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From Awareness to Adoption: Communication Pathways in the Regenerative Agriculture Landscape

Chedulla Venkata Sai Anusha [a++*], Saravanan Raj [a#] and Sandipamu Raahalya [a†]

[a] *National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Regenerative agriculture is emerging as a transformative solution to address the environmental and economic challenges of conventional farming. This study explores the adoption of regenerative agricultural practices in Prakasam and Kadapa in Andhra Pradesh, and Rangareddy and Mahbubnagar in Telangana, focusing on the role of communication channels in knowledge dissemination. The research employs a mixed-methods approach, combining qualitative and quantitative data which was gathered through semi-structured interviews from farmers (120), extension officers (40), NGOs (4), FPOs (5), input suppliers (5), and SHGs (10) and qualitative responses were thematically analyzed using NVivo 14, following Braun and Clarke's (2006) coding framework. Findings indicate that peer learning (85.83%) which is informal channel, social media

[++] *MANAGE Research Intern;*
[#] *Director (Agricultural Extension);*
[†] *MANAGE Fellow;*
**Corresponding author: E-mail: anusha7102000@gmail.com;*

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(79.17%) which is digital channel, and extension services (73.33%) which is institutional channel are the most effective channels for promoting regenerative farming. Face-to-face interactions, particularly through farmer-led networks, training workshops, and demonstration farms, significantly influence knowledge transfer and adoption. However, financial, knowledge, and policy gaps hinder progress. Integrating regenerative agriculture into rural schemes, strengthening digital access, promoting peer learning, and enhancing stakeholder collaboration and extension capacity are vital for scaling sustainable practices. This study underscores the importance of strategic communication and policy interventions in fostering sustainable agricultural transformation.

Keywords: Regenerative agriculture; sustainable farming; knowledge dissemination; peer learning; extension services; farmer networks.

1. INTRODUCTION

Agriculture is at a turning point where rising food demands must be balanced with environmental sustainability. The escalating global population exerts increasing pressure on agricultural systems to produce food efficiently and sustainably (Ronald, 2011). Striking a balance between sustainability, which necessitates resource conservation and intergenerational equity, and profitability, which ensures the economic viability of agricultural activities, has become a central focus in contemporary discourse, research, and policy formulation (Cavallo et al*.,* 2019). Conventional agricultural practices, while effective in boosting productivity, have led to soil degradation, loss of biodiversity, water scarcity, and greenhouse gas emissions (Herrero et al*.,* 2015).

Regenerative agriculture is often mistaken as just a collection of good farming techniques. Regenerative Agriculture means “no-to-low external input” (Voisin et al., 2024). In fact, it is a structured approach based on key principles that work together to restore soil health and improve farm sustainability. This approach is built on the foundation of Conservation Agriculture, a concept developed by the Food and Agriculture Organization (FAO, 2021) and backed by over 30 years of global research (Kassam et al., 2009). Conservation Agriculture focuses on protecting natural resources, improving soil quality, and making farming more resilient to climate change.

In India, the Indian Council of Agricultural Research (ICAR) and various regional initiatives have played a pivotal role in advancing Conservation Agriculture as the scientific basis for regenerative farming. Through targeted research and outreach, these programs have helped establish a strong foundation for sustainable agricultural practices.

One of the key efforts includes ICAR’s **Consortium Research Platform (CRP)** on Conservation Agriculture, which was developed to support nationwide research on essential principles such as minimal soil disturbance, continuous soil cover, and crop diversification elements that align closely with regenerative agriculture (ICAR, 2024).

Additionally, ICAR-NRRI (National Rice Research Institute) hosted a significant workshop in July 2024, in partnership with the National Academy of Agricultural Sciences (NAAS) and the Indian Society of Soil Science. This event highlighted the importance of Conservation Agriculture in enhancing resource efficiency and building climate-resilient farming systems.

ICAR also oversees several **All India Coordinated Research Projects (AICRP)** that reflect Conservation Agriculture principles (ICAR, 2025), including:

- AICRP on Dryland Agriculture
- AICRP on Integrated Farming Systems
- AICRP on Agroforestry

These projects contribute to region-specific research and promote adoption across diverse agro-ecological zones.
Regenerative agriculture expands on this foundation by combining five core principles that must be used together to achieve real results:

1. **No-till farming** – avoids disturbing the soil, helping to prevent erosion and support soil life.
2. **Permanent soil cover** – keeps the soil protected with crops or mulch, improving moisture and organic matter.
3. **Crop diversity** – growing different types of crops to improve soil nutrients and reduce pests.

4. **Livestock integration** – using animals to recycle nutrients and add value to the farm.
5. **Local adaptation** – adjusting practices to suit the local climate, soil, and community needs.

These principles work best when applied together. Using just one or two may help, but won't lead to full regeneration. That's why it's important to promote regenerative agriculture as a complete system, supported by strong communication, good policies, and teamwork among farmers, researchers, and institutions. If single practices are promoted under the label of regenerative agriculture, since they will not result in the expected effects converting the term regenerative agriculture into a meaningless buzzword.

The global regenerative agriculture market size was valued at USD 1.19 billion in 2024 and is projected to reach USD 4.30 billion by 2033, growing at a CAGR of 16.1% from 2025 to 2033 (Grandview Research Report, 2024)

This growth is driven by increasing consumer awareness of sustainable farming, climate concerns, and the demand for organic, nutrient-rich food. Regenerative agriculture improves soil health, carbon sequestration, biodiversity, and ecosystem resilience, making it a viable alternative to conventional farming. However, high initial investment costs, limited awareness, and regulatory challenges hinder widespread adoption. Some regenerative practices, such as cover cropping and agroforestry, require upfront financial commitments that small and medium-sized farmers struggle to afford. Additionally, subsidies favouring conventional farming and complex certification processes create market barriers. Despite these challenges, major corporations, governments, and NGOs are investing in research, policy frameworks, and certification programs to promote regenerative practices.

North America dominates the global regenerative agriculture market, with the United States leading adoption due to government support, consumer demand, and corporate investments. Asia-Pacific is emerging as a high-growth region, with China and India driving demand through policy initiatives and rising awareness of sustainable farming. Market segmentation indicates crop-based regenerative agriculture holds the largest share due to increasing demand for organic grains, fruits, and vegetables, while livestock-based regenerative systems are also growing due to the rising demand for sustainably produced meat and dairy. Companies like Nestlé, General Mills, and Indigo AG are integrating regenerative principles into their supply chains, enhancing transparency and sustainability. The market is also witnessing trends such as precision agriculture, blockchain traceability, and investment in regenerative supply chains, ensuring that sustainable farming becomes a key part of the future agricultural landscape.

