P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating (2025): 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 9; September 2025; Page No. 613-616

Received: 17-07-2025
Accepted: 19-08-2025

Indexed Journal
Peer Reviewed Journal

Agricultural Innovation System (AIS) in Bundelkhand region of Uttar Pradesh: Linkages among Stakeholders

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DOI: https://www.doi.org/10.33545/26180723.2025.v8.i9i.2471

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Abstract

This study aimed to assess the role and linkages among stakeholders in the Agricultural Innovation System particularly in the Bundelkhand region of Uttar Pradesh. The study was conducted in all seven districts of the region during 2022–2025. A Total of 280 stakeholders (researchers, professors, extensionists in line departments, in-charge of NGOs, Managers of supporting institutions, owners of agro-service providers, and Progressive Farmers) were selected using the snowball sampling method. Respondents were individually interviewed to collect primary data. Actor-oriented tools, such as actors' linkage maps and actor linkage matrix, were used in the present study. The actor linkage map reflects that progressive farmers have strong linkages with all stakeholders in the study area. Researchers have moderate and strong linkages with stakeholders, owners of supporting institutions have strong linkages with owners of agro-service providers, and in-charge of NGOs of the Agricultural Innovation System. The actor linkage map also revealed that in-charge of NGOs have weak linkages with the owners of agro-service providers in the AIS.

Keywords: Actor linkage matrix, agricultural innovation system, stakeholders, relationship, snow ball sampling

Introduction

The idea of innovation can be traced back to Rogers' definition, which describes it as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 1962) [15]. Later, Gibbons *et al*. (1994) [3] noted that innovation is a complex concept that requires the merging of boundaries in the creation of scientific knowledge. From this foundational idea, the concept of innovation systems has developed. The term 'Systems of Innovation' was first introduced by Lundvall (1985) [8], who drew inspiration from Friedrich List's (1841) work. Agriculture has consistently been a key topic in global development discussions. Since a large portion of the rural population in developing nations depends entirely or partially on agriculture, the sector is vital for economic growth. Broadly speaking, agricultural challenges range from local infrastructure issues to global trade concerns. In this setting, the role of Agricultural Extension and Advisory Services (AEAS) is rapidly changing. Initially set up as agencies or organizations to offer technology or advice to farmers, AEAS has become an essential part of rural development. This transformation is driven by shifting dynamics, including reduced political and financial backing, the resulting downsizing and decentralization of the public extension system, and increased diversity with private and civil society organizations and ICT-based services (Sulaiman and Davis, 2012) [19].

According to Rogers (1962) [15], innovations that are seen as having a higher relative advantage, compatibility, trialability, and observability, while being less complex, tend to be adopted more swiftly than others. Agricultural innovation systems consist of a learning alliance network that includes a diverse range of stakeholders from both the public and private sectors, such as researchers, extension workers, progressive farmers' organizations, NGOs, input suppliers, marketers, and government policymakers, all working together to improve knowledge, skills, and products along the value chain (Maru *et al*. 2018, Klerkx and Begemann 2020, Zwane 2020) [9, 7, 21]. Innovations emerging from the R&D system are crucial for optimizing resource use. However, beyond structured experimentation, grassroots-level technologies and methods developed by

innovative farmers are significantly benefiting the farming community (Nain *et al*. 2024) [13].

The agricultural sector can bolster other economic sectors through backward and forward linkages, which are vital for any business. To strengthen these linkages, it is important to promote new farming approaches that cover all stages from production to consumption (Singh *et al*. 2023) [16]. The connections among stakeholders help in understanding the relationships between actors within an innovation system (IS) and highlight the strong and weak links within the network (Matsaert 2002; Biggs and Matsaert 2004; Hall 2007; Mohammad *et al*. 2012) [10, 1, 4, 12]. However, a drawback of this tool is its inability to assess the quality of these relationships or the specific nature of the connections (Matsaert *et al*. 2005) [11]. The processes of acquiring knowledge and learning within IS are inherently interactive, often requiring extensive linkages (Hall *et al*. 2006b) [5], such as partnerships, transactions, and networks. These connections, along with the relationships that govern them, are crucial for the flow of knowledge within an innovation system (Anonymous, 2012). The effectiveness of IS is shaped by policy and support structures, which sustain and activate various factors that nurture the system; therefore, sensitive policy formulation is essential to optimize IS outcomes (Hall *et al*. 2005, 2006a) [5]. The innovation system approach also provides a valuable framework for examining the linkages among stakeholders in agricultural innovation. These actors are associated with various entities, including companies, organizations, institutes, corporations, universities, and research centers. They can be classified as private, public, and NGO/semi-public, based on their size, funding sources, and operational focus as either service- or profit-oriented enterprises. These actors may operate at local, regional, national, or international levels (Suchiradipta and Raj, 2015) [18].

