Platform*, *Mahila Kisan Sashaktikaran Pariyojana*, *Namo Drone Didi*, and *KrishiSakhi*.

This review paper explores how digital technologies can improve rural women's access to education, employment, and entrepreneurial opportunities, while also highlighting the associated opportunity and challenges of digital empowerment. Such challenges restrict women's ability to fully utilize digital tools and platforms. While the expansion of digital technologies has contributed positively to women's empowerment, the study underscores the need for targeted capacity-building programmes, safe and inclusive digital environments, and supportive policies to ensure meaningful and sustained participation of women farmers in digital agricultural initiatives.

Keywords: Women empowerment, Digital technology, challenges and opportunity



T-6 O-13: Assessment of Gender Concerns in Use of Digital Tools for Future Action Strategies

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Gender refers to the characteristics of women, men, girls and boys that are socially constructed. This includes norms, behaviours and roles associated with being a woman, man, girl or boy, as well as relationship with each other. Gender concerns in the application of digital tools range from unequal access and embedded biases in AI to online safety issues. The major gender concern in the application of digital tools i.e. digital divide, skill gap, bias in technology design, online safety and violence, socio-cultural norms, economic barriers, achievements of genders concern in application of digital tools: Empowerment opportunities, awareness and mobilization, policy recognition, targeted interventions, while action points focus on inclusive policy-making, education reform, and creating safe digital spaces. The major action points in regarding gender concerns in the application of digital tools-integrate a gender analysis, promote STEM education and carriers ensure affordable and accessible infrastructure, implement legal and safety frameworks, design inclusive digital tools, promote digital literacy and skill training collect disaggregated data, challenges harmful social norms. Achievements include targeted digital literacy programs and policy changes, increased women, girl participation in digital technologies crucial to economies as well as global sustainability. What'sapp is an important tool of our daily life. What'sapp is a good mode to stay connected with friends, family and also have made its way towards official uses lately. What'sapp has over 3 billion monthly active users globally (MAU) as of 2025, making it the world's leading messaging app, with India as its target market (over 500 M users) and its projected to reach 3.5 billion by year-end. In the field of agriculture technology dissemination scientists or experts provides the probable solutions to the concerned farmer those ask for solution of his problem, attaching picture or videos. The increased participation of women and girls in digital technologies and innovation, their engagements as students and professionals in agricultural science, technology, engineering's and mathematics is crucial to economies around the world as well as the global transition to sustainability.

Key Words: Social media, Digital tools, Gender concern, STEM education, Digital divide, Digital literacy, WhatsApp



T-6 O-14: Empowering Women Self Help Groups through Digitalization in Arid Zone of Rajasthan

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A project was undertaken for enhancing the income of farm women through entrepreneurship development by ICAR-CAZRI, Jodhpur from 2021-2024. Under the project, 10 women SHGs were formed in ten selected villages as per National Rural Livelihood Mission (NRLM) *Rajeevika* model in Jodhpur district of Rajasthan. CAZRI's interventions focussed on capacity development, technology integration and digitalization. Beneficiary farmer's fields were mapped with GPS and customized integrated farm plans were made for integrating water harvesting, solar energy, horticulture, crop cultivation and food processing. CAZRI trained and facilitated these SHGs to develop one satellite food processing centre in each village. The SHGs were trained in post-harvest processing of pearl millet and indigenous fruit based recipes. The SHGs were linked with financial institutions and FSSAI. SHGs produced various kinds of processed products with packaging, logo and labels and sold through various regional and national melas and millet summits. SHG members learnt marketing skills including managing the sale counter, financial transaction through digital platforms and online modes. They became familiar with various operations such as conducting meetings, banking operations, FSSAI license, small saving, loaning to members, depositing the instalments in SHG, business to business (B2B) and business to consumer (B2C) dealings. Since second year of establishment, these SHGs participated in 26 events and earned an income of around eight lakh rupees. At the end of the study, it was found that 40% of SHG members adopted digital tools resulting in 53% increase in efficiency in financial management and transparency. Digital record-keeping systems have enhanced accuracy in tracking transactions, loan repayments, and group savings, thereby improving accountability and decision-making. Finally, empowering SHGs through digitalization resulted in the participation of two SHG members in G-20 summit in 2023. Capacity building of SHGs in digitalization of their operational and financial transactions was found as crucial as technology integration, value addition and marketing.

Key words: Digitalization, Empowerment, Millets, Self-Help Group, Women.



T-6 O-15: Digital Agriculture as a Pathway to Women's Economic and Decision-Making Empowerment in Smallholder Farming Systems of Eastern India

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Digital agriculture substantially enhances women's access to timely information, markets, and financial services, yet a persistent gendered digital divide constrains their full participation in India's agrarian transformation. This study addresses the limited empirical evidence on how structured digital interventions affect women's economic and decision-making empowerment in smallholder farming systems, with a specific focus on West Bengal. The research was conducted during 2023–2025 in four districts (Nadia, Murshidabad, Purba Bardhaman, Bankura) of West Bengal using a quasi-experimental design with 240 women farmers (120 participants in digital advisories and 120 controls), combining baseline–endline surveys, focused group discussions, and platform usage analytics as data collection tools. Digital services included mobile-based agro-advisories, market price alerts, and video-mediated extension delivered through women-led community resource persons. Results show that treated women recorded a 24–28% increase in gross farm income, a 19% reduction in production risk (measured by year-on-year yield variability), and a 31% rise in independent agricultural decision-making scores compared to controls. Household dietary diversity scores improved by 14%, and 62% of participants reported stronger bargaining power in producer groups and markets. The findings demonstrate that gender-responsive digital agriculture can serve as a scalable pathway for inclusive growth in West Bengal, while highlighting the need for targeted capacity-building and infrastructure support to close the rural gender digital divide in India.

Keywords: Gender digital divide; ICT-enabled extension; smallholder livelihoods; decision-making autonomy; inclusive agri-tech adoption.



T-6 O-16: Women Empowerment through the Namo Drone Didi Scheme

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Drone technology has emerged as transforming tool in agriculture, offering significant benefits in improving efficiency, reducing input costs, and enhancing crop productivity. In this context, the present study attempts to examine women empowerment through the flagship Central Government initiative Namo Drone Didi, implemented in the year 2023. The study was conducted by considering ten self-help groups (SHGs) effectively functioning in various districts of Karnataka that have availed Namo Drone Didi. Women empowerment was assessed in economic terms by estimating the profitability accrued to Drone Didi's through renting drones for the application of plant protection chemicals (PPCs) to growers in Karnataka. In addition, an attempt was made to estimate the economic worthiness of using drones for PPC application. Enterprise budgeting and partial budgeting techniques were employed to ascertain the economic feasibility of drone usage. The results indicated that the selected Drone Didi's widely used drones for the application of plant protection chemicals to control pests and diseases, predominantly in red gram fields, followed by maize. The Drone Didi's used drones for pest and disease control over an area of about 350 acres per year, incurred total cost of Rs. 1,22,500.00, and earned a profit over variable cost @ Rs. 94,500.00. The net profit accrued was Rs.17,500.00, which substantial contributing significantly to the empowerment of women functioning as Drone Didi's. The economic worthiness of chemical application through drones ranged from Rs. 1165.74 per acre in maize to Rs. 3426.68 per acre in red gram. This income has made the women to become economically empowered and encouraged them to take up this as an entrepreneurial activity to have social recognition.

Keywords: Women empowerment, Self-help groups, Namo drone didi, Partial budgeting



Theme VI : Poster

Gender concerns in application of digital tools – Achievements and Action points





T-6 P-1: Path and Regression Analysis of Socio-Personal Characteristics Influencing Aspirations of Tribal Farm Women for Self-Reliance with Gender Concerns in the Application of Digital Tools

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The study explores the socio-personal factors influencing the aspirations of tribal farm women for self-reliance in the tribal-dominated districts of Middle Gujarat—Dahod, Panchmahals, Chhotaudepur, and Mahisagar. Employing an ex-post-facto design, data were collected from 240 respondents using a structured and pre-tested Gujarati interview schedule. The analysis employed regression and path analysis techniques. Eighteen independent variables were considered, including age, education, farming experience, social media utilization, family type, occupation, and others, with aspirations for self-reliance as the dependent variable. Results revealed that self-confidence, farming experience, type of family, and decision-making ability significantly impacted women's aspirations. Regression results showed that eight variables had a statistically significant effect, with self-confidence emerging as the most influential. Path analysis highlighted that self-confidence and decision-making ability not only had strong direct effects but also mediated substantial indirect effects from other variables like education and attitude towards agriculture. Despite government programs like MKSP, DAY-NRLM, and PMKSY aiming to empower tribal women, structural challenges such as literacy gaps, cultural norms, and limited access to extension services persist. This study underscores the necessity of inclusive, gender-sensitive agricultural extension services that align with the cultural context and aspirations of tribal women. Promoting education, resource access, and leadership in extension activities can foster sustainable livelihoods and support India's broader goals under the Sustainable Development Goals (SDGs).

Keywords: Aspirations, Self-reliance, Tribal farm women and Socio-personal characteristics



T-6 P-2: Gender Concerns in Application of Digital Tools

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Digital technologies are increasingly promoted as instruments for social inclusion, economic empowerment, and improved service delivery. However, growing evidence suggests that the benefits of digitalization are not gender-neutral. Women and girls, particularly in developing and rural contexts, continue to face multiple structural barriers that limit their access to, use of, and benefits from digital tools. These barriers include lower levels of education, restricted mobility, unequal control over household and community resources, limited digital skills, and persistent sociocultural norms that prioritize men's engagement with technology. Consequently, digital interventions may unintentionally reinforce existing gender inequalities when gender dynamics are not explicitly integrated into program design, implementation, and evaluation. Gender disparities in digital participation are driven more by social and economic inequalities than by technological availability alone. Even in contexts where devices and internet connectivity are present, women often experience limited autonomy in technology use and fewer opportunities for skill development. Household-level evidence shows that men frequently control digital resources, while women's digital engagement is constrained by care giving roles and normative expectations, resulting in unequal participation in online education, employment, and entrepreneurial activities. Moreover, evaluations of digital inclusion programs commonly rely on output-oriented indicators, such as the number of female users, without adequately assessing sustained use, empowerment outcomes, or changes in decision-making power. Digital technologies may intensify family and community tensions when shifts in traditional gender roles are not supported by adequate social dialogue and institutional mechanisms. As digital tools alone cannot bridge gender gaps, sustainable digital inclusion is required addressing underlying gender norms, power relations, and structural inequalities through integrated, gender-sensitive policy and community-based interventions. To address these challenges, there is a need to emphasize the need for gender-responsive indicators, participatory monitoring and evaluation approaches, and context-specific social analysis. Strengthening digital literacy, confidence, and institutional support for women is essential for ensuring meaningful and equitable digital participation.

Keywords: Gender, Sustainable digital inclusion and Digital tools



T-6 P-3: Empowerment of Rural Women by Participation in Agri-Based Enterprises

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The present study was conducted in all the five districts of Konkan region of Maharashtra namely Palghar, Thane, Raigad, Ratnagiri and Sindhudurg with the major objective to study the empowerment of rural women in agri-based enterprises. Total 250 trained rural women were selected from all five districts of Konkan region and 'ex-post-facto' research design was used for the present study. The data were collected by personal interview of trained rural women. The dependent variable 'empowerment of rural women' was measured with the help of specially developed scale. Age, education, family size, family type, land holding, annual income, source of information, social participation, economic motivation, risk orientation and training received were selected as independent variables. It was also observed that five components of empowerment of rural women i.e. psychological, cultural, social, economic and political had medium level of empowerment. Whereas 63.20 per cent of rural women had medium level of overall empowerment followed by 19.60 per cent had high and 17.20 per cent of them had low level of overall empowerment. Finding of relational analysis revealed that the selected variables *viz.*, education, land holding, annual income, source of information, social participation, economic motivation, risk orientation and training received had positive and significant relationship with their empowerment. Multiple regression relational analysis showed that the three variable *viz.*, education, risk orientation and training received were significant at 0.01 level of significance.

Keywords: Empowerment, rural women, agri-based enterprises,



T-6 P-4: Femtech: Innovation, Impact, and the Future of Female Healthcare

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FemTech, or feminine technology, has emerged as a transformative sector within the digital health landscape, focusing on women's unique biological, reproductive, and psychosocial health needs across the life course. Historically, women's health concerns—including menstruation, fertility, pregnancy, menopause, and chronic gynecological conditions—have been systematically underrepresented in medical research, clinical trials, and healthcare innovation, leading to delayed diagnoses, inadequate treatment protocols, and unequal access to quality care. In response to these gaps, FemTech leverages digital technologies such as mobile applications, wearable devices, artificial intelligence, and telehealth platforms to provide personalized, preventive, and accessible healthcare solutions. This paper presents a comprehensive overview of the evolution and scope of FemTech, examining its applications in menstrual and fertility tracking, maternal and pregnancy care, menopause management, mental health support, diagnostics, and community-based wellness platforms, with particular emphasis on the role of artificial intelligence and data analytics in enabling predictive insights, early disease detection, and individualized care pathways. The study also examines the economic and societal implications of FemTech, highlighting its potential to improve women's productivity, workforce participation, and overall quality of life, while representing a rapidly expanding global market for healthcare innovation. Despite its promise, the FemTech ecosystem faces significant challenges, including persistent funding disparities, cultural stigma surrounding women's health topics, digital divides affecting rural and low-income populations, concerns related to data privacy and surveillance, limited clinical validation of digital tools, and standardized design approaches that overlook biological, cultural, and socioeconomic diversity. The paper further examines the role of extension organizations and public sector initiatives in improving health literacy, promoting equitable access, integrating FemTech solutions with existing healthcare systems, and advocating for ethical and inclusive regulatory frameworks. It concludes that while FemTech holds substantial potential to reshape women's healthcare by fostering empowerment, inclusivity, and data-driven decision-making, its long-term sustainability depends on user-centered design, feminist data practices, rigorous clinical evidence, and policy frameworks that prioritize women's wellbeing over commercial scalability.

Keywords: FemTech; Women's Health; Digital Health Innovation; Artificial Intelligence in Healthcare; Telemedicine; Reproductive Health; Maternal and Menopause Care; Health Equity; Data Privacy and Ethics



T-6 P-5: Gender Concern in Agriculture: Exploratory Analysis of Women-led Farmer Producer Organization

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Farmer Producer Organization (FPO) is an effective institutional mechanism aiming to uplift farmers and particularly women farmers dealing with various activities like input to market intelligence. A qualitative study was carried out to study how women-led FPOs play a crucial role in bridging the gap and providing digital knowledge among rural women. For this, the secondary data was relied on to collect data on women-led FPOs and documents using various websites like SFAC, NABARD, and popular articles published in journals. Ethiopians Womens Coffee Farmers Cooperatives, Kenya Cooperatives Creameries Dairy Cooperatives, Mahasakti Mahila Milk Producer Company Limited and Harikranti Adivasi Cooperative Society are the FPOs showcasing how women empowerment and gender concerns can be bridged through collective action (FPOs). FPOs are key in empowering women by providing income generation sources, digital knowledge and social inclusion.

Keywords: Farmer Producer Organization, Qualitative Data, women empowerment, Gender Concern

T-6 P-6: Barriers faced by Farm Women in adopting Digital extension tools

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Farm women play a critical role in agriculture, contributing significantly to crop production, livestock management and post-harvest operations. Despite their contributions, they often face limited access to agricultural information, resources, and extension services. The emergence of digital technologies, such as mobile applications, SMS advisories, online platforms, and social media, has the potential to bridge this information gap and empower women farmers. However, adoption of digital extension tools remains limited due to multiple barriers, including low digital literacy, poor internet connectivity, limited access to devices, socio-cultural restrictions, heavy workload and lack of gender-responsive digital content. A review of literature from studies and other indicates that addressing these challenges requires targeted digital literacy programs, improved rural digital infrastructure, affordable access to devices, and development of localized, women-centric digital content. Strengthening selfhelp groups, involving extension agencies, and implementing user-friendly ICT strategies can promote inclusive agricultural development and ensure that women farmers benefit fully from digital extension services. The paper highlights the critical barriers and provides actionable suggestions to enhance digital inclusion for farm women.

Keywords: Farm women, Digital extension, Women farmers, Digital literacy; Genderresponsive extension, Digital inclusion, Rural connectivity, Empowerment of women farmers



T-6 P-7: Gender Digital Divide in Agriculture: Evidence and Extension Implications for Inclusive Rural Development

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The expansion of digital technologies in agriculture has transformed information delivery, advisory services and market access. However, empirical evidence shows that these benefits remain unevenly distributed across genders, particularly in rural areas. This paper synthesizes findings from recent empirical studies, national surveys and documented extension interventions to examine the magnitude of the gender digital divide and its implications for women's participation in agriculture. Statistical evidence indicates that only about 25 percent of rural women in India have access to the internet compared to 49 percent of men, while smartphone ownership among rural women remains below 30 percent. Further, less than 20 percent of rural women farmers directly access ICT-enabled extension services, often depending on male family members for agricultural information. The analysis identifies socio-cultural norms, low digital literacy, limited control over digital devices, time poverty and gender-blind extension approaches as major constraints to women's digital engagement. Empirical evidence from gender-responsive extension initiatives shows that targeted digital literacy training, women-focused advisory content and participatory digital platforms can increase technology use and adoption of improved practices by 30–40 percent, along with enhanced decision-making autonomy at the farm level. The findings underscore the critical role of agricultural extension systems in converting digital access into meaningful livelihood outcomes for women farmers. The paper concludes that strengthening gender-responsive digital extension is essential for reducing inequality, improving farm productivity and promoting inclusive and sustainable agricultural development.

