



RESEARCH ARTICLE

Social network dynamics of direct seeded rice (*Oryza sativa* L.) farmers

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Abstract

Direct seeded rice (DSR) is a time, cost and resource-efficient alternative to conventional rice transplanting, but farmers face challenges in its adoption. This study aims to analyse farmers' social networks to understand how they access information on DSR practices and identify key influencers to promote wider adoption. The study was conducted during 2021 and 2023 using a three-stage sampling process to interview 240 technology-adopter farmers from Bhagalpur and West Champaran districts of Bihar, India to analyse the social networks of farmers practicing DSR. The study revealed that formal communication sources (government agencies and extension agents) were the most important sources of information, followed by the progressive farmers, farmer friends and input dealers for key informational support regarding DSR technology. These various sources can be utilised as channels for disseminating information about agricultural innovations, including DSR. The results of this study will aid public and private organisations in promoting new ideas among farmers through these established social networks.

Keywords: Bihar; communication source; direct seeded rice; innovation; social network analysis; technology adoption

Introduction

Rice (*Oryza sativa* L.) is the principal staple crop of more than 60 % of the world population and it is the most important crop in terms of global food security (1). Due to its strategic importance in global food, Rice is one of the most important staple food crops in the world, feeding more than half of the global population and playing a crucial role in food security, livelihoods and economic development. Given its strategic importance in global food systems, enhancing and sustaining rice productivity remains a major concern for researchers, policymakers and farming communities worldwide. In this global context, India plays a pivotal role in rice production. As the second-largest producer of rice after China, India contributes significantly to global rice output and food security. This prominent position has further strengthened India's status as an agricultural powerhouse and highlights the need for continuous efforts to improve rice productivity and sustainability in the country (2). In some regions, such as Bihar, as per 2022–23, rice is cultivated on about 3.2 million hectares (Mha), mostly under rainfed conditions, with annual production ranging between 5 and 7 million tonnes (Mt) and average yields of 2400–2500 kg/ha though 25 of 37 districts remain low-yielding (1000–1500 kg/ha) compared to 3900–4000 kg/ha in Punjab and Haryana. Conventional puddled transplanting, the dominant practice in the state, is water and labour-intensive, degrades soil structure by forming a hardpan that hampers subsequent crops, contributes to higher methane emissions and faces growing constraints from labour shortages and groundwater depletion. These challenges have driven interest in resource-conserving alternatives like direct seeded rice (DSR). However, the traditional technique of transplanting rice into standing water in puddles is still

used, which is increasingly being questioned on the grounds of its low labour productivity and water-intensive nature, as well as its long-run. The soil physical structure degradation adversely affecting its quality and productivity (3). A promising alternative to traditional transplanting is DSR, a method where rice seeds are sown directly in the field in specific rows, bypassing the need for transplanting seedlings from nurseries (4). Direct seeded rice is less labour-intensive, allows for mechanisation, conserves water and improves yields by 3–17 % compared to transplanted rice. It also uses 19 % less water and enhances water productivity by 25–48 % (5). Direct seeded rice, as a modern approach to enhancing rice productivity, needs broader adoption to fully realise its potential (6). Thus, wide level adoption of innovation of this kind is influenced by multiple factors, such as the decision-maker's personality, social connections, individual circumstances and family status. The adoption process begins when potential users share information with facilitating agents and most of this information is disseminated through interpersonal channels within these networks (7, 8). A social network is a web of interconnected individuals (9) and social network analysis (SNA) is used to study the relationships between individuals, organisations and entities that facilitate information flow (10). Understanding these social networks is crucial for agricultural authorities and extension planners, as they can identify and leverage key communication channels to effectively disseminate information to farmers (11). The characteristics of these networks can either promote or hinder the adoption of DSR (12). Direct seeded rice has emerged as a promising alternative to conventional transplanting methods due to its potential to reduce labour requirements, water use and production costs while maintaining crop productivity. However, the adoption and diffusion of DSR technology are

