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UNLOCKING AGRICULTURAL INFORMATION NETWORKS: A SOCIAL NETWORK ANALYSIS APPROACH

V. V. S. S. Anusha[1], S. R. Patel[2] and Vinaya Kumar, H.M[3]

1 Research scholar, Anand Agricultural University, Anand -388110
2 Principal, College of Agriculture, Jabugam, Anand Agricultural University, Anand -388110
3 Assistant Professor of Agricultural Extension, office of the Vice Chancellor, KSNUAHS, Shivamogga, Iruvakki -577412
Email : anushavelamuri12@gmail.com

ABSTRACT

Indian extension system persistently encountered challenges related to the ineffective dissemination of agricultural information and lack of intensive private extension. Social Network Analysis (SNA) focuses on how actors are located in a network and studies their multidimensional relationship. The present study aims to explore the information-seeking patterns of the farmers using SNA and understand the effective and efficient means of communication that the extension system can tap further. Two districts (Anand and Vadodara) of Gujarat were conveniently selected from which two blocks and two villages each were purposively selected for the study. By employing random sampling, a total of 120 respondents were interviewed. The analysis using UCINET software elicited that respondents had 36 nodes contacted for attaining information for production aspects, with 27 and 23 nodes for protection and marketing, respectively. However, the density (0.553) and transitivity (0.705) were high for the protection network, implying a stronger connection between the nodes and having a lower average geodesic distance (1.450), conveying that the information dissemination related to protection aspects happens rapidly. Non-dominance of either public or private entities in the marketing network emphasized the need for attention. At the node level, input dealers were of significant value in the network, and the respondents of Vadodara had more accessibility to agriculture information than the Anand district. The study's findings contribute significantly to the existing literature by shedding light on the challenges within the Indian extension system, emphasizing the importance of Social Network Analysis in understanding farmers' information-seeking patterns and highlighting key areas for improvement in agricultural communication and information dissemination.

Keywords : *extension system, information, production, protection, marketing, social network analysis, UCINET*

INTRODUCTION

The ineffective dissemination of information and lack of adoption of new technology are always reasoned on the inadequacy in the number of extension personnel (Takahashi et al., 2020). Reports show that for every 1156 operational farm holdings in India, there is only one extension personnel to serve, which is a massive gap (Singh, 2019). To address that situation time and time, a constant suggestion of increasing the working staff of agriculture is suggested, but the gap fulfillment has never been recorded.

The scientific community strives to improve agriculture by developing location-specific economic inputs/technology. The true success of these inputs does not happen when they are developed but when they are actually adopted by the end-user (farmer) and serve the purpose. For this, access to agriculture information for a farmer becomes mandatory, providing opportunities to improve farm practices that contribute to a better livelihood (Chen & Lu, 2019). Over time, efforts were made to reach the farming community in several ways and means. Nowadays in India, on one side, some farmers still rely on the most traditional way, Radio (Nagar et al., 2021); on the other end, they use the internet and mobile advisories; thereby, it becomes essential to understand information-seeking patterns prior to the technology dissemination.

The existing studies have considered information-seeking behaviour as an independent variable and classified the obtained response into low, medium and high categories (Riaz et al., 2022), giving only a one-dimensional understanding. This attribute data gives an idea about different sources of information available by farmers but not about how these sources are connected, which could be better used to increase the efficiency of information dissemination. The current study uses Social Network Analysis (SNA) to fill this gap.

Theoretical background about SNA

SNA investigates social structures through networks and graph theory. It involves quantitative (measures) and qualitative (maps) analysis of the flow of relationships (Jagriti et al., 2021) and relationship changes between knowledge-possessing entities by assigning values to connections in the network. The focus of SNA is always between the people, not within. Network data comprises actors referred to as nodes and the relationship between actors as ties or edges depicting how actors are embedded in the overall network. It supports sampling methods as a 'full network' method for studying all group actors, which is possible only when the group is small. The snowball sampling starts with focal actors and proceeds further to the actors based on the response given by the prior. This method could overstate the connectedness and ignore the isolates, dampening the prior intentions to study the network distribution (Hanneman & Riddle, 2005). In this study, the Ego-centric method (with ego only) was used, which focuses only on individuals (Tesfaye et al., 2019), giving out details about the network as a whole and how it affects individuals. Though the data is amicable to interval and ordinal (grouped, full-rank) measurement, commonly nominal is used where an open-ended question is posed. If the response received is yes, it is coded as one and the absence of it as zero. To process the data, metrics used mainly in this study were:

Table 1: Description of network metrics used in the study

Sr. No	Network metrics	Description
1	**Degree**	Obtained by counting the number of links held by an actor in a network.
2	**Density**	Conveyed by the number of feasible linkages divided by the total number of links an actor has with other actors in the network. It shows if every actor in a network can contact every other actor.
3	**Betweenness**	Conveys which actor is more likely to be in communication paths playing a bridge or connectivity role in the network.
4	**Eigenvalue**	It measures the importance of an actor in a network. It also measures how well a given actor is linked to other well-linked actors in the network.
5	**Transitivity**	The tendency where two nodes are connected to a third increases the likelihood that they will connect. Transitivity, quantified by a *clustering coefficient,* is a local property of a node's neighborhood that indicates the level of cohesion between the neighbors of a node
6	**Average geodesic distance**	The length of the shortest path, or the minimal path, between nodes *i* and *j*. The average geodesic distance can be used to measure the efficiency of the information flow within the network.
7	**Core-periphery**	It consists of an identification of a network's nodes into a densely connected core and a sparsely connected periphery.

Compilation from Hanneman and Riddle (2005), Goetz et al. (2017)

Why study farmers' social networks?

A social network is defined as a highly interconnected group of people that supports a social system and provides patterns of relationships (Beni Houd & El Amrani, 2022). SNA as a tool shows how people interact, how information and resources are shared between and among them, and how the roles and connections between people are organized.

SNA can be used in any organizational setup, village (Nyantakyi-Frimpong et al., 2019), or community to understand the information dissemination pattern among various actors existing. By this, we can identify centrally located individuals in the network who are influential in transmitting essential information, commonly referred to as opinion leaders. Studies (Joseph et al., 2016) were formulated to identify opinion leaders and confirmed that the characteristics of the participants with high centrality align with the attributes stated by Rogers (1995). Vishnu et al. (2019) explored the critical information source in uptaking specific technology (calcium supplement for livestock). It highlighted that farmers engaged in two types of networks: the information acquisition network, relying on formal extension systems (veterinary doctor), and the information support network, depending on informal systems to discuss and get a better understanding of the technology use. Filippini et al. (2020) studied the production, information, and market network in hilly regions of Italy. It stated that sharing

information was not interrupted by the sparse population and distance of the hilly area. Still, the sharing of resources conveyed by the production network was limited to nearby. The market network with limited nodes shows the non-necessity and non-reliance of interpersonal networks. Based on these observations, the study interpreted whether networks help in the adoption of new technologies (smartphones).

Ofolsha et al. (2022) state that the large size of the social network of a farmer favors him in group formation where information and knowledge are shared, which in turn increases future participation in farmer-producer organizations. Therefore, using SNA helps to draw future plans based on the communication network. Going through an extensive review of the literature, it was clear that understanding the social network of farmers will aid in faster dissemination of technology and identify the strong links to promote further and potential and weak links in accelerating their involvement.

OBJECTIVE

Thereby, this following study was formulated to explore the information-seeking patterns of the farmers using SNA and understand the effective and efficient means of communication that the Indian extension system can tap further.

METHODOLOGY

An exploratory study was formulated to ascertain 'What is' the information-seeking pattern of the study area.

Anand and Vadodara, two districts of Gujarat, were conveniently selected because of their proximity to the researcher. From each district, two blocks, namely the Anand and Khambat blocks of the Anand district and the Karjan and Padra blocks of the Vadodara district, were selected, ensuring that one was nearer to the city and the other was distant. Following the above-stated rule, two villages were selected from each block, making up eight villages. Using simple random sampling, 15 farmers were selected, making 120 respondents considered in the study.

A well-structured pre-tested interview schedule was prepared. Section one focused on the profile characteristics such as age, landholding, farming experience, credit, and membership in an organization. Section two has open-ended questions such as 'What are the information sources you rely on - for production aspects (seed, package of practices, schemes, etc.), for protection (pest and diseases identification, chemicals, bio-control, etc.) and regarding marketing aspects (point of sale, price, etc.)?' The interviews lasted two months and were conducted from June to August 2022.

The data collected depicts the two-mode network, which means association between individuals and organizations. This two-mode data must be converted into one mode for further processing (Wang et al., 2020), giving the network distribution of different information sources that respondents consult.

