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Linkage Network Structures of Farmers: Analysing FPOs of M.P. and Bihar in India

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ABSTRACT

Effective linkages among farmers play a crucial role in fostering growth within the agriculture sector. This study conducted during 2020-23 utilizes social network analysis to examine the backward and forward agribusiness linkages of farmers in Dairy Farmer Producer Organizations (FPOs) in Madhya Pradesh and Bihar. Through focused group discussions, a comprehensive list of private and government institutions acting as linkage actors for each FPO were compiled. The findings highlight that farmers primarily rely on strong informal ties for accessing agricultural information and services. Furthermore, a disparity is observed between the FPOs in Bihar and Madhya Pradesh, with the former having a smaller number of linkage actors. The FPO in Bihar demonstrates stronger associations with government institutions and officials, while the FPO in Madhya Pradesh exhibits stronger connections with private entities, including the food processing industry, artificial insemination (AI) technicians, and veterinary doctors. The study provides valuable insights into the connectedness of network actors, underscores the importance of multi-actor alliances, and emphasizes the implications of centrality measures in determining network dynamics.

INTRODUCTION

The agriculture and allied sectors play a vital role in the Indian economy, serving as its backbone. Despite employing nearly 55 per cent of the total workforce, agriculture contributes only 18.8 percent to the country's Gross Value Added (GVA) in the year 2021-22 at current prices (Ministry of Agriculture & Farmers' Welfare, 2022). Moreover, the agricultural sector can support other sectors of the economy through backward and forward linkages, which are essential for any enterprise. To foster these linkages, it is crucial to promote new approaches to farming that encompass all aspects from production to consumption. Research by Anríquez (2007) has shown that a rapidly growing agriculture sector can generate powerful forward and backward linkages, facilitated by network ties among stakeholders. Establishing agribusiness linkages faces a major obstacle: small land holdings among Indian farmers. To overcome this, collectivization of producers, especially small and marginal farmers, into producer organizations is an effective solution. Farmer collectivization reduces transaction costs, provides economies of scale, and enables knowledge sharing, cost efficiencies, marketing, and risk reduction (Parthiban et al., 2015; Kanitkar, 2016; NABARD, 2019; Kumar et al., 2021; Kumari et al., 2022). Farmer Producer Organizations (FPOs) mobilize farmers and enhance their collective production and marketing strength. Farmer Producer Companies disrupted middlemen chains, enabling direct selling to traders or end

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consumers, improving farmers' financial conditions and lifestyles (Salokhe et al., 2017; Nain et al., 2019; Gorai et al., 2022).

To succeed and gain higher returns, agribusinesses must network effectively. In-depth studies on networking dynamics in rural areas are crucial to understand the role of efficient networking in forming successful linkages in agriculture. This research has emphasised on the significance of establishing strong networks for the development and growth of agribusinesses.

METHODOLOGY

In developing countries, it is rare for households to focus just on one single source of income (Reardon, 2007). Dairy FPOs practiced crop farming alongside animal husbandry to maximise and diversify their income. The dairy industry in India has been instrumental in driving socio-economic progress by creating employment and income-generating prospects in rural regions (Das et al., 2020). For the study FPOs were selected from two north Indian states, M.P. and Bihar. Despite being a significant state with ample natural resources, Bihar continues to encounter obstacles such as low productivity, insufficient institutional support, and inadequate governance (Joshi et al., 2012). M.P. has earned highest award 'Krishi Karman' for six consecutive years and tops in production of pulses and food grains. Both M.P. and Bihar have nearly same agricultural productivity of 2199 and 2302 kg/ha, respectively (Ministry of Agriculture and Farmers Welfare, Govt of India, 2019-20). In dairy sector, average yield per In-Milk animal for M.P. and Bihar are 4.46, 4.38 (Buffalo) and 2.84,3.34 (Cow) kg/day respectively (Ministry of Agriculture and Farmers Welfare, Govt of India, 2017-18). But, in the 'Ease of Doing Business' ranking, over the years there has been large gap among the two states with Bihar always in the lower rungs. This depicts the difference in entrepreneurial environment and linkages among the actors of enterprises. So, studying both states gave an opportunity to assess the differences and similarities and comparison of linkages for a successful entrepreneurial environment. NABARD promoted Dairy FPOs (one from each state) were selected through simple random sampling. Selected 'Dairy' FPOs: *Magadh* Agriculture Farmers Producer Company Limited (Gaya, Bihar); *Parvati* Milk Producer Company Limited (Bhopal, M.P.)