influenced not only by its technical advantages but also by farmers' social interactions, information exchange patterns and access to knowledge networks. Understanding these social dynamics is essential for promoting wider adoption of DSR among farming communities. Social networks are conceptualised as a set of interconnected actors who engage continuously to negotiate, create opportunities and meet individual or collective goals (13). These networks facilitate essential information flow, help reduce information asymmetry and provide access to resources necessary for adopting farm innovations. (14). These networks are usually regarded as an imperative process through which smallholder farmers can access agricultural information and innovation as well as major determinants of social learning (15). Nonetheless, the spread of technology in a network is determined by the comparative location of different network actors, their size and structure and the structure of the network (16). The way in which people get information in various sources can be exposed through distinct structural patterns of social relations (17). According to the network approach, the structure and dynamics of social systems are shaped more by the relationships among actors than by the individual attributes of those actors (16). In this attempt, the structural patterns of network related to information flow of rice farmers in DSR are mapped based on this proposition. Several sources of information that the respondent farmers had on DSR-related matters were identified and categorised to be applied in this study (18). The local interpersonal sources usually interrelate within boundaries of a certain community whereas the cosmopolite interpersonal ones relate farmers with sources outside the local social structure (19). The various information sources or actors, involved in the dissemination of DSR technology include both formal institutional channels namely the agriculture technology manager (ATM), block technology manager (BTM) and Krishi Vigyan Kendra (KVK) and informal peer-based channels, comprising progressive farmers, opinion leaders and farmers' friends.

Communication patterns and information systems are widely being studied through the utilisation of social network theories and mapping techniques (20). Social network analysis challenges the traditional perception of analysing an individual as the unit and advances the investigation of the relationship between individuals (17, 21). The centrality measures of SNA are also to be used to explore the properties of the social ties on a specific aspect (22). Previous studies indicate, SNA is widely utilised among scientists to map and describe information networks especially in relation to a certain technology (23). For DSR farmers, these networks enable the exchange of timely knowledge and innovations related to DSR practices, allowing them to stay updated on advancements and best practices in DSR technology (24). Social networks are particularly important for smallholder farmers, as they act as key mechanisms to access information and innovation relevant to DSR practices and play a crucial role in social learning (25). The network approach thus posits that we should focus on relational properties between units, rather than individual units themselves, to understand how DSR information flows.

This study uses SNA in mapping these structural features, which are the important sources of information to DSR farmers. Sources are categorised into three types, cosmopolite interpersonal which involves linking farmers to external sources outside the community, local interpersonal which involves linking at the

community level and cosmopolite impersonal which is mainly the mass media sources with no direct interaction. The analytical tools of SNA diverge from the traditional unit approach of analysis in that an interaction between the members of a social network is analysed to examine how DSR farmers exchange information about DSR techniques. The measures of centrality also help to understand such social ties. This study is based on the social constructivism and social learning theory to analyse these dynamics. Social constructivism brings attention to the role of social interactions in the process of knowledge construction, in which DSR farmers tend to appreciate peer learning and experience sharing. This strategy assists in describing how the knowledge about the DSR methods is gained by the active interaction with informed actors in the network. Moreover, homophily (the propensity of people to relate and connect with others who share similar features, interests, or demographics) is a common feature of such interactions facilitating mutual understanding and influencing DSR adoption choices. The social learning theory explains the way in which the alterations in the individual level of understanding spread to the extended communities of practice by means of social activity. The advantage of having a dense DSR network is that the social learning is enhanced by greater information exchange between actors, thereby promoting collaborative learning due to the close, deliberate connections. Nevertheless, social learning varies with the differences in networks and this affects the potential of each farmer to obtain and share knowledge related to DSR within the networks. Using SNA to analyse the networks of DSR farmers, this paper aims to reveal the dynamics of social networks that motivate DSR adoption and how farmers exploit such networks to gain a better insight and utilisation of DSR innovations.

