

## Understanding Agricultural Information Networks in West Bengal, India

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### ABSTRACT

*Information related to agricultural practices (such as crop management, input sourcing, financing, marketing and so on) is the crucial input of this coping mechanism grounds, for better decisions in farming and allied activities. These diverse information needs of farmer are satisfied by the fellow farmers, extension personnel, agricultural research and education establishment, and agricultural extension organizations through an unseen interconnected path of communication, called 'Agricultural information Network'. Thus, there is a need of a strong innovative analytical tool to understand the functioning this complex information networks in order to successfully manage and improve it. Social Network Analysis (SNA) is an innovative analytical tool which provides excellent scope to analyse complex networking system. The present study applied SNA methodology to explore the invisible nature of communication networks Chhatna block, bankura district in West Bengal, related to agriculture and allied sectors in terms of five information domains - seed and planting material (SPM), fertilizer and plant protection (FPP), irrigation (I), animal husbandry (AH) and marketing of agricultural products (M). Purposive as well as complete enumeration technique was adopted for this study. Information related to the structural and compositional variables (seed/planting material, irrigation, market information, age, caste, education, family type, and social participation and mass media exposure) were collected and SNA properties (No of ties, Centrality, Density) used to describe and visually represent the collected data. Findings revealed the fact that, SPM and FPP networks were similar in nature, both being tightly knit and having same central actors. Whereas, I network has a strong core and AH and M both networks are relatively sparse in appearance and these three networks are distinct in terms of central actors.*

**Keywords:** Agriculture; Information network; Social network analysis;

Agriculture is a nature-based complex livelihood and the primary source of income for the majority of Indian farmers. Farmers' livelihood security depends heavily on this uncertain nature of the vocations and since its outcomes are unpredictable, farmers often need to contrive coping strategies to combat with such uncertainties. The most important input of this coping mechanism grounds on tapping the diverse information related to agricultural practices (such as crop management, input sourcing, financing, marketing and so on) that helps make better decisions in farming and allied activities. These diverse information needs are

satisfied by the fellow farmers, extension personnel, agricultural research and education establishment, and agricultural extension organizations. An effective and efficient information delivery system plays a critical role to provide reliable and useful information to the farmers (Demiryurek *et al.*, 2008). This needed information is delivered through an invisible interrelated route of communication among the farmers—the communication network. A communication network is an interconnection of individuals who are connected by the exchange of information in a social system (Rogers & Kincaid 1981; Rogers 1995). Farmers, extension organization,

researcher, all are the actors in this communication network and play a crucial role for sustaining agriculture both in the short and long terms. Therefore, there is a need to understand the functioning these communication networks in order to successfully manage & improve it.

Sociologists have also emphasised on the importance of a person's embeddings in social network in determining his behaviour, for example the adoption of innovations by farmers (*Conley and Udry, 2004*). Few empirical literature shows how resource-poor farmers in developing nations exchange information, services and material through social networks and how these sharing leads to social learning and technology adoption (*Monge et al., 2008*). Understanding of the communication network in a specific farming system may provide the recognition of basic structures, components, weakness and gap of the system and the different sources of information used by these different components (*Demiryurek, 2000*). This approach can also reduce these gap areas by proper restructuring in the existing communication structure.

For understanding this complex interrelated pattern of the communication network a strong innovative analytical tool is needed which can empower the farmers and agriculture development organizations to reveal the invisible networking patterns feeding an agricultural development system. Social Network Analysis (SNA) is such an innovative approach, which focuses on the inquiry of a set of actors and a set of relations between them, the ways in which people are connected through various social familiarities ranging from casual acquaintance to close familiar bonds (*Wasserman & Faust 1994; Hanneman & Riddle, 2005*). It has received growing attention in recent years in a variety of fields ranging from sociology, anthropology, economics and politics, to psychology, business, mathematics and physics (*Freeman, 2004*).

Although the application of SNA is relatively new in the context of communication network related to agriculture, it could be anticipated through a systematic review of existing literature that it will help one to answer the questions: Who are the influential actors(individual/institution) in a communication network?. How do these actors interact among themselves? What is the nature of communication networks related to different types of information? What are the communalities and differences among those networks? Besides, this will help agricultural development administrators to deliver

reliable and relevant information through these influential actors and by designing the existing networks towards an efficient delivery of information and extension services.

