Archives of Current Research International

Volume 24, Issue 8, Page 75-81, 2024; Article no.ACRI.122880
ISSN: 2454-7077

Centrality of Information Sources in Agricultural Input Networks: Insights from Social Network Analysis

Keesam Manasa [a++*], Basavaprabhu Jirli [b#], Sidharth S [a++], B. Srishailam [c†] and MD. Saifuddin [a++]

[a] Dairy Extension Division, National Dairy Research Institute, Karnal, Haryana, India.
[b] Centre for Multi-disciplinary Development Research (CMDR), Dharwad, Karnataka, India.
[c] Agricultural Extension, Krishi Vigyan Kendra, Longding, ICAR-Research Complex for NEH Region, Arunachal Pradesh, India.

Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/acri/2024/v24i8850

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/122880

Original Research Article

Received: 27/06/2024
Accepted: 31/08/2024
Published: 02/09/2024

ABSTRACT

Input dealers being credible localite sources of information for farmers have huge potential of aiding faster diffusion of innovations. Under this context, understanding how the input dealers' access and exchange information is essential for enriching them with updated information and improving the agricultural value chain. This study employs Social Network Analysis (SNA) to explore the centrality measures—degree centrality, closeness centrality, and betweenness centrality—of various

[++] Ph. D Research scholars;
[#] Director;
[†] Subject Matter Specialist;
**Corresponding author: Email: keesamsaimanasa1996@gmail.com;*

Cite as: *Manasa, Keesam, Basavaprabhu Jirli, Sidharth S, B. Srishailam, and MD. Saifuddin. 2024. "Centrality of Information Sources in Agricultural Input Networks: Insights from Social Network Analysis". Archives of Current Research International 24 (8):75-81. https://doi.org/10.9734/acri/2024/v24i8850.*

information sources utilized by input dealers in Nagar Kurnool and Wanaparthy districts of Telangana during 2020. The analysis reveals that traditional sources, such as extension agents and other input dealers, are highly central to the network, with both scoring the highest in degree and closeness centrality (0.733 and 0.698, respectively). These sources are not only frequently accessed but also serve as key bridges within the network, facilitating the flow of information. Digital platforms like smartphones show growing importance, with significant degree centrality (0.667), yet they play a less critical bridging role. In contrast, social media and print media exhibit lower centrality scores, indicating their peripheral influence. The findings suggest that while traditional information sources remain dominant, digital platforms are emerging as valuable tools for information dissemination highlighting the need for strategies that strengthen traditional channels while integrating digital tools to enhance the efficiency and reach of agricultural information networks. This research contributes to a deeper understanding of the complex information ecosystem in agriculture, offering insights for policymakers and stakeholders aiming to optimize information flows within the sector.

Keywords: Agricultural input dealers; social network analysis; centrality measures.