Research Methodology

The current study was conducted in all seven districts (Banda, Chitrakoot, Hamirpur, Mahoba, Jhansi, Jalaun, and Lalitpur) in the Bundelkhand region of Uttar Pradesh. The actor linkage matrix was used to study the linkage among different actors and the direction and strength of the information flow between them. Linkages must be mapped, and their nature and function must be understood, in order to comprehend interaction patterns. It is a useful tool for pinpointing particularly significant links, quantifying the strength of linkages, and consequently documenting a given situation or the outcomes of an event (Mohammed *et al*., 2012; Suchiradipta and Raj, 2014) [12, 18].

An in-depth study of primary and secondary sources was conducted to understand the linkage between sectors in the AIS. The various actors in the system were asked to indicate other actors from whom they received information and their reciprocal links with all other actors in the system. In the current study, observation was used to study the linkage and information-seeking and sharing behaviors of several actors in the agricultural innovation system through personal interviews. The discussions were open-ended. The answers received from the actors about their linkages with other actors in the agricultural innovation system were cross-checked with the latter. Information on the strength of the linkages and reciprocal linkages in the agricultural innovation system was summarized in matrix form.

Linkages in Actor linkage matrix

The matrix explained the direction of information movement. The matrix also revealed the strength of various linkages.

Strength of linkages

Strong
Moderate
Weak
Negligible
No linkages

Elements in the Actor Linkage Matrix

1. Researchers
2. Extensionists in the Line Department
3. In-charge of NGOs
4. Manager of Supporting Institution
5. Owner of Agro-service Providers
6. Progressive farmers

Results

Table 1 indicates that researchers had a strong linkage with progressive farmers and those in-charge of NGOs, followed by moderate linkages with extensionists, managers of supporting institutions, and owners of agro-service providers. The table shows that the extensionists and in-charge of NGOs and progressive farmers had a strong linkage with most stakeholders. Extensionists, researchers, managers of supporting institutions, and owners of agro-service providers had moderate linkages with the majority of stakeholders. The actor linkage matrix indicates that those in-charge of NGOs, extensionists, progressive farmers, and owners of supporting institutions had strong linkages with the majority of stakeholders. Researchers had moderate linkages with the majority of stakeholders, while agro-service providers had weak linkages with the majority of stakeholders, particularly those in charge of the NGOs. Managers of supporting institutions and in-charge of NGOs had strong linkages with the majority of stakeholders. Simultaneously, the managers of supporting institutions had a strong link with the owners of agro-service providers and progressive farmers. There was a moderate linkage between researchers and extensionists. Furthermore, owners of agro-service providers and progressive farmers had strong linkages with many stakeholders. Simultaneously, owners of agro-service providers had a moderate linkage with researchers and extensionists, but it was weak for those in charge of NGOs. The table also shows that progressive farmers had a strong linkage with all stakeholders. The findings are in resemble with the findings of Suchiradipta and Raj (2015) [18], Dominic *et al*. (2022) [2], Singh *et al*. (2023) [17] and Ramya *et al*. (2024) [14].

Table 1: Distribution of stakeholders according to their linkage with other stakeholders

Actors	Researchers	Extensionists	In charge of NGOs	Supporting institution	Agro-service providers	Progressive farmers
Researchers	-	Moderate	Strong	Moderate	Moderate	Strong
Extensionists	Moderate	-	Strong	Moderate	Moderate	Strong
In charge of NGOs	Moderate	Strong	-	Strong	Weak	Strong
Supporting institution	Moderate	Moderate	Strong	-	Strong	Strong
Agro-service providers	Moderate	Moderate	Weak	Strong	-	Strong
Progressive farmers	Strong	Strong	Strong	Strong	Strong	-