Regenerative agriculture plays a critical role in addressing socio-economic challenges in farming communities (Gosnell et al*.,* 2019; Pearson, 2007; Ikerd, 1993). Beyond environmental benefits, regenerative agriculture supports rural livelihoods by enhancing farmer resilience, reducing input costs, and creating diversified income opportunities. Smallholder farmers, who are highly vulnerable to climate change, can improve soil fertility and yield stability through regenerative methods. By adopting regenerative practices, the farmers can build resilience against unpredictable weather patterns, improve soil fertility, and enhance productivity in a sustainable manner (McLennon et al*.,* 2021; Schreefel et al*.,* 2020; Khangura et al*.,* 2023).

The transition to this model is supported by extension services, demonstration farms, digital platforms, and farmer-led networks, which help disseminate knowledge and encourage adoption. The promotion of regenerative agriculture relies on effective extension services and the active participation of multiple stakeholders (Priya et al*.,* 2025).

Policymakers play a crucial role in enabling this shift through subsidies for organic inputs, research funding, and tax incentives for sustainable farming. NGOs, agribusinesses, and consumer-driven initiatives further promote regenerative agriculture by investing in sustainable supply chains, eco-labelling programs, and market linkages that offer fair prices to farmers. Farmer Field Schools (FFS) and participatory research programs further empower farmers by fostering peer-to-peer learning and engaging them directly in experimentation and knowledge-sharing (Sharma et al*.,* 2024).

The use of digital platforms, mobile applications, and social media has revolutionized agricultural extension by making information more accessible

(Singh et al., 2023). As governments, corporations, and consumers increasingly recognize the benefits of regenerative agriculture, it is poised to become a mainstream, scalable solution for global food security and climate resilience. Driving forces for the sustainable practices among the small-scale growers are their consumers (community supported agriculture, restaurants, Farmers' Markets, and farm stands) and extreme climate conditions (Mpanga et al*.,* 2021).

Despite its numerous benefits, the widespread adoption of regenerative agriculture faces several obstacles, including knowledge gaps, financial constraints, weak market linkages, policy limitations, and climate variability. Many farmers lack technical expertise, while upfront costs and limited government subsidies make transitioning difficult, especially for smallholders. Additionally, consumer awareness and market access remain inadequate, preventing farmers from securing premium prices for regenerative produce. To overcome these challenges, a multi-faceted approach is essential, expanding farmer training programs, providing financial incentives, strengthening market linkages, implementing policy reforms, and promoting climate-resilient regenerative practices. By coordinating efforts among farmers, policymakers, businesses, and consumers, regenerative agriculture can enhance soil health, biodiversity, and climate resilience, ultimately creating a more sustainable global food system. By keeping in view all these aspects, the objective of this study is to analyse the transmission channels driving the promotion of regenerative agriculture, emphasizing their reach and impact.

2. MATERIALS AND METHODS

This study adopted a mixed-method research design, integrating both qualitative and quantitative approaches to obtain a holistic understanding of regenerative agriculture adoption in Andhra Pradesh and Telangana. The combination of methods enabled the study to explore not only statistical trends but also farmers' experiences, attitudes, and challenges associated with regenerative practices. The research was conducted in four districts, Prakasam and Kadapa in Andhra Pradesh, and Rangareddy and Mahbubnagar in Telangana. These areas were purposively chosen due to their active participation in regenerative farming initiatives such as the Andhra Pradesh Community-managed Natural Farming (APCNF) program and various NGO-supported projects. The selected districts also represent distinct agro-ecological and socio-economic settings, offering a diverse range of insights into farming systems and adoption behaviors.

Participants were identified through a snowball sampling technique, beginning with key contacts who referred others engaged in regenerative agriculture. The final sample comprised 120 farmers, 40 extension officers, 4 NGOs, 5 Farmer Producer Organizations (FPOs), 5 input suppliers, and 10 Self-Help Groups (SHGs). The inclusion criteria required participants to have at least two years of involvement in regenerative or natural farming. Demographic data such as age, education, gender, and farm size were collected to ensure diversity and transparency in the sample composition.

The quantitative data were analyzed using descriptive and inferential statistics to evaluate adoption patterns, communication effectiveness, and environmental outcomes. The qualitative data were examined through thematic analysis using NVivo 14, following the six-phase approach proposed by Braun and Clarke (2006), which includes familiarization, coding, theme generation, reviewing, defining, and reporting.

Potential biases linked to the snowball sampling method, such as dependence on personal networks and overrepresentation of connected participants, were acknowledged. To reduce these effects, referrals were taken from different stakeholder groups to ensure varied perspectives. Reliability and validity were enhanced by pre-testing research instruments, maintaining consistent data collection procedures, documenting field notes, and using triangulation and peer debriefing to confirm accuracy and coherence of the findings.

To collect data, semi-structured interviews with both closed and open-ended questions were conducted. Qualitative data was analyzed using thematic analysis via NVivo 14, following the Braun and Clarke (2006) framework for coding and visualization. Descriptive statistics summarized the data on transmission channels such as government programs, extension services, and media, assessing their effectiveness in promoting regenerative agriculture.

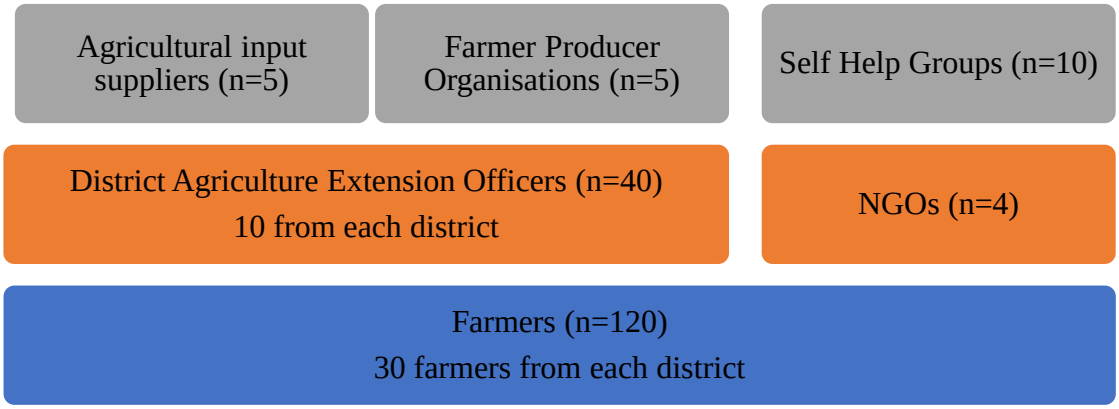

Chart 1. The survey conducted on the agricultural landscape of Andhra Pradesh for regenerative farming practices