1. INTRODUCTION

India with its exploding population has reached the top of the ladder and became the world's most populous country with a population of 1.42 billion [1]. Ensuring food and nutritional security to this huge population becomes a tough task since the arable land is only 60.45 per cent of the total land area [2]. Along with these, Indian agriculture is characterised by fragmented land holdings, erratic monsoons, inadequate infrastructure, limited credit access, market inefficiencies, climate change, policy and implementation gaps, lack of modern technology adoption, agricultural distress and farmer suicides [3-4]. These factors ultimately affect agricultural productivity, sustainability and wellbeing of millions of farmers. One of the crucial ways to increase the productivity is by coupling the quality inputs with improved farm practices. Agricultural inputs which include chemicals, equipment, feed, seed, energy and information are considered as the heart of rural marketing and rural development [5]. They contribute to the growth of agriculture as well as farmers income. While tangible inputs contribute directly to farm productivity and profitability, intangible inputs like farm information invisibly contributes through helping the farmer to identify efficiencies, facilitating adoption of new innovations for profitable farming [6]. Input dealers, who serve as intermediaries between farmers and suppliers, are pivotal in the distribution of agricultural inputs such as seeds, fertilizers, and pesticides. They are often the first point of contact for farmers seeking advice on crop management and technology adoption. Understanding the dynamics of how these input dealers' access and exchange information is therefore essential for improving the overall agricultural value chain. Social network analysis (SNA) provides a robust framework for exploring the relationships and interactions among various stakeholders within a network [7-8]. Social Network Analysis (SNA) explores social structures using the principles of networks and graph theory. It includes both quantitative analysis (using measures) and qualitative analysis (using maps) of relationship dynamics [9] tracking changes in relationships among entities with knowledge by assigning values to the connections within the network. SNA primarily focuses on the interactions between individuals rather than their internal characteristics. Network data consists of actors, called nodes, and the relationships between them, known as ties or edges, illustrating how these actors are integrated into the broader network. SNA also accommodates sampling methods, including the 'full network' approach for comprehensive analysis. Centrality in Social Network Analysis (SNA) refers to the importance or influence of a node (an actor or entity) within a network. By examining the centrality measures—such as degree centrality, closeness centrality, and betweenness centrality—of different information sources utilized by input dealers, we can gain insights into the flow of information and identify key influencers within the network. This study aims to analyse the centrality of various information channels, including traditional sources like extension agents and universities, as well as digital platforms such as smartphones, WhatsApp, and social media. The findings from this analysis will help in identifying the most influential information sources and understanding the structure of information networks among input dealers. Such insights can inform the

development of targeted interventions to enhance the efficiency of information dissemination, ultimately supporting better decision-making processes and improving agricultural outcomes.

2. METHODOLOGY

The study was conducted in Nagar Kurnool and Wanaparthy districts of Telangana state during the year 2020. Ex post facto research was employed. Under Nagar Kurnool district, Nagar Kurnool, Bijnepally and Achampet mandals were selected and Under Wanaparthy district, Wanaparthy, Kothakota and Pebbair mandals were selected randomly. A total of 60 input dealers were selected on the basis of random sampling, taking 10 from each mandal making a total of 30 from each district. Data was collected using a structured questionnaire and in-depth interviews which was designed to capture details about the information sources used by input dealers, including traditional sources (extension agents, universities, print media) and digital platforms (smartphones, WhatsApp, YouTube, Facebook). In addition to the questionnaire, interviews were conducted with a subset of the input dealers to gain deeper insights into the nature of information exchange and the role of interpersonal relationships within the network. Social network analysis was employed to examine the structure and dynamics of information exchange among input dealers. Obtained data was analysed using software to calculate the centrality measures and visualize the networks.

3. RESULTS

3.1 Degree Centrality

Degree centrality measures of the sources of information of the input dealers are presented in the Table 1. Degree centrality referrers to the number of direct connections a node has with other nodes i.e., an information source. A higher degree centrality indicates that the information source is more frequently accessed or interacted with by input dealers. It was observed that Extension agents and other input dealers recorded highest centrality values (0.733) which indicates that they are most frequently consulted sources of the input dealers. Next to that were smartphones with a degree centrality of 0.667. University recorded the next value with 0.600 followed by WhatsApp and Facebook both recording 0.550. Lowest degree centrality was noticed with Print media (0.133).