Snowball sampling was followed to select 30 farmers from each FPO for studying the linkage network. Snowball sampling design preserves the information of the network structure (Kolaczyk, 2009). The key actors (organisations/institutions/ officials/individuals) in the forward and backward linkages with whom farmers of a FPO had contact was documented through focussed group discussion. One-step modified reputational snowball sampling approach (Farquharson, 2005; Harris et al., 2008) was used to identify key actors in linkages for each FPO. Initially the Board of Directors of the FPO were contacted to compile a list of all the actors with whom they had contact for FPO functioning. Then that list was reviewed by the other selected farmer members and the other actors were added (if any) to the list. While this approach had the drawback of truncating the respondents' linkage network to only include strong connections (Maertens & Barrett, 2013), it had the advantage of capturing the most significant links as perceived by the respondents, thus saving time.

To know the characteristic of ties among farmers and linkage actors 'Tie Strength' and 'Tie Direction' variables were used. The strength of a tie (strong or weak) indicates the overall level of social interconnectedness and the potential for information or resource exchange among individuals (Granovetter, 2005). Strong ties form with family members, neighbours, relatives, friends or group members. Weak ties are characterized by infrequent interactions and little or no emotional investment between actors (Granovetter, 2005; Hampton, 2011). Weak ties include extension agents, formal institutions, agri-officials or researchers. Tie strength measured in frequency percentage basis for a time interval (Thou et al., 2013). The 'Tie Direction' (mutual or one way) reflected about the reciprocity of connections among farmers and actors.

The questions were asked to know 'Tie Strength' and 'Tie Direction'. If a farmer mentioned neighbours/relatives/friends or group members among the most influential links for agriculture named as strong Tie whereas if a farmer mentioned formal institutions/agri-officials/researchers/extension agent or private institutions among the most influential links for agriculture was regarded as weak tie. Regarding tie direction; whether a farmer perceived the contacts with the actors are mutual or a farmer perceived the contacts with the actors are one way.

Social Network Analysis (SNA) was used to delineate the linkage network for FPOs. To determine the links of farmers with the actors, participants were asked how often they had contact with each of the listed actor. The response categories were daily, weekly, monthly, quarterly, yearly or no contact. To aid in structural analysis, the contact measure was dichotomized with a cut-off of quarterly contact (Harris et al., 2008). Having contacts with actors once or more in the previous quarter (three months) was marked as having contact '1', while no contact in the previous quarter was marked '0'.

For the study, responses of only farmers were collected to know about the links/contacts with actors (Stork & Richards, 1992). If a farmer said having contact with the actor, then contact was considered, with no need to confirm from the actor. Thus, we could draw undirected, unweighted, 2- Mode networks for FPOs, with farmers and actors as the two set of entities. Software used were UCINET 6.747 (Borgatti et al., 2002) (trial version) and NetDraw 2.176 (open source) for network visualisation and computing centrality measures. For the centrality measure, Degree Centrality was calculated. Degree centrality refers to the quantity of connections a node possesses. The greater the number of linkages (ties), the higher the level of centrality, and vice versa. This metric highlights the significance of a specific actor within the network. It could be denoted as (Landherr et al., 2010).

$$\sigma D(x) = \sum_{i=1}^{n} a_{ix},$$

where, σD is the degree centrality score for node x using an adjacent matrix A= (a_{ij}).

RESULTS AND DISCUSSION

Characteristics of social ties for the farmers of FPOs

From Table 1, it was found that higher percentage of farmers in Parvati FPO (83%) had trust in strong ties for agricultural

Table 1. Characteristics of social ties for the farmers of FPOs

	Tie strength		Tie Direction	
	Strong	Weak	Mutual	One way
Magadh, Bihar (n=30)	23 (76.67%)	7 (23.33%)	18(60.00%)	12(40.00%)
Parvati, M.P. (n=30)	25 (83.33%)	5 (16.67%)	13(43.33%)	17(56.67%)

information and services, compared to a lower percentage (77%) of farmers in Magadh FPO. In terms of information flow within a network, both strong ties and weak ties plays equally important roles (Bandiera & Rasul, 2006). Weak ties are crucial for introducing innovations and acquiring new knowledge, while strong ties among farmers facilitate the adoption of these innovations by a larger group. Previous studies have also observed a similar trend, where a combination of weak ties with extension agents and strong ties with close associates emerged as the primary sources of information (Thuo, 2012). Understanding and leveraging these social ties can have implications for effective information dissemination, technology adoption, and innovation diffusion in the agricultural sector.