The present study has analysed network data collected on five important types of information through social network analysis and has described them in terms of conventional network properties. Then, the properties of five different networks were compared to point out their communalities and differences. This was followed by discussion on the implications of these finding for agricultural extension services.

## METHODOLOGY

The present study followed the principles and techniques of social network analysis (SNA) (*Wasserman & Faust, 1994*). A social network is conceptualized as a set of people (or organizations or other social entities) connected by a set of social relationships, such as friendship, co-working or information exchange. SNA analyses these social relations as patterns of points and lines in a mathematical space with formal properties analysed with precision (*Crossley et al., 2009*). The simplest form of a social network is pair of linked actors or 'dyad', one of which is called an 'ego', the other is its 'alter'. *Muange et al. (2014)*, following the social contagion theory (*Burt, 1987*), hypothesized that social proximity (such as geographical location, gender, education etc.) of two farmers bring them together and facilitates mutual learning. The social proximity is further influenced by social relationships (such as kinship ties, friendship etc.) leading to their characterization in terms of flow of information related to farming. This intensity is measured by 'centrality' concept, reflecting the position/power of a node in the network. The centrality may again be 'degree' (total number of ties a node has to other nodes), 'closeness' (measure of reciprocal of the geodesic distance of a node to all other nodes in the network), and 'between's' (number of times a node occurs along the shortest path between two others). Further, it is important to know the nature of the whole network, apart from the characteristics of the nodes with which it is constituted of. Average of centrality scores, network size (the no. of ties), network density and network centralization are some of the whole network properties. While 'density' reflects the number of all linkages divided by the number of possible linkages within the network (*Cantner & Graf, 2006*), centralization expresses how

central is a network's most central node in relation to the centrality of other nodes.

One of the most important challenges in the SNA is the selection of respondents. Researchers either follow a whole network approach (Goswami & Basu, 2010), sampled actors or sampling of paired actors (Chandrasekhar & Lewis, 2011). While whole network approach has intrinsic weakness of covering large population and can only trace social relationship within the community, the sampling of actors may not precisely represent the nature of the network. Still, we followed a whole network approach in the present study, because we wanted to rigorously examine the nature of agricultural information network in a given context/ community, without any explicit urge for generalization. Moreover, during the piloting phase, we found that the isolated settlement to be studied had most of the information sources situated within the village. We interviewed all 100 respondents in an isolated settlement

of the study village. Another challenge of network data collection is the specification of number of choices to be made by the respondents. In the present study, three names of information sources were recorded for the individual nodes. Although, this approach might underestimate information sources in excess of the numbers asked for (three for our case), this has successfully been used in community-level studies (Bandiera & Rasul, 2006).

This study used farm survey data collected from Chhatna Block of Bankura District of West Bengal, India during March to May 2014. The study location was purposively selected with an assumption that the challenged ecosystem of the area might create diversity in coping strategy of farmers, which would be manifested by diverse information networks. The area was predominated by people having farming as their mainstay of livelihoods. Further, the tribal demographic feature was expected to pose unique nature of

**Table 1. Five information domains and nature of information covered by them**

Information domains	Nature of information
<i>Seed/planting material</i>	New seed /planting material, their qualities, how to cultivate, where to get, at what price etc.
<i>Fertilizer/pesticide and plant protection</i>	Diagnosis of disease/insects, weeds, type of damage, measure/pesticide to apply, how to apply, classification of fertilizer/pesticide, which fertilizer to apply, at what dose etc.
<i>Irrigation</i>	When, how much, from where to acquire, when available, at what rate, meeting of irrigation committee etc.
<i>Animal husbandry</i>	Fodder, disease/disorder diagnosis, treatment, artificial insemination, calf management, breed of birds, vaccination, feed, marketing of milk, meat, egg etc.
<i>Market information</i>	Market rate, where to sale, price trend, speculation, form of market produce, market rate of consumable produce, their trends etc.