3. RESULTS AND DISCUSSION

3.1 Adoption of Regenerative Agricultural Practices

The study assessed the adoption of regenerative agricultural practices among farmers. The findings from list 1 indicate that farmers are increasingly adopting techniques that enhance soil health, conserve water, and promote biodiversity. Among these, live mulching emerged as the most widely adopted practice, followed by organic manures, intercropping, and rainwater harvesting (Colombi et al., 2025). Weighted Mean Score (WMS) with 3-point scale (fully = 3, partially = 2, not adopted = 1) was used to calculate the adoption level of the regenerative practices. The approach to analyse the adoption of single practices does not reflect in any way the concept of regenerative agriculture. Regenerative agriculture is only regenerative, if the 5 core principles are applied together; the selection of single practices does not result in regenerative or sustainable farming but is just a good practice within conventional farming. This point is explained in most of the literature on Conservation Agriculture, which constitutes the universally applicable principles or regenerative agriculture, and which does only develop the full potential of the regenerative effects when minimum soil disturbance (no-till), permanent soil cover and diversity are applied continuously together on the same field.

List 1. Adoption levels of regenerative agriculture practices

Sl. No.	Regenerative Practice	% Adoption	Distribution (Full / Partial / None)	WMS	Adoption Level
1	Live mulching	90	90 / 20 / 10	2.67	Highly Adopted
2	Organic manures	85	85 / 25 / 10	2.63	Highly Adopted
3	Intercropping	80	80 / 30 / 10	2.58	Highly Adopted
4	Rainwater harvesting	75	75 / 30 / 15	2.50	Highly Adopted
5	Vermicomposting	70	70 / 35 / 15	2.46	Moderately Adopted
6	Cover cropping	65	65 / 30 / 25	2.33	Moderately Adopted
7	No till farming	60	60 / 35 / 25	2.29	Moderately Adopted
8	Livestock management	55	55 / 30 / 35	2.17	Moderately Adopted
9	Light traps	50	50 / 35 / 35	2.13	Moderately Adopted
10	Multi-cropping	50	50 / 35 / 35	2.13	Moderately Adopted
11	Seed treatment	45	45 / 35 / 40	2.04	Moderately Adopted
12	Agroforestry	40	40 / 30 / 50	1.90	Moderately Adopted
13	Fruit varieties (home garden)	35	35 / 25 / 60	1.83	Moderately Adopted
14	Organized fruit forests	30	30 / 25 / 65	1.75	Moderately Adopted
15	Nakshatravanam	25	25 / 20 / 75	1.63	Moderately Adopted

3.2 Transmission Channels Driving the Promotion of Regenerative Agriculture, Emphasizing their Reach and Impact

1. For farmers:

- 69.17% of the farmers used local experts and farming networks as the source of information to know and learn about regenerative agriculture (Singh et al*.,* 2022).
- 65.83% of the farmers rely on farming communities as the primary sources.
- 52.50% of the farmers receive trainings, workshops, demonstrations about regenerative agriculture through APCNF.

Communication channels used by farmers in the adoption of regenerative agriculture:

Farmers adopt regenerative agriculture through multiple communication channels, with peer learning (85.83%) emerging as the most influential (Lasdun et al., 2025). Farmer-to-farmer interactions facilitate informal knowledge exchange and experiential learning, reinforcing the importance of community-driven adoption. Social media (79.17%) has also become a powerful tool, enabling digital engagement and widespread awareness of sustainable practices. The high usage of social media platforms suggests that digital engagement has become a key tool for spreading awareness about sustainable agricultural techniques (Jabeen *& Gul* 2023). Extension officers (73.33%) remain a trusted source, highlighting the continued relevance of formal advisory services in guiding farmers through the transition. Traditional media like radio (63.33%) and newspapers (57.50%) still play a role, with a preference for radio suggesting that audio-based dissemination is more accessible, especially in rural areas.

Among digital communication methods, mobile text messages (51.67%) (Singh et al., 2015) and community meetings (51.67%) have moderate reach, indicating a growing reliance on technology alongside collective decision-making platforms. Television (44.17%) and telephone calls (43.33%) have lower utilization, likely due to limited interactivity, while farmers' magazines (35.83%) rank the lowest, showing a shift from print to digital and peer-based learning. The findings emphasize the need to strengthen peer learning, social media outreach, and extension programs through farmer-led demonstrations and digital extension services, ensuring greater adoption of regenerative agriculture (Choruma et al*.,* 2024).

Source of information through face-to-face channels:

Face-to-face interactions remain essential for knowledge dissemination in regenerative agriculture, with peer learning (85.83%) being the most influential channel (Christy et al*.,* 2018). Farmers rely on fellow farmers for firsthand insights and practical experience, reinforcing the value of experiential learning. Extension agents (73.33%) also play a significant role in providing scientific knowledge and expert guidance, highlighting the importance of formal advisory services. However, since their reach is lower than peer learning, integrating farmer-led extension models could enhance their impact. Local leaders (65.00%) and Self-Help Groups (64.17%) also contribute significantly, as community influencers and financial support systems encourage the adoption of regenerative practices. Additionally, peers and relatives (60.00%) facilitate social knowledge exchange, indicating that trust-based networks are crucial in agricultural decision-making.

Other institutional sources, including NGOs (53.33%), FPOs (41.67%), and cooperatives (44.17%), contribute to knowledge transfer but have lower reach, suggesting the need for stronger outreach initiatives. Agri dealers (45.83%), traditionally associated with input sales, are emerging as advisors on sustainable practices, further diversifying knowledge sources. These findings underscore the importance of strengthening farmer-to-farmer interactions, extension programs, and community-driven initiatives through participatory training and localized demonstrations to accelerate the adoption of regenerative agriculture (Collins et al*.,* 2025).