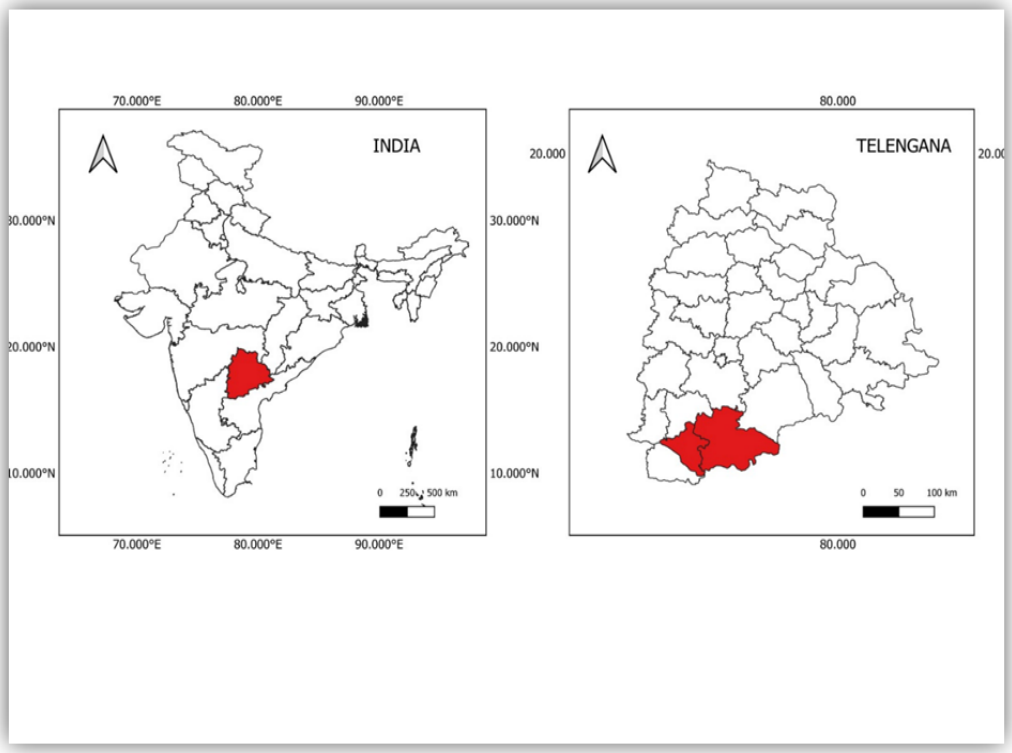

Fig. 1. Location of study area in Telangana state

Table 1. Degree Centrality measures of Information sources of input dealers

Sl. No	Source of Information	Degree Centrality
1	Extension Agent	0.733
2	University	0.600
3	Smartphone	0.667
4	Print media	0.133
5	Other Input Dealers	0.733
6	WhatsApp	0.550
7	YouTube	0.550
8	Facebook	0.400

3.2 Closeness Centrality

Table 2 unfolds the Closeness centrality measures of the input dealer's information sources. Closeness centrality measures how quickly a node can access information from all other nodes in the network. A higher closeness centrality means the information source is in a favourable position to quickly gather information from the network. It is evident from the data that Extension agents and other input dealers both score high in closeness centrality (0.698), indicating that they are not only frequently accessed but also in positions where they can quickly disseminate or receive information across the network. Next immediate one was smartphone (0.649) followed by university (0.607). WhatsApp and YouTube both recorded a closeness centrality of 0.578 followed by Facebook with 0.507. The least closeness centrality of all was recorded by print media (0.416) which suggests that it was not only least used but also less effective in quickly spreading information within the network.

Table 2. Closeness Centrality measures of Information sources of input dealers

Sl. No	Source of Information	Closeness Centrality
1	Extension Agent	0.698
2	University	0.607
3	Smartphone	0.649
4	Print media	0.416
5	Other Input Dealers	0.698
6	WhatsApp	0.578
7	YouTube	0.578
8	Facebook	0.507

Table 3. Betweenness Centrality measures of Information sources of input dealers

Sl. No	Source of Information	Betweenness Centrality
1	Extension Agent	0.188
2	University	0.124
3	Smartphone	0.128
4	Print media	0.004
5	Other Input Dealers	0.369
6	WhatsApp	0.068
7	YouTube	0.067
8	Facebook	0.029