Keywords: Gender digital divide, Agricultural extension, Digital inclusion, Women farmers, ICTs in agriculture, Sustainable development



Theme VII : Oral

Intelligent technologies and sustainable food systems





T-7 O-1: Role of Artificial Intelligence (AI) in Natural Farming for Enhancing Sustainability

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Artificial Intelligence(AI) in natural farming enhances sustainability by enabling precision resource management, reducing waste through data-driven insights on water, nutrients, and pesticides, while also offering predictive analytics for weather and pest/disease outbreaks, leading to timely interventions, better yields, and minimized environmental impact through tools like drones, sensors, and smart apps for crop monitoring and targeted actions. Precision Resource Management (PRM) is a data-driven approach to optimize resource use (like water, fertilizer, capital, or labor) by applying the right amount, to the right place, at the right time, using technologies such as GPS, sensors, drones, and data analytics, to minimize waste, boost efficiency, increase profitability, and promote sustainability, famously applied in Precision Agriculture to manage crop variability. It shifts from broad strategies to targeted actions, ensuring resources meet specific needs, leading to higher yields with less environmental impact.

Smart Monitoring & Automation uses sensors, IoT, and software to collect real-time data from devices, analyze it for insights (like condition monitoring), and automatically trigger actions for efficiency, safety, and convenience in homes, industries, and agriculture, reducing manual intervention and optimizing performance. It involves technologies like IO-Link for industrial data, microcontrollers, and cloud platforms for remote control and analysis, moving beyond simple alerts to intelligent, predictive management.

Decision Support Systems (DSS) are interactive, computer-based tools that help organizations make better decisions by analyzing data, models, and knowledge to solve complex, semi-structured, or unstructured problems, supporting managers and knowledge workers in planning and analysis. They differ from standard systems by focusing on decision-making, integrating various data sources, offering analytical models, and providing user-friendly interfaces for exploring alternatives and consequences, enhancing efficiency, collaboration, and strategic insight. By integrating AI, natural farming becomes more efficient, sustainable, and productive, meeting food demands without compromising ecological balance.

Key words: Artificial intelligence, Precision Resource Management, Natural farming, GPS.



T-7 O-2: Smart Mobile Applications for Sustainable Rice Farming

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Sustainable agriculture aims to improve soil health, enhance productivity, ensure efficient resource use, and mitigate the adverse impacts of climate change while restoring ecological balance. Rice is a vital food crop supporting food security and livelihoods for millions of people in India. However, rice cultivation faces several challenges, including climate variability, pest and disease outbreaks, nutrient imbalances and rising production costs. Farmers are under increasing pressure to meet the rising food demand, highlighting the need for smart and efficient farming solutions. Sustainable rice crop management is therefore essential to increase productivity while conserving natural resources and minimising environmental impacts.

Advances in information and communication technologies (ICT), especially mobile applications, provide innovative solutions to address these challenges. Mobile apps enable farmers to access timely, location-specific advisories on crop management, pest and disease identification, nutrient management and carbon footprint etc. The integration of Artificial Intelligence (AI) with machine learning (ML) further enhances decision-making through image-based diagnosis and data-driven recommendations.

With this background, multiple mobile applications have been developed to support sustainable rice crop management. The Rice Clinic mobile app provides easy-to-use diagnostic support for identifying major pests, diseases, weeds, and nutrient deficiencies along with recommended management practices. The RAISE – Rice AI Stress Evaluator uses artificial intelligence and image-based analysis to detect biotic and abiotic stresses in rice and deliver instant, field-level advisories. The NAPSRI app supports precise nutrient and fertiliser management to improve input-use efficiency and soil health, while the Rice Carbo Tracker app helps to monitor carbon footprints and promote climate-smart rice cultivation. Together, these apps empower farmers with timely, data-driven, and sustainable decision-support tools.



T-7 O-3: Digital Agriculture for Sustainable Food Systems and Atmanirbhar Bharat

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India's agricultural sector is at a pivotal moment in its development trajectory. As the nation pursues the vision of Atmanirbhar Bharat (Self-Reliant India), the integration of digital technologies into the food and agriculture sector has become a national priority. This transformation is not merely technological; it is deeply socio-economic and environmental. Digital tools such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data, remote sensing, drones, robotics, blockchain, and mobile-based advisory systems have emerged as powerful enablers of productivity, sustainability, inclusiveness, and resilience. These technologies are helping address long-standing challenges including climate variability, resource degradation, low productivity, fragmented supply chains, market inefficiencies, and limited access to real-time information among farmers especially small and marginal farmers who constitute the backbone of Indian agriculture. It examines how digital agriculture can serve as a catalyst for building sustainable food systems aligned with the principles of Atmanirbhar Bharat. It highlights the role of digital innovation in enhancing productivity, optimizing inputs, strengthening climate-smart practices, improving food safety, reducing post-harvest losses, and creating transparent and efficient supply chains. In addition, it analyses the socioeconomic impacts of digitalization particularly how digital extension services, farmer-producer organizations (FPOs), e-commerce platforms, and agri-startups contribute to rural employment, entrepreneurship, and financial inclusion. The paper also discusses policy frameworks, national initiatives, and institutional mechanisms that are accelerating India's agricultural digital transformation. The write-up argues that a digitally empowered agricultural ecosystem is essential for achieving national goals such as doubling farmer income, reducing carbon intensity, achieving sustainable production, and ensuring food and nutritional security. It concludes by proposing a multi-dimensional roadmap encompassing policy reforms, infrastructure development, research and innovation, capacity building, and public-private partnerships. These interventions will be instrumental in steering India towards a resilient, technology-driven, and self-reliant food system for the future.

KeyWords: Digital Agriculture; Sustainable Food Systems; Atmanirbhar Bharat; Smart Technologies and Climate-Smart Farming



T-7 O-4: Sensor based drip irrigation method to achieve sustainable food system through Direct Seeded Rice (DSR) in command area

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Rice (*Oryza sativa* L.) is a staple food crop for more than half of the world's population, predominantly grown in water-intensive paddy fields. However, increasing water scarcity due to climate change and competition for water resources necessitates the adoption of more efficient irrigation techniques. Conventional transplanted rice production faces issues like lowering water tables, lower productivity, methane emissions, soil health deterioration and labour scarcity. Direct seeded rice (DSR) technologies can minimize environmental impact and increase productivity. A field experiment was carried out at Water and Land Management Institute (WALMI), Dharwad during *kharif* 2025-26 to study the effect of different irrigations method on yield of DSR. The experiment was laid out in Randomized Block Design with five treatments and four replications. Treatments consisted of alternate wetting and drying, sprinkler irrigation, drip-irrigation, automated drip irrigation system and conventional flooding (Farmer's practice). The results revealed that paddy grown in automated drip irrigation system showed significantly higher plant height, root length, number of panicles, dry matter, panicle length, no. of grains per panicle and grain yield (65.51 q/ha). It was statistically comparable with conventional flooding methods of rice cultivation. An automated drip irrigation system, is known for its high water use efficiency (WUE), is emerging as a viable alternative to traditional flood irrigation methods in rice cultivation. An automated irrigation system providing water on-demand was designed using time based, volume based, sensor based based drip irrigation proves to be a real time feedback control system which efficiently monitors and controls all drip irrigation system activities. Thus, direct seeding of rice in tail end command area using seed drill with automated drip irrigation system could be considered as an alternative eco-friendly technique under the present scenario of water scarce situation and around 68 % water is being saved which ensures to reach water to tail end farmers of command area.

Keywords: Rice, DSR, Irrigation, Yield, Automated drip irrigation, Command area



T-7 O-5: Digitalization in Dairy Farming: Adoption, Training, Constraints, and Recommendations

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Digitalization has emerged as a transformative tool in agriculture, offering dairy farmers opportunities to improve productivity, animal health, and profitability through timely access to information, advisory services, and market linkages. This study explores role of digitalization in dairy farming by analysing adoption of digital technologies, the impact of training and communication sources, and constraints faced among 120 dairy farmers in Nashik district of Western Maharashtra. Data were collected using a structured interview schedule covering socio-economic characteristics, herd management practices, sources of information, training, innovativeness, achievement motivation, and scientific orientation.

Findings revealed that majority of farmers were middle-aged, educated, and had medium farming experience, with herd sizes and income levels influencing their likelihood of adopting digital technologies. Television, mobile applications, and the internet were the most frequently used sources of information, although overall digital adoption was moderate. Only 14% of farmers had received formal training, highlighting gaps in digital literacy and advisory dissemination. Correlation analysis indicated that education, experience, herd size, income, communication source utilization, training, and innovativeness were significantly positively associated with digital adoption. Key constraints identified included high cost of veterinary medicines, low milk prices, insufficient technical knowledge, and limited access to expert support. Farmers suggested solutions such as provision of affordable inputs, on-farm demonstrations, stronger linkages with agricultural institutions, and structured training programs.

The study highlighted the critical role of digital extension services in bridging knowledge gaps, improving management practices, and enhancing income for dairy farmers. It recommends the integration of mobile apps, online advisories, and digital training modules with conventional extension systems to promote efficient, technology-driven dairy farming.

Keywords: Digital adoption, Dairy farming, Training, Communication sources, Constraints, Recommendations, Extension services



T-7 O-6: Digital Tools–Based Bibliometric Analysis using VOSviewer

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VOSviewer is a software tool for constructing and visualizing bibliometric networks. These networks may for instance include journals, researchers or individual publications and they can be constructed based on citation bibliographic coupling co-citations or co-authorship relations. Using databases such as Web of Science and Scopus, this approach analyzes publication patterns through tools including R (bibliometrix package) and CiteSpace etc. to identify research trends, influential authors, institutions, and countries, as well as collaborative networks. The analysis reveals dominant research domains. Findings also indicate a steady evolution of research focus, the emergence of advanced technologies such as artificial intelligence in extension research, and increasing international collaboration, particularly involving developing countries. Overall, VOSviewer bibliometric analysis provides a data-driven overview of the intellectual structure and growth of the field, while highlighting knowledge gaps and future research directions to support extension research and methodology.

Key words: Bibliometric Analysis, VOSviewer



T-7 O-7: Weather and Market information based Decision Support System (DSS) to meet needs of the farmers – A case study of KRISHIDHARE

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In spite of significant development in agriculture and substantial increase in the food grain production, farmers in India are faced with several challenges. Major challenge faced by farmers includes monsoon and market related issues. To solve this problem, an Expert System (ES) may become a powerful tool which is a dire need of the day for farmers, extension workers and Government officials. ES can provide on-line information on different crop management issues like diagnosing and controlling noxious and commonly found insect-pests and diseases, crop economics and designing schedule for irrigation and fertilization application etc. One such expert system KRISHIDHARE has been developed under ICAR funded project. Initially it was developed for four crops namely cotton, Red gram, ground nut and tomato. It was tested in four Clusters by collecting benchmark data and utilization pattern. The content was developed for cotton, Pigeon pea, Groundnut and Tomato for three weather conditions – Normal, above normal and below normal. The expert system was developed using Firebase (Google Cloud) for secure and scalable user authentication and management, ensuring seamless user on boarding and data handling. The expert system was uploaded on farmers mobile phones and demonstrated the features and method of use. The use of the expert system and information retrieved is monitored continuously and also Information accessed and adopted is being monitored. The results revealed that farmers. The results revealed that about one third of the farmers utilize weather and price forecast information, while over 30 per cent of the farmers had utilized the AI for pest and disease diagnosis. Comparative less number of farmers utilized the expert system for agronomic practices such as nutrient management and weed management. Overall the opinion of the farmers on the use of expert system is satisfactory. It is observed that such composite expert systems need time to make complete use. It is planned to scale the expert system KRISHIDHARE to larger area.



T-7 O-8: Sustainable Weed Management in Sugarcane: Problems and Opportunities

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Competition by weeds during the growing season of the crop for soil moisture, mineral constituents, sunlight, and space along with unhealthy nutrient management practices is the major constraint in enhancing the crop productivity. Besides, reducing the crop yield directly, heavy infestation of weeds interfere with crop harvest and elevate farm production costs through energy spent in controlling them. A weed which escapes the control measures and produces seed at maturity, further multiplies weed control problems by acting as a source of seed bank replenishment and re-infestation in the subsequent years. In sugarcane, the reduction in cane yield due to weeds ranged from 40–67 %, the highest being in those areas where farmers are not familiar to improved weed management technologies. Weed control is most critical early in the season prior to the sugarcane canopy closure over the row middles. Wide spacing in between sugarcane rows allows wide range of weed flora to grow profusely. The kind of weed species and the duration of its infestation have a major impact on stalk size, number of millable canes and finally the cane and sugar yields. Further, it severely reduces not only the tonnage, but also its quality besides hindering in the various field operations and harbouring insect-pests and disease. The nature of weed problem in sugarcane cultivation is quite different from other field crops because of inherent capacity of slow initial crop growth and heavy input requirements. The intensity and diversity of weed flora in sugarcane is dependent on the planting season. Owing to heavy nutrient application and frequent irrigation favours emergence of more flush of weed flora in the same growing season. There are several perennial weeds causing immensely losses in plant and ratoon cane crop in the tropical and subtropical regions of the country as well as the world. These weeds are so damaging that the losses can be experienced as high as 90% of the total crop yield in various part of the world. Although weeds are a challenge in the current sugarcane production system in India, there are many opportunities exist for developing sustainable and effective weed management programmes for main and ratoon crop. A huge quantity of trashes ranging from 12-15 tons/ha) can be effectively utilized as a component of IWM practices besides improving the resource use efficiency. In sugarcane, weeds are generally controlled with manual and cultural manipulations. Now-a-days timely availability of labour is a problem. So, the herbicide uses for weed control in sugarcane is considered to be economical and thus becoming increasingly popular. Hence, providing a weed free environment is absolutely essential to realize the full potential of new varieties and to make the best use of key production factors like nutrients, moisture and other natural resources. There are several weed management techniques which may be started much before planting as a preventive measure and may continue in the standing field crop by way of physical, mechanical, and chemical methods of weed management to improve the cane yield and farmer income.

The integration of AI and robotics is revolutionizing weed control in sugarcane farming, offering more precise, efficient, and sustainable solutions compared to traditional methods. These technologies leverage advanced algorithms and data analysis to optimize weed management strategies. By integrating AI into sugarcane farming practices, Indian farmers can achieve higher yields, lower production costs, and improved resource management- all of which are crucial for sustaining the rising demand driven by increased domestic sugar consumption and the expanding Ethanol Blended Petrol (EBP) Programme.

Key words: Artificial intelligence, robotics, weed, biofuel, sugar



T-7 O-9: Digital Interventions in National Nutrition Mission

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Digital interventions have emerged as transformative tools in India's nutrition mission, particularly through the PoshanAbhiyaan (Prime Minister's Overarching Scheme for Holistic Nourishment) and its integrated digital infrastructure. Launched in March 2018, the mission targets reducing stunting, underweight, and low birth weight by 2% annually among children, pregnant women, and lactating mothers, with the aim of achieving significant improvements in maternal and child nutrition outcomes. The Integrated Child Development Services (ICDS) scheme, complemented by digital monitoring systems such as the ICDS-CAS (Common Application System) and Poshan Tracker, represents a paradigm shift from traditional paper-based reporting to real-time, technology-enabled data collection. These systems harness mobile applications to track beneficiaries, monitor service delivery, and enable evidence-based decision-making at multiple governance levels. The practical implementation of digital tools demonstrates considerable promise and challenges requiring strategic navigation. The Poshan Tracker, the world's largest mobile-based nutrition surveillance system, has substantially increased Anganwadi Centre (AWC) operational days from 35% to 89% and facilitated measurement of 83.55 million children's anthropometric indicators. However, digitalization has simultaneously introduced complexities: Anganwadi workers face digital literacy gaps, infrastructure limitations, technical burdens, and increased workload demands. While 72% of workers report positive impacts on their work efficiency, challenges including hardware malfunctions, connectivity issues, and staff training gaps persist. To maximize digital interventions' potential in advancing nutrition outcomes, comprehensive strategies must balance technological advancement with worker capacity-building, infrastructure investments, and systemic policy reforms that prioritize both beneficiary welfare and frontline worker sustainability.

Key words: PoshanAbhiyan, National Nutrition Mission, ICDS-CAS, Poshan Tracker, Anganwadi workers, ICT



T-7 O-10: From Farm to Fork: Digital Applications for Quality Control and Food Safety

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Ensuring food quality and safety across the value chain has become a global priority in the context of rising food demand, complex supply chains, and increasing consumer awareness. Digital applications are transforming food safety management by enabling real-time monitoring, traceability, and data-driven decision-making from farm to fork. According to the World Health Organization (WHO), unsafe food causes 600 million cases of foodborne diseases and 420,000 deaths annually worldwide, highlighting the urgent need for robust quality control systems. Digital technologies such as blockchain, Internet of Things (IoT) sensors, artificial intelligence (AI), and mobile-based quality testing tools are increasingly being adopted to address these challenges. The Food and Agriculture Organization (FAO) reports that digital traceability systems can reduce food safety incidents by 20–30 % by enabling rapid identification of contamination sources and improving compliance with standards. In India, food safety digitization through platforms such as the Food Safety Compliance System (FoSCoS) and digital licensing under FSSAI has significantly improved inspection efficiency and transparency, with over 1.5 million food businesses digitally registered by 2023. IoT-enabled cold-chain monitoring has further reduced post harvest losses, which currently account for ₹92,651 crore annually according to government estimates. Despite these achievements, challenges related to data integration, cost of adoption, digital literacy, and infrastructure gaps particularly among smallholders and informal food operators persist. Strengthening digital food safety ecosystems therefore requires coordinated action involving policy support, capacity building, interoperability of platforms, and inclusive technology design. Overall, digital applications offer scalable and reliable solutions to enhance food quality control, minimize health risks, and build consumer trust, contributing directly to sustainable food systems and public health outcomes. Keywords: Food Safety; Quality Control; Digital Traceability; Blockchain; Internet of Things (IoT); Artificial Intelligence; Smart Food Systems



T-7 O-11: Smart Extension for Safer Plant Protection: Integrating Behaviour Change, Compliance, and Food Safety

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Vegetable production is among the most pesticide-intensive farm enterprises, and the literature consistently reports unsafe plant-protection practices that elevate farmer exposure and residue risks in market produce. This review synthesizes evidence on (i) socio-economic characteristics of vegetable growers (predominantly middle-aged, small/marginal holders with variable schooling and limited training), (ii) field-level pesticide use (frequent broad-spectrum sprays, dose escalation, spraying at risky hours, and weak compliance with label directions and pre-harvest intervals), and (iii) knowledge–attitude–practice gaps (awareness of hazards is often medium/low and rarely converts into consistent PPE use, safe storage, and safe disposal). Across studies, information flow is heavily mediated by peers and input dealers, while extension contact and structured capacity building remain inadequate. Building on this evidence, we propose a digital extension roadmap that combines mobile micro-learning, WhatsApp/IVR advisories, QR/label-scan decision support for dose and toxicity symbols, geo-tagged spray logs, and linkage to residue-testing/traceability systems to enable safer, residue-conscious vegetable value chains. The agenda prioritizes behaviour change, compliance, and food safety outcomes.