The obtained responses for the profile were calculated using SPSS software and tabulated following statistical tools as mean, frequency, and percentage. The data was processed using UCINET and NETDRAW for network visualization to depict the information-seeking pattern.

RESULTS AND DISCUSSION

Before mapping out the network, the profile characteristics studied and presented in Table 2 give initial background about respondents. Nearly two-thirds of the respondents were 40 to 63 years old and had farm experience ranging from 12 to 36 years. The respondents were primarily small (42.50%) and marginal farmers (22.50%) without any membership in organizations (47.50%). Though half of the respondents availed credit from formal sources, an equivalent amount (41.70%) opted for no credit, depicting their weak association with financing entities.

Table 2: Profile of the respondents (n=120)

Sr. No	Profile	Range	Number	Per cent
1	**Age**	<39.85	19	15.80
		39.85-63.49	78	65.00
		>63.49	23	19.20
2	**Landholding**	Marginal (<2.5 acres)	27	22.50
		Small (2.5- 5 acres)	51	42.50
		Small- Medium (5- 10 acres)	22	18.30
		Medium (10- 25 acres)	14	11.70
		Large (> 25 acres)	06	5.00

Sr. No	Profile	Range	Number	Per cent
3	**Farming experience**	<11.43	22	18.33
		11.43-36.43	79	65.83
		>36.43	19	15.84
4	**Credit**	No credit	50	41.70
		Only from informal sources	08	6.70
		Only from formal sources	61	50.80
		Both informal and formal sources	01	0.80
5	**Membership in organizations**	No membership	57	47.50
		In one	39	32.50
		In two	20	16.70
		In three	04	3.30

Whole network properties

The number of entities from which information was collected is depicted as the total number of nodes, which was highest for production (35), followed by protection (27) and marketing (23), as depicted in Table 3. Commonly, friends were the critical nodes in all three aspects and input dealers in two networks. The number of links in the network to the total number of possible linkages is given by density. From Table 3, the protection network was denser (0.553) than production. Transitivity, similar to mathematical expression, means when two nodes are connected to a third, it increases the likelihood that they will connect themselves. And this is again exhibited to a maximum (0.705) in the protection network. The above results reveal that having more nodes does not translate to better connectivity.

The least number of connections (ties) that must be traversed to get between any two nodes is described by average geodesic distance. The protection network displayed a short distance (1.450), which means information related to plant protection aspects was disseminated quicker than production. The core-periphery property highlights the network's core area with actors that support good communication in contrast to the periphery, which is dense. For the production network, seven nodes form the core, protection with four, and marketing with only three.

Table 3: Whole network properties (n-120)

Characteristic	Production	Protection	Marketing
Total no of nodes	35	27	23
Density	0.418	0.553	0.379
Transitivity	0.667	0.705	0.549
Key nodes (Degree)	Friends (383), Input dealers (339), Gram Sevak (314), Whatsapp group (242), Meetings of Input Dealers (218)	Friends (305), Input dealers (299), Agrostar (203), GD (171), Meeting of Private companies (135)	Friends (137), Secondary wholesaler (74), APMC (83), Commission agent (69), Newspaper (52)
Avg Geodesic distance (SD)	1.607 (0.538)	1.450 (0.503)	1.636 (0.513)
Core Periphery	Input dealer, Gram Sevak, Meetings of Input dealers, Friends, Agrostar, Whatsapp group	Input dealer, Friends, Agrostar, GD	Friends, Commission agents, APMC

Since the selection of districts was purposive based on the level of cosmopoliteness, a comparative attempt was made to understand any existing difference in information-seeking. From Table 4, it was interpreted that in the Anand district, for production information, gram sevak played a predominant role of liaison with a high betweenness value (29.57). In Vadodara district, input dealers and a private company named Agrostar had a betweenness score of 53.72 and 47.15. The latter district is urban compared to the former, attributing access to more usage of private entities services.