For the "Tie Direction," it was observed that farmers from Magadh FPO had a higher percentage (60%) of mutual or bi-directional ties compared to Parvati FPO. This finding suggests that there is a reciprocal flow of information among farmers and linkage actors in the network. Ties that involve reciprocal relationships tend to be stronger and have a higher likelihood of lasting over time (Carolan, 2014; Daly, 2010). Reciprocal relationships enable agribusinesses to establish trust, reliability, and mutual support, fostering sustained interactions and positive outcomes for all involved.

Social network Structures and measures for farmers of FPOs

Results of the social network analysis, displaying the 2-mode linkage networks between farmers and actors is presented in this section. Node size is proportional to the degree centrality for the node. Distance among nodes is proportional to geodesic distance (shortest straight path; an edge) among them.

Network structures/ maps

Figure 1 depicts the linkage network map for Magadh FPO, Bihar. Here it was found that farmers and actors equally distributed across the network, suggests that there is a balance of power and influence among actors in the network. Majority of farmers had equal links to the actors. With high centrality of farmers, farmers can depend on their collective power to take advantage of their

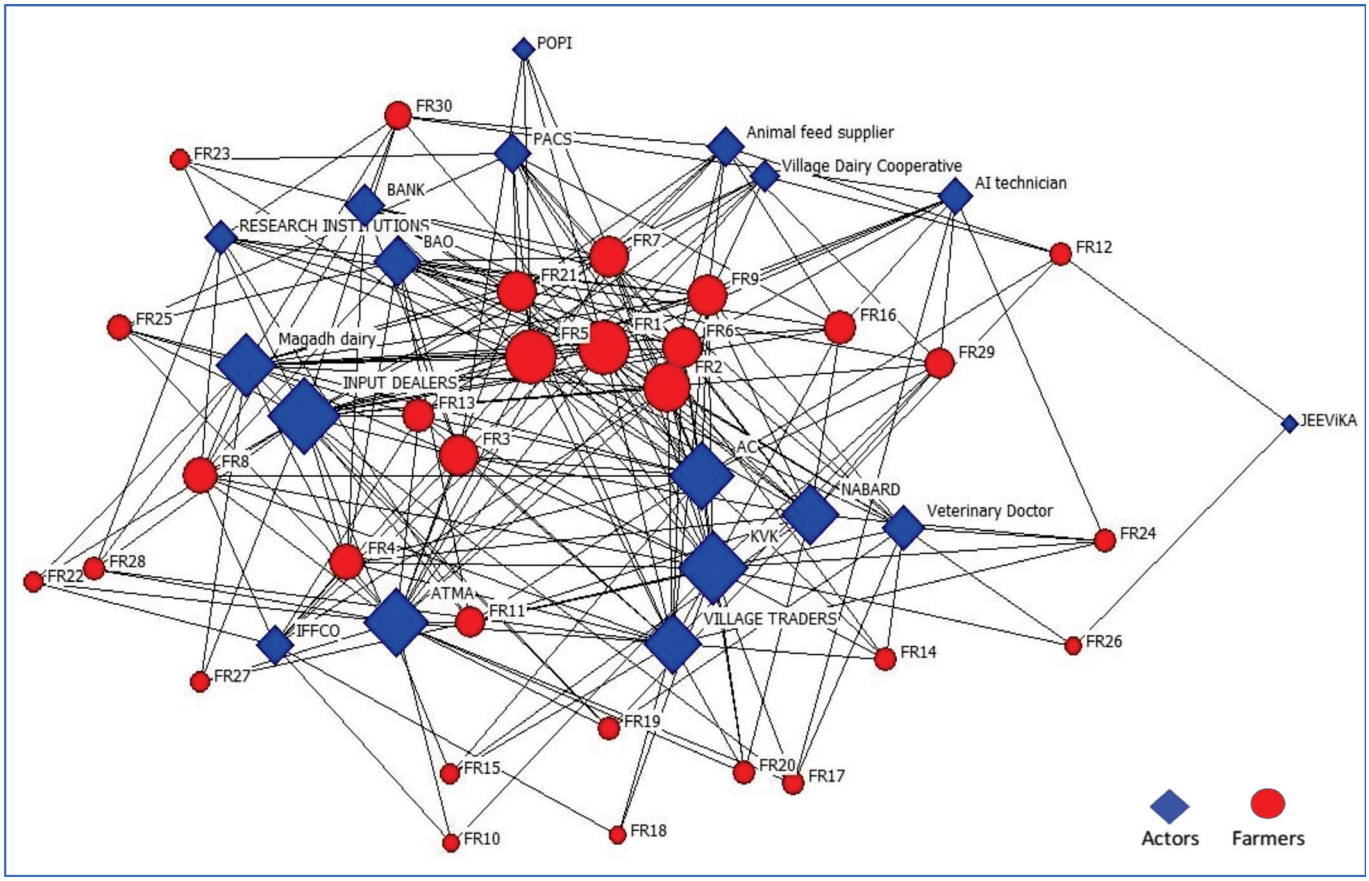

Figure 1. Linkage network for Magadh FPO

central position by influencing other actors in the network (Chindime et al., 2016). This is positive for agricultural development as it suggests that farmers are not dependent on a single source for their needs and are connected to a diverse set of actors. Actors with larger nodes, like Input Dealers, KVK, NABARD, AC, Magadh Dairy, and ATMA, are highly contacted by farmers, highlighting their crucial role in providing inputs, services, credit, and market links to improve farmers' livelihoods and incomes. Some peripheral actors, such as AI technician, Village Dairy Cooperative, Animal feed supplier, and PACS, may offer niche services valuable to specific farmers. Strengthening linkages with these actors could be beneficial. JEEViKA, with limited connections, should increase interaction and collaboration with farmers, as it has a vital role in supporting the farmers in FPO and improving rural livelihoods in Bihar.