Materials and Methods

The study was conducted in the Indian state of Bihar between 2021–23, employing a descriptive research design. A total of 240 respondents were selected from Bhagalpur and West Champaran districts, which were purposively chosen due to their relatively higher adoption of DSR technology and the successful implementation of DSR promotion programmes in these areas (Department of Agriculture, Government of Bihar, 2024). These districts have emerged as important centres for DSR adoption, making them suitable locations for studying farmers' social networks and information exchange patterns related to the technology. A multistage sampling procedure was adopted for the study. Bhagalpur and West Champaran districts were purposively selected based on the prevalence of DSR cultivation and the respondent farmers were then selected randomly from the identified DSR adopters in the selected districts. Data collection involved the use of a semi-structured interview schedule and multiple techniques, including household surveys and key informant interviews. To assess social networks variables, all the respondents were asked about their preferred information sources across five key information domains: seed/planting materials, fertilisers and plant protection inputs, irrigation, harvesting and government initiatives. These five information domains were pre-selected and ranked through participatory rural appraisal (PRA) exercises and focus group discussions (FGDs) conducted with villagers prior to the field survey.

Social network analysis

Social network analysis method was used to outline respondents' information networks concerning the identified technology (26). Network mapping served as a tool to examine the connections between various information sources (27). To gain a comprehensive view of the operational information network on climate-smart (CS) practices, bimodal networks of the diverse information sources were created which involves two distinct node types here, farmers and information sources (extension agents, progressive farmers, friends, input dealers) with links only running between the two sets, not within either. Survey questions were structured based on prior studies to outline network structures related to CS information flow (28). UCINET-6 for Windows, a comprehensive social network analysis program was used to analyse the network data (28). Additionally, the network visualisation tool NetDraw was utilised to arrange nodes in 2-dimensional (2D) space and perform basic network analysis. Key node characteristics were described using statistical criteria such as degree, closeness and betweenness centrality scores. Network properties were characterised by measures of centrality (degree/closeness/betweenness), network size, network density and network centralisation. List of actors in the information diffusion process is presented in Table 1.

Results and Discussion

The analysis revealed distinct patterns of information exchange among DSR farmers across the five information domains. Variations were observed in the structure and intensity of communication networks, reflecting differences in farmers access to information and knowledge sources. Data was collected using a household survey to examine information flows and communication patterns related to DSR among farming communities. The study focused on five key information domains: seed and planting materials (SPM), fertiliser and plant protection (FPP), irrigation (I), harvesting (H) and government schemes (GS), as presented in Table 1. The network analysis employed centrality information of network as a whole and ego network and produced the network diagrams to provide details of the flow of information within community in each of the five categories of information. The social network analysis of information flow on different domains of the DSR with varying patterns in centrality measurements as well as demonstrating the structural location and power of actors within the network (Table 2).

The density of the whole network fluctuated between 16–23 % amongst which the highest value was 23 % in the irrigation and government scheme domains, which means that actors in these domains were more interconnected. The means of the degrees were between 1.9–2.6 indicating that each actor had around two connections on average; therefore, the findings are consistent with the earlier studies, which suggest that extension networks in Indian agriculture tend to have sparse links that are functionally meaningful (29, 30).

Degree centrality

The results of in-degree and out-degree centralities show that the information exchange is evenly distributed in domains. The SPM domain exhibited mean in-degree and out-degree values of 2.8. The corresponding in-degree and out-degree centralisation indices were 16.7 % and 4.1 %, respectively, indicating a moderate concentration of information receiving ties and a relatively dispersed pattern of information sharing within the network. This indicates the absence

Table 1. Network measure on various domains

Centrality measures	Seed and planting material domain			Fertiliser and plant protection domain			Irrigation domain			Harvesting domain			Government scheme domain		
	Mean	Std. Dev.	Centralisation	Mean	Std. Dev.	Centralisation	Mean	Std. Dev.	Centralisation	Mean	Std. Dev.	Centralisation	Mean	Std. Dev.	Centralisation
In degree centrality	2.8	3.0	16.7	2.0	2.8	13.5	2.3	2.5	9.8	2.2	2.8	16.6	2.3	3.5	15.2
Out degree centrality	2.8	1.2	4.1	2.0	2.0	2.8	2.3	2.3	3.7	2.1	2.1	2.7	2.8	2.8	1.7
In closeness centrality	6.5	9.8	14.9	10.9	8.9	25.3	9.6	9.2	20.7	7.3	8.2	16.5	9.2	8.2	20.8
Out closeness centrality	8.4	8.45	20.7	8.4	8.45	20.5	9.4	6.9	19.7	4.7	4.87	16.3	6.2	6.2	19.9
Betweenness centrality	35.6	53.9	3.3	169.9	337.2	6.5	112.9	203.5	8.9	61.84	125.6	7.5	104.9	188.9	9.7
Particulars	Network density- 16 No. of ties- 234 Avg. degree- 1.9			Network density- 21 No. of ties- 297 Avg. degree- 2.4			Network density- 23 No. of ties- 322 Avg. degree- 2.4			Network density- 21 No. of ties- 256 Avg. degree- 2.3			Network density- 23 No. of ties- 322 Avg. degree- 2.6		