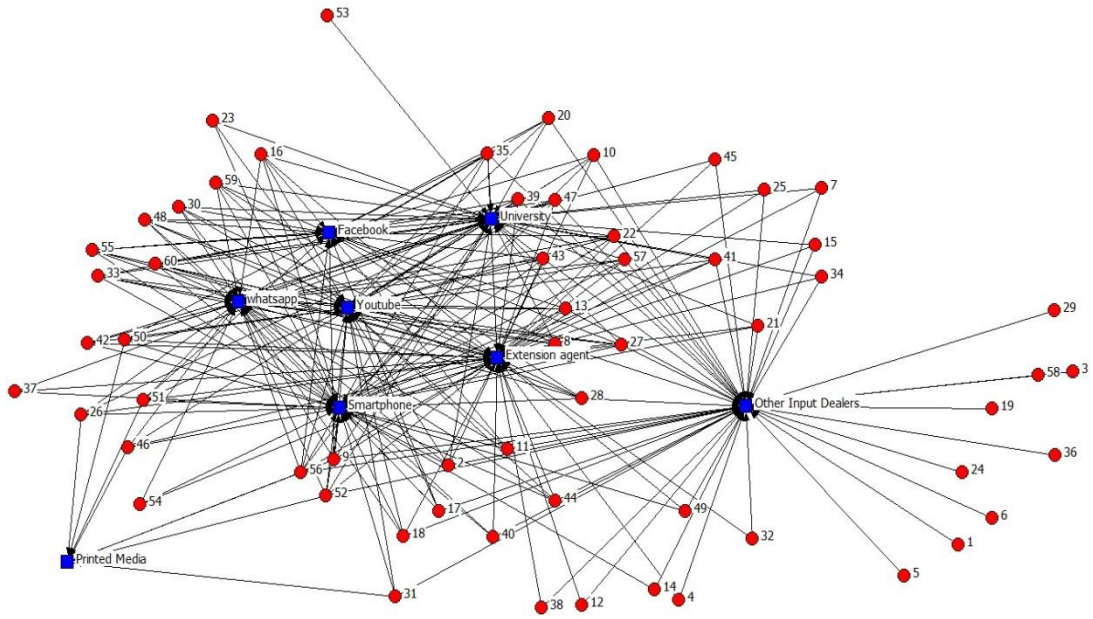

Fig. 2. General Information Network of Input Dealers

3.3 Betweenness Centrality

A glimpse of measures of Betweenness centrality were presented in Table 3. Betweenness centrality measures the extent to which a node acts as a bridge within the network, controlling the flow of information between other nodes. A higher betweenness centrality indicates a more significant role in connecting different parts of the network. The results revealed that other input Dealers source has the highest betweenness centrality (0.369) among all indicating that it serves as a crucial intermediary or connector within the network. Extension agent are the next important bridges with a betweenness centrality of 0.188. they were followed by smart phone and university which recorded values of 0.128 and 0.124 respectively. WhatsApp and YouTube almost recoded the same values i.e., 0.068 and 0.067 respectively followed by Facebook (0.029). Lastly the least betweenness measure was obtained by print media with a value of 0.004.

4. DISCUSSION

The results of the social network analysis of information sources among agricultural input dealers provide important insights into the dynamics of information dissemination within this critical sector. The centrality measures—degree centrality, closeness centrality, and betweenness centrality—revealed the varying roles and influences of different information sources in shaping the knowledge and practices of input dealers. The findings were clearly showing the dominance of traditional information sources. The high degree and closeness centrality scores of extension agents [10] and other input dealers underscore their continued dominance as key information sources within the agricultural sector. With both scoring the highest in degree centrality (0.733) and closeness centrality (0.698), it is evident that these traditional sources are heavily relied upon by input dealers for timely and relevant agricultural information [11-12]. This finding is consistent with the understanding that personal interactions and trust-based relationships are crucial in the agricultural sector, where input dealers often prefer to rely on direct advice from experts and peers rather than newer, less personal sources. The role of other input dealers as significant information brokers is further emphasized by their high betweenness centrality (0.369), indicating that they frequently act as intermediaries in the network, facilitating the flow of information between different sources. This highlights the importance of peer networks among input dealers, where the exchange of knowledge and experiences among colleagues serves as a vital channel for information dissemination. Apart from the dominance of the traditional information sources it is also conveying the growing importance of the digital platforms. This was indicated by the relatively high degree and closeness centrality of smartphones (0.667 and 0.649, respectively) that depicts the growing importance of digital platforms as tools for accessing agricultural information. The smartphone, as a versatile and readily accessible tool, has become an essential part of the information ecosystem for input dealers. This shift towards digital platforms is likely driven by the increasing availability of agricultural apps, online resources, and real-time updates, which provide input dealers with convenient and diverse sources of information. However, the lower betweenness centrality of smartphones (0.128) suggests that while they are widely used, they do not play as significant a bridging role within the network as traditional sources. This could be due to the fact that digital platforms, while efficient in disseminating information, may not yet be fully integrated into the interpersonal networks that are crucial for bridging different parts of the agricultural information network. Further the centrality measures for social media platforms like WhatsApp, YouTube, and Facebook, as well as for print media, reveal their relatively limited influence within the network. While WhatsApp and YouTube have moderate degree centrality (0.550), their low betweenness centrality scores (0.068 and 0.067, respectively) indicate that these platforms are not central to the information exchange network and do not significantly influence the flow of information between other sources. Print media, with the lowest degree centrality (0.133) and closeness centrality (0.416), is evidently the least utilized source of information among input dealers. Its minimal betweenness centrality (0.004) further highlights its peripheral role, suggesting that it is not a preferred medium for accessing or disseminating information within the network. This decline in the influence of print media is likely due to the shift towards digital sources that offer more timely, interactive, and accessible information.