Mean rating of parameters of face-to-face communication channels:

The effectiveness of face-to-face communication channels in promoting regenerative agriculture was assessed based on familiarity, authenticity, interactivity, reliability, usefulness, and credibility (Evance, 2018) in Table 1. Among all channels, fellow farmers ranked highest in familiarity (1.00), authenticity (0.87), interactivity (0.78), and credibility (0.92), making peer learning the most effective method (ECC = 0.81). Farmers trust firsthand experiences and local adaptations, reinforcing the importance of farmer-to-farmer

networks in knowledge dissemination (Magnan et al., 2015). Extension agents also played a crucial role, scoring high in technical quality (0.86), credibility (0.86), and acceptability (0.95), with an overall effectiveness score of 0.78. However, their lower interactivity (0.47) suggests the need for more participatory and hands-on learning approaches. Similarly, Self-Help Groups (ECC = 0.74) proved to be highly reliable and useful, fostering collaborative learning among farmer communities.

NGOs and FPOs showed moderate effectiveness, particularly in technical knowledge and credibility, but struggled with familiarity and likability, highlighting the need for stronger community engagement strategies. Local leaders, cooperatives, and agri dealers were found to be less effective (ECC = 0.41–0.56), serving more as supplementary sources rather than primary knowledge channels. The findings emphasize that a blended communication approach, leveraging peer learning, extension services, and institutional support is essential for maximizing knowledge dissemination and adoption of regenerative agriculture (Inutan et al., 2025). Enhancing interactivity in formal channels while strengthening farmer-led initiatives can significantly improve the effectiveness of outreach efforts.

Source of information through mass media channels:

Mass media plays a crucial role in spreading awareness about regenerative agriculture, with social media (79.17%) emerging as the most widely used platform (Jabeen & Gul, 2023). Farmers rely on Facebook, WhatsApp, and YouTube for easily accessible and interactive learning. Community workshops (65.00%) and radio (63.33%) also serve as key sources, demonstrating the effectiveness of both digital and traditional communication methods. Television (60.83%), websites and blogs (52.50%), and SMS-based services (51.67%) are moderately utilized, reflecting the growing role of digital platforms while still acknowledging the importance of broad-reach mass media like TV and radio.

However, print media (43.33%) and mobile apps (45.83%) remain less utilized, suggesting that technological literacy, smartphone accessibility, or lack of awareness may limit adoption. While social media dominates digital communication, radio and TV remain essential for farmers with limited internet access, and community workshops offer hands-on experiential learning. To maximize knowledge dissemination, a combined approach integrating social media, traditional media, and interactive learning platforms is necessary (Hong et al., 2025). Efforts should focus on improving digital literacy, promoting mobile-based agricultural solutions, and ensuring accessibility for diverse farming communities.

Mean rating of parameters of mass media communication channels:

Mass media communication channels play a crucial role in disseminating information about regenerative agriculture to farmers. The effectiveness of these channels is assessed based on parameters such as familiarity, authenticity, interactivity, likability, reliability, technical quality, usefulness, credibility, and acceptability are shown in Table 2, with television (ECC = 0.79) and social media (ECC = 0.78) ranking as the most effective channels (Guntukogula et al., 2023). Television is widely trusted due to its high familiarity (0.92), authenticity (0.88), and credibility (0.86), while social media excels in interactivity (0.75) and usefulness (0.83), making it an engaging tool for knowledge dissemination. Radio (ECC = 0.77) remains a reliable source, particularly for farmers without internet access, though its lower interactivity (0.24) limits two-way communication. SMS and text messaging (ECC = 0.72) are moderately effective, offering personalized agricultural updates, while print media (ECC = 0.67) is valued for its credibility (0.73) but lacks interactive engagement. Community workshops (ECC = 0.67) prove to be highly effective in hands-on learning and farmer-to-farmer knowledge exchange, making them an essential complement to digital platforms.

However, websites (ECC = 0.58), online learning platforms (ECC = 0.59), and mobile apps (ECC = 0.62) have lower effectiveness due to limited awareness, lower credibility, and accessibility issues. While mobile apps score well in interactivity (0.74) and authenticity (0.73), they require stronger credibility and usability enhancements for wider adoption. These findings highlight the need for an integrated communication strategy that combines traditional media (television, radio, print), digital platforms (social media, mobile apps), and interactive formats (SMS, community workshops). To improve digital adoption, efforts should focus on enhancing awareness, building trust, and improving user accessibility to online agricultural resources (Yang et al., 2024).

Table 1. Mean rating of parameters of face-to-face communication channels

Communication channels	Parameters									
	Familiarity $\bar{x}$	Authenticity $\bar{x}$	Interactivity $\bar{x}$	Likability $\bar{x}$	Reliability $\bar{x}$	Technical quality $\bar{x}$	Usefulness $\bar{x}$	Credibility $\bar{x}$	Acceptability $\bar{x}$	ECC $\bar{x}$
Extension agents	0.73	0.80	0.47	0.69	0.80	0.86	0.83	**0.86**	**0.95**	0.78
Fellow farmers	**1.00**	**0.87**	**0.78**	**0.87**	0.73	0.56	0.92	0.65	0.87	**0.81**
Peers and relatives	0.41	0.25	0.73	0.39	0.31	0.36	0.47	0.43	0.34	0.41
SHGs	0.69	0.72	0.52	0.59	**0.82**	**0.92**	**0.88**	0.85	0.69	0.74
NGOs	0.58	0.69	0.35	0.42	0.78	0.81	0.85	0.83	0.51	0.64
FPOs	0.73	0.80	0.47	0.69	0.80	0.86	0.83	0.86	0.55	0.73
Local leaders	0.58	0.53	0.42	0.53	0.53	0.53	0.58	0.58	0.61	0.54
Co-operatives	0.47	0.58	0.43	0.42	0.49	0.58	0.60	0.58	0.56	0.52
Agri dealers	0.54	0.73	0.38	0.49	0.54	0.63	0.62	0.55	0.56	0.56
										0.64

ECC= Effectiveness of communication channel, $\bar{x}$= Mean rating index for parameters of effective communication channel.
Scale of effectiveness: Not effective- 0; Less effective- <0.5; Effective->0.5; More effective- 1