Table 2. List of information sources in direct seeded rice (DSR) networks

Sl. No.	Various information sources of DSR or actors
1	Agriculture technology manager
2	Block technology manager
3	Farmers friend
4	Progressive farmers
5	Opinion leaders
6	Krishi Vigyan Kendra

DSR: direct seeded rice.

of single dominating actor who receive and spread information on seeds, overbearing the flow. The same moderate decentralisation was found in fertiliser and plant protection domain (in-degree 13.5; out-degree 2.8) and irrigation domain (in-degree 9.8; out-degree 3.7 %). These outcomes are like previous research in which the existence of decentralised mechanisms of knowledge diffusion were observed to boost the ability of farmers to integrate resource-saving technologies (20).

When comparing the government scheme domain, it was recorded that there were moderate in-degree centralisation (15.2 %) and low out-degree centralisation (1.7 %), which implies that the actors can obtain information about schemes through many sources and fewer actors directly spread information about schemes. This minimum external flow may help create delays in awareness and enrolment, which is in line with evidence of poor last-mile correspondence in agricultural programs (31).

Closeness centrality

Centrality aspects that were in-closest were the highest in fertiliser and plant protection domain (mean 10.9, centralisation 25.3 %), which implies that the actors of this network have access to information more rapidly than in other domains. Closeness centrality in this area is high indicating effective flow of information, this pattern may be due to strong interactions among input dealers, extension agents and peer farmers, which facilitate the exchange of information and knowledge within the network. Similarly, irrigation domain also exhibited high values of closeness (mean 9.6, centralisation 20.7 %), which can be explained by the critical position of irrigation information in the performance of DSR and the propensity of farmers to participate in water-related advisories (32).

The centrality patterns were also more comparable and the irrigation domain recorded the highest mean of 9.4 meaning that actors who shared knowledge concerning irrigation would have a greater influence on the network. The lowest scores were registered in the harvesting domain (mean 4.7) representing more lengthy channels of relaying information and perhaps lower perceived significance of acquiring information in the initial decision phases of DSR.

Betweenness centrality

Betweenness centrality was the most varied in domains. The highest mean value was observed in the fertiliser and plant protection (169.9, SD 337.2), which is indicative of the existence of several very powerful brokers, who regulate the flow of important information. These results confirm previous reports that there is a tendency of input dealers and progressive farmers to be the key brokers in crop management networks (33). The government scheme domain (mean 104.9) and irrigation domain (mean 112.9) also portrayed important brokerage functions, which represent strategic actors that help to overcome gaps between farmers and institutional agencies.

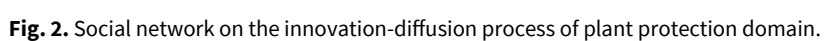
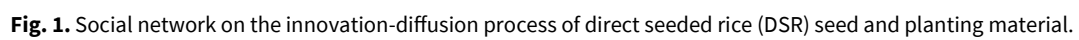
On the other hand, the area with the least betweenness (mean 35.6) was the seed and planting material domain, which indicates that flow of information distribution is more balanced and less reliant on important mediators. This type of decentralising has been observed in seed dissemination networks where community-scale sources of seeds have diminished dependency on individual nodes (34).