Table 4: A comparative table of node properties of the production network

Sr. No	Anand						Vadodara					
	Actor	Degree	Actor	Betweenness	Actor	Eigen Value	Actor	Degree	Actor	Betweenness	Actor	Eigen Value
1	ID	219	GS	29.57	F	0.483	F	141	ID	53.72	F	0.514
2	F	242	MID	10.88	ID	0.462	GS	129	A	47.15	GS	0.47
3	GD	192	F	10.88	GD	0.391	ID	120	F	40.64	ID	0.449
4	GS	185	GD	10.88	GS	0.347	GD	97	GS	37.84	GD	0.349
5	MID	169	ID	7.12	MID	0.3	A	78	GD	25.03	A	0.272

A = Agrostar, F= Friends, GD = Group discussion GS = Gram Sevak, ID = Input dealer, MID = Meetings of Input dealers

For the protection network depicted in Table 5, though input dealers were equally dominant in both districts, the presence of social media platforms in the top five marks the difference. Farmers of Anand district relied on locally available entities as friends, input dealers, and group discussions, whereas Vadodara farmers, as cosmopolitans, accessed Agrostar and YouTube for protection information.

Table 5: A comparative table of node properties of the protection network

Sr. No.	Anand						Vadodara					
	Actor	Degree	Actor	Betweenness	Actor	Eigen Value	Actor	Degree	Actor	Betweenness	Actor	Eigen Value
1	F	203	ID	28.09	ID	0.518	ID	105	F	41.69	ID	0.646
2	ID	194	F	13.09	F	0.51	F	102	ID	39.99	F	0.547
3	GD	144	GD	13.09	GD	0.371	A	74	EF	16.46	A	0.326
4	PCM	131	PCM	7.09	PCM	0.291	YT	70	YT	10.36	YT	0.301
5	A	129	A	7.09	A	0.277	EF	38	A	10.36	EF	0.159

A = Agrostar, EF= Experience Farmer, F= Friends, GD = Group discussion, ID = Input dealer, PCM = Private Companies Meetings, YT= Youtube

The node properties for the marketing network were displayed in Table 6. No significant difference exists in nodes approached for obtaining marketing information among both districts. Friends and secondary wholesalers were the predominant choices for obtaining market information (Negi et al., 2018). Reliance on newspapers was more with higher betweenness value in Anand district, and as a tight-knit group, usage of WhatsApp (a messaging site) groups was predominant. The node group discussion (Reddy et al., 2020) was a common information-sharing source for the production and protection aspects.

Just like the Indian agriculture scenario, the sample of the study, when classified, showed a majority of respondents as small and marginal farmers. Negi et al. (2018) reported that the information sources accessed depend on landholding; most small and marginal farmers rely on informal channels like input dealers and local traders for marketing and end up fetching lower prices than the Minimum Support Price (MSP). Therefore, the results displayed about the information-seeking pattern in this study will be true to the current scenario. As a state, Gujarat stood on the pillar of a milk cooperative society named AMUL. However, this success of group formation wasn't replicated with other agricultural commodities. As a result, the farmers in the study showed limited membership in the organization. They reasoned that improper group functioning and not availing any financial benefits by retaining the group discouraged them from proceeding further.

Table 6: A comparative table of node properties of the marketing network

Sr. No.	Anand						Vadodara					
	Actor	Degree	Actor	Betwee-nness	Actor	Eigen Value	Actor	Degree	Actor	Betwee-nness	Actor	Eigen Value
1	F	78	F	41.68	F	0.711	F	59	F	24.12	F	0.617
2	CA	46	NP	11.06	CA	0.432	SWS	47	APMC	19.49	SWS	0.5
3	APMC	43	SWS	9.10	APMC	0.377	APMC	46	SWS	11.5	APMC	0.405
4	SWS	27	CA	7.54	SWS	0.259	NP	30	CA	4.09	CA	0.264
5	W	23	APMC	4.30	W	0.143	CA	23	CCI	3.63	NP	0.237

APMC = Agricultural Produce & Livestock Market Committee, CA= Commission agents, CCI = Cotton Corporation of India, F= Friends, NP = Newspaper, SWS = Secondary Wholesaler, W = Whatsapp group

The involvement of private companies in holding meetings and demonstrations in association with local input dealers becomes a significant information source for the farmers, indicated by higher betweenness values. The benefits of such an association became questionable as respondents reported an increase in the cost of production. Understandably, farmers are keen to get information; therefore, active collaborations between public and private entities (Norton & Alwang, 2020) strengthen the information network and could disseminate qualitative beneficial information to a broader set of farmers in a limited time.

Apart from Gram sevak, there was no representation of other public sector entities (Agriculture officer, Subject matter specialist of Krishi Vigyan Kendra (KVK)). Though this observation could be justified by the vast distance between the study area and the location of the KVK, it emphasizes the Indian Council of Agricultural Research to roll out additional KVKs to enhance the accessibility of credible information services to farmers (Osei et al., 2017) uniformly across the district.