Table 2. Mean rating of parameters of mass media communication channels

Communication channels	Parameters									
	Familiarity $\bar{x}$	Authenticity $\bar{x}$	Interactivity $\bar{x}$	Likability $\bar{x}$	Reliability $\bar{x}$	Technical quality $\bar{x}$	Usefulness $\bar{x}$	Credibility $\bar{x}$	Acceptability $\bar{x}$	ECC $\bar{x}$
Television	0.92	0.88	0.32	0.79	0.81	0.86	0.83	0.86	0.83	0.79
Radio	0.85	0.85	0.24	0.87	0.75	0.76	0.91	0.84	0.87	0.77
Print media	0.88	0.77	0.44	0.56	0.69	0.71	0.57	0.73	0.64	0.67
SMS and Text messaging	0.86	0.72	0.78	0.52	0.77	0.82	0.68	0.65	0.69	0.72
Websites and blogs	0.57	0.69	0.55	0.42	0.78	0.61	0.55	0.53	0.51	0.58
Social media platforms	0.92	0.80	0.75	0.69	0.80	0.86	0.83	0.76	0.65	0.78
Community workshops and events	0.73	0.76	0.82	0.63	0.53	0.63	0.65	0.68	0.61	0.67
Online learning platforms	0.47	0.66	0.67	0.53	0.69	0.58	0.60	0.54	0.54	0.59
Mobile apps	0.54	0.73	0.74	0.59	0.64	0.62	0.62	0.55	0.56	0.62
										0.69

ECC= Effectiveness of communication channel, $\bar{x}$= Mean rating index for parameters of effective communication channel.
Scale of effectiveness: Not effective- 0; Less effective- <0.5; Effective->0.5; More effective- 1

2. For extension workers:

Regenerative agricultural practices promoted by extension workers to farmers:

Extension workers actively promote regenerative agriculture with a strong focus on natural and organic farming techniques. Zero Budget Natural Farming (85%) is the most widely recommended practice, emphasizing low-cost, sustainable methods that maintain soil fertility without external inputs (Ayyadurai et al*.,* 2024). Similarly, biofertilizers and biopesticides (82.5%) are promoted to reduce chemical dependency and enhance soil microbial activity. Water conservation techniques such as rainwater harvesting & micro-irrigation (77.5%) and mulching (75%) play a crucial role in improving soil moisture retention, especially in drought-prone regions. Practices like green manuring, intercropping, crop rotation, vermicomposting, and integrated farming systems (IFS) are widely encouraged to enhance soil health and biodiversity. However, agroforestry (60%) and cover cropping (55%) receive moderate promotion, and no-till farming (50%), despite its benefits for soil conservation, faces adoption challenges due to conventional ploughing practices. While extension workers are successfully advocating for diverse regenerative techniques, increased efforts are needed to boost awareness and adoption of conservation-based practices like no-till farming and cover cropping for long-term sustainability (Kabenomuhangi, 2024).

Type of communication channel used by extension workers to promote regenerative agriculture to farmers:

Extension workers primarily use interactive and experiential learning methods to promote regenerative agriculture, with group trainings and workshops (95%) being the most widely utilized (Das et al*.,* 2025). These sessions facilitate hands-on learning and real-time discussions, reinforcing farmer education. Peer-to-peer learning (92.5%) and demonstration farms (90%) further emphasize trust-based knowledge exchange and practical exposure, making them highly effective in encouraging adoption. Community meetings (85%) and one-on-one farm visits (75%) provide personalized guidance and collective learning opportunities. Digital platforms, including online learning (75%) and social media (70%), are gaining importance, offering wider accessibility but requiring improvements in internet access and digital literacy. Mass media channels such as radio (50%) and printed materials (55%) serve as supplementary tools, while agricultural fairs (37.5%) and government collaborations (45%) remain underutilized due to logistical constraints. The findings suggest that experiential learning remains the most effective, while expanding digital outreach and strengthening farmer networks could further accelerate the adoption of regenerative agriculture (Lasdun et al*.,* 2025).

Mean rating of parameters of communication channels used by extension officers:

The effectiveness of various communication channels in promoting regenerative agriculture was assessed based on key parameters such as credibility, interactivity, usefulness, and reliability is shown in Table 3. Group trainings and workshops (ECC = 0.76) emerged as the most effective channel, excelling in interactivity (0.80), credibility (0.82), and reliability (0.79), highlighting the value of structured, hands-on training (Meena, 2010). Peer-to-peer learning (ECC = 0.72) also ranked high, particularly in authenticity (0.80) and interactivity (0.82), emphasizing the importance of farmer-led knowledge exchange. Demonstration farms (ECC = 0.70) scored well in reliability (0.81) and usefulness (0.82), proving that visual, experience-based learning enhances farmer confidence in new practices. Moderately effective channels included social media (ECC = 0.62), which was engaging but lacked credibility (0.48), and one-on-one farm visits (ECC = 0.62), valued for personalized guidance but needing better technical resources. Online learning platforms and mobile apps (ECC = 0.60) showed potential, with high technical quality (0.85) but lower trust and accessibility due to digital literacy challenges.

Less effective communication methods included radio and TV broadcasts (ECC = 0.57) and collaborations with government programs (ECC = 0.57), which had moderate reliability (0.70) but lacked interactivity (0.40–0.55). Printed materials (ECC = 0.46) were rated lowest, with poor interactivity (0.25) and usefulness (0.38), suggesting they work best as supplementary tools rather than standalone sources. Agricultural fairs (ECC = 0.58) had moderate effectiveness but were limited by accessibility and sporadic events. The findings highlight that interactive and experiential learning methods such as workshops, peer learning, and demonstration

farms are most effective, while digital platforms need credibility improvements and traditional media is best suited for raising awareness rather than detailed training. A multi-channel approach that integrates practical training, peer exchange, and digital tools can maximize the impact of extension services in promoting regenerative agriculture adoption (Inutan et al*.,* 2025).

3. For NGOs:

The results from Table 4 indicate that NGOs play a crucial role in promoting diverse regenerative agricultural practices among farmers. RySS, WASSAN, CSA, and Aranya Agricultural Alternatives actively support initiatives such as natural farming, soil health improvement, and water conservation. Their collective efforts emphasize sustainable resource management, ecological balance, and reduced dependence on chemical inputs.

The findings from Table 5 reveal that NGOs employ a wide range of communication channels to promote regenerative agriculture among farmers. Both traditional and digital platforms—such as field schools, training camps, social media, and mobile apps—are used to enhance farmer engagement and knowledge sharing. This diversified approach helps ensure broader outreach, participatory learning, and effective dissemination of sustainable farming practices.