Keywords: Pesticide safety; Digital extension; Vegetable growers; PPE compliance; Food safety/Residue monitoring





Theme VII : Poster

Intelligent technologies and sustainable food systems





T-7 P-1: Farm mechanization and Overview

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Farm mechanization has emerged as a vital aspect of modern agriculture in India, driven by increasing food demand, declining yields, and scarcity of farm labour. It refers to the application of farm power to agricultural tools and machinery, ensuring optimal utilization of land, labour, water, and other resources. Mechanization not only reduces drudgery and saves time but also contributes significantly to sustainable agricultural development. Studies indicate that it can increase farm productivity by 12–32% and farmers' gross income by 29–49%, thereby improving overall efficiency and profitability. However, the decreasing average landholding size has resulted in a growing proportion of small and marginal farmers, who often lack access to advanced mechanization. At present, the benefits are largely concentrated among large farmers. To bridge this gap, targeted promotion of mechanization for smallholders is essential. In the Konkan region, where land is highly fragmented, universities have developed hand-operated equipment to reduce women's workload and provide practical training for effective usage. Mechanization in such contexts reduces cultivation costs, enhances time efficiency, and improves farmers' socio-economic status. Group approaches, such as the formation of Common Interest Groups (CIGs) and farmer clusters, hold great potential for collective mechanization in field crops. Government schemes and subsidies further support the adoption of such practices. While awareness of agricultural and post-harvest equipment exists among farmers, challenges still restrict their full adoption. Looking ahead, mass media campaigns and greater involvement of rural youth can accelerate mechanization, ensuring higher productivity, improved rural livelihoods, and sustainable agricultural growth.

Keywords: Farm mechanization, Konkan, Agriculture, Productivity, Livelihood.



T-7 P-2: Digital Twin Technology in Rural Development

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Digital Twin Technology (DTT) is rapidly emerging as a transformative digital innovation for rural development. By creating virtual replicas of physical assets, processes, and systems, DTT enables real-time monitoring, simulation and data-driven decision-making (Grieves & Vickers, 2017). In rural sectors, digital twins are being applied across agriculture, water resource management, infrastructure, healthcare and disaster risk reduction. Key applications include precision farming, soil and crop health monitoring, irrigation optimization, livestock management, climate forecasting, and planning of rural roads, energy networks and smart villages through the integration of IoT, satellite data, GIS and artificial intelligence. The technology delivers multiple benefits: efficient resource utilization, cost reduction, predictive maintenance, enhanced resilience to climate risks, improved service delivery and evidence-based governance (Fuller et al., 2020). Globally, countries such as the United States, China and the European Union are advancing digital twin applications in smart agriculture, climate modeling and rural infrastructure planning (OECD, 2021). In India, adoption is gaining momentum through initiatives like Digital India, smart agriculture programs, satellite-based monitoring and pilot projects in water and land-use planning (NITI Aayog, 2022). Furthermore, digital twins support participatory rural planning by enabling visualization of development scenarios for policymakers and local communities. They also enhance early warning systems for floods, droughts, and extreme weather events, thereby strengthening rural resilience (UNDP, 2021). Despite challenges related to data availability, digital literacy and infrastructure gaps, continued investment and capacity building can significantly expand their rural impact. Overall, DTT offers strong potential to drive sustainable, inclusive and resilient rural transformation.

Keywords: Digital Twin Technology (DTT), Rural Development, Precision Farming, Smart Villages, IoT& GIS Integration, Sustainable Transformation.



T-7 P-3: Intelligent Technologies and Sustainable Food Systems in Prawn – Paddy- Fish – Horticultural Integrated Farming to get Profitable Double and Triple Income to Farmers so as to Make them to Be Proud Part of “Atmanirbhar Bharat”

---- First of its kind initiative in India

DR. DANDU JAGANNADHA RAJU, U.K. VISWANADHA RAJU, DR. M.V. KRISHNAJI
DR. A. SRINIVASA RAO, DR. N. MALLIKARJUNA RAO, DR. P. SUDHA JACOB

Prawn Cultivation's big dollar returns becomes dicey and gamble due to white spot syndrome and recent American Tariffs. To mitigate it, an Integrated Intelligent Technologies developed by Dr. DANDU JAGANNADHA RAJU's FOUNDATION, Bhimavaram, Andhra Pradesh, as a first of its kind in India to get Triple Income to farmers in Prawn (Shrimp) culture with high Quality produce and environmental friendly output just by growing paddy organically with local varieties in the middle of the prawn tank and at the same time getting good quality prawn by growing it in trenches all around the same pond and simultaneously growing vegetables, fruits and flowers on the same tank bunds to get triple income and make the farmer sustainable and profitable at the same time more green coverage and better natural aeration to prawn.

The Methodology followed was one big farmer was purposively selected. Old prawn tank having three acres plot was selected purposively. The locally cultivated three popular Paddy varieties were selected and slowly made them acclimatized to the salinity conditions, prevailing for prawn culture. Some of the vegetables and fruits also selected and grown on the same prawn tank bunds.

The prawn middle catch of 40% was done at its 47th day with 8.7 grams weight and measuring 3.5 tonnes i.e., 100 count of prawn. Final harvesting of prawn at its 75 days 50 count 20 grams/prawns 5.8 tonnes with a total of 9 (Nine) tonnes per acre and 5.1 Tonne of Paddy Per Hectare with a net Rupees 5.00 Five lakhs profit.

Final findings of our intelligent technologies surprised to note the symbiosis factor worked well as the Ammonia and Nitrate gases released by prawn were absorbed by paddy vice-versa. The oxygen released by paddy and vegetables was made use off well by prawn, there by water quality was perfectly maintained well all through, which has helped for better prawn growth.



T-7 P-4: Challenges in Production and Marketing of Major Vegetables: Farmers' Perceptions and Digital Solutions

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The present study was undertaken to analyse the production and marketing challenges faced by vegetable growers, with special emphasis on farmers' perceptions and the potential role of digital solutions in addressing these constraints. The study was conducted in Bilaspur district of Chhattisgarh, which was purposively selected due to its high area and production under tomato and brinjal cultivation. For sampling, Belha and Masturi blocks were selected, and six representative villages from each block were chosen randomly. From each selected village, ten vegetable growers were randomly selected, constituting a total sample size of 120 respondents. Primary data were collected through a pre-tested structured interview schedule. The analysis of constraints revealed that challenges varied across crops, with production-related problems emerging as dominant. Among tomato growers, the most severe constraint was the incidence of insects and diseases, reported by 51.21 per cent of respondents, indicating inadequate access to timely and reliable plant protection information. Market price fluctuation was the second major constraint faced by 31.70 per cent of respondents, reflecting limited access to real-time market intelligence. Weather variability, reported by 13.41 per cent of growers, highlighted the lack of location-specific weather advisories. Constraints related to cold storage and transportation were reported by 8.53 per cent, while high costs of plant protection measures affected 7.31 per cent of respondents.

The suggestions put forth by vegetable growers underscored the need for technology-enabled interventions. A majority (51.21 per cent) suggested the provision of timely information on pest, insect, and disease management, which could be effectively delivered through digital advisory platforms and mobile-based extension services. About 31.70 per cent of respondents suggested the fixation of prices during the season, indicating the relevance of digital market platforms and price information systems. Further, 10.97 per cent emphasized the need to reduce plant protection costs, while 14.63 per cent suggested the establishment of village-level cold storage facilities supported by digital supply chain management systems. The study concludes that integrating digital technologies in extension, market access, and post-harvest management can significantly reduce production and marketing challenges faced by vegetable growers.

Keywords: Vegetable growers; Production constraints; Marketing challenges; Tomato and brinjal; Farmers' perceptions; Digital solutions; Pest and disease management; Market price fluctuation; Digital extension services



T-7 P-5: Effect of Raised Planting of Maize Cultivation in Ashoknagar District MP

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Maize has emerged as a viable alternative to soybean in Ashoknagar district due to declining soybean productivity caused by heavy pest incidence and high production risks. During the kharif season of 2025–26, maize cultivation expanded to approximately 200,000 hectares owing to its lower input costs and superior cost–benefit ratio. However, conventional sowing using seed drills resulted in substantial crop losses under heavy rainfall conditions. This study evaluated the effectiveness of the Raised Bed Planting (RBP) method in enhancing maize productivity, soil moisture dynamics, residual moisture conservation, and economic returns under both heavy rainfall and dry spell conditions. The study was conducted with ten purposively selected farmers from Malawani village, Ashoknagar district, each cultivating one acre of maize. Data on crop productivity and soil parameters were collected through field observations and structured interviews, with yield assessments conducted from a 225 sq. ft. sampling area. Soil moisture status during the crop season and residual moisture after harvest were evaluated using the feel and appearance method. Results indicated that RBP significantly improved all yield attributes. The mean number of cobs per plant increased from 1.65 under conventional sowing to 2.83 under RBP. Cob length, cob weight, and grain weight per cob were also higher under RBP, resulting in a mean grain yield of 85.59 q ha⁻¹, compared to 45.35 q ha⁻¹ in conventional plots. RBP improved soil drainage during heavy rainfall, retained adequate moisture during dry periods, and enhanced residual soil moisture after harvest. Economically, RBP reduced the cost of cultivation (₹20,000 ha⁻¹ vs. ₹25,000 ha⁻¹), increased net income (₹78,000 ha⁻¹ vs. ₹31,000 ha⁻¹), and achieved a superior cost–benefit ratio (3.90 vs. 1.24).

The study demonstrates that Raised Bed Planting is a sustainable, resource-efficient, and profitable technology for maize cultivation, particularly under conditions of erratic rainfall and moisture stress



T-7 P-6: From Food Security to Nutrition Inequality: Organic Food Systems and Social Stratification in India

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India's food system has historically prioritized food security through the expansion of calorie-dense staple grains, a strategy that was essential in preventing famine but is increasingly inadequate in addressing present-day nutritional challenges. Despite being one of the world's largest food producers, India faces a deepening nutrition paradox: according to recent estimates, over 220 million people remain food insecure, while diet-related non-communicable diseases have risen sharply, with adult obesity more than doubling since the early 2000s. This paper argues that the national challenge has shifted from food security to nutrition inequality, manifested through a socially stratified food system. Using secondary data from national surveys, policy documents, and global reports, the study conceptualizes the emergence of a "two-plate" food system. One plate represents a relatively small, affluent segment with access to organic, diverse, and nutritionally balanced diets, while the other represents the majority who depend largely on subsidized cereals and low-cost ultra-processed foods, contributing to high levels of child stunting (over 35 per cent) and widespread anemia among women. The paper critically examines the role of organic food systems within this divide and shows that although organic and regenerative agriculture offer benefits for soil health, climate resilience, and nutritional quality, they currently occupy less than 2 per cent of India's cultivated area, limiting their accessibility and impact. The study concludes that reducing nutrition inequality requires a shift from calorie-centered policies to nutrition-sensitive food systems that integrate organic farming with inclusive markets, public procurement, and targeted policy support.

Keywords: Food security; Nutrition inequality; Organic food systems; Social stratification; Two-plate food system; Sustainable agriculture.



T-7 P-7: Traditional Agricultural Wisdom and Its Scientific Validation: Evidence from Ancient Indian Literature

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Ancient Indian texts contain a substantial body of knowledge on agriculture, environment, and climate, much of which has not been adequately examined within contemporary scientific research. This study undertakes an Epigraphical and textual analysis of agricultural practices described in classical Sanskrit works, particularly *Krishi Parashar* and *Vrikshayurveda*, to assess their relevance in present-day agricultural and agro meteorological contexts. The analysis draws upon inscriptions and literary references related to land classification, seed treatment, crop suitability, plant nutrition, pest and disease management, water prospecting, and rainfall prediction. Particular emphasis is placed on the rainfall forecasting methods described in *Krishi Parashar*, both to evaluate their reliability and to understand the indigenous reasoning and cultural context underlying these practices. To examine the relationship between traditional rainfall predictions and recorded observations, Spearman's rank correlation coefficient was applied using historical rainfall data from the Indian Meteorological Department. Analysis of early twentieth-century data (1901–1920), examined in two decadal blocks, revealed a positive and statistically significant correlation ($r_1 = 0.824$ and $r_2 = 0.793$) at the 5 per cent level. Further analysis using extended long-term data also showed a strong positive and significant relationship ($r = 0.92$), reinforcing the consistency of traditional predictions with observed rainfall patterns. The findings demonstrate that the methods outlined in *Krishi Parashar* possess notable empirical validity. This research stands as a testament to the enduring relevance of traditional wisdom in navigating the complexities of weather forecasting within the Indian agricultural landscape and argues for the systematic documentation and integration of indigenous knowledge systems into contemporary scientific discourse.

Keywords: Ancient Indian agriculture; *Krishi Parashar*; *Vrikshayurveda*; Epigraphical study; Indigenous knowledge systems; Rainfall prediction; Sustainable agriculture.



T-7 P-8: Attitude of farmers towards use of Artificial intelligence in Sugarcane cultivation

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Sugarcane is an important commercial crop contributing significantly to sugar, bioenergy and rural livelihoods in India. In recent years, Artificial Intelligence (AI) has emerged as a promising tool for improving productivity and sustainability in sugarcane cultivation. This review article examines the role of AI-based technologies in sugarcane farming and analyzes farmers' attitudes towards their adoption. The review covers major AI applications such as remote sensing, machine learning models, decision support systems and sensor-based technologies including soil moisture sensors for irrigation scheduling, NPK sensors for nutrient management, leaf wetness sensors for pest and disease monitoring and automated weather stations for real-time agro-meteorological data. Special emphasis is given to pilot initiatives implemented through Krishi Vigyan Kendra (KVK), Baramati, which demonstrate the practical usefulness of AI tools under field conditions. Findings from various studies indicate that farmers generally perceive AI technologies as beneficial due to improved decision-making, efficient resource use, reduced input costs and enhanced crop productivity. However, the level of adoption is influenced by factors such as awareness, technical knowledge, cost of technology, access to training and institutional support. The review highlights the critical role of extension services, on-field demonstrations and capacity-building programs in shaping positive farmer attitudes towards AI. The article concludes that strengthening extension-led interventions and ensuring the availability of affordable AI solutions are essential for wider adoption, thereby promoting sustainable sugarcane production and improving farmers' livelihoods.

Keywords: Artificial Intelligence, Sugarcane cultivation, Krishi Vigyan Kendra, Decision making, Capacity building.



T-7 P-9: Trends in sustainable food system via technology

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Ensuring food security while mitigating environmental degradation, climate change and the loss of ecosystem services has become a major challenge for global agri-food systems. This necessitates a transition toward sustainable food system models that balance productivity with ecological and social well-being. The present study examines the role of cutting-edge digital technologies in promoting sustainable food systems. Emerging innovations such as artificial intelligence, big data analytics, the Internet of Things (IoT), robotics, drones, digital agriculture platforms and gene-based technologies are redefining agricultural production, processing, supply chains and consumption patterns. A systems-based “farm-to-fork” approach highlights how digitalization and AI enhance efficiency, optimize resource use and support decision-making across the agri-food value chain. Sensing, smart and sustainable technologies facilitate automation, real-time monitoring, improved connectivity and integration of renewable energy, thereby contributing to environmental sustainability and climate resilience. However, prevailing global policy narratives largely emphasize productivity-driven technological interventions, which often reinforce industrial food systems and neglect ecosystem trade-offs and social equity concerns. The study underscores the importance of responsible innovation, inclusive and supportive policy frameworks and ecosystem-sensitive assessment methods. It concludes that digital technologies, when aligned with sustainability goals, can contribute significantly to resilient, equitable and environmentally sound food system transformations rather than merely increasing food output.

Keywords: Digital agriculture, Artificial intelligence, Sustainable food systems, Farm-to-fork approach, Climate resilience



T-7 P-10: Assessment of Biomass Residue Availability and Usage in Arecanut and Eucalyptus Plantations

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The present study assessed the availability and utilization patterns of biomass residues generated from Arecanut and Eucalyptus plantations in the Uttara Kannada district of Karnataka. Field-level data were collected through personal interviews, semi-structured schedules, and physical observations across different landholding categories. The results revealed that Arecanut plantations generated biomass residues ranging from 3.77 to 8.04 tonnes per acre per year, with relatively higher residue generation observed in small and medium landholdings. In Eucalyptus plantations, biomass residue availability ranged from 3.16 to 5.28 tonnes per acre per year, with marginal and small landholdings contributing comparatively higher quantities. Major biomass residues identified included leaves, husk, poles, sheath, sticks, and bark. While a portion of these residues was utilized for composting, mulching, and construction purposes, a considerable share was disposed of through open burning and dumping practices. This indicates suboptimal utilization of plantation biomass resources and highlights the need for improved residue management strategies. The findings underscore the potential for effective biomass valorization through sustainable conversion technologies such as briquetting, contributing to waste reduction, renewable energy generation, and enhanced environmental sustainability.