**Table 2. Description of node and network properties used in the study**

Node/network property	Description
<i>Centrality</i>	Measure of the number of ties that a node has relative to the total number of ties existing in the network as a whole; centrality measures include degree, closeness, and betweenness.
<i>Degree centrality</i>	Total number of ties a node has to other nodes. A node is central, when it has the higher number of ties adjacent to it
<i>Closeness centrality</i>	Measure of reciprocal of the geodesic distance (the shortest path connecting two nodes) of node to all other nodes in the network. A node is "close" if it lies at short distance from many other nodes
<i>Betweenness centrality</i>	Number of times a node occurs along the shortest path between two others
<i>Network size</i>	Total number of nodes in a network
<i>Network density</i>	Number of ties, expressed as percentage of the number of ordered/unordered pairs. When density is close to 1.0, the network is said to be dense, otherwise it is sparse
<i>Network centralization</i>	how central its most central node is in relation to how central all the other nodes are; calculated as sum in differences in centrality between the most central node in a network and all other nodes

**Sources:** Wasserman & Faust (1994); Scot & Carrington (2011); Borgatti et al (2009); Hanneman and Riddle (2005); Asres et al. (2012); Freeman (1979); Misra et al. (2014)

information networks. Moreover, researcher's background and close familiarity with respect to the study area, people, officials, conversance with local dialect also influenced the sampling scheme.

The respondents were interviewed through personal interview methods with the help of pre-tested structured interview schedule. A broad set of socio-economic-demographic and farm-related information was recorded. For recording data on social networks, all the respondents were asked questions on their choices of information sources (individual farmers) on five distinct information domains - seed/planting material, fertilizer/pesticide and plant protection, irrigation, animal husbandry and market. The scope of these information domains are given in Table 1. These five information domains were identified and prioritized by participatory exercises with the villagers prior to the actual field survey. The respondents were asked to respond against questions such as – Who do you approach/consult for procuring quality seed/planting material? The responses were measured by a binary variable – Yes=1, No=0.

The network data was analysed by *Ucinet 6* for Windows (*Borgatti et al., 2002*), a comprehensive social network analysis software. *Ucinet* is a standalone uncertainty analysis software package, whose main focus is dependence modeling for high dimensional distributions. *Netdraw* (*Borgatti, 2002*) is a program for drawing networks that implements several algorithms for laying out nodes in 2-dimensional space, and for performing basic analysis on the networks. For describing node characteristics we used centrality scores – degree centrality, closeness centrality and between's centrality of selected central nodes (following statistical criterion), and for describing network property we used – network centrality – degree/closeness/between's, network size, network density, network centralization. A brief description of these node and network properties is given in Table 2.