For Parvati FPO (Figure 2), findings show that there is a clear distinction between the bigger and smaller node size of farmers. The bigger node size farmers have more direct links with all the actors, whereas smaller node size farmers have limited connections with only the major actors. Those who are at the center of a network have the power to determine which new ideas or information are disseminated to others, while those on the outer edges are not as closely involved in the daily workings of the network, as pointed out by Cross et al., (2001). The research outcome highlights the importance of addressing the needs of smallholder farmers who are located at the periphery of the network map. Actors with biggest nodes include the Dairy Industry, Input Dealers, ATMA, APMC Mandi, RAEO, KVK, and Veterinary Doctor. Strengthening linkages among actors in the agribusiness ecosystem is essential. Smaller node size actors like NCDEX, IFFCO, Bank, Agro Industry, POPI, Research Inst., MPSCDF, and NABARD should actively engage with smallholder farmers, providing necessary resources and services. This would benefit farmers and enhance integration and resilience in the agribusiness ecosystem.

Gaining a comprehensive understanding of the positioning of farmers within a broader institutional framework is essential. This understanding has significant implications (Chindime et al., 2016). It allows us to delve into specific details regarding the collaborative generation and adoption of new knowledge, practices, and technologies by farmers (Klerkx et al., 2009), which ultimately affects their capacity for innovation. Additionally, comprehending the network structure and the roles of key participants can assist in developing interventions that aim to improve connectivity and inclusivity for all farmers in the Farmer Producer Organization (FPO). A crucial objective is to ensure that all farmers have fair access to participate in the network and leverage the available resources and opportunities.

Network measures

Comparing the network measures of Parvati FPO and Magadh FPO (Table 2), we find differences in the number of actors, ties, and average degree. Parvati FPO has more linkage actors (21) than Magadh FPO (18). This suggests that Parvati FPO has a more extensive reach and more potential for knowledge sharing and resource mobilization. The size of the network indicates the degree