Keywords: Arecanut plantations; Eucalyptus plantations; biomass residues; residue utilization; waste management; briquetting



T-7 P-11: Awareness Among Farmers about Agricultural Pollutants and Pollution Causing Practices

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Present study was undertaken in Sangli district of Maharashtra state in year 2024-25. The three talukas i.e. Kadegaon, Palus and Miraj from Sangli district were selected for this purpose. So those were using maximum fertilizers, pesticides, irrigation, and other Agricultural inputs. Ten respondents were randomly selected from each village. The data were collected through personal interview. Around 50.66 per cent respondents had medium level of awareness regarding pesticides pollution. Among them 53.33 per cent respondents had medium level of awareness regarding fertilizers pollution. The average awareness score of respondents regarding pollution due to harvest waste was found to be 5.33 per cent. In case of food processing waste the average awareness score of respondents regarding agricultural pollution was found to be 3.39, which ranked 8th. The percentage of low level of awareness was 26.00 while 42.66 per cent of the respondents had medium level of awareness. The average awareness score of respondents regarding sewage water pollution was 3.57; 60.66 per cent respondents had medium level of awareness. With respect to the pollution from salt and silt, drained by irrigation water, only 16.66 per cent respondents had low level of awareness, whereas 32.00 per cent had high level of awareness and 51.33 per cent of the respondents had medium level of awareness, which ranked 1st with average score of 3.98. Nearly three fifth (58.00 per cent) respondents had medium level of awareness with respect to livestock waste pollution. With regards to pollution due to dead bodies of animal, 30.66 per cent respondents were highly aware while half (51.33 per cent) of the respondents had medium level of awareness. For the noise pollution by farm machineries, 54.00 per cent of the respondents had medium level of awareness, while 20.00 per cent and 26.00 per cent respondents had high and low level of awareness. It is evident from the study that more than two third (78.00 per cent) of the respondents had medium level of overall awareness regarding agricultural pollution whereas 15.00 per cent of the respondents had low level of overall awareness and only 7.00 per cent of the respondents had high level of overall awareness regarding agricultural pollution. Further, the different measures being used by farmers for controlling agricultural pollution. It has been concluded that there is need to provide training, guidance, knowledge and credits to rural farmers, so to increase awareness and enhance to socio-economic status.

Key words: Awareness, agricultural awareness, agricultural pollution, pollutants, etc.



T-7 P-12: Role of Digital Applications in Improving Accessibility and Food Safety of Major and Minor Millets

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Major and minor millets are increasingly positioned as strategic crops for achieving nutritional security, climate resilience, and sustainable food systems. However, their widespread adoption is constrained by persistent challenges related to accessibility, quality control, and food safety across production, storage, processing, and distribution stages. These challenges are particularly acute for minor millets, which often suffer from fragmented supply chains, inadequate post-harvest infrastructure, and limited regulatory oversight. In this context, digital applications have emerged as transformative tools capable of addressing systemic inefficiencies while strengthening food safety governance.

Digital technologies such as the internet blockchain, artificial intelligence, and mobile-based platforms facilitate real-time monitoring of critical quality parameters, including moisture levels, storage conditions, transportation hygiene, and traceability of millet grains and products. The integration of digital traceability systems enables end-to-end visibility from farm to consumer, thereby reducing contamination risks, minimizing post-harvest losses.

Beyond quality control, digital applications significantly enhance the accessibility of major and minor millets by connecting farmers to procurement agencies, markets, and consumers through digital supply-chain platforms and e-commerce channels. Such systems improve market integration, price transparency, and timely availability, particularly benefiting smallholder farmers engaged in minor millet cultivation. Additionally, mobile applications and digital advisory tools support capacity building by disseminating best practices related to food safety, quality assurance, and regulatory compliance.

Keywords: Millets; Accessibility; Food safety; Digitalization; Quality assurance



T-7 P-13: Quality control and food safety through digital applications

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The global food industry is currently facing persistent challenges in meeting consumer expectations for safe and high-quality food products. Rapid industrialization of food processing, large-scale production, and extensive distribution networks have increased the risks associated with food contamination, adulteration, and inconsistent quality standards, particularly when food products are manufactured in bulk and transported across diverse regions (Naga Palakurti, 2022). These challenges highlight critical shortcomings in conventional food safety management systems. According to the World Health Organization, approximately 600 million people worldwide suffer from foodborne illnesses each year due to the consumption of contaminated food, clearly indicating significant gaps in existing food safety practices. In this context, artificial intelligence (AI) has emerged as a promising technological intervention to strengthen food quality control and safety assurance mechanisms. AI-driven technologies, including machine learning algorithms, computer vision systems, and Internet of Things (IoT) devices, enable accurate identification, assessment, and control of food quality and safety risks across the food supply chain. These technologies facilitate real-time monitoring, early detection of contamination, and objective evaluation of product quality, thereby reducing human error and improving efficiency. The primary focus of recent research is on exploring advanced AI applications such as artificial neural networks (ANNs) and convolutional neural networks (CNNs) for detecting quality attributes in food and agricultural products. These models offer high precision in pattern recognition and image-based analysis, making them effective tools for automated quality inspection. Furthermore, rapid urbanization and population growth are expected to intensify pressure on global food systems. By 2050, nearly 70% of the world's population is projected to live in urban areas, with the global population reaching approximately 10 billion (Ali Ikramet *et al.*, 2024). This demographic shift underscores the urgency of adopting AI-enabled solutions to ensure safe, quality food for a growing urban population.

Keywords: Food safety, Quality control, Artificial intelligence, Machine learning, Computer vision, Internet of Things (IoT), ANN and CNN.



T-7 P-14: Role of Digital Applications in Improving Accessibility and Food Safety of Major and Minor Millets

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Keywords: Millets; Accessibility; Food safety; Digitalization; Quality assurance



T-7 P-15: Enhancing Quality Control and Food Safety through Digital Applications in Agricultural and Food Systems

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Ensuring food quality and safety has become a critical concern in agricultural and food systems due to increasing consumer awareness, complex supply chains, and rising incidences of food contamination. From farm production to post-harvest handling, processing, storage, and marketing, lapses in quality control can lead to significant health risks, economic losses, and erosion of consumer trust. In this context, digital applications are emerging as effective tools for strengthening quality assurance and food safety management. Digital technologies such as sensor-based monitoring systems, blockchain-enabled traceability platforms, mobile inspection applications, Internet of Things (IoT) devices, and data analytics are increasingly being used to monitor food quality parameters in real time. These tools support continuous tracking of temperature, moisture, hygiene conditions, pesticide residues, and storage environments, thereby minimizing contamination risks and post-harvest losses. Digital traceability systems enable transparent movement of food products across the value chain, improving accountability and facilitating quick response during food safety incidents. The integration of digital applications also enhances the efficiency of regulatory compliance and certification processes. Mobile-based inspection tools and digital record-keeping systems support faster audits, improved reporting, and better coordination among producers, processors, extension agencies, and regulatory bodies. For farmers and small food enterprises, access to digital quality management tools can improve market access, reduce rejection rates, and promote adherence to food safety standards. Despite their potential, challenges such as high initial costs, limited technical skills, inadequate infrastructure, and low awareness among smallholders continue to restrict widespread adoption. Extension services play a vital role in addressing these constraints by building capacity, promoting awareness, and facilitating access to user-friendly digital solutions. Strengthening linkages between technology providers, extension systems, and food value chain actors is essential for inclusive implementation. The use of digital applications in quality control and food safety contributes to safer food systems, reduced losses, and improved consumer confidence. An integrated approach combining digital innovations with effective extension support can significantly enhance food safety outcomes and support sustainable agricultural development.

Keywords: Food safety, Quality control, Digitalization, Traceability, Extension



T-7 P-16: Strengthening Quality Control and Food Safety through Digital Applications in Food Value Chains

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Ensuring food quality and safety has become increasingly complex due to the expansion and fragmentation of agricultural value chains. Conventional food safety mechanisms largely depend on end-point inspections, which often overlook risks emerging during production, handling, storage, and transportation stages. A value chain-based approach supported by digital applications offers an opportunity to move from reactive control measures toward preventive and system-oriented food safety management. Digital tools such as mobile-based compliance records, sensor-driven monitoring systems, digital Hazard Analysis and Critical Control Point (HACCP) platforms, and traceability technologies enable continuous and real-time capture of quality and safety information across different stages of the food value chain. These applications support early detection of contamination risks, improve coordination among value chain actors, and enhance transparency and accountability from farm to consumer. By integrating digital solutions across interconnected stages, food safety risks can be addressed in a more comprehensive and timely manner. The adoption of digital applications presents significant opportunities for strengthening quality assurance, reducing post-harvest losses, improving regulatory compliance, and enhancing consumer confidence in food systems. Digital traceability systems also facilitate quicker response during food safety incidents and improve access to premium markets for producers and food enterprises. However, several challenges constrain effective implementation, particularly for smallholders and small food enterprises. High costs of technology adoption, limited digital literacy, data ownership and governance concerns, infrastructure gaps, and unequal access to digital platforms remain key barriers. Addressing these challenges requires supportive institutional frameworks, capacity-building initiatives, and extension-led facilitation to ensure inclusive participation. An integrated digital food safety system, supported by appropriate policies and extension services, can play a critical role in strengthening quality control mechanisms and promoting safer, more sustainable food systems.

Keywords: Food safety, Quality control, Digitalization, Traceability, Value chain



T-7 P-17: Digital Innovations Driving Transparency and Safety in Modern Food Systems

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Ensuring robust quality control and food safety has emerged as a critical global priority in the context of increasingly complex supply chains and rising consumer expectations for transparency. Digital technologies including Internet of Things (IoT) sensors, blockchain-enabled traceability, artificial intelligence (AI), machine learning (ML) and cloud-based platforms are reshaping conventional food safety and quality assurance systems. These tools facilitate real-time monitoring, predictive risk assessment and seamless traceability across the food value network. Recent industry analyses show that by 2025, approximately 78 per cent of food processing enterprises have integrated some form of digital transformation to enhance operational efficiency and traceability, while 62 per cent intend to expand their digital investments over the next three years. More than 80 per cent of manufacturers employ digital solutions to meet regulatory compliance and strengthen food safety measures, and about 70 per cent view digital transformation as indispensable for maintaining safety standards. IoT technologies adopted by over 55 per cent of firms support continuous monitoring of temperature, humidity and logistics conditions, thereby reducing spoilage and quality degradation. Additionally, nearly 65 per cent of companies utilize big data analytics and cloud infrastructures to improve inventory optimization and supply chain visibility. Blockchain applications further enhance product provenance verification and increase recall accuracy, with more than 3.6 billion food units globally tagged with RFID or QR codes in 2024. Blockchain-based systems have also improved audit compliance by 33 per cent among suppliers in Europe and North America. Despite significant progress, persistent challenges such as high deployment costs, data privacy risks, interoperability constraints, and limited digital literacy among smaller producers hinder widespread adoption. Nevertheless, with targeted investments, enabling policy support, capacity building, and strengthened stakeholder collaboration, digital innovations can substantially reinforce global food quality control and safety frameworks.

Keywords: Digital applications, Quality control, Traceability, Blockchain, IoT sensors, Artificial Intelligence, Food supply chain.





Theme VIII : Oral

Digital technology for climate-smart agriculture





T-8O-1: Data-Driven Harvest: Transforming Indian Agriculture with Digital CSA (Climate Smart Agriculture)

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Climate change poses the single greatest threat to global food security, subjecting the world's 500 million smallholder farmers to increasingly erratic weather patterns, devastating droughts, and unforeseen pests. Digital Technologies for Climate-Smart Agriculture (CSA) offer a pivotal solution, transforming farming from a reactive struggle into a model of data-driven resilience and sustainability.

Globally, the CSA transition is powered by the integration of cutting-edge tools. **Precision agriculture** harnesses IoT sensors, satellite imagery, and Artificial Intelligence (AI) to optimize every aspect of the farm. For instance, international initiatives utilize AI-driven platforms to deliver highly localized weather advisories, reducing risk exposure. In parts of Africa, mobile money platforms facilitate transactions and share real-time market prices via simple SMS, ensuring financial stability and reducing post-harvest losses, making complex technology accessible.

The impact is equally transformative in India. The national *Agri-stack* initiative seeks to unify various agricultural services into a seamless digital ecosystem. At the state level, localized projects are demonstrating ground-level success: the **Climate Smart Villages** project in districts of Madhya Pradesh, like Sehore and Rajgarh, integrates digital soil health cards and predictive analytics with traditional wisdom, helping farmers choose optimal, climate-resilient crop varieties. Furthermore, the digitalization of the value chain through the **MP Farm Gate App** and **E-Mandi** systems provides price transparency and direct market access, securing farmers' income against economic shocks linked to climate variability.

In essence, Digital CSA is more than technological enhancement; it is a movement to democratize knowledge and empower the most vulnerable. By fusing big data with hyper-localized context, these technologies promise to sustainably increase yields, enhance resilience to climate hazards, and, where possible, contribute to mitigation efforts by lowering the agricultural carbon footprint. Scaling these digital innovations is indispensable for securing equitable and sustainable livelihoods for the future of farming.



T-8 O-2: Digital Climate Services for Improving Adaptive Capacity of Women Dairy Farmers in Haryana

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Digital climate services have emerged as powerful tools for enhancing climate resilience and improving farm level operational decision, particularly among vulnerable groups such as women dairy farmers. The present study aimed to assess the effectiveness of the *NDRI Climate Services Mobile App* in improving the operational decision for dairy management practices of women dairy farmers in Haryana. Sirsa district of Haryana, identified as a women-centric climate hotspot due to its high exposure to heat stress, limited adaptive resources, and gendered vulnerabilities, was purposively selected for the study. An experimental research design was employed with 80 women dairy farmers from eight villages, divided equally into experimental and control groups. Data were collected through pre and post tests and analysed to estimate the average treatment effect of the mobile application. Results revealed significant improvements in key climate sensitive management practices among the experimental group after the intervention. Notably, substantial treatment effects were observed in **heat stress management (1.00; $p \leq 0.05$)**, **reproductive management (0.80; $p \leq 0.05$)**, and **calf management (0.87; $p \leq 0.01$)**, indicating the strong influence of NDRI climate service mobile app on operational decision. Although improvements were recorded in feeding, housing, watering, and health-related practices, these changes were not statistically significant. Overall, the findings demonstrate that digital climate advisories, when tailored and delivered through user friendly mobile platforms, considerably enhance the adaptive capacity and management efficiency of women dairy farmers. The study underscores the importance of integrating gender responsive digital tools in climate-smart dairy development programmes across climate change induced vulnerable districts of India.

Key words: Adaptive capacity, Climate smart dairy farming, Digital climate services, Women dairy farmers



T-8 O-3: A Study on Accessibility and Utilization of DAMU Agro-advisory Information by Farmers in Jalore, Rajasthan

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The present study aims to assess the utilization of various information sources by farmers to access agro-advisories disseminated under the District Agro-meteorological Unit (DAMU) in Jalore district of Rajasthan. DAMU plays a vital role in supporting farmers through weather-based agricultural advice, helping them in crop planning and management. The research explores the extent to which different communication channels, including personal contacts, social media, mobile applications, radio, and television, are used by farmers to receive and interpret DAMU advisories. A structured survey was conducted among selected farmers using purposive and random sampling methods. Data were analyzed using descriptive statistics, mean percent score, and ranking methods. The findings reveal that social media platforms like WhatsApp and Facebook, followed by personal contact and mobile-based services, are the most commonly used sources. The study highlights the importance of enhancing the accessibility and effectiveness of these channels for better dissemination of weather-based advisory services.

Keywords: DAMU, GKMS, KVK, Agro-advisories, ICT, Weather Forecast.



T-8 O-4: Theme 8: Digital technology for Climate Smart Agriculture

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Climate change poses unprecedented challenges to agricultural sustainability, threatening food security for India's growing population. Digital technologies have emerged as transformative tools for advancing Climate Smart Agriculture, offering data-driven solutions to enhance productivity, resource efficiency, and environmental resilience. This abstract explores the integration of digital innovations in Indian agriculture and their potential to address climate-related challenges.

The Government of India has demonstrated strong commitment through initiatives like the Digital Agriculture Mission (2021-2025) with an outlay of ₹28,170 million and the IndiaAI Mission with ₹103,719.2 million, specifically targeting agricultural applications. Recent data indicated that 1,000 agri-tech startups are operational in India, with more than 450 agriculture-based technology-driven enterprises emerging as of 2019.

IoT sensors monitor soil moisture, pH, and crop stress in real-time, facilitating precision irrigation and fertilization to cut water use by up to 30% and enhance yields. AI and machine learning predict pest outbreaks and crop yields with 90% accuracy, while drones provide multispectral imagery for targeted interventions, reducing chemical inputs. Big data analytics and blockchain ensure transparent supply chains and soil management, supporting adaptation strategies. Research demonstrates that precision agriculture can increase productivity by 20-25% while reducing water consumption by approximately 30%. IoT-enabled smart irrigation systems improve water-use efficiency by 40-60% compared to conventional methods, crucial for water-stressed regions.