Domain wise important network actors

The social network measures on seed and planting material domain of DSR in the sampling area (Fig. 1). The main actors in diffusion process were with the scores of 91, 41 and 21 which were government institution, input dealers and extension officers from farm science centre respectively. The network measures in the plant protection domain. The key actors in the information-sharing network were nodes 105, 104 and 106, representing Farm Science Centre (KVK) officials, progressive farmers and Agricultural University personnel, respectively (Fig. 2). These actors occupied central positions in the network and played a significant role in disseminating plant protection information among stakeholders. Irrigation domain of DSR information network is showed in Fig. 3 where the central actors in diffusion process were 91, 93 and 95 who are opinion leaders, government institutions and input dealers respectively. The network measures for the harvesting domain of DSR (Fig. 4). The most influential actors identified in the network were actor 110 (progressive farmer), actor 41 (village-level worker) and actor 22 (input dealer). Their high network centrality suggests that they served as major information hubs, playing a pivotal role in the diffusion of harvesting technologies and practices within the farming community. The network measures in the government schemes domain of DSR (Fig. 5). The key actors in the information diffusion network were nodes 120, 118 and 36, representing block agriculture officers, input dealers and Farm Science Centre (KVK) officials, respectively. Their central positions in the network indicate their significant role in disseminating information related to government schemes and facilitating farmers' access to various agricultural support programmes.

Conclusion

The present study investigated the farmers' social networks across five domains, such as seed and planting material (SPM) domain, fertiliser and plant protection measures domain, irrigation domain, harvesting domain, government schemes domain was studied in the present investigation. Based on the result of the study it is concluded that indegree centrality was high for the government schemes domain. The results revealed that the out-degree centrality was high for the plant protection domain. The in-closeness and out-closeness centrality were high for the plant protection domain and seed and planting material domain respectively. The betweenness centrality was high for plant protection domain. Overall, the highest rate of diffusion occurred in plant protection domain. The irrigation domain and government scheme domain had largest network density and number of ties in the whole network. Average degree was high for government scheme domain. The main actors in diffusion process in these domains were government officials, extension workers, agricultural universities, progressive farmers and farm science centres. As seen social network through the help of these stakeholders spread of information to another farmer in farmer's network occurs. Importance must be given to these