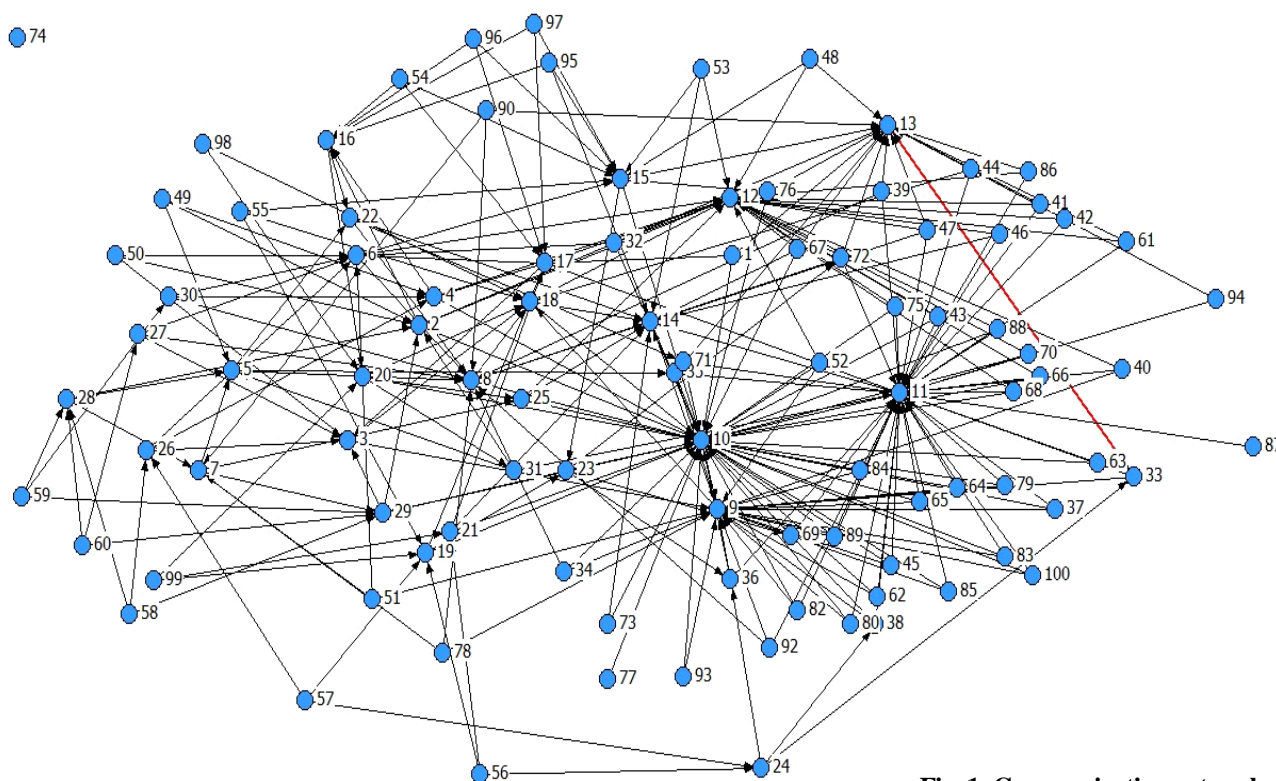
## RESULTS AND DISCUSSION

*Social network for different information domains and their description:* The data gathered through the household survey provided information on the information flows within the community and their patterns on five distinct domains of information namely seed and planting material (SPM), fertilizer and plant protection (FPP), irrigation (I), animal husbandry (AH) and marketing of agricultural produce (M). The network

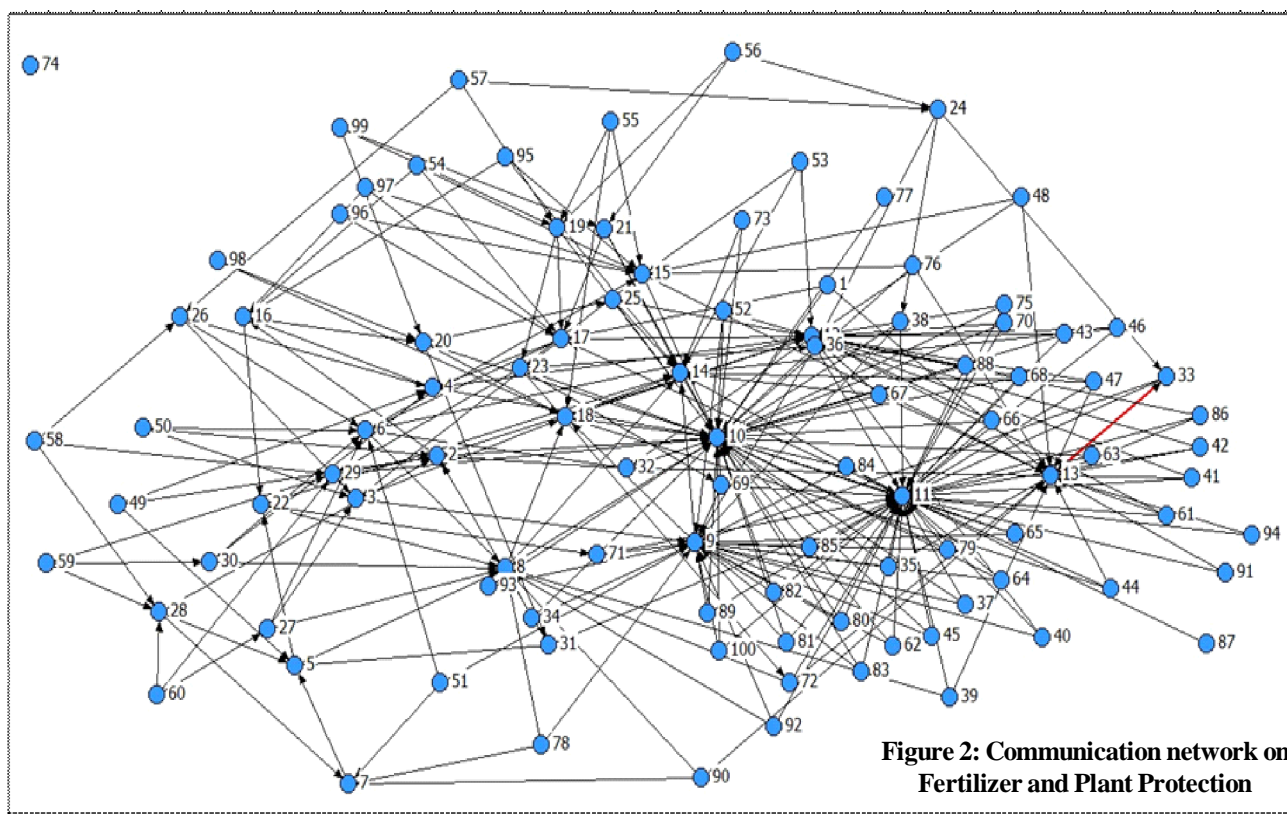
**Table 3: Whole network properties for all the information domains**