The integration of mobile platforms and regional language advisory services has enhanced accessibility for smallholder farmers. Digital platforms facilitate real-time monitoring of soil health, crop conditions, and weather patterns, enabling timely interventions. However, challenges persist including high initial costs, limited digital literacy, and inadequate rural internet connectivity affecting technology adoption rates.

Climate Smart Agriculture supported by digital technologies represents a viable pathway toward sustainable intensification, enhanced resilience, improved resource efficiency, and reduced environmental footprint, essential for meeting the nutritional demands of 1.4 billion people while adapting to climate variability.



T-8 O-5: Digital Technologies for Climate-Smart Agriculture: Strengthening Farmer Resilience through Extension Services in the Bundelkhand Region

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Agriculture in the Bundelkhand region is increasingly challenged by erratic rainfall, recurrent droughts, land degradation, and limited access to timely information. These climate-induced stresses have significantly affected the livelihoods of small and marginal farmers, making the adoption of climate-smart agricultural practices essential for sustaining productivity and resilience. Climate-smart agriculture emphasizes adaptation, risk reduction, and efficient resource use, but its success depends largely on effective knowledge dissemination and farmer engagement. Digital technologies are gradually reshaping agricultural extension systems by enabling faster, more targeted, and climate-responsive advisory services. Mobile-based agro-advisories, weather forecasting applications, digital soil health information, remote sensing tools, and ICT enabled livestock advisory platforms are emerging as important support mechanisms for farmers facing climate uncertainties. In Bundelkhand, such digital interventions have the potential to improve decision-making related to crop selection, sowing time, water management, and livestock care, thereby reducing vulnerability to climate shocks. Despite these opportunities, several constraints continue to limit the effective use of digital tools in the region. Low levels of digital literacy, inadequate internet connectivity, affordability issues, and limited availability of location-specific content remain major challenges. Extension services play a critical role in addressing these gaps by acting as intermediaries between technology and farmers. Extension personnel not only facilitate access to digital platforms but also help interpret climate information, build trust, and promote region specific solutions. Strengthening extension systems through capacity building, localized digital content, and inclusive delivery models is essential for ensuring wider adoption of climate-smart practices. A combined extension approach that integrates traditional face to face methods with digital innovations can enhance farmers' adaptive capacity and long-term resilience. Such an approach aligns with the broader goal of sustainable food systems and contributes to building a climate-resilient and self-reliant agricultural sector in vulnerable regions like Bundelkhand.

Keywords: Climate-smart agriculture, Digital extension services, Farmer resilience, Livelihood, Bundelkhand region



T-8 O-6: Leveraging Digital Technologies in Agricultural Extension to Advance Climate-Smart Agriculture

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Climate change poses unprecedented challenges to agricultural systems by intensifying production risks, resource uncertainty, and livelihood vulnerability, particularly among smallholder farmers. Climate-smart agriculture has emerged as a strategic framework to enhance productivity, strengthen resilience to climate variability, and reduce environmental impacts. Agricultural extension systems play a crucial role in operationalizing climate-smart agriculture at the farm level. However, conventional extension approaches are often constrained by limited outreach, delayed information delivery, and inadequate contextualization. Digital tools such as mobile-based advisory services, artificial intelligence enabled decision support systems, remote sensing, geographic information systems, and social media platforms are increasingly integrated into extension systems. These technologies enable real-time, location-specific, and climate-informed advisories, supporting timely decision-making related to crop planning, input use, pest and disease management, and climate risk mitigation. Digital extension platforms also promote two-way communication, facilitating feedback mechanisms, peer learning, and participatory knowledge exchange among farmers, extension personnel, researchers, and other stakeholders. Leveraging digital technologies enhances the adoption of climate-smart practices, including precision nutrient management, water-efficient irrigation, diversified cropping systems, and the use of climate-resilient varieties. In addition, digital extension strengthens institutional coordination, improves access to weather and market intelligence, and supports evidence-based policymaking for climate adaptation and mitigation. This underscores the importance of a blended extension approach that integrates digital innovations with conventional, human-centred extension methods. Strengthening institutional capacities, ensuring equitable digital access, and fostering public-private partnerships are essential for realizing the full potential of digital technologies in advancing climate-smart agriculture.

Keywords: Climate Smart Agriculture, Digital Extension, Technology, Vulnerability, Adaptation



T-8 O-7: Analysis of Factors Contributing to Socio-Economic Status of Flood Affected Dairy Farmers

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Floods are known to affect on socio-economic status of the dairy farmers by having severe impact on their assest possession, fodder availability and farm power possession. The research study was conducted during 2021-22 in Belgaum district of North Karnataka. The study was conducted to identify the factor loadings of variables and their contribution to the variation in socio-economic status of the dairy farmers through factor analysis method. A total of 60 respondents were selected from flood affected district using purposive random sampling method. Personal interview method was used to collect the data. The results revealed that the first and second component together explained the variation to the extent of 34.56 per cent, while all the five components together explained 67.68 per cent of variation. The factor analysis studied had resulted the eigen values of the five principal components as 2.52, 1.96, 1.83, 1.41 and 1.06 respectively.

Key words : Factor analysis, Socio-economic status, Flood, Dairy Farmers



T-8 O-8: From Climate Risk to Resilience: An e-Atlas of Climate Risk Hotspots and Feasible Adaptation Options for Dairy Farming in South Asia

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Dairy farming ensures regular source of income, nutritional security, and employment, especially for small and marginal households across South Asia. The South Asian dairy farming contributes 72 and 30 percent of milk production in Asia and world, respectively. But, the tripartite dynamics of climate change, vulnerability of population and dairy production potential in South Asia make it of utmost dire need to open a dialogue to address the negatives of climatic risks through the development of adaptation options. Therefore, the present study attempts to quantify the climatic hazards in South Asia followed by the assessment of climate-related risk pertaining to dairy production systems and assess the adaptation options feasible for South Asia through an e-atlas namely Atlas of Climate Adaptation in South Asian Agriculture (ACASA). Composite index-based climate assessment risk and spatial hotspot analysis was in two-time frame i.e. baseline (2000s) and 2050s in two GHG emission scenarios (SSP2-4.5 and SSP5-8.5) at 0.05° x 0.05° spatial resolution. The analysis underpins the prominent impact of climate-related hazards like heat stress, rainfall deficits, and the Temperature-Humidity Index (THI) on cattle and buffalo populations in South Asia, particularly in India, Afghanistan, and Pakistan. As global warming intensifies, the region is expected to experience increased heat stress and rising THI levels, with cold stress diminishing by 2050. This will exacerbate risks, especially in the Indo-Gangetic Plains and coastal regions of South Asia. While adaptation strategies like disease management, nutrition, and genetic modification are found to be suitable, their effectiveness varies across the region, highlighting the need for tailored approaches to mitigate climate impacts on livestock. The results suggest a need for urgent, region-specific interventions to provide protection to ensure the sustainability of livestock production systems in the face of escalating climate challenges. The study will facilitate policy makers and climate scientists in the customization of location specific adaptation strategies to combat climate change in South Asia.

Key Words: ACASA, Adaptation strategies, Climate Change, Dairy farming, Hotspots, Risk, South Asia



T-8 O-9: Climate-Smart Water Conservation: An IoT-Based Approach to Real-Time Precision Irrigation in Agriculture

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Climate variability, erratic rainfall, groundwater depletion, and rising energy costs have intensified the challenge of efficient water management in agriculture, making conventional irrigation practices increasingly unsustainable. In this context, IoT-based real-time precision irrigation has emerged as a climate-smart solution that enables data-driven and adaptive water application. By integrating soil-moisture and weather sensors, wireless communication networks, cloud-based analytics, and automated control systems, smart irrigation delivers water based on real-time crop and soil conditions rather than fixed schedules. Evidence synthesised from recent review studies and a 2025 field-level assessment in India shows that such systems consistently achieve 20-50% improvements in water-use efficiency, along with reduced irrigation losses, lower energy consumption, and improved application efficiency under drip irrigation. It was reported that reduced labour requirements, improved operational efficiency, and better irrigation decision-making were enabled by real-time monitoring. The 2025 shift toward low-cost sensors, mobile-based interfaces, AI-assisted decision support, and alignment with Sustainable Development Goal 6 has enhanced the scalability and practicality of smart irrigation. Overall, IoT-enabled precision irrigation represents a robust, climate-resilient pathway for conserving water while sustaining agricultural productivity

Keywords: Climate-smart irrigation, Internet of Things (IoT), Water-use efficiency.



T-8 O-10: Impact of Climate Smart Agriculture Education and Real Time Weather Advisory Services on Agricultural Sustainability In Madhya Pradesh

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The transformation of Indian agriculture from the traditional "Training and Visit" model to modern digital systems " 'digital divide' and pseudo-gender discrimination is facing serious difficulties. The study examined the impact of climate intelligence, Climate Smart Agriculture (CSA) and real-time climate advice on sustainable agricultural development in Sehore district of Madhya Pradesh. Using a holistic clinical approach based on systems theory, the study used a multi-stage randomized sampling approach to evaluate 300 respondents with different network connections in five villages. The study compares the impact of the 'Phygitel' (Physical + Digital) model that connects Farmer-Producer Organisations (FPOs) and fellow 'Climate Sakhi' authors with unique digital and traditional advisory methodologies. The results showed that the physical model was significantly better than the other methods, with the maximum average soybean yield of 14.5 quintals per hectare and the control group 11.1 quintals. Financial the Phygitel Interventions boosted its net profit by 51.1% (₹36,880 per hectare) and improved its profit-cost ratio to 2.18. Notably, this model successfully narrowed the gender gap and increased women's participation to 68% compared to 12% in the control group. The Regression analysis revealed that climate recognition visits and FPO membership are as key expectations for technology adoption. The study concluded that sustainable agricultural development requires socio-technical linkages, where decentralized human empowerment provides the "last mile" of connectivity and democratizes access to climate-resilient technologies for vulnerable farming communities.

Keywords: Climate Climate-Smart Agriculture (CSA), Digital Extension, 'Phygitel' Models, Artificial Intelligence (AI), Agriculture Extension.



T-8 O-11: Strategic Prioritization of Carbon Farming Techniques Using Analytical Hierarchy Process

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Enhancing carbon sequestration in agriculture is essential for mitigating climate change while sustaining productivity, soil health and farm livelihoods. However, the diversity of available carbon sequestration techniques-ranging from conservation agriculture, integrated nutrient management, agroforestry, water and moisture management, ratoon crop management, residue recycling, to integrated farming systems-creates complexity in evidence-based selection and prioritization. In this context, intelligent technologies and decision-support systems are increasingly important for guiding sustainable food system planning. This study employs the Analytical Hierarchy Process (AHP) as a computer-assisted, multi-criteria decision-intelligence framework to evaluate and prioritize carbon sequestration techniques, with relevance to sugarcane-based production systems and integration with digital advisory platforms. A structured AHP model was developed by defining the selection of optimal carbon sequestration techniques as the overarching goal. Major practice domains were treated as alternatives, while a comprehensive set of evaluation criteria was identified, including agronomic performance, economic feasibility, environmental impact, soil carbon and soil health enhancement, resource-use efficiency, agro-ecological suitability, socio-economic feasibility, policy and institutional support and operational feasibility. Expert-based pairwise comparisons were conducted using AHP-supported computational modelling to derive relative weights for criteria, sub-criteria and individual practices. Consistency ratios were calculated to ensure logical coherence and reliability of judgments within the intelligent decision framework.

Keywords: Analytical Hierarchy Process (AHP); Carbon Sequestration Techniques; Multi-Criteria Decision; Digital Advisory Platforms; Soil Carbon Management



T-8 O-12: Enhancing Climate Resilience in Rice farming Systems through Digital Technologies: Insights from Telangana, India

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Digital tools for climate-smart rice farming enhance resilience to climate variability by integrating real-time data on weather, soil conditions, and crop growth stages to support timely, site-specific decision-making. These tools mitigate greenhouse gas emissions by optimizing input use and promoting low-emission practices, while improving productivity and resource-use efficiency. Studies by the ICAR–Indian Institute of Rice Research (IIRR), Hyderabad on farmers’ fields demonstrate the effectiveness of IoT-based smart irrigation systems for climate-smart water management. Field experiments and extension pilots in selected districts of Telangana State show that sensor-guided irrigation, particularly when combined with Alternate Wetting and Drying (AWD), can reduce irrigation water use by 25–40% compared to continuous flooding, while sustaining or increasing grain yields by 5–12%. Automation of irrigation scheduling reduces labor requirements by 20–30% and lowers energy consumption associated with groundwater pumping. By minimizing prolonged anaerobic soil conditions, digitally supported AWD practices contribute to methane emission reductions of approximately 30–50%. In addition, a digital soil analyser developed and licensed by IIRR enables rapid soil assessment and delivery of agronomic advisories with digital reporting. The real-time, plot-level data generated through IoT-enabled irrigation systems enhances farmers’ resilience to climate variability by enabling timely responses to erratic monsoon rainfall, drought spells, and heat stress. Collectively, these digital innovations strengthen farmers’ adaptive capacity to erratic monsoon rainfall, droughts, and heat stress, while generating measurable outcomes that support India’s climate-resilient agriculture agenda and advance progress towards Sustainable Development Goals related to zero hunger (SDG 2), water-use efficiency (SDG 6), clean energy (SDG 7), responsible resource use (SDG 12), and climate action (SDG 13).



T-8 O-13: Adoption of Climate Smart Agricultural Practices Impact on Food Security of Smallholder Farmers in Muzaffarpur District of Bihar, India

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Indian agriculture is undergoing a digital shift, propelled by technologies such as drones, farm robots, and smart soil sensors, particularly in regions dominated by small and marginal farmers. This transition addresses pressing challenges including labour scarcity, water limitations and climate variability. Since the last decade, rapid integration of robotics, remote sensing, GIS, artificial intelligence, machine learning and IoT has enabled precise crop monitoring, targeted input delivery, and efficient resource management. Agriculture takes the lion's share to Ethiopia's economy, serving as the main source of employment, income, and food security for smallholder farmers. However, the sector remains highly vulnerable to climate change due to its heavy reliance on erratic rainfall. This study aimed to identify the determinants of Climate-Smart Agriculture (CSA) practice adoption and assess its impact on the food security of smallholder farmers. A cross-sectional survey of 280 smallholder farmers was conducted using multistage sampling. The Multivariate Profit Model was employed to identify adoption determinants, while the Endogenous Treatment Effect model was used to estimate Climate Smart Agricultural (CSA)'s impact on food security in Bihar. Findings revealed that farmers were most likely to adopt crop diversification (53.8%), followed by water management (47.5%) and soil and land management (45.6%). The joint adoption probability was 5.33%, while the likelihood of adopting no CSA practices was only 6.4%, indicating strong complementarities among practices. The analysis confirmed both synergies and trade-offs in CSA adoption patterns. The Endogenous Treatment Effect model demonstrated that CSA adoption significantly improved food security, increasing daily calorie intake by 218.63 kcal per capita among adopters compared to non-adopters. The results were robust, supported by strong instrument relevance and model validity. The study concludes that enhancing CSA adoption can significantly improve food security and smallholder livelihoods. Therefore, promoting CSA through field demonstration by development agent works, strengthening cooperatives, irrigation investment, farmer training, and access to affordable credit is recommended to empower farmers, enhance productivity, and support sustainable agricultural development in line with national and global climate resilience goals.

Keywords: Adoption, climate smart agriculture, food security, digital farming and technology



T-8 O-14: Effect of Climate Smart Agriculture Adoption on Wheat Production Technology in Muzaffarpur District of Bihar

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Agriculture plays a pivotal role in Indian's economy, as a large portion of the rural population depends on it as their primary source of income. Wheat is the most important crop for India particularly because the country is one of the largest producers of this commodity in the world. The ecological area in the context of India is an emergence area of climate change. Climatic factors influence the growth procedure and productivity of wheat in India. The purpose of this research is to evaluate the impact of CSA (climate smart agriculture) adoption on net returns from wheat production in Muzaffarpur district of Bihar. It is considered an innovative cleaner production agriculture system. CSA also aims to enhance agricultural productivity and strengthen farmers' capacity to counter adverse weather conditions. Therefore, the existing study intends to find out the effect of CSA on wheat net returns and the aspects that affect the adoption of CSA techniques. The study was conducted in three blocks: Bandra, Sakra, and Aurai. The study used a multistage sampling method to choose the 320 respondents comprising 160 CSA adopters and 160 non-adopters. The data was collected using a properly designed structured questionnaire. The data shows that the average road distance and market distance equals 12 km and 9.60 km respectively. Findings of the study revealed that the participants' average age stands at 45.35 years and they possess 11.83 years of education (ranging from 5 to 21 years) with a household member count of 8.68. The farmers' average monthly income stands at Rs. 30,780 per month while their land distribution amounts to 14.78 acres and they possess 5.53 livestock units. The average distance to agricultural farms stands at 4.44 km. Farmers who have fertile land make up 77.72% of the total while 53.23% earn income beyond farming and 76.83% have access to credit and 63.45% are linked to extension services. The logit model was used to estimate the factors influencing the adoption of CSA practices. The outcomes of this study indicate that distance from the main road, age, distance from the farm, and household size negatively affect farmer's adoption behavior. The research proposed crucial recommendations to enhance CSA techniques' implementation.

Keywords: Adoption, climate smart agriculture, wheat, digital agriculture and agri-drone



T-8 O-15: Synergizing Climate-Smart and Precision Agriculture via Extension Education: Digital Technologies for Sustainable Food Systems and Atmanirbhar Bharat (2015–2026)

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Agricultural systems across the globe are navigating an unprecedented polycrisis—a convergence of climate volatility, natural resource depletion, and economic instability. In India, where more than 80% of farmers are small and marginal, these pressures are intensified by localized climate shocks such as erratic monsoons, unseasonal heatwaves, and declining soil health. Conventional, linear models of agricultural extension are increasingly inadequate in responding to such dynamic and site-specific risks.