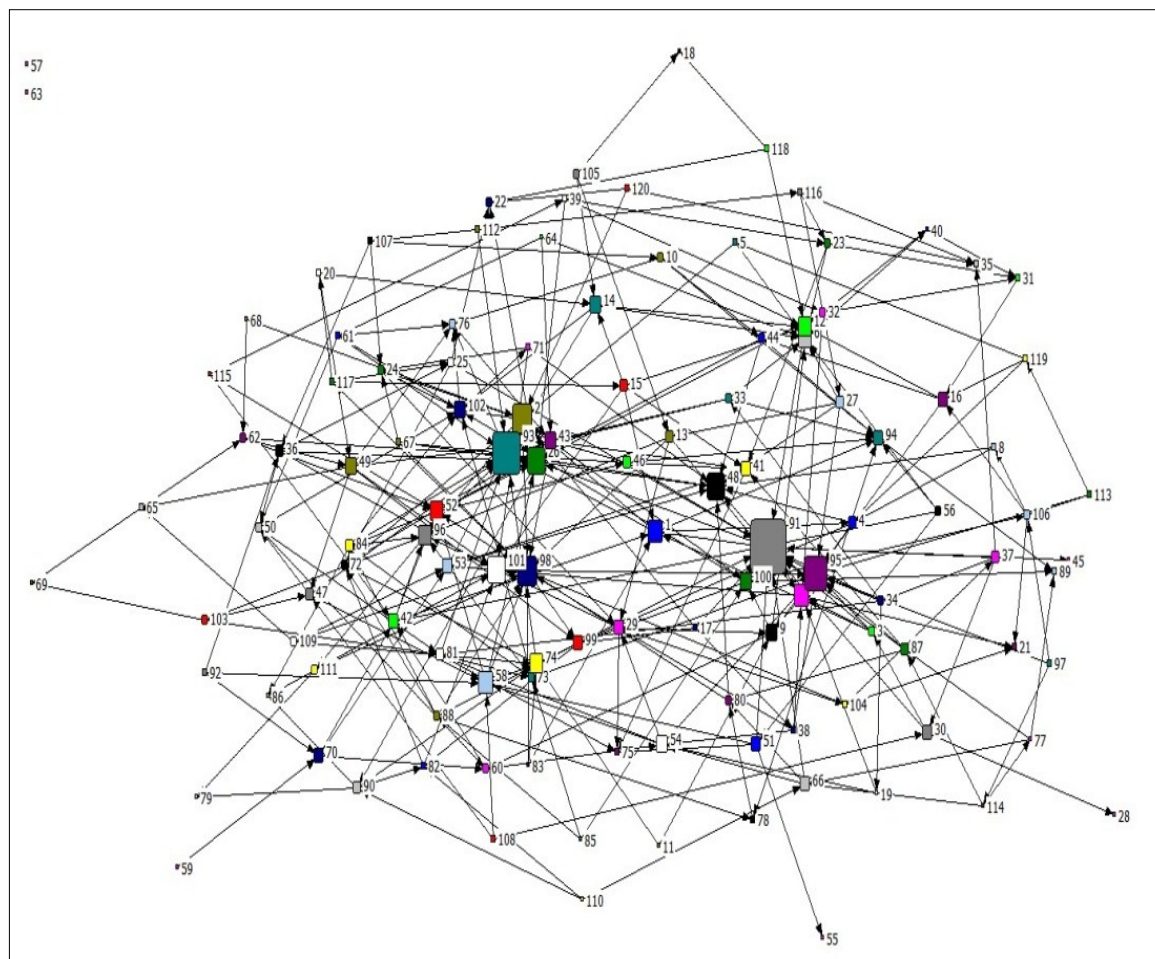


Fig. 3. Social network on the innovation-diffusion process of direct seeded rice (DSR) irrigation.