Mass media like DD Kisan occupied space in the network, but respondents raised concerns about content. The topics covered were more generalized over being location-specific. A set of respondents used social media like YouTube and Facebook to obtain information. Still, the rate of conversion (information viewed to information practiced) was not remotely close, showing that access to information is not merely enough. The centrality of the DD Kisan channel can be increased by creating location-specific content that ensures utility over awareness. Social media tools like WhatsApp (Norton & Alwang, 2020) and YouTube (local institutions) can be put to better use by public extension systems for pooling the farmers growing similar crops together and delivering information in real-time.

After achieving food sufficiency, India's immediate focus was to build farmers' economic stability. On this road, concepts like Market-Led Extension (MLE), doubling the farmer's income, arose. MLE aligns the farmers to think from rupee to rupee and extends the extension personnel role from delivering not only a package of practices but also market information. However, the whole network properties indicate better degree, density, transitivity, and average geodesic distance for protection and protection networks over marketing (Filippini et al., 2020). It conveys the respondents are not actively seeking marketing information, contradicting the observations of Riaz et al. (2022). The absence of public entities such as Gram Sevak, the agriculture and extension officer, and the subject-matter experts of Krishi Vigyan Kendra as actors in the market network depicts the state of MLE, which remained as a concept in books rather than translating into action.

Informal sources such as friends group discussions showed centrality in all three networks. Though this is a common scenario in Indian farming communities, the informal associations displaying dominance (Lahiri, 2016) in the network are claimed to be due to the non-availability of any other credible source. The Agricultural Technology Management Agency (ATMA) scheme introduced one Farmer Friend (FF) for two villages to act as a vital link between farmers and extension workers at the village level. The more robust informal networks observed in the study inform the government to extend this number further for substantial farmer-to-farmer extension (Takahashi et al., 2020).

There is a difference in the number of nodes accessed between the two districts. The farmers residing in Vadodara, a bigger city than Anand, had taken information from various sources. It conveys that the availability of agriculture information varies from place to place, and cosmopolite respondents were more inclined to receive information from different sources. Due notice to be given that higher nodes do not mean efficient information dissemination, other network properties like density and transitivity matter to depict the strength of a network.

CONCLUSION

For farmers, the need for agricultural information never ends. With the advent of time, farmers try different ways and means to meet their needs. Social network analysis on farmers' information-seeking patterns helps map out sources of information and how they are connected. The presence of Gram Sevak in the production network represents the public entity, the dominance of input dealers in protection, and the absence of credible sources of information in the marketing network. With these insights, the policy implications are made to the government to increase farmer friends under ATMA and collaborate with private entities to organize demonstrations and meetings and For ICAR to extend the services of KVK uniformly across the district and tap the presence of mass and social media by providing specific information. In this way, SNA helped us find the missing links and strengthen the existing ones that will enhance quality information for farmers.

POLICY IMPLICATIONS

The policy implications drawn from this study highlight critical areas for improvement in India's agricultural extension services. The pervasive shortage of extension personnel, with just one for every 1156 operational farm holdings, underscores the need for a substantial increase in the agricultural workforce. Merely suggesting an increase in staff numbers has not yielded tangible results, urging policymakers to devise more effective strategies for workforce enhancement. Adopting Social Network Analysis (SNA) offers a nuanced understanding of farmers' information-seeking behavior, emphasizing the importance of not just the quantity but the quality and efficiency of information dissemination.

The study suggests a multi-faceted approach to address these challenges. First, policies should prioritize digital literacy programs to empower farmers to utilize modern communication channels effectively. This includes leveraging the internet, mobile advisories, and social media for targeted information dissemination. Second, fostering collaborations between public and private entities is crucial. Private companies, when strategically integrated into the extension system, can contribute significantly to demonstrations, meetings, and the overall information network. Third, recognizing the differences between districts, policies should be tailored to the unique characteristics of each area, acknowledging the cosmopolitan nature of certain districts that may require different strategies.

Moreover, the study advocates for a comprehensive approach to Market-Led Extension (MLE), emphasizing the role of extension personnel in not only delivering production-related information but also market insights. Finally, continuous monitoring and adaptation of policies are crucial to keep pace with evolving information dissemination patterns. By addressing these key areas, policymakers can enhance the effectiveness of agricultural extension services, bridge information gaps, and facilitate the timely adoption of new technologies among farmers in India.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to the research presented in this article.

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