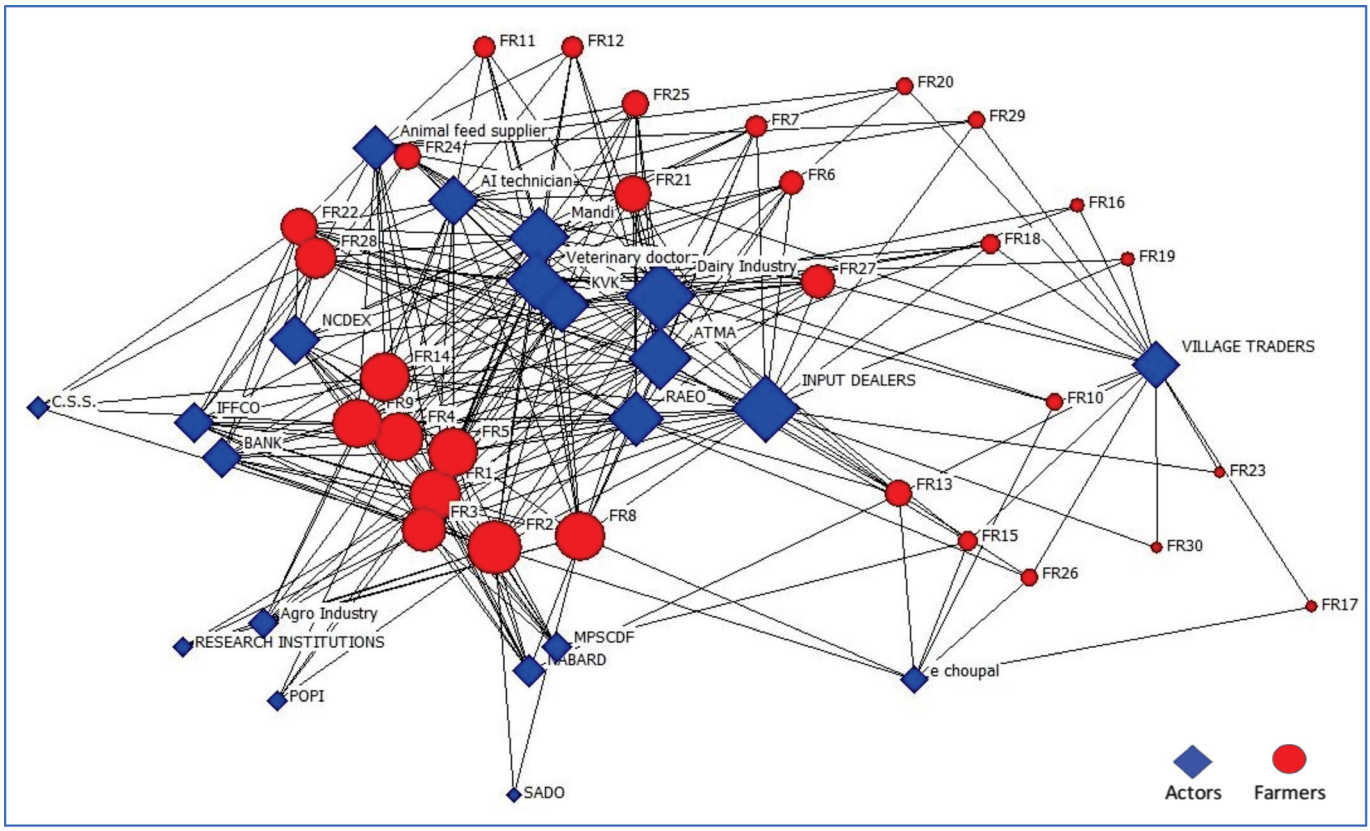

Figure 2. Linkage network for Parvati FPO

Table 2. Network Measures for linkage networks of Dairy FPOs

Variables	Magadh, Bihar	Parvati, M.P.
No. of nodes	48 (30+18)	51 (30+21)
No. of observations	540 (30×18)	630 (30×21)
No. of ties	233	264
Average degree (farmer)	7.767	8.8
Density	0.431	0.419
Diameter	5	4
Compactness	0.55	0.55
Average distance (among any two node)	2.128	2.125

of interconnectedness between farmers and other actors, as affirmed by Matuschke (2008). However, Magadh FPO has a higher network density (0.431), indicating tighter connections among farmers. A denser network has more social interactions and the learning alliance of the participants would be much more effective, as cited by Mashavave et al., (2013). Both FPOs show equal cohesion in terms of compactness and average distance. Magadh FPO's network diameter (5) is slightly larger than Parvati FPO (4), indicating greater distance between a few nodes. This could be an area for improvement in Magadh FPO's network, as it may require more effort to connect these distant nodes. A larger network size coupled with greater density indicates a higher level of interactivity and faster communication within the network (Helsley & Zenou, 2014), as well as a higher degree of innovativeness (Davis et al., 2008). Understanding these network structures helps in designing interventions for knowledge sharing, resource mobilization, and capacity building.