4. For SHGs:

Type of communication channel used by SHGs to promote regenerative agriculture to farmers:

Self-Help Groups (SHGs) use a multi-channel approach to promote regenerative agriculture, combining experiential, community-driven, and digital methods. Farmer Field Schools (FFS), peer-to-peer learning, SHG meetings, and demonstration farms are the most effective face-to-face channels, providing hands-on training and real-time knowledge exchange (Sutherland & Marchand, 2021). Workshops, training camps, and exposure visits further enhance learning by allowing farmers to witness successful regenerative practices firsthand. Resource centres serve as local hubs for continued knowledge access, while pamphlets and posters act as supplementary materials. Digital platforms like WhatsApp, social media, and YouTube are growing in importance, enabling quick updates and remote learning, though effectiveness depends on internet access and digital literacy. Local radio programs help reach farmers in remote areas through expert discussions and success stories. While traditional face-to-face learning remains the most effective, digital tools are increasingly vital for scaling up outreach. To improve impact, SHGs should enhance digital literacy and collaborate with NGOs and government programs for wider adoption of sustainable farming practices.

5. For FPOs:

Type of communication channel used by FPOs to promote regenerative agriculture to farmers:

Farmer Producer Organizations (FPOs) play a pivotal role in promoting regenerative agricultural practices among farmers by utilizing diverse communication channels to facilitate knowledge sharing and adoption (Patil et al*.,* 2025). These include hands-on Farmer Field Schools (FFS), workshops, and demonstration farms that provide practical training; digital tools like mobile apps and webinars for continuous learning; printed materials, community radio, and TV programs for widespread dissemination; and platforms such as agricultural fairs, social media, and YouTube to share success stories and best practices. FPOs also foster peer-to-peer mentoring and collaborate with NGOs, government programs, and agricultural experts, ensuring farmers transition effectively to sustainable and profitable farming.

6. For input suppliers:

Type of communication channel used by input suppliers to promote regenerative agriculture to farmers:

Input suppliers play a crucial role in advancing regenerative agriculture by providing resources like organic fertilizers and eco-friendly solutions while educating farmers through various channels (Feliziani et al., 2025). They use on-farm demonstrations, workshops, and farmer meetings to showcase sustainable practices, and leverage mobile-based communication, social media, and printed materials to share tips and success stories. Participation in trade fairs and collaborations with FPOs, NGOs, and government programs help expand outreach, while helpline support addresses farmer queries. These strategies ensure accurate guidance, driving the adoption of environmentally sustainable and economically viable farming methods.

Table 3. Mean rating of parameters of communication channels used by extension officers

Communication channels	**Parameters**									
	Familiarity $\bar{x}$	Authenticity $\bar{x}$	Interactivity $\bar{x}$	Likability $\bar{x}$	Reliability $\bar{x}$	Technical quality $\bar{x}$	Usefulness $\bar{x}$	Credibility $\bar{x}$	Acceptability $\bar{x}$	ECC $\bar{x}$
One-on-one farm visits	0.55	0.70	0.65	0.72	0.68	0.40	0.71	0.74	0.45	0.62
Group trainings and workshops	**0.75**	0.78	0.80	0.76	0.79	0.60	0.81	0.82	**0.76**	**0.76**
Community meets	0.68	0.72	0.50	0.45	0.73	0.42	0.74	0.75	0.38	0.59
Demonstrations and field days	**0.75**	**0.80**	0.78	0.79	**0.81**	0.35	**0.82**	**0.83**	0.45	0.70
Social media	0.73	0.77	0.55	**0.80**	0.48	0.30	0.81	0.76	0.39	0.62
Radio or TV	0.63	0.68	0.40	0.55	0.70	0.71	0.52	0.42	0.49	0.57
Printed materials	0.53	0.60	0.25	0.30	0.62	0.66	0.38	0.41	0.35	**0.46**
Online learning platforms and mobile apps	0.48	0.65	0.80	0.67	0.72	**0.85**	0.40	0.45	0.42	0.60
Agricultural fairs or exhibitions	0.55	0.68	0.72	0.70	0.50	0.39	0.73	0.47	0.46	0.58
Peer-to-peer learning	0.73	**0.80**	**0.82**	0.79	0.77	0.45	0.81	**0.83**	0.48	0.72
Collaborations	0.58	0.72	0.68	0.40	0.75	0.35	0.76	0.49	0.37	0.57

ECC= Effectiveness of communication channel, $\bar{x}$= Mean rating index for parameters of effective communication channel.
Scale of effectiveness: Not effective- 0; Less effective- <0.5; Effective->0.5; More effective- 1

Table 4. Regenerative agricultural practices promoted by NGOs to farmers

Sl. No.	Regenerative agriculture practices	NGOs promoting it
1	Zero-Budget Natural Farming (ZBNF) / Community Managed Natural Farming	RySS, WASSAN
2	Non-Pesticidal Management (NPM)	CSA
3	Agroforestry & Permaculture	Aranya Agricultural Alternatives
4	Soil Health Management	RySS, CSA, WASSAN
5	Water Conservation & Rainwater Harvesting	WASSAN, Aranya Agricultural Alternatives
6	Livestock Integration & Organic Manure	RySS

(RySS- Rythu Sadhikara Samstha, WASSAN- Watershed Support Services and Activities Network, CSA- Centre for Sustainable Agriculture)

Table 5. Type of communication channel used by NGOs to promote regenerative agriculture to farmers

Sl. No.	Communication Channel	NGOs Using It
1	Farmer Field Schools (FFS)	RySS, WASSAN, CSA
2	Extension workers & Community Resource Persons	RySS, WASSAN
3	Workshops & Training camps	Aranya Agricultural Alternatives, CSA
4	Mobile apps & Digital platforms	RySS, CSA, WASSAN
5	Community radio & Podcasts	CSA
6	Short films & Video demonstrations	RySS, CSA
7	Farmer-to-Farmer learning	RySS, WASSAN
8	Printed manuals, pamphlets & posters	CSA, Aranya Agricultural Alternatives
9	Field exposure visits & Farmer conventions	RySS, WASSAN
10	Social media & YouTube channels	RySS, CSA
11	WhatsApp & SMS alerts	RySS, WASSAN, CSA

Table 6. Comparative table for communication strategies by stakeholders in promoting regenerative agriculture

Stakeholder	Communication channels/Strategies	Key features / Purpose
Farmers	-Peer-to-peer learning - Social media (WhatsApp, YouTube) - Extension services - Community meetings -Demonstrations - Radio, newspapers, TV - Mobile SMS	Informal and experiential learning; trust-based, accessible; digital and traditional mixed usage
Extension workers	- Group trainings & workshops - Peer learning - Demonstration farms - One-on-one visits - Social media - Online learning - Radio/TV, print materials - Government collaborations	Emphasize experiential, interactive training; increasing digital use; formal guidance and technical support
NGOs	- Farmer Field Schools (FFS) - Extension workers & community resource persons - Training camps - Digital platforms	Community-centric, participatory, and multimedia strategies; bridge between science and practice