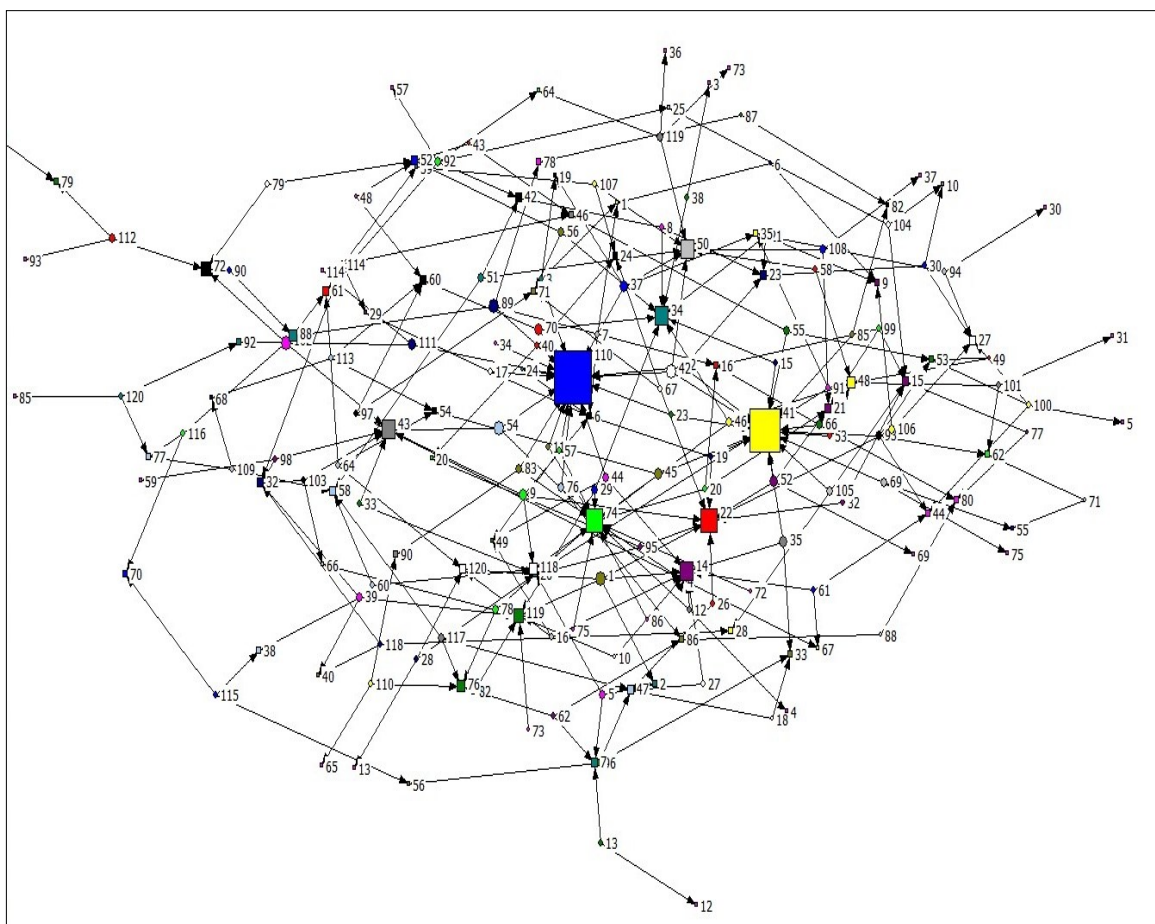


Fig. 4. Social network on the innovation-diffusion process of direct seeded rice (DSR) harvesting.

stakeholders to accelerate the diffusion process in farmer network for timely and effectively diffusion of direct seeded rice (DSR) technology or any other agricultural innovation.

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References

- Government of India; 2026.
3. Mishra AK, Kumar S, Singh R. Sustainable rice intensification in Bihar: Overcoming the pitfalls of traditional puddling. *Indian J Agric Sci.* 2025;95(2):142–50.
4. Ashraf U, Mo Z, Tang X. Direct-seeded versus transplanted rice in Asia: Climatic effects, relative performance, and constraints—a comparative outlook. In: *Agronomic Rice Practices and Postharvest Processing*. Apple Academic Press; 2018. p. 51–100. <https://doi.org/10.1201/9780429488580-11>
5. Kumar J, Dave AK, Nirala H, Naik RK. Productivity, economics and resource conservation perspectives of direct seeded rice method of establishment: Evidence from Chhattisgarh. *J Pharmacogn Phytochem.* 2021;10(1S):39–44.
6. Pathak H, Tewari AN, Sankhyan S, Dubey DS, Mina U, Singh VK, et al. Direct-seeded rice: Potential, performance and problems—a review. *Curr Adv Agric Sci.* 2011;3(2):77–88.
7. Rogers DMA. Knowledge innovation system: The common language. *J Technol Stud.* 2003;19:2–8.
8. Coley TG, Christopher U. Social learning through networks: The adoption of new agricultural technologies in Ghana. *Am J Agric Econ.* 2021;83:668–73. <https://doi.org/10.1111/0002-9092.00188>
9. Marin A, Wellman B. Social network analysis: An introduction. Sage Publications; 2011. p. 11–25. <https://doi.org/10.4135/9781446294413.n2>
10. Matuschke I. Evaluating the impact of social networks in rural innovation systems: An overview. Washington (DC): International Food Policy Research Institute (IFPRI); 2012. IFPRI Discussion Paper.
11. Issac ME, Erickson BH, Quashie-Sam SJ, Timmer VR. Transfer of knowledge on agroforestry management practices: The structure of farmer advice network. *Ecol Soc.* 2007;12:32. <https://doi.org/10.5751/ES-02196-120232>