5. CONCLUSION

The findings emphasize the complexity of the information landscape in agriculture, where traditional and digital sources coexist and complement each other in influencing the practices and decisions of input dealers.

Understanding and leveraging these dynamics is crucial for enhancing the efficiency and effectiveness of information dissemination in the agricultural sector. These findings suggest that traditional sources like extension agents and peer input dealers remain vital in the information dissemination process, while digital platforms, although growing in importance, have not yet surpassed the influence of traditional channels in this context. Given the central role of extension agents and peer networks, efforts to improve the effectiveness of these traditional sources should be prioritized. Strengthening the capacity of extension services and fostering stronger connections among input dealers could further enhance the flow of valuable agricultural information. At the same time, the increasing role of digital platforms, particularly smartphones, suggests a growing opportunity to leverage technology in reaching input dealers. While these platforms are not yet central to the network, their widespread use indicates significant potential for growth. Developing more targeted and integrated digital tools, such as mobile apps and online platforms tailored to the needs of input dealers, could enhance their influence within the network and complement traditional information sources. Further, implications based on the findings on degree centrality for future research are mentioned below which could contribute to developing strategies for improving information dissemination and adoption of new technologies in the sector:

1. **Exploration of Digital vs. Traditional Sources**: Since extension agents and other input dealers have the highest degree centrality, future research could explore why traditional sources still dominate despite the growing presence of digital platforms like smartphones. Investigating factors such as trust, accessibility, and the perceived reliability of traditional vs. digital sources would provide deeper insights into the dynamics of information dissemination.
2. **Impact of Social Networks on Information Flow**: Given that high degree centrality is associated with frequent interactions, future studies could examine how the social networks of input dealers influence the degree centrality of different information sources. Research could focus on understanding how social connections, trust, and community networks affect the choice and frequency of using specific information sources.
3. **Adoption of Digital Platforms**: The relatively high degree centrality of smartphones indicates their growing importance as an information source. Future research could investigate the factors driving the adoption of digital platforms among input dealers. Studies could also explore barriers to adoption and how these platforms can be better integrated into the information ecosystems of input dealers.
4. **Longitudinal Studies on Centrality Shifts**: Conducting longitudinal studies to track changes in degree centrality over time would help identify trends in how the use of information sources evolves. Such research could reveal shifts in the reliance on traditional vs. digital sources and how these shifts impact the overall network structure.
5. **Contextual Differences Across Regions**: Future research could explore whether the degree centrality of information sources varies across different geographic regions or agricultural contexts. Comparative studies could identify regional differences in the use of information sources and provide insights into how local factors influence centrality measures.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that generative AI technology named Chat GPT version 3.5 was used for interpretation of data while writing the manuscript

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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