Stakeholder	Communication channels/Strategies	Key features / Purpose
	- Community radio & podcasts - Short films & video demos - WhatsApp/SMS alerts - Printed materials	
FPOs	- FFS and workshops - Demonstration farms - Mobile apps & webinars - Social media & YouTube - Printed materials - Agricultural fairs - NGO/government collaborations	Strengthen collective action and shared learning; digital and offline mix; organize access to experts/markets
SHGs	- SHG meetings - Peer learning - Demonstration farms - Exposure visits - Resource centers - Pamphlets/posters - WhatsApp/social media - Local radio	Grassroots mobilization; local, inclusive and supportive learning networks; increasing digital adoption
Input suppliers	- On-farm demonstrations - Farmer meetings - Social media - Mobile messaging - Printed materials - Helpline support - Trade fairs - Collaborations with NGOs/FPOs	Promote sustainable products; combine product marketing with education; often first-contact for new practices

Social Network Analysis of different stakeholders involved in regenerative agriculture:

A. Social Network Analysis of Stakeholders in Regenerative Agriculture

Fig. 1 illustrates the stakeholder interaction network involved in promoting regenerative agriculture, developed using Social Network Analysis (SNA). The analysis was conducted using **Gephi (v0.10.1)**, an open-source platform for network visualization, applying the **ForceAtlas2 layout algorithm** to position nodes based on the strength of their connections. Data matrices were processed using **UCINET** for relational structure modelling and **NodeXL** for computation of centrality metrics and preliminary Excel-based analysis.

This analysis highlights the roles and relationships among six key stakeholder groups: Extension Officers, NGOs, SHGs (Self-Help Groups), Farmer Producer Organizations (FPOs), Input Suppliers, and Farmers. Edge thickness and colour represent the strength of interactions (red: strong, orange: moderate, green: weak), with directed edges denoting the flow of information, resources, or influence.

B. Key Observations

1. **Central Actors**: Extension Officers and NGOs emerged as highly central, maintaining strong ties with Farmers, SHGs, and FPOs. Extension Officers are instrumental in disseminating knowledge and supporting policy implementation, whereas NGOs facilitate capacity building and provide technical/financial assistance (Mishra et al*.,* 2023).
2. **Intermediary Roles**: FPOs serve as crucial intermediaries by connecting farmers with input suppliers and aggregating resource needs. They also support SHGs in accessing quality inputs and market services (Mishra et al*.,* 2022).

- **Peripheral Actors**: Input Suppliers demonstrated limited integration within the network, with fewer connections to farmers or SHGs, indicating a need for strategic engagement. SHGs remain moderately connected, largely dependent on NGOs and FPOs for access to knowledge and inputs.

Table 7. Stakeholder Network Centrality and Functional Roles in Agricultural Development

Stakeholder	Degree Centrality	Betweenness Centrality	Role
Extension Officers	High	High	Knowledge transfer agents and coordination hubs
NGOs	High	Moderate–High	Training and support providers; connectors of SHGs
FPOs	High	Moderate	Intermediaries linking inputs to farmers
SHGs	Moderate	Low	Localized actors with limited outreach capacity
Farmers	Moderate	Low	Beneficiaries with indirect influence
Input Suppliers	Low	Very Low	Weakest linkages; minimal strategic integration

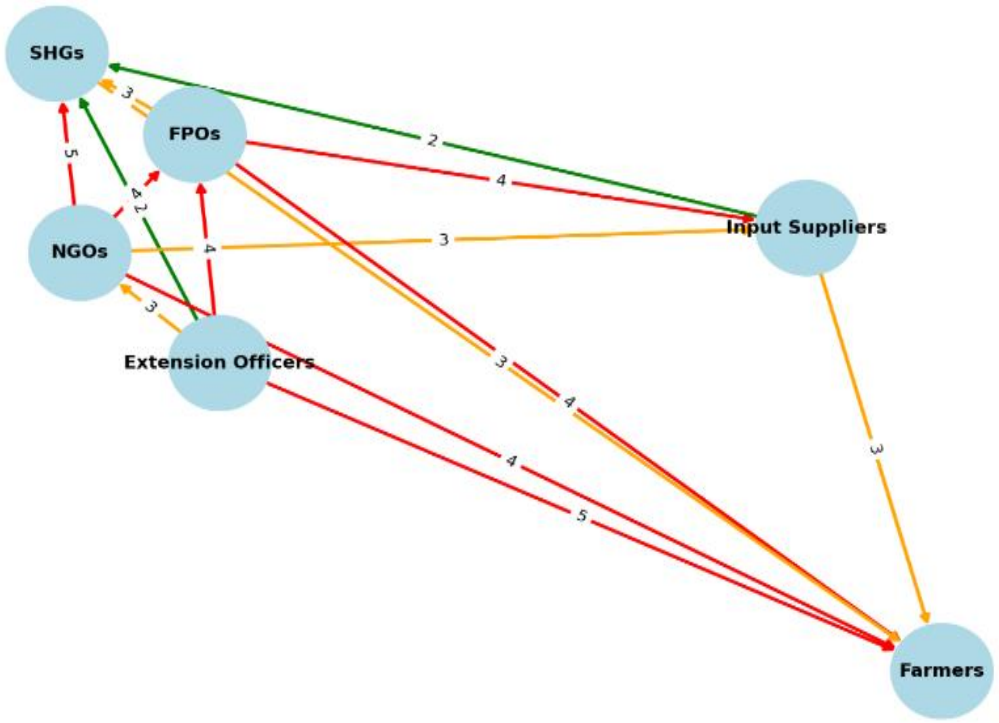

Fig. 1. Social Network Analysis

C. Centrality Metrics Summary

The results from Table 7 show that extension officers and NGOs hold central positions within the agricultural development network, acting as key facilitators of knowledge flow and coordination. FPOs serve as important intermediaries connecting farmers with resources, while SHGs and farmers have moderate influence with localized engagement. Input suppliers remain the least connected, indicating limited participation in collaborative initiatives.

D. Recommendations for Strengthening the Network

To reinforce weak connections, particularly among Input Suppliers, SHGs, and Extension Services:

- **Multi-Stakeholder Platforms**: Establish stakeholder forums to enhance trust, coordination, and joint planning across actors.
- **Integrated Extension Models**: Encourage Input Suppliers to participate in demonstration events and extension field

days to synchronize product offerings with regenerative needs.