Comparing linkage actors in different settings of both FPOs

Degree centrality is the measure of direct ties the linkage actors have with the farmers, as also mentioned by Matous et al., (2015). Comparing degree centralities (DC) for linkage actors in the FPOs (Table 3), we found that ATMA had the same degree centrality in both FPOs. KVK has higher degree centrality in Magadh FPO, indicating a stronger presence and influence in their social network. Agri officials BAO and AC had higher degree centrality with Magadh farmers (0.43 and 0.67, respectively) compared to SADO and RAEO with Parvati farmers (0.07 and 0.57, respectively). Higher degree centrality with Magadh farmers suggests more guidance, resource allocation, and access to government schemes. NABARD had higher degree centrality with Magadh FPO (0.30), indicating access to funding, credit facilities, or development programs. Banks had similar degree centrality (0.37 and 0.40) for both FPOs, indicating a similar level of engagement. State dairy cooperatives, BSMCFL and MPSCDF, had similar degree centrality (0.23 and 0.27), suggesting similar engagement and support. Contrasting destinations for dairy produce indicate different market channels and supply chains. However, the contrasting destinations for dairy produce—Parvati farmers selling to a food processing company and Magadh farmers selling to a local cooperative—indicate different market channels and supply chains in operation. The links between the Central Semen Station in Bhopal and a small number of big dairy farmers in the Parvati FPO suggest targeted collaborations in the field of artificial insemination and breeding. Veterinary doctor services were more frequently utilized by Parvati farmers (0.60) compared to Magadh FPO (0.40) suggests a greater utilization of these specialized

Table 3. Centrality measures for Dairy FPO

Magadh, Bihar		Parvati, M.P.	
Actors	DC (nDC)*	Actors	DC (nDC)*
ATMA	20(0.67)	ATMA	20(0.67)
KVK	22(0.73)	KVK	17(0.57)
Research Institutions	8(0.27)	Research Institutions	4(0.13)
POPI	4(0.13)	POPI	4(0.13)
Bank	11(0.37)	Bank	12(0.40)
BAO	13(0.43)	SADO	2(0.07)
AC	20(0.67)	RAEO	17(0.57)
NABARD	17(0.57)	NABARD	9(0.30)
IFFCO	10(0.33)	IFFCO	12(0.40)
Input Dealers	23(0.77)	Input Dealers	22(0.73)
Village Traders	17(0.57)	Village Traders	14(0.47)
PACS	10(0.33)	Mandi	19(0.63)
Magadh dairy	18(0.60)	Dairy Industry	23(0.77)
Village Dairy Cooperative (BSMCFL)	7(0.23)	MPSCDF	8(0.27)
Animal feed supplier	10(0.33)	Animal feed supplier	13(0.43)
AI technician	9(0.30)	AI technician	15(0.50)
Veterinary Doctor	12(0.40)	Veterinary doctor	18(0.60)
JEEViKA	2(0.07)	C.S.S.	5(0.17)
		Agro Industry	8(0.27)
		NCDEX	15(0.50)
		e-Choupal	7(0.23)

*(DC- Degree Centrality, nDC-Normalised Degree Centrality)

services by farmers in that region indicating a higher demand for animal healthcare and reproductive services, potentially driven by factors such as greater income, dairy production systems and livestock size/number. Similarly, AI (Artificial Insemination) technicians had a higher degree centrality in the Parvati FPO (0.50) compared to the Magadh FPO (0.30). An actor's strategic position within a network can determine the different roles they play, such as central connectors, boundary spanners, information brokers, or peripheral specialists, as highlighted by Chan & Liebowitz (2006). The findings reveal variations in the degree centralities of different actors, pointing to differences in knowledge dissemination, government support, financial assistance, market channels, and specialized services, thus providing valuable insights into the structural and relational aspects of the FPOs. Social network analysis helps to identify critical stakeholders and barriers, as brought up by Wang et al., (2020). Understanding these network structures can inform targeted interventions and strategies to strengthen collaboration, resource allocation, and agricultural development in each FPO (Nain et al., 2015).

CONCLUSION

The study of linkage networks in agriculture has several important implications, including: improved understanding of market dynamics, better targeting of interventions, enhanced competitiveness, increased economic opportunities and improved policy making. The study provides insight into the relationships between actors in the agriculture and dairy sector, including farmers, traders, processors, and retailers. This can improve understanding of market dynamics, enhance competitiveness by improving the efficiency of supply chains, reducing transaction costs, and increasing the quality and reliability of products. By understanding the structure of linkage networks, valuable information is provided for policymakers to identify the key actors and bottlenecks in the agriculture sector. The information can be used to target interventions and investments in areas that will have the greatest impact on improving the agriculture sector and design policies that will support its development and growth.

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