This paper presents a systematic review and socio-technical synthesis of literature published between 2015 and 2026, proposing a Socio-Technical Nexus that integrates Climate-Smart Agriculture (CSA), Precision Agriculture (PA), and digitally enabled Extension Education. Using the Driver–Pressure–State–Impact–Response (DPSIR) framework, the review demonstrates that agricultural resilience emerges only when ecological interventions are reinforced through technological precision and socially embedded knowledge systems.

The synthesis reveals that AI-enabled irrigation and nutrient management systems can reduce water and fertilizer wastage by 20–30%, while recent advances in on-device (edge) artificial intelligence overcome connectivity barriers in remote regions, achieving up to 90.1% accuracy in crop stress detection. Case evidence from national initiatives such as Kisan e-Mitra and the National Pest Surveillance System illustrates how digital public infrastructure has scaled advisory services to millions of farmers. However, empirical findings indicate that technological adoption is mediated by social variables: social participation and scientific orientation together explain nearly 65% of farmers’ adaptive capacity.

The paper concludes that policy frameworks must move beyond input-centric subsidies toward Resilience-Linked Incentives that reward measurable outcomes such as water savings, and digital literacy. Such a shift is essential to humanize technological innovation and ensure equitable, climate-resilient agricultural transformation.



T-8 O-16: Digital Technologies for Climate-Smart Agriculture to Enhance Sustainable and Increased Agricultural Production

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Climate change is exacerbating the challenges facing agriculture worldwide (Hassoun *et al.*, 2022). It poses significant threats to agriculture, including rising temperatures, changes in weather patterns, more frequent extreme events and changes in pest dynamics that threaten food security and the livelihoods of farming communities worldwide (Balasundram *et al.*, 2023, IPCC, 2019). The ever-changing climate poses a significant challenge to food production, directly affecting crop yields (Muluneh, 2021). The impact of climate change on agriculture is particularly acute in developing countries based on subsistence agriculture, where farmers are highly dependent on weather conditions (Jatav, 2024, Watson, 2014). Increasing production per unit area or expanding the existing agricultural land are important to meet the food demand of the rapidly growing population. To address the challenge, digital agricultural technologies have been used to increase access, to agricultural information such as weather forecasts, provide agricultural extension services and reduce the cost of project implementation as well as shorten the time-of-service delivery. Satellite-based measurements can be used to predict crop yield (e.g., sorghum yield was predicted 30 days before harvesting). Results also indicated that ICT are effectively improve crop production (increase in wheat yield was range between 40 and 80%). On the other hand, the results of the digital farm machinery (e.g., laser land levelling) ensured that wheat yield and water productivity can be increased up to 5.0 t/ha and 1.28 kg/m³, respectively over the wheat national average yield of 1.7 t/ha. (Bashir M.A., 2023). Overall, the integration of digital technologies into climate-smart agriculture represents a promising pathway to achieving sustainable agricultural production, enhanced food security, and long-term environmental sustainability in the face of a changing climate.

Keywords: Digital technology, climate change, agricultural production.



T-8 O-17: Assessment of Adoption Prediction of Digital Climate Advisory Services among Smallholder Dairy Farmers in Bihar

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India's dairy sector stands at a crossroads where climate change, rising heat stress, and fluctuating milk productivity intersect with the livelihoods of millions of smallholder dairy farmers. These farmers, who form the backbone of dairy production, now face mounting vulnerability as conventional extension systems struggle to adapt to emerging climatic risks. As the nation moves toward the vision of 'Atmanirbhar Bharat', climate advisory services have emerged as a need of hour to provide farmers with timely, contextual, and actionable climate information. In this context, the present study assessed the adoption potential of the 'NDRI Climate Services' mobile application using the Adoption and Diffusion Outcome Prediction Tool (ADOPT) developed by Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. The study was conducted in Bihar, a state highly vulnerable to climate change and ranking fifth in India's livestock population, with primary data collected through structured personal interviews based on the ADOPT framework from 40 smallholder dairy farmers in the Buxar and Sitamarhi districts. Findings revealed a S-shaped adoption curve for 'NDRI Climate Services' mobile application, with the peak adoption level estimated at 70%, time to near-peak adoption projected at eight years and time to 50% of the peak adoption at 3.6 years. Sensitivity analysis identified local village/community-level costs and benefits as the key driver of adoption. While farmers currently perceived only a "small local community advantage", enhancing this perception to a moderate community-level benefit could raise peak adoption level to 87%. These findings affirm that promoting peer demonstration farms, cooperative incentives, and multi-channel extension linkages can effectively leverage Bihar's community centric dairy networks to accelerate app diffusion and empower smallholder dairy farmers as agents of self-reliance, which is essential for realizing the broader vision of Atmanirbhar Bharat.

Keywords: NDRI Climate Services, ADOPT model, Atmanirbhar Bharat, Smallholder dairy farmers, Community benefits, Climate change



T-8 O-18: Gaps in Digital Extension and Their Influence on Climate-Smart Agriculture Adoption in Semi-Arid Telangana

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Digital technologies are increasingly promoted to support climate-smart agriculture in India. However, their actual use among dryland farmers remains limited, especially in semi-arid regions. Understanding how digital extension services influence farmers' adoption of climate-smart practices is important for building sustainable food systems and strengthening Atmanirbhar Bharat.

The present study was conducted in four semi-arid districts of Telangana—Mahabubnagar, Wanaparthy, Nagarkurnool and Gadwal. A descriptive research design was followed. Primary data were collected from 240 dryland farmers using a structured interview schedule. The study analysed farmers' mass media exposure, extension contact, training on climate-related issues, perception towards climate change and adoption of soil and water conservation practices to understand their role in promoting climate-smart agriculture.

The results showed that most farmers had medium to low exposure to digital and mass media sources. Only a small proportion of farmers regularly accessed mobile-based advisories, weather forecasts and digital training programmes. Adoption of climate-smart practices such as rainwater harvesting, micro-irrigation, composting, integrated nutrient management, crop diversification and livestock integration was found to be higher among farmers who had better access to training, mass media and extension services.

The study also identified major constraints affecting digital extension. Poor access to digital advisory services, limited availability of climate-resilient inputs, weak institutional support and low awareness of government schemes emerged as the most critical barriers. These constraints restricted farmers' ability to take timely decisions and effectively adopt climate-smart practices.

The findings highlight the need to strengthen digital extension systems, expand mobile-based advisory services, improve access to climate-related training and promote ICT-enabled farmer groups to enhance the adoption of climate-smart agriculture and ensure sustainable food systems in semi-arid regions.



T-8 O-19: Climate-Smart Digital Agriculture

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Rapid progress in digital innovation is reshaping contemporary agriculture and is increasingly central to the advancement of Climate-Smart Agriculture (CSA). As farming systems are exposed to escalating climate risks—such as floods, droughts, heat stress, erratic rainfall, and growing pest and disease pressure—there is a clear shift toward precision-based, adaptive, and data-enabled farm management. Digital agriculture responds to this need by combining technologies including remote sensing, Internet of Things (IoT)-based sensors, artificial intelligence, machine learning, big-data analytics, automation, geographic information systems, and cloud-enabled decision-support platforms to improve productivity, climate resilience, and environmental stewardship.

Climate-smart digital tools enable real-time tracking of soil moisture, crop health, weather variability, irrigation requirements, and pest-disease incidence using inputs from satellites, drones, field sensors, and smart farm machinery. Data processed through AI-driven analytical frameworks is translated into actionable advisories that assist farmers in selecting appropriate sowing windows, optimizing water and nutrient use, minimizing production risks, and preparing for climate extremes through early-warning and forecast systems. The growing reach of digital advisory services and precision agriculture platforms has also strengthened linkages among farmers, research institutions, Krishi Vigyan Kendras, agribusiness stakeholders, and technology providers, supporting wider adoption of climate-resilient practices—particularly in climate-vulnerable regions such as Assam and the Northeastern states, where digitally enabled extension services can significantly enhance rice-based, oilseed, and allied production systems.

Despite its potential, the uptake of climate-smart digital agriculture faces constraints related to data reliability, platform compatibility, high start-up costs, limited digital infrastructure in rural areas, cybersecurity concerns, shortage of skilled human resources, and unresolved issues around data ownership and privacy. Even so, advancements in AI-based climate forecasting, automated irrigation systems, and real-time risk assessment technologies offer strong prospects for expanding CSA interventions. By enabling informed, timely decision-making and more efficient use of natural resources, digital agriculture is guiding the sector toward a more resilient, low-carbon, and sustainable food system.

Keywords: climate, resilience, advisory services, digital technology





Theme VIII : Poster

Digital technology for climate-smart agriculture





T-8P-1: Digital Technology for Climate-Smart Agriculture

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Digital technology is transforming the global agricultural landscape by enabling more resilient, efficient, and sustainable farming systems in the face of climate change. Climate-smart agriculture (CSA) leverages data-driven tools such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain to optimize resource use, monitor environmental conditions, and support adaptive decision-making for farmers. These technologies enhance productivity while reducing greenhouse gas emissions and conserving biodiversity through precision irrigation, soil health monitoring, and smart pest control (Ahmed et al.; Vishnoi&Goel). Recent studies highlight that digital advisory services and mobile-based platforms are accelerating the adoption of CSA practices among smallholder and next-generation farmers, particularly in Africa and Asia, by providing real-time climate data, market access, and sustainable agronomic recommendations (Ma & Rahut; Molle et al.). Despite these advances, challenges persist in digital literacy, data integration, and access to ICT infrastructure, especially among smallholders in developing regions (Quarshie et al.). Integrating emerging technologies such as AI-driven analytics and blockchain-enabled traceability systems into CSA frameworks presents a pathway toward climate resilience, transparency, and food security (Gryshova et al.). Overall, digital transformation offers unprecedented opportunities to scale climate-smart agriculture, enabling farmers to adapt sustainably to the challenges of a changing climate.

Keyword: - Climate-smart agriculture, ICT, climate change, productivity.



T-8 P-2: Extension approaches in changing climate for increasing income through MIDH in Bundelkhand Region- A case study

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In central India, the farmers of Bundelkhand region are always practicing to increase their production and net profit from the horticultural crops which they are growing at their fields in poly/green houses provided under the scheme of MIDH (Mission for Integrated Development of Horticulture). Whatever vegetable crops (tomato, brinjal, chilly, cauliflower, cucumber and bottle guard etc.) they might cultivate, the bottom line is to invariably get better price from their produce. The increase in farmers' income either by intensifying the existing enterprises or can move towards crop diversification (by growing the new vegetable crops), value addition or successful market linkages to increase their income and standard of living in the region through different extension approaches in changing climatic conditions. Under the MIDH scheme a farmer Sh. Ram Lal Prajapati from the village Badagaon district Tikamgarh (Madhya Pradesh) in Bundelkhand region had started 2 polyhouses (4000 Square meter each) for growing different vegetable crops. The 50 percent subsidy was also provided to the beneficiary by the state horticultural department i.e. Rs. 16.80 Lakh. The cost of cultivation of seedlings of different vegetables came Rs. 12.36 Lakh approximately and the net profit was worked out Rs. 6.84 Lakh per acre (4000 sq. m.) whereas the B:C ratio was 1:1.81 which is acceptable. If we assume the average life of polyhouse 10 years then the payback period will be 3 years. Therefore, the scheme is economically viable under the existing climatic conditions in the region. Hence, the scheme is recommended for replication in other areas in the district and region. The only constraint is this, that the scheme is suitable for progressive/innovative farmers of large categories who can afford the 50 percent cost of polyhouses from their own resources and are ready to bear the climatic/economic risks. The adopted model of MIDH polyhouses is serving integrated and sustainable vegetable farming through diversification of profitable units and marketing linkages in Bundelkhand region of central India.



T-8 P-3: Adoption Behaviour of Farmers towards Climate-Resilient Agricultural Practices in Western Maharashtra

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Climate change-induced variability in rainfall patterns, rising temperatures and the increased frequency of extreme weather events have significantly affected agricultural productivity, farm income and livelihood security in Western Maharashtra. In response, climate-resilient agricultural practices such as drought-tolerant crop varieties, crop diversification, micro-irrigation systems, soil and water conservation measures, integrated nutrient management and climate-based agro-advisory services are being promoted to enhance farm resilience and sustainability. However, the adoption behaviour of farmers towards these practices varies considerably due to socio-economic, technological and extension-related factors. The present study, undertaken under the theme of climate-smart and sustainable agriculture, aimed to analyse the adoption behaviour of farmers towards climate-resilient agricultural practices in Western Maharashtra. A multistage random sampling technique was employed to select 150 farmers from three agro-climatic zones. Primary data were collected using a structured interview schedule covering socio-economic characteristics, awareness levels, extent of adoption and factors influencing adoption behaviour. The data were analysed using descriptive statistics, adoption indices and correlation analysis. The findings revealed that a majority of farmers exhibited a medium level of adoption of climate-resilient agricultural practices. Higher adoption was observed for practices such as drip irrigation, crop diversification and soil and water conservation measures, whereas adoption of climate-based agro-advisory services and stress-tolerant crop varieties remained at a moderate level. Education, farm size, access to extension services, participation in training programmes and exposure to information and communication technologies showed a positive and significant relationship with adoption behaviour. Major constraints perceived by farmers included inadequate technical guidance, high initial investment costs and limited availability of location-specific climate information. The study concludes that strengthening agricultural extension systems through capacity-building initiatives, ICT-enabled advisory services and participatory extension approaches is crucial for enhancing the adoption of climate-resilient agricultural practices and promoting sustainable and climate-smart farming systems in Western Maharashtra.

Keywords: Adoption behaviour, Climate-resilient agriculture, Climate change adaptation, Agricultural extension, Climate-smart agriculture, Western Maharashtra.



T-8 P-4: Role of Big Data and IoT in Advancing Climate-Smart Agricultural Practices

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In the face of climate change, agriculture must evolve to become more resilient, sustainable, and efficient. Climate-smart agriculture (CSA) offers solutions to adapt and mitigate the adverse effects of climate change, and the integration of digital technologies, particularly Big Data and the Internet of Things (IoT), plays a crucial role in its advancement. Big Data refers to the large volumes of data collected from diverse sources, including satellite imagery, weather forecasts, and field sensors. IoT enables real-time monitoring of environmental conditions, soil health, crop growth, and water usage, among other factors. Together, these technologies provide farmers with actionable insights to optimize agricultural practices, improve resource management, and enhance decision-making. By analyzing Big Data, farmers can predict weather patterns, forecast pest outbreaks, and assess soil health, allowing for timely interventions that minimize crop loss and resource waste. IoT-based sensors enable continuous monitoring of field conditions, leading to precise irrigation, fertigation, and pest control, reducing the environmental footprint of farming. Additionally, these technologies facilitate the development of climate-resilient farming systems, contributing to increased productivity and sustainability. The synergy between Big Data and IoT not only empowers farmers with data-driven solutions but also helps policymakers and stakeholders in designing targeted strategies for sustainable agricultural development. This abstract explores the transformative potential of these technologies in advancing CSA practices and highlights their role in enhancing productivity, reducing emissions, and ensuring food security in the face of a changing climate.

Keywords: Big Data, Climate-Smart Agriculture, IoT, Precision Farming, Sustainable Agriculture.



T-8 P-5: Drone Technology as a Frontier for Climate-Smart Agriculture: Evaluating Large-Scale Demonstrations in Wardha District

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Drone spraying is digital technology for climate-smart agriculture by enabling precision application of inputs like fertilizers, pesticides, fungicide based on real-time data, drastically reducing wastage of chemicals, water, labour, minimizing environmental impact, increasing efficiency and optimizing resource use, moving farming from blanket application to site-specific management for higher yields and sustainability. In the semi-arid cotton and soybean belts of district Wardha, traditional crop protection methods are becoming increasingly unsustainable due to erratic behaviour of weather patterns resulting increase of pest and diseases and reduces the yield. KVK, Wardha has addressed these challenges by demonstrating Unmanned Aerial Vehicles as a precision intervention across 120 villages of 8 talukas of Wardha district, positioning drone technology as a cornerstone of digital climate smart agriculture. This study aims to evaluate the efficacy of drone technology in promoting climate-smart practices. Comparative field data was generated by measuring resource utilization between traditional manual spraying and UAV-based Ultra-Low Volume spraying. The findings demonstrate that drone technology significantly advances the three pillars of Climate Smart Agriculture. Water Security: UAVs reduced water consumption by 90%, requiring only 10–15 liters per acre compared to the 200 liters required by manual methods-a critical advantage in moisture-stressed zones. Environmental Integrity: The precision of drone nozzles reduced chemical drift and wastage by 20–25%, protecting the soil-water ecosystem from excessive pesticide loading. Operational Resilience: By covering one acre in under 7 to 8 minutes, drones provided a timely response to pest threats during short weather windows, which is impossible with traditional manual labor. The large-scale deployment of drones by KVK Wardha serves as a successful model for scaling digital technology in climate-smart agriculture. By substituting resource-heavy traditional methods with precision UAV technology, demonstrations of drone technology enhances the adaptive capacity of marginal farmers while ensuring ecological sustainability. The study recommends the integration of drone services into Custom Hiring Centres (CHCs) to ensure equitable access to climate-resilient tools for the last-mile farmer.