- **SHG Capacity Building**: Deliver training on the identification and procurement of sustainable inputs, improving their autonomy.
- **ICT-Based Linkages**: Leverage mobile platforms or apps to facilitate direct communication between SHGs, farmers, and suppliers.
- **Incentive Mechanisms**: Provide certifications or preferential market access to Input Suppliers endorsing regenerative products.
- **Role of FPOs**: Strengthen FPO functions in aggregating demand, negotiating on behalf of SHGs, and ensuring access to quality inputs.
- **Continuous Network Monitoring**: Regular SNA assessments should be conducted to track changes in connectivity and adjust interventions accordingly.

4. CONCLUSION

Regenerative agriculture offers a sustainable alternative to conventional farming, addressing critical issues such as soil degradation, biodiversity loss, and climate change. This study underscores the pivotal role of diverse communication channels in promoting the adoption of regenerative practices among farmers in Andhra Pradesh and Telangana. Peer learning, social media, and extension services serve as influential conduits for knowledge exchange, while NGOs, FPOs, and SHGs contribute significantly to capacity-building through structured training programs and practical field demonstrations.

While regenerative agriculture yields substantial benefits such as improved soil health, efficient water use, and reduced reliance on chemical inputs its broader implementation is hindered by financial constraints, informational barriers, and insufficient policy frameworks. To overcome these challenges, the study advocates for a more organized and targeted approach to communication, emphasizing the need for actionable strategies and measurable outcomes. Enhancing farmer networks, expanding digital outreach, and blending experiential learning with formal advisory mechanisms can accelerate adoption. Moreover, integrating quantitative data and offering concrete policy recommendations will strengthen the scientific rigor and practical relevance of these initiatives. Building synergies among stakeholders including government bodies, input providers, and market actors will be vital in cultivating a supportive ecosystem for sustainable agricultural transformation.

By refining communication strategies and addressing systemic obstacles, regenerative agriculture can evolve from a niche concept into a mainstream solution, securing long-term food resilience, economic viability, and ecological balance.

5. POLICY IMPLICATIONS

1. **Mainstream Regenerative Agriculture**: Integrate regenerative practices into government schemes such as RKVY, PKVY, and MGNREGA to scale adoption across smallholder farming communities.
2. **Strengthen Communication Ecosystems**: Recognize **peer learning, extension services, and digital platforms** as essential public goods and invest in their expansion and quality enhancement.
3. **Promote Inclusive Collaboration**: Facilitate multi-stakeholder coordination (NGOs, SHGs, FPOs, input suppliers, and extension officers) through formalized local governance platforms.
4. **Target Weak Network Links**: Improve connections between **SHGs and input suppliers**, and between **farmers and policy influencers**, to ensure equitable access to eco-friendly inputs and information.
5. **Incentivize Private Sector Participation**: Provide subsidies, tax breaks, or recognition to input suppliers promoting regenerative inputs and partnering with community institutions.
6. **Invest in Capacity Building:** Design long-term **training programs for all actors**, especially SHGs and extension workers, focusing on regenerative techniques, participatory methods, and digital tools.

Actionable Recommendations by Stakeholder:

Farmers:

- **Participate in Farmer Field Schools (FFS)** and local demonstration plots to build hands-on knowledge.

- **Leverage digital tools** like WhatsApp and YouTube for real-time guidance on practices like live mulching, composting, and intercropping.
- **Form or join SHGs/FPOs** to access bulk inputs, technical advice, and marketing support.

Extension Officers:

- **Increase farmer-led demonstrations** and interactive sessions on lesser-known practices like no-till farming and agroforestry.
- **Partner with input suppliers** for co-delivered trainings to bridge gaps in product knowledge and adoption.
- **Promote digital literacy** by facilitating training on mobile apps and online learning platforms.

NGOs:

- **Strengthen community resource persons (CRPs)** to act as liaisons between research, extension, and farmer groups.
- **Create short videos, radio content, and podcasts** in local languages to reach low-literacy or remote populations.
- **Support SHG training** in eco-input assessment, procurement, and application.

FPOs:

- **Serve as input and knowledge hubs** for SHGs and smallholders, facilitating access to regenerative products.
- **Digitally map farmer needs** and organize bulk purchases for cost-effective input supply.
- **Document success stories** of regenerative adoption and share them through fairs and online platforms.

SHGs:

- **Engage in participatory learning activities** such as village-level workshops and exposure visits.
- **Negotiate as collectives** with input suppliers and FPOs for discounts and tailored solutions.
- **Promote savings-based models** to fund micro-enterprises in composting or nursery management.

Input Suppliers:

- **Conduct on-field demos** jointly with FPOs or NGOs to build trust and visibility of regenerative products.
- **Offer product kits** bundled with usage guides and helpline support for new users.
- **Partner in awareness drives** via fairs, WhatsApp broadcasts, and training camps to build brand and market reach.

Suggestions for Future Research:

1. **Quantitative Impact Assessment**
    - Future studies can measure the **direct impact of regenerative practices** on soil health, crop yield, and farmers' income across seasons using longitudinal or experimental designs.
2. **Comparative Analysis Across States**
    - Comparative studies between **different states or agro-climatic zones** can help understand regional variations in adoption drivers, communication effectiveness, and policy support.
3. **Digital Extension Effectiveness**
    - Evaluate the **effectiveness of digital platforms** (e.g., mobile apps, YouTube channels, WhatsApp groups) in scaling up regenerative knowledge and behavioral change among farmers.
4. **Gender and Social Inclusion**
    - Examine the **gender dynamics** and inclusion of **marginalized groups** in the adoption and promotion of regenerative practices, especially the role of women-led SHGs and tribal farmer groups.
5. **Behavioral Insights and Motivation Factors**
    - Explore the **psychosocial and economic motivations** influencing farmers' decisions to adopt or reject regenerative practices through behavioral science approaches.

6. **Role of Private Sector and Market Incentives**
    - Investigate the potential of **market-based instruments** (e.g., carbon credits, eco-labels, regenerative product premiums) and the role of **agribusinesses and input suppliers** in influencing adoption.
7. **Policy Experimentation and Design**
    - Conduct **policy experiments or pilot interventions** to assess which incentives (training, subsidies, insurance, certification) most effectively promote adoption at scale.
8. **Network Influence and Information Flow**
    - Use advanced **Social Network Analysis (SNA)** to trace how knowledge flows among farmers and stakeholders over time, and identify key influencers or bottlenecks.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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