		In Degree Centrality				Out degree Centrality				In Closeness centrality				Out Closeness Centrality				Betweenness Centrality			
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
X1	X2	2.83	7.49	0	48	2.83	0.66	0	5	9.85	16.43	0	72.83	9.85	2.45	0	13.43	78.40	192.93	0	1080.51
SPM	283.00	2.83	7.49	0	48	2.83	0.66	0	5	9.85	16.43	0	72.83	9.85	2.45	0	13.43	78.40	192.93	0	1080.51
FPP	280.00	2.80	7.49	0	48	2.80	0.69	0	5	9.72	16.27	0	72.67	9.72	2.43	0	13.43	80.46	198.37	0	1099.69
I	280.00	2.80	7.80	0	51	2.80	0.66	0	5	10.58	17.71	0	72.67	10.58	2.03	0	13.10	62.42	152.02	0	824.33
AH	281.00	2.81	7.51	0	47	2.81	0.66	0	5	10.52	6.99	0	67.42	10.52	2.51	0	13.77	72.94	180.84	0	1091.11
M	243.00	2.43	2.04	0	17	2.43	0.92	0	3	11.73	8.90	0	39.82	11.73	5.94	0	19.12	235.17	413.35	0	2476.97

(SPM= Seed/planting material, FPP= Fertilizer/Plant Protection, I=Irrigation, AH=Animal Husbandry, M= market information)  
 (X1=Domain; X2=Density; X3= No. of Ties; X4=Avg. Degree; A=Mean; B= SD, C= Minimum; D=Maximum)