12. Brown B, Samaddar A, Datt KS, Leipzig A, Kumar A, Singh DK, et al. Understanding decision processes in becoming a fee-for-hire service provider: A case study on direct seeded rice in Bihar, India. *J Rural Stud.* 2021;87:254–66. <https://doi.org/10.1016/j.jrurstud.2021.09.025>
13. Borgatti SP, Mehra A, Brass DJ, Labianca G. Network analysis in the social sciences. *Science.* 2009;323(5916):892–5. <https://doi.org/10.1126/science.1165821>
14. Hoang LA, Castella JC, Novosad P. Social networks and information access: Implications for agricultural extension in a rice farming community in northern Vietnam. *Agric Human Values.* 2006;23(4):513–27. <https://doi.org/10.1007/s10460-006-9013-5>
15. Matuschke I, Qaim M. The impact of social networks on hybrid seed adoption in India. *Agric Econ.* 2009;40(5):493–505. <https://doi.org/10.1111/j.1574-0862.2009.00393.x>
16. Goswami R, Basu D. Influence of information networks on farmer's decision-making in West Bengal. *Indian Res J Ext Educ.* 2011;11(2):50–6.
17. Thuo MW. Social network effects on groundnut farming: The case of Kenya and Uganda [dissertation]. University of Connecticut; 2012.
18. Adolwa IS, Okoth PF, Mulwa RM, Esilaba AO, Mairura FS, Nambiro E. Analysis of communication and dissemination channels influencing the adoption of integrated soil fertility management in western Kenya. *J Agric Educ Ext.* 2012;18(1):71–86. <https://doi.org/10.1080/1389224X.2012.638782>
19. Dutta R. Information needs and information-seeking behavior in developing countries: A review of the research. *Int Inf Libr Rev.* 2009;41(1):44–51. <https://doi.org/10.1080/10572317.2009.10762796>
20. Spielman DJ, Davis K, Negash M, Ayele G. Rural innovation systems and networks: Findings from a study of Ethiopian smallholders. *Agric Human Values.* 2011;28:195–212. <https://doi.org/10.1007/s10460-010-9273-y>
21. Batagelj V, Mrvar A. Exploratory social network analysis with Pajek. Cambridge University Press; 2011.
22. Gava O, Favilli E, Bartolini F, Brunori G. Knowledge networks and their role in shaping the relations within the Agricultural Knowledge and Innovation System in the agroenergy sector: The case of biogas in Tuscany (Italy). *J Rural Stud.* 2017;56:100–13. <https://doi.org/10.1016/j.jrurstud.2017.09.009>
23. Behrend FD, Erwee R. Mapping knowledge flows in virtual teams with SNA. *J Knowl Manag.* 2009;13(4):99–114. <https://doi.org/10.1108/13673270910971860>
24. Yadav S, Kumar V, Singh S, Kumar RM, Sharma S, Tripathi R, et al. Growing rice in eastern India: New paradigms of risk reduction and improving productivity. In: *The Future Rice Strategy for India.* Academic Press; 2017. p. 221–58. <https://doi.org/10.1016/B978-0-12-805374-4.00008-7>
25. Gonsalves JF. A new relevance and better prospects for wider uptake of social learning within CGIAR. CCAFS Working Paper; 2013.
26. Haldar S, Misra S, Pal S, Basu D, Goswami R. Understanding agricultural information networks in West Bengal, India. *Indian Res J Ext Educ.* 2016;16(1):25–34.
27. Surabhi M, Subash SP, Anurag AK. Understanding the knowledge and social networks in India: Case study of Bihar. In: *Proceedings of the 2015 Conference of the International Association of Agricultural Economists*; 2015; Milan, Italy. p. 1–34.
28. Cobb NK, Graham AL, Abrams DB. Social network structure of a large online community for smoking cessation. *Am J Public Health.* 2010;100(7):1282–9. <https://doi.org/10.2105/AJPH.2009.165449>
29. Sulaiman RV, Hall A. Beyond technology dissemination: A knowledge system perspective on agricultural extension. *Outlook Agric.* 2002;31(4):225–33. <https://doi.org/10.5367/000000002101294119>
30. Raman KR, Singh L, Reddy MN. Social networks and technology adoption in Indian agriculture. *J Rural Stud.* 2018;60:30–40.
31. Glendenning CJ, Babu SC, Asenso-Okyere K. Review of agricultural extension in India. Washington (DC): International Food Policy Research Institute (IFPRI); 2010. Discussion Paper No. 1041.
32. Jat ML, Gupta R, Sidhu HS, Kamboj BR, Gupta N. Conservation agriculture for sustainable intensification in South Asia. *Agric Ecosyst Environ.* 2017;252:3–14.
33. Andrews C, Dutta A, Hazra K. Knowledge networks in agricultural innovation: The role of input dealers and farmer intermediaries. *Agric Syst.* 2016;149:55–65.
34. McGuire S, Sperling L. Seed systems smallholder farmers use. *Food Secur.* 2016;8(1):179–95. <https://doi.org/10.1007/s12571-015-0528-8>

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