Key words: Drone, Large Scale Demonstrations, Climate Smart Agriculture, Sustainability



T-8 P-6: Climate Smart Agriculture- Opportunities and Challenges

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Climate change has emerged as one of the most critical challenges to global agriculture, threatening food security, livelihoods, and environmental sustainability. Rising temperatures, erratic rainfall patterns, frequent droughts, floods, and soil degradation have significantly affected crop productivity and farm incomes, particularly in developing countries like India where agriculture remains the primary source of livelihood for millions. In this context, Climate Smart Agriculture (CSA) offers a comprehensive and integrated approach to address the dual challenge of ensuring food security while responding effectively to climate change. CSA focuses on three key pillars: enhancing agricultural productivity, strengthening resilience and adaptation to climate variability, and reducing greenhouse gas emissions wherever possible. This highlights the concept, evolution, and practical applications of CSA, emphasizing climate-smart practices in crop management, livestock management, soil and water conservation, and agroforestry systems. It further discusses the role of institutional support, ICT-based advisory services, climate information systems, and Climate Smart Villages (CSVs) in facilitating farmer adoption of resilient technologies. Evidence from research studies and case examples across different regions of India demonstrates that the adoption of CSA practices leads to improved yields, reduced production risks, efficient resource use, and enhanced farm profitability. However, despite its potential, the large-scale adoption of CSA faces several constraints, including limited access to finance, inadequate awareness, yield instability, declining soil fertility, and policy and institutional gaps. This concludes that mainstreaming CSA requires coordinated efforts involving policymakers, extension systems, research institutions, and farming communities. Strengthening extension services, promoting digital and ICT-enabled advisory platforms, and fostering public-private partnerships are essential for scaling climate-smart innovations. Overall, Climate Smart Agriculture represents a sustainable pathway to transform agriculture into a more resilient, productive, and environmentally responsible sector in the face of climate change.

Keywords: Climate Smart Agriculture; Climate Change Adaptation; Agricultural Resilience; Sustainable Farming Systems; Climate-Smart Technologies; ICT in Agriculture; Food Security



Theme IX : Oral Market intelligence and digital applications





T-90-1: Sugarcane Information System: An Efficient ICT- based Innovation in Sugarcane Marketing

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Uttar Pradesh has the distinction of being the largest sugarcane and second largest sugar producing state of the country. Being a perishable crop, sugarcane must be crushed at the earliest after harvesting as it deteriorates with the time, converting sucrose into invert sugar which are non-crystallizable. Therefore, sugarcane farmers remain in contact with their respective sugar mills from sowing to harvesting of cane through their Cooperative Cane Development Societies. Sugarcane Information System (SIS), developed by UP Sugarcane Department, is an e-governance initiative, using technology like websites, SMS, IVRS, GPS, and HHC to bring transparency and efficiency to sugarcane procurement, linking farmers, mills, and purchase centres for real-time data on surveys, supply tickets, weighing, and payments. Sugar mills developed their websites and all information from supply ticket to sugarcane price payment is being uploaded on daily basis. This facilitates sugarcane farmers to see in detail the data regarding sugarcane survey of their area, supply, sugarcane weighment, sugarcane price payment *etc.* Using this system, information regarding survey, issue of supply ticket and cane supply is also being sent to millions of farmers through SMS. Computerisation of out cane purchasing centre made by establishing the HHC's benefiting the farmers and sugar mills, latest information is being also supplied to sugarcane farmers through IVRS system. Updated information regarding sugarcane development and marketing is being supplied to farmers with transparency and accuracy. This financially-viable and socially acceptable innovation proved to be revolutionary step in the interest of the farmers. Such model is replicative and may be used in other major cane growing states of India.



T-9 O-2: Agricultural Market Intelligence as an Extension Tool for Improving Farm Income: Evidence from Andhra Pradesh

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Numerous local and worldwide developments are being made to the agricultural market environment. These variables have an impact on farm revenue and agricultural price dynamics. Most of the farmers are unable to comprehend and utilize price behavior and market information to their advantage. The market intelligence and information are essential to help farmers and merchants to decide what to cultivate, when to sell, and where to sell. In light of this, Agricultural Market Intelligence Centre (AMIC) was established at ANGR Agricultural University, Andhra Pradesh with an aim to forecast and disseminate the market information to stakeholders to realize better price for their produce. The price forecasts for different crops were analyzed using secondary data with ANN, ARIMA etc., and after judging the estimates using the primary data, the forecasts were released during regular intervals which matches with the crop production & marketing seasons. The price forecasts estimated for different crops are directly disseminated to the registered farmers through text as well as voice Short Message Services. All these forecast bulletins were uploaded to angrau.ac.in and University magazine 'Vyavasayam', RythuBharosa magazine of Govt. of AP, displayed in 10,776 RythuSeva Kendra's (RSK's) spread in all village, etc. They are also made available with toll free Farmer's Call Centre of Govt. of AP and ANGRAU establishments. The accuracy of the forecasts was achieved between 86.54 to 96.38% for the crops under study when compared with the real-time market prices. The article emphasizes the impact of price forecasts released by AMIC, ANGRAU. The study was conducted in AP state during 2024-25 with a sample of 434 respondent farmers cultivating six major crops namely Groundnut, Cotton, Black gram, Maize, Turmeric and Jowar. Out of the total sample, 61.11 per cent were aware of price forecasts disseminated through different sources and 33.13 per cent of farmers followed the advice of AMIC. The study revealed that on average, each farmer who adopted the AMIC advice was benefited with an amount of Rs. 451 per quintal of sale proceeds. In the sphere of Digital technologies, proper market intelligence can develop sustainable food systems and can become a co-worker for Atmanirbhar Bharat.



T-9 O-3: Smart Market Intelligence in Agricultural Extension

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Market intelligence supported by digital applications has emerged as a critical driver for strengthening agricultural extension systems in a rapidly evolving agri-food economy. This paper examines the role of smart market intelligence and digital applications in improving farmers' decision-making, market participation and income realization. Digital tools such as mobile applications, web portals, social media platforms, SMS alerts, Interactive Voice Response (IVR) systems, e-markets, geospatial technologies and data analytics platforms enable real-time access to price trends, demand forecasts, market arrivals, weather-linked advisories and post-harvest management information. Integration of market intelligence with digital extension services facilitates informed decisions related to crop planning, input use, harvesting schedules, storage and marketing strategies. These platforms significantly reduce information asymmetry between farmers and markets, enhance bargaining power and improve transparency across agricultural value chains.

The review highlights key benefits of smart digital market intelligence, including timely dissemination of price signals, cost-effective advisory delivery, personalized recommendations, improved market linkages, risk mitigation and enhanced profitability. Market-oriented digital extension also strengthens value chain coordination and supports small and marginal farmers in responding to price volatility and climatic uncertainties. However, challenges such as limited digital literacy, inadequate internet connectivity, data reliability issues, language barriers and low trust in digital marketplaces continue to constrain widespread adoption.

Innovative approaches such as artificial intelligence-based price forecasting, predictive analytics, agricultural QR codes, localized market dashboards and integration of extension content with e-commerce platforms offer promising opportunities to overcome these limitations. The paper concludes that smart market intelligence-driven digital applications, when effectively integrated with conventional extension approaches, can substantially enhance market orientation, resilience and income security of farming systems. Strategic investments in digital infrastructure, capacity building, institutional support and validation of market information are essential to fully harness the potential of smart digital agricultural extension for sustainable rural livelihoods.

Keywords: Market intelligence, Digital applications, Agricultural extension, e-markets, Price forecasting, Data-driven advisory services



T-9 O-4: Understanding Farmers' Engagement with Social Media for Agricultural Market Information: Usage Patterns and Constraints

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The rapid expansion of digital technologies has transformed agricultural information systems, offering new opportunities for farmers to access timely and market-oriented information. The present study examines farmers' engagement with social media for accessing agricultural market information, with specific emphasis on their socio-personal and communication characteristics, extent and purpose of social media use, and constraints encountered in its utilization. The study was conducted in Darbhanga district of Bihar using a descriptive research design. A total of 120 farmers were selected through simple random sampling from three blocks representing urban, peri-urban, and rural settings. Primary data were collected through a structured interview schedule. The extent of social media usage was measured using a Likert scale, purposes of use were analysed through weighted mean scores, and constraints were ranked using Garrett's ranking technique.

The findings revealed that a majority of respondents belonged to the middle age group, possessed moderate educational attainment, had small landholdings, and exhibited medium levels of information-seeking behaviour, mass media exposure, and extension contact. Most farmers (74.16%) demonstrated a medium level of social media usage, with WhatsApp, YouTube, and Facebook emerging as the most frequently used platforms. Social media was primarily utilized for weather-based advisories, market price awareness, knowledge sharing, and digital product promotion. Correlation and regression analyses indicated that education, mass media exposure, and extension contact were significant positive predictors of social media usage, while age showed a negative association. Major constraints identified included lack of technical knowledge, limited awareness, preference for traditional information sources, inadequate digital skills, and communication barriers related to language and content complexity. The study underscores the need for capacity-building interventions, localized content development, and strengthened extension-digital linkages to enhance effective use of social media for agricultural market access and informed decision-making among farmers.

Key Words: Farmer, Social Media, Market, Information, Usage



T-9 O-5: A study on Awareness and Impact of e-NAM Scheme among the farmers of Pune Sub-division of Maharashtra State

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This study was conducted in 2 APMC mandi of Sangli district of Pune Subdivision of Maharashtra State. The data was collected from 100 Farmers with the help of structured interview schedule. The study revealed that, The majority of the respondents (45.00 per cent) were found in the middle age group *i.e.* 31-60 years. Maximum numbers of respondents (49.00 per cent) belonged to General caste. Maximum numbers of respondents (32.00 per cent) were having 10th Pass of education. The maximum respondents (97.00 per cent) were engaged in agriculture as a occupation. The majority of respondents were having Electric motor (28.00 per cent) as farm power. The majority of respondents were always receiving information from Agricultural Co-operative Bank (57.00 per cent), The majority of respondents were having one membership of social organization (55.00 per cent). The most of the respondents (54.00 per cent) were earning annual income between Rs.1,00,000 – 2,00,000 per annum. The majority of respondents were having knowledge about pre-requisites for e-NAM registration like copy of Id proof (100.00 per cent),.The majority of respondents were having high utilization pattern of e-NAM scheme in Mango (15.00 per cent), Farmers receiving (average cash Rs/Qtl) have been increased after utilization of e-NAM scheme, In economical constraints, the majority of respondents were facing problem of Delayed cash (85.00 per cent). Annual income (0.333951), were having positive correlation with of awareness level. Social participation (0.388337), were were having positive correlation with of utilization pattern.

Keywords: e-NAM, Awareness level, Annual income.



T-9 O-6: Agri Exchange: A Comprehensive Digital Platform for Agri Exports

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Agri Exchange is APEDA's official trade portal and represents a pioneering initiative by APEDA, Government of India, with online trading as its core feature. It was developed through a joint collaboration between UNCTAD and the Ministry of Agriculture, the portal provides a global digital platform that connects buyers and sellers in the agricultural sector, enabling them to offer, negotiate, and finalize trade deals online. In addition to facilitating trade, the portal is enriched with the latest national and international agricultural statistics. Trusted sources such as UN Comtrade, FAO, and DGCIS are utilized, with regular updates to ensure accuracy and relevance. The portal hosts up-to-date information on approximately 783 products, including those under APEDA's mandate as well as products outside its purview. It also features details on Sanitary and Phytosanitary (SPS) measures, Maximum Residue Limits (MRLs), country profiles, agricultural export service providers, and current market news. Agri Exchange aims to deliver timely and relevant information tailored to the needs of stakeholders in the agricultural economy, particularly those involved in agricultural commodity trade. Its vision is to support and empower the agri-business community by enabling informed decision-making and sustained growth through effective use of the portal. It offers an integrated solution with insights into importing countries, global agricultural production, trade statistics, international prices, and the regulations and tariff structures of importing nations. Furthermore, Agri Exchange provides step-by-step export guidance covering quality standards, packaging and labelling requirements, warehousing and cold storage, logistics, export documentation, government incentives and subsidies, Letter of Credit procedures, and buy/sell leads.. Developed by APEDA, Agri Exchange simplifies the sourcing process and enhances global awareness of India's agricultural products among international importers.



T-9 O-7: Analysis of Dairy Supply Chain and Implications of Advisory Services of Uttar Pradesh

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Uttar Pradesh is the highest milk-producing state in India. Uttar Pradesh contributes around 18% of the total milk produced in India. Uttar Pradesh state was selected on the basis of average milk production and the districts (Azamgarh and Kanpur Nagar) were selected based on the purposively from both districts who were involved in dairy value chain for the present study. From each of the two districts 40 milk producers, 4 input suppliers, 4 cooperative, 8 processing unit, 4 wholesaler, 4 retailer, 4 sweet shop and 10 consumers so as to constitute sample size 78. Random sampling method was used for the selection of actors which were involved in dairy value chain. Both primary and secondary data were collected for the present study. Primary data was collected using interview method. The secondary data collected by reviewing literature and internet sources pertaining to the relevant study. The collected data was statistically analyzed and interpreted using percentage analysis. The major actors in value chain were milk producers, input supplier, processing unit cooperative society, sweetshops, wholesalers, retailer and consumers. To enhance opportunity for value chain actors, we need to understand the main value actors affecting the entire value chain. The study analyzed the basic components of value chain as activity, information flow and channel before it reaches the end user. Farmers indicated that milk yield is highest during the first four months of lactation and decline thereafter. However it depends on the month of calving, feed availability, milking experiences etc. The mean milk yield per day was an average of 20 liters for exotic breeds, 10 liters for cross breeds and 6 liters for local breeds. During investigation it was found that milk producers' largest portion of milk was sold to milk market (local milk mandi) 27.5 percentage followed by 22.5 percent sold to sweet shop, 20 percentage of milk sold through home delivery, 15 percentage of milk sold in local area and 10 percent of milk was sold directly to the consumers from farm. And only 2.5 percent of milk was sold to cooperative society. From the result it is clear that milk producers are still not connected to organized sector. So there is a need to more attraction of milk producer so that they can sell milk directly to organized sector to get more benefits.

Keyword: Stakeholders, channels dairy farming, socio economic status, value addition, U.P.



T-9 O-8: Prediction of Consumer Behaviour on Purchasing Organic Ginger using Machine Learning in Ri-Bhoi district, Meghalaya

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Growing consumer awareness for good health, longevity and desire for enhanced quality of life has necessitated renewed attention on consumption of foods with special medicinal or health properties, generally known as functional foods. Ginger, with its renowned therapeutic attributes, has huge potential in this segment. Promoting ginger based agri-preneurship can help farmers boost economic returns, particularly in the form of value addition at the farm level. Understanding consumer behaviour is critical in this context, as it would empower producers and manufactures to better align products with evolving expectations and demand patterns. Based on this rationale, a study was taken up to predict consumer behaviour on purchasing ginger using machine learning. The study was conducted in the C&RD Block Umsning of Ri-bhoi district, Meghalaya. A purposive sampling method was used to select 96 respondents from the residential complexes of three central government institutes: CPGS-AS, Central Agricultural University (Imphal), ICAR NEH Region and (iii) North Eastern Space Applications Centre. Primary data collection was done using a structured interview schedule. IBM SPSS Modeler software was employed to identify the most appropriate machine learning models for analysing the dataset. The results revealed that majority (80.21%) of the respondents had higher affinity towards purchasing organic products (ginger) while 19.79% were indifferent towards the product type. Among the supervised machine learning models evaluated, the Neural Network demonstrated the highest accuracy (90.00%), followed by Logistic Regression (88.00%) and the Bayesian Network (78.00%). Neural Network model was used for prediction and predictor variables were ranked by importance, with 'Values on organic produce' emerging as the most influential predictor, followed by 'Need on Traceability of Organic Produce' and 'Consumer Preference'. The findings highlight the potential of artificial intelligence and machine learning in providing reliable market intelligence for agricultural commodities. It is recommended that prior to the implementation of any agricultural commodity development programme, prediction of consumer behaviour for the commodity can be performed with high accuracy using ML. This approach can significantly contribute towards strengthening value-chain interventions and agripneurship initiatives.

Key words: Consumer behaviour, Artificial intelligence, Machine learning, Ginger



T-9 O-9: Impact of Digital Market Intelligence Applications on Farmers' Price Realization

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Small and marginal farmers in India often face difficulties in obtaining fair prices for their agricultural produce due to limited market access, lack of timely price information, seasonality of crops and dependence on traditional marketing channels. These challenges restrict farmers decision-making ability regarding where and when to sell their produce. Digital market intelligence applications have emerged as an effective tool to address these constraints by providing real-time market information and analytical support. The present study assesses the impact of digital market intelligence applications on farmers price realization, with special reference to farmer cooperatives cultivating storable crops. The study focuses on a mobile-based digital platform that integrates farmers, traders, markets, government agencies and end users, thereby improving transparency and market participation. The system uses machine learning-based price forecasting models to predict future price trends and generate sales recommendations on optimal selling time. In addition, K-Nearest Neighbor (KNN) algorithms are applied for market comparison, while the Haversine algorithm enables location-based market identification using GPS data. The platform allows farmers to sell their produce at different levels of the marketing chain, including markets, merchants and end users, thus expanding marketing options. A web-based interface enables government authorities to monitor prices, enforce minimum price regulations (Hamibhav) and address farmer grievances. Field testing and analysis of historical price data indicate that the application contributes to improved price realization and enhances farmers confidence in marketing decisions. The study concludes that digital market intelligence applications have significant potential to strengthen farmers marketing efficiency and income and can be scaled to other storable agricultural commodities.

keywords: Digital market intelligence, Price realization, Farmer cooperatives, Machine learning, Agricultural marketing, Mobile-based applications



T-9 O-10: Impact of E-tendering on prices of major agricultural commodities in Karnataka

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Digital technologies are transforming agriculture by fostering sustainable food systems through efficient resource management and real-time monitoring of production processes. As part of this broader digital ecosystem, digital marketing or E-marketing plays a transformative role in improving market access, strengthening market intelligence and enhancing price transparency. In this context, the present study analysed the impact of ReMS (Unified Market System) on the prices of major commodities in Karnataka. The key agricultural commodities considered were Arecanut, Paddy, Groundnut, Silk cocoon, Copra, Dry Chilli, Turmeric and Cotton. Secondary data on monthly modal prices of key commodities were obtained for the selected e-markets and non-e markets from www.krishimaratavahini.kar.nic.in for the period from January 2009 to December 2024. The study employed difference-in-difference regression (DiD) model to examine the price behaviour of commodities during the pre- and post-e-tendering regimes. The findings revealed that e-tendering has significantly increased the real prices of key commodities ranging from Rs.55.64 in groundnut to Rs.5463.34 in drychilli enhancing transparency, reducing collusion and strengthening market intelligence. In the post e-tendering regime, the prices in e-markets increased significantly, while those in non e-markets fell, leading to a widening of the price gap across the selected commodities. These findings highlighted that e-tendering has improved marketing efficiency and increased farmer income by ensuring fair price realization and boosting trust in the market system through strengthening market intelligence. The study underscored the transformative potential of digital platforms, such as e-marketing, in agriculture and offered policy insights for replicating such interventions across India's agricultural markets.