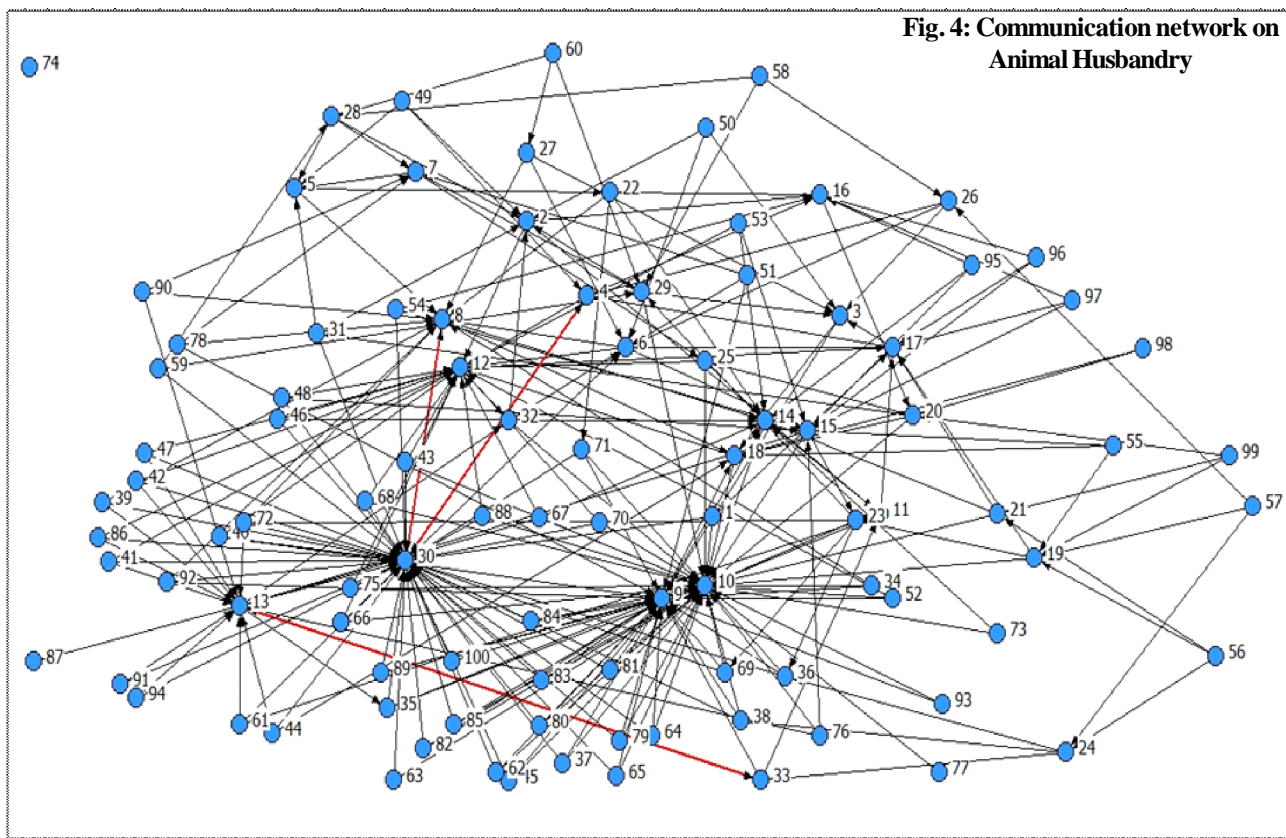
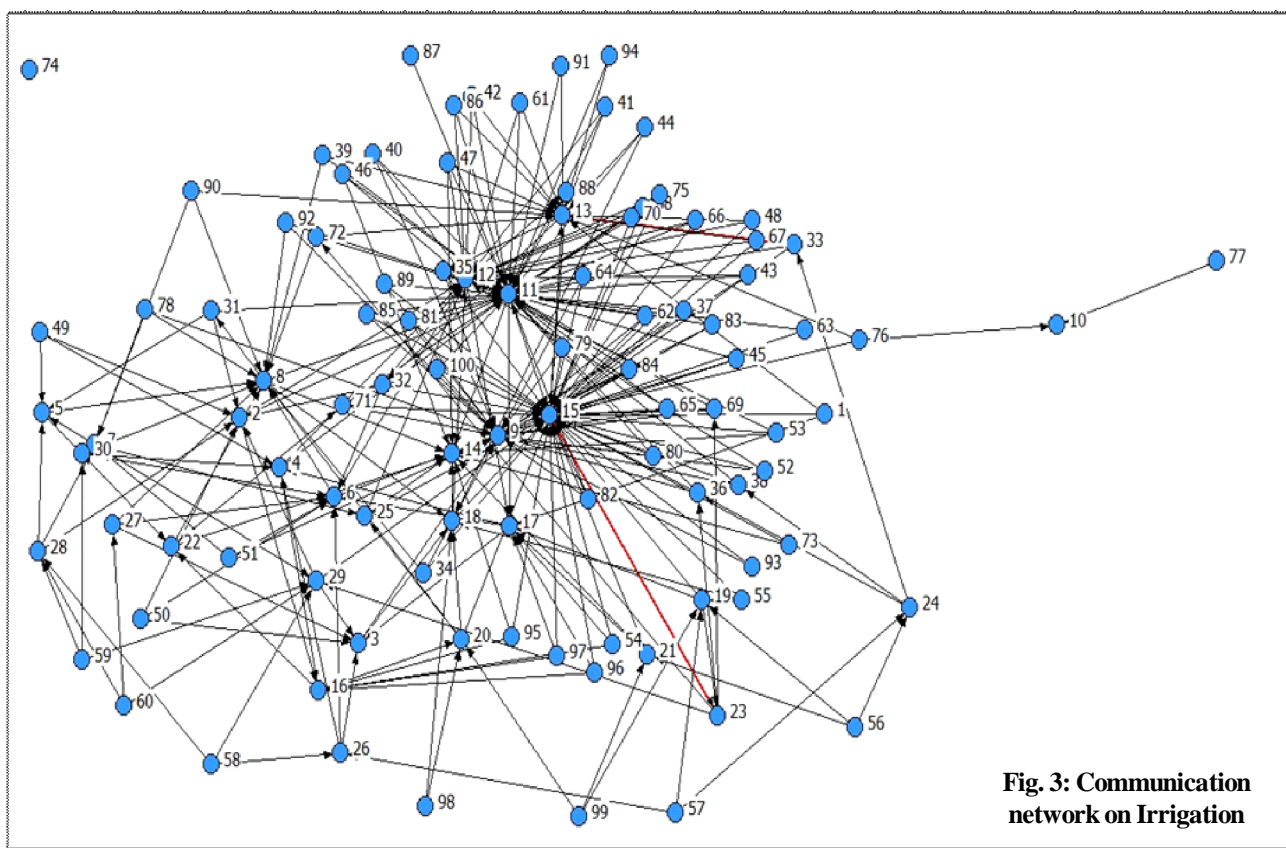
**Fig. 1: Communication network on Seed and Planting materials**