Discussion

The findings from the present study highlight the centrality of progressive farmers, in-charge of NGOs, and extensionists in strengthening the agricultural innovation system (AIS) in the Bundelkhand region. The Actor Linkage Matrix (ALM) revealed that progressive farmers maintained strong linkages with all stakeholders, confirming their role as crucial intermediaries between research, extension, and grassroots farming communities. This aligns with the notion of progressive farmers as "bridges of trust" who combine experiential knowledge with scientific inputs, thereby accelerating technology dissemination and adoption (Suchiradipta & Raj, 2015; Dominic *et al*., 2022) [18, 2]. Researchers demonstrated strong linkages with NGOs and progressive farmers and moderate connections with extensionists, supporting institutions, and agro-service providers. This suggests that while researchers contribute significantly to knowledge generation, their outreach is often mediated through other actors rather than direct engagement with all stakeholders. Similar patterns have been observed in other innovation system studies, where research institutions maintain selective but influential collaborations (Hall, 2007; Klerkx & Begemann, 2020) [4, 7]. Strengthening these moderate linkages could further integrate scientific knowledge with field realities. Extensionists emerged as key facilitators with strong ties to NGOs, progressive farmers, and researchers. Their role as coordinators of information flow reflects the pluralistic extension landscape in India, where public agencies increasingly collaborate with non-state actors and ICT-based platforms (Sulaiman & Davis, 2012) [19]. The strong partnerships between extensionists and in-charge of NGOs observed in this study resonate with the "interactive learning" principle of AIS, where trust-based collaboration enhances knowledge sharing and joint problem-solving (Hall *et al*., 2006b) [5]. In-charge of NGOs and managers of supporting institutions were also found to maintain strong linkages with most stakeholders, indicating their growing relevance in delivering services, capacity-building, and connecting farmers with markets and input providers. This reflects the ongoing diversification of extension beyond state agencies, consistent with earlier findings on pluralistic extension systems (Maru *et al*., 2018; Zwane, 2020) [9, 21]. However, agro-service providers exhibited weaker linkages with NGOs, suggesting a potential disconnect between commercial service providers and development-focused actors. Bridging this gap could enhance the effectiveness of value chain development in the region.

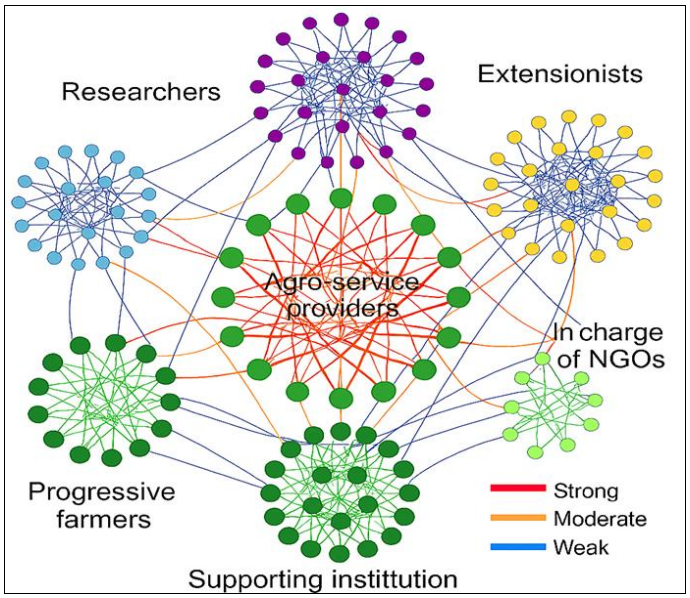

Fig 1: Linkage map of Stakeholders towards Agricultural Innovation System

Overall, the ALM results confirm that strong and moderate linkages dominate the AIS of Bundelkhand, with relatively few weak or negligible connections. The presence of multiple strong ties indicates a reasonably functional network that facilitates multidirectional information flows. Yet, the observed variations in the strength of relationships highlight opportunities for targeted policy interventions. For instance, fostering stronger researcher–extensionist–agro-service provider linkages could improve technology delivery and service integration. Similarly, promoting structured partnerships between in-charge of NGOs and agro-service providers may reduce fragmentation in

advisory services. These findings reinforce earlier conclusions that agricultural innovation systems thrive when actors engage in complementary roles within a network rather than as isolated entities (Biggs & Matsaert, 2004; Ramya *et al*., 2024) [1, 14]. In the Bundelkhand context, strengthening underdeveloped linkages while consolidating strong ones could address local challenges such as low productivity, market inefficiencies, and climate vulnerability. The results therefore underscore the need for policies that not only sustain existing linkages but also incentivize inclusivity and collaboration among diverse actors to maximize the potential of Agricultural Innovation System.

Conclusion

The study of the actor linkage matrix in the Bundelkhand region revealed that progressive farmers, in-charge of NGOs, and extensionists play pivotal roles in strengthening the agricultural innovation system. Progressive farmers demonstrated strong linkages with all stakeholders, confirming their role as central actors in technology dissemination and knowledge exchanges. NGOs and managers of supporting institutions also maintained strong connections with most actors, reflecting their growing importance in capacity building and service delivery. Researchers, while strongly connected with NGOs and progressive farmers, exhibited only moderate linkages with extensionists and agro-service providers, indicating the need to strengthen research–field interfaces in the region. Agro-service providers were well-linked with progressive farmers and supporting institutions but maintained weak ties with NGOs, highlighting a gap between commercial service delivery and development-focused actors.

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