Keywords: e-tendering, market intelligence, difference – in – difference (DID), Price discovery



T-9 O-11: Consumers' Acceptance and Willingness to Pay for Nutri-Rich Foods: Empirical Evidence from Discrete Choice Experiment

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Nutrition-sensitive agriculture is increasingly recognized as a vital strategy for addressing malnutrition and micronutrient deficiencies in India. Nutri-rich foods such as biofortified cereals, millet-based products, and fortified staples offer promising solutions; however, their large-scale adoption depends on consumer acceptance and willingness to pay (WTP). This study empirically examines consumers' preferences, valuation, and WTP for nutri-rich foods using a Discrete Choice Experiment (DCE) and Mixed Logit modeling framework. Primary data were collected from 200 consumers across urban (57.5%) and rural/semi-urban (42.5%) areas using a structured survey. The results indicate high awareness and positive attitudes toward nutri-rich foods, with 79.5% of respondents willing to pay a price premium. Among those willing to pay extra, 34.2% were willing to pay up to 10%, 28.1% were willing to pay 11–20%, and 22.8% were willing to pay 21–30% above the base price. Government certification emerged as the most trusted attribute (44%), followed by brand reputation (20%) and organic claims (19%). The Mixed Logit model results reveal that certification and taste–quality attributes are the strongest determinants of consumer valuation. Willingness to pay estimates show that consumers are willing to pay ₹14.7 (29% premium) for government certification and ₹17.3 (35% premium) for nutrition/health logos. Taste and quality attributes exerted even stronger effects, with consumers willing to pay ₹14.0 (28%) for acceptable taste and ₹27.2 (54%) for better taste and quality. In contrast, the type of nutri-rich food (biofortified, millet-based, or fortified) had a low and statistically insignificant influence on WTP. The findings highlight that trust (certification) and sensory satisfaction (taste and quality) dominate consumer decision-making, outweighing technical product categories. The study provides critical insights for policymakers, food processors, and agricultural extension systems to strengthen certification mechanisms, enhance product quality, and design consumer-centric awareness campaigns to accelerate adoption of nutri-rich foods in India.

Keywords: Nutri-rich foods; Willingness to Pay; Discrete Choice Experiment; Food certification; Taste and quality



T-9 O-12: Digital Transformation of Agricultural Markets through Market Intelligence

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Market intelligence and digital applications play an important role in improving the marketing and management of agricultural goods in India. Market intelligence involves collecting and analyzing information related to crop prices, demand and supply, weather conditions, and market trends. With the growth of digital technologies, this information has become more accurate, timely, and easily accessible to farmers and other stakeholders.

In India, digital platforms such as **e-NAM (National Agriculture Market)** provide real-time price information and connect farmers directly with buyers across different markets. Mobile applications like **Agmarknet, Kisan Suvidha, and mKisan** help farmer's access data on market prices, weather forecasts, and advisory services. Technologies such as **big data analytics, artificial intelligence, and IoT-based sensors** support better crop planning, yield estimation, and price forecasting. These tools help farmers decide what crops to grow, when to sell, and where to sell for better returns.

Digital applications also reduce the role of middlemen, improve transparency in price discovery, and minimize post-harvest losses through better supply chain management. Market intelligence systems help farmers manage risks related to price fluctuations and climate uncertainty. Overall, the use of market intelligence and digital technologies strengthens agricultural marketing systems, improves farmers' income, and supports sustainable growth of the agricultural sector in India.

Key words: Market intelligence, Digital applications, **e-NAM, mKisan**, improves farmers' income



Theme IX : Poster Market intelligence and digital applications





T-9P-1: Market Intelligence and Digital Applications

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Market intelligence (MI) refers to collecting, analyzing, and using data to understand a market's environment. It helps organizations make informed decisions.

Key components of MI:

- Customer Insights – behaviors, preferences, needs
- Competitor Analysis – strengths, weaknesses, strategies
- Market Trends & Forecasting – industry shifts, future demand
- Product Intelligence – performance, pricing, differentiation
- Environmental Scanning – economic, regulatory, technological changes

Goals:

- Identify growth opportunities
- Improve product/market fit
- Predict risks and disruptions
- Make data-backed strategic decisions

Digital applications are software solutions (web, mobile, cloud-based) that help automate processes, deliver services, or create digital experiences.

Common types:

- Web & Mobile Apps
- Data Dashboards
- AI/ML-Powered Tools
- ERP/CRM Systems
- E-commerce Platforms
- IoT Applications
- Automation & RPA Tools

Typical business uses:

- Customer engagement
- Operations automation
- Smart analytics
- Digital transformation
- Workflow management

Market Intelligence and Digital Applications Work Together

Modern organizations integrate MI into digital apps to create intelligent systems.

Examples:

- Real-time dashboards for competitor trends
- AI-driven recommendation systems (built from customer MI)
- Predictive sales apps using market forecast data
- Automated competitor tracking tools
- Mobile apps for field intelligence collection

Benefits of combining both:

- Faster strategic decision-making
- Automated data collection
- Higher accuracy with AI-driven analytics
- Personalized digital experiences (driven by MI)
- Stronger competitive advantage



T-9 P-2: Agricultural Market Intelligence Route to Farmers' Empowerment

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The market information for selling an agricultural commodity is the power of agrarian society. The present world is transforming through digital means of information via using ICT tools like mobile in hand of farmers. Agricultural market intelligence (AMI) is evolving from traditional price-monitoring to a data-driven decision-making engine that integrates real-time market information and predictive analytics of price fluctuations in future. In the present scenario in India, AMI platforms like e-NAM portals, price trends, insect-pests' outbreaks and logistics bottlenecks-based information are supporting farmer in decision making and to seize the excellent price opportunities and other market benefits. This awareness empowers farmers to choose finest crop varieties, timing of sowing/harvest, negotiate better prices and access credit and insurance products. Moreover, the advances in artificial intelligence and IoT devices ascertaining an early-warning systems for climate shocks and automated trading platforms. Emerging models such as farmer-centric mobile apps, AI-driven market advisory services and public-private data collaboratives are expected to bridge information gaps and improve farmer incomes. Hence, agricultural market intelligence can transform agriculture from a risk-laden sector into a resilient, aligned with national food security and sustainability goals. The market intelligence including price forecasts for major crops in advance through various print and mass media, Agricultural Department, Marketing Department, Agricultural Market Committees, web portals on components such as competitors, customers, products and the overall market scenario etc. these insights empower farming community to grab the fair price of their produce as per demand and supply principles routed via multiple markets connect in country or international as well.



T-9 P-3: Ninjacart: Transforming Fresh Produce Supply Chains Through Technology and Traceability

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Ninjacart is India's largest technology-enabled B2B fresh produce supply chain platform, connecting farmers directly with retailers and food businesses to reduce intermediation, food loss, and price volatility in perishables markets. Founded in 2015, the company now serves over 800,000 farmers, 100,000 retailers, and more than 20,000 resellers across 120+ cities, moving over 1,000–1,400 tonnes of fruits and vegetables daily from more than 40,000–44,000 farmer suppliers, typically within 12 hours of harvest. Research case studies and industry analyses highlight Ninjacart's use of in-house supply chain algorithms, big data, predictive analytics, mobile applications, and IoT devices to build a just-in-time, paperless logistics network comprising 200+ collection centers and 1,200+ warehouses, which has enabled waste reduction to below 1%, compared with up to 35% in traditional wholesale chains.

Empirical evidence shows that Ninjacart's model improves farmer welfare by enabling transparent, pre-harvest price and demand communication, guaranteed off-take, and bank-account payments within 24 hours, contributing to an estimated 15% increase in farmers' net realized income while mitigating the risks of delayed payments and exploitation by intermediaries. On the demand side, retailers benefit from reliable quality, consistent supply, and dynamic pricing supported by real-time inventory tracking and route optimization. The firm's FoodPrint traceability initiative further strengthens food safety and consumer trust by using RFID tags and digital identifiers to map the entire "farm-to-fork" journey, allowing end consumers to view farmer identity, harvest time, logistics chain, and handling history via an online viewer integrated with partner e-commerce platforms.

Financial performance data indicate rapid scaling: Ninjacart's revenue increased 74% year-on-year to approximately ₹2,002.7 crore in FY 2023–24 while losses narrowed, supported by expansion into marketplace services for farmers and traders, and partnerships with lenders such as IDFC First Bank for embedded agri-finance. This abstract proposes to critically examine Ninjacart as a benchmark model for sustainable, data-driven fresh produce supply chains in India.

Keywords: Ninjacart, Fresh produce supply chain, Food traceability (FoodPrint), Data-driven logistics



T-9 P-4: E- commerce platforms and their contribution to Atma-Nirbhar Bharat

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The COVID-19 pandemic caused unprecedented disruption to global socio-economic systems, severely affecting lives, livelihoods and business activities across the world. India too experienced a sharp economic contraction due to prolonged lockdowns and supply-chain disruptions. However, amid this crisis, e-commerce emerged as a critical support system for the Indian economy by ensuring continuity of trade, access to essential goods and employment generation. Observing the rapid recovery of economies such as China through self-reliance, India introduced several initiatives including Atma-Nirbhar Bharat, Vocal for Local and Make in India to strengthen domestic production and economic resilience. This paper examines the emerging trends of e-commerce in India and analyzes its role in realizing the vision of Atma-Nirbhar Bharat. It highlights how digital platforms have empowered indigenous entrepreneurs, small and medium enterprises, farmers and artisans by improving market access and promoting inclusive growth. The study also explores the post-COVID impact of e-commerce on economic revival, employment generation, innovation and technological adoption. Based on secondary data, facts and policy initiatives, the paper identifies e-commerce as a catalyst for self-reliance by strengthening local supply chains, encouraging domestic manufacturing and supporting the objectives of Make in India. The findings suggest that e-commerce has significant potential to accelerate India's journey toward a sustainable, digitally enabled and self-reliant economy.

keywords: E-commerce, Digital markets, Atma-Nirbhar Bharat, Make in India, Vocal for Local, Market access.



T-9 P-5: Agriculture Marketing through e-NAM, Opportunities and Challenges: A Review

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The agriculture marketing system in India has long been affected by problems such as limited market access, lack of price transparency, dominance of intermediaries and information asymmetry. To address these issues the government of India introduced the e-NAM (electronic national agriculture market) as a digital platform aimed at integrating agriculture markets and promoting transparent, competitive and efficient marketing of agriculture produce. The present review of published papers synthesizes research findings on agriculture marketing through e-NAM with specific focus on its opportunities and challenges. The study is based on systematic review of fifteen research papers published in international, Asian and Indian journals including ICAR recognized publications covering different states of India. The selected studies were critically analyzed to identify major opportunities and challenges associated with adoption and functioning of e-NAM. The findings reveal that e-NAM offers several opportunities, including improved market access beyond local mandis reported in 8 out of the 15 studies, transparent price discovery through online bidding in 7 studies, enhancement of farmer's profit margin in 7 studies, reduction in role of intermediaries was reported in 5 studies. These advantages highlight the potential of e-NAM as effective market-led extension initiative. The review also identified key challenges limiting the utilization of e-NAM, including low awareness and limited technical knowledge of stakeholders reported in 9 studies out of 15 studies, lack of regular training and extension support in 8 studies, insufficient assaying facilities in 6 studies, inadequate digital infrastructure in 5 studies. The study concludes that strengthening extension interventions, capacity building programs, digital literacy initiatives and infrastructure development is essential to convert the opportunities of e-NAM into sustainable benefits for farmers and improve the efficiency of the agriculture marketing system in India.

Keywords: Electronic national agriculture market (e-NAM); Agriculture marketing; Digital agriculture platform; Online bidding; Market access; Price discovery.



T-9 P-6: Market Intelligence as a Tool for Reducing Information Asymmetry in Agricultural Markets

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Market intelligence plays a crucial role in addressing the persistent issue of information asymmetry in agricultural markets, where producers, traders, and consumers often operate with unequal access to market data. Information gaps lead to inefficiencies, unfair pricing, and increased vulnerability for farmers, especially in developing regions. By leveraging digital tools and real-time data, market intelligence can significantly reduce these asymmetries, enabling more informed decision-making and better market outcomes. Digital platforms, mobile-based applications, and data analytics are increasingly being used to provide farmers with timely information on market prices, demand trends, weather forecasts, and crop conditions. These technologies help farmers access real-time data that was previously unavailable to them, improving their ability to negotiate fair prices, optimize crop production, and manage risks. Additionally, market intelligence systems can assist traders and consumers by providing more transparency in price setting and market dynamics, contributing to the efficiency of the supply chain. However, challenges remain in ensuring broad adoption, especially among smallholder farmers. Limited access to technology, low digital literacy, and high costs of implementation can hinder the effective use of market intelligence tools. Furthermore, trust in digital platforms and the quality of data remain concerns that must be addressed to enhance their credibility and effectiveness. In the context of agricultural extension, integrating market intelligence into extension services offers an opportunity to empower farmers with market-relevant knowledge, reduce exploitation, and improve their income potential. A coordinated approach involving government bodies, technology providers, and extension agents is essential to overcoming barriers and ensuring equitable access to market intelligence for all stakeholders.

Keywords: Market intelligence, Information asymmetry, Digital tools, Market access, Transparency



T-9 P-7: Status of Small Ruminant Markets, Marketing Facilities, and Marketing Channels in the Kalyana Karnataka Region of Karnataka

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This study assessed the status of goat marketing, availability of market facilities, and marketing channels in the Kalyana Karnataka (KK) region of Karnataka, India. An ex-post facto research design was used in Bidar and Kalaburagi districts, selecting three livestock markets from each (total: six markets). Primary data were collected through semi-structured questionnaires from market functionaries, traders, and farmers, and analyzed using simple statistical tools. The analysis of livestock markets in the Kalyana Karnataka region revealed that there are around 30 markets for goats. District-wise analysis showed that the number of goat markets was highest in Kalaburagi district, followed by Bidar, Raichur, Koppal, Ballari, and Yadgir districts. Almost all these markets are held weekly, and the majority are administered by local trusts, followed by APMCs. All regular markets are held once a week, but the day of the market varies from one to another. This arrangement helps avoid overlapping market days and facilitates the movement of animals from one market to another if they are not sold. Seven major marketing channels were identified in goat marketing, with the **Farmer–Trader–Farmer** channel being the most common. Farmers frequently sell their animals directly to other farmers or butchers due to perceived exploitation by middlemen, while butchers also prefer purchasing directly from farmers and rarely buy through middlemen.

Available marketing facilities in small ruminant markets include loading/unloading areas, animal shed fencing, feed and fodder, veterinary services, water supply, street lighting, and vehicle parking, which were present in almost all markets. Internal roads were surfaced with kaccha (unpaved), tar, or concrete. However, security personnel facilities were absent in most markets. The study emphasizes the need to strengthen infrastructure and streamline marketing systems to enhance efficiency and improve stakeholder welfare in the small ruminant value chain.



T-9 P-8: Stakeholder's constraints in goat and chevon marketing in Kalyana Karnataka region of Karnataka

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The present study was conducted to identify the various constraints faced by different stakeholders in the marketing of live goats and chevon. An ex-post facto research design was employed in Bidar and Kalaburagi districts of Kalyana Karnataka. From each district, three markets were selected, and from each market, 10 sellers, 10 buyers/butchers, and 5 middlemen were interviewed, resulting in a total sample of 60 sellers, 60 buyers/butchers, and 30 middlemen. The data were tabulated and analysed using simple statistical tools.

The results revealed that the major constraints in live goat marketing faced by goat farmers were low market prices, exploitation by middlemen, unscientific methods of price fixation, disease prevalence in goats, unorganized markets, non-availability of market information, transportation problems, poor market infrastructure, lack of space in markets, and high market fees. The major constraints faced by middlemen included disease prevalence in goats, transportation problems, regulations in animal markets, lack of continuity in animal supply, non-availability of market information, high market fees, non-availability of fodder in markets, poor market infrastructure, lack of space, and unorganized markets. The major constraints in chevon marketing faced by butchers were: exploitation by middlemen, transport regulations, disease prevalence in goats, transportation problems, low demand for stored meat, non-availability of proper meat storage facilities, lack of low-cost technology for slaughter, poor management by farmers, unorganized markets, poor market infrastructure, regulations on animal slaughter, lack of credit facilities, lack of incentives for modernization and hygienic slaughter, shortage of skilled labour, and lack of market information. The study concluded that training programmes should be implemented for scientific goat management, scientific slaughter practices, and scientific price fixation methods, which should be actively encouraged.

Keywords: Goat markets, market price, scientific management, slaughter practices, constraints