**Figure 2: Communication network on Fertilizer and Plant Protection**



**Fig. 2: Communication network on Fertilizer and Plant Protection**

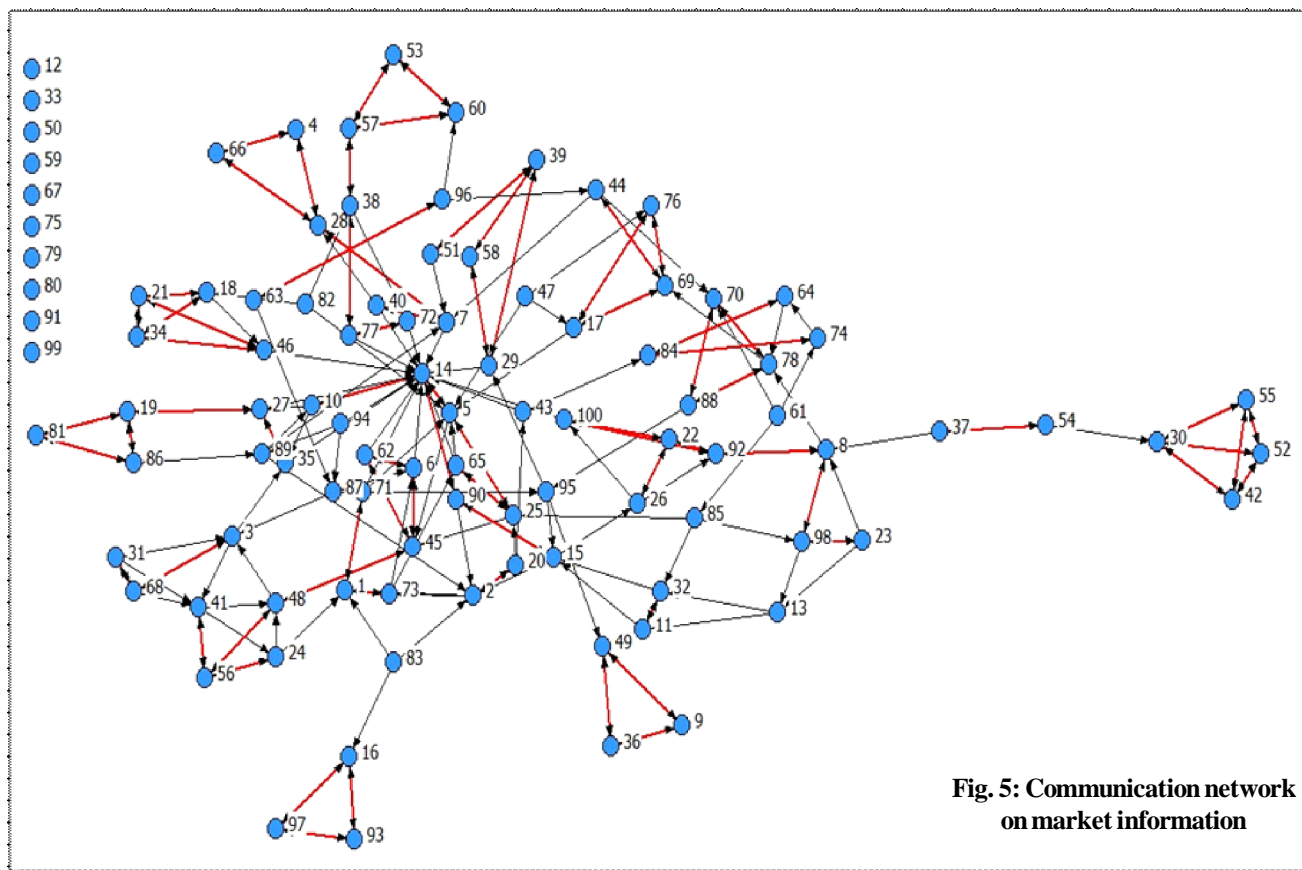


analysis used centrality data for the whole network and ego network and generated the network diagrams to provide information on how information flowed within the community for all these five information domains. Analyses also characterized specific role of certain individuals within those networks. We also compared the differential nature of the five networks and their central nodes.

*The nature of the communication networks :* here were 100 actors with a web of 283, 280, 280, 281 and 243 ties in the communication networks on seed and planting material (Fig. 1), Fertilizer/Plant Protection (Fig. 2), Irrigation (Fig. 3), Animal Husbandry (Fig. 3) and Market information (Fig. 4) respectively (Table 3). Network densities, which is an indicator for the level of connectedness in a network, were 0.03 for SPM, FPP, I and AH networks and 0.02 for M network. This implied that only 2-3% of all possible direct linkages are present in these networks. In a relatively dense network a central node's alters (node connected with the ego) also communicate with each other facilitating faster information spread and technology adoption (Valente 1995; Abrahamson and Rosenkopf 1997), which has not happened to all the five networks. But, at the same

time a relatively lower density helps avoiding super connectedness and brittleness in the network (Redman and Kinzig 2003). Moreover, it might offer low-risk lock-in in the information flow (Bodin and Norberg 2005). From a visual check of the networks, it may be observed that SPM and FPP networks are much similar in appearance, both being tightly knit and having 3-4 central actors. I network has a strong core, but the whole of the periphery is not necessarily dependent on the core nodes for information flow. AH network is relatively sparse in appearance with few central nodes. On the other hand, M network is clearly sparse in nature without any distinct core or even central actor.

The mean in-degree centrality of the whole network for SPM was 2.83. The figures for FP, I, AH and M networks were 2.80, 2.80, 2.81 and 2.43 respectively. This data tells us that there is a potential to increase the interconnections among actors in the M network, which could contribute to improving the marketability of the agricultural produce. The mean in-closeness centrality was highest in M network (11.73), followed by I (10.58), AH (10.52), SPM (9.85) and FPP (9.72). The mean betweenness centrality was highest in M network (235.17), followed by FPP (80.46), SPM (78.40), AH (72.94) and I (62.42).



*The central actors in the networks* : It was found that the few central actors played central role in the all the networks, except M network. To determine which of the actors are more important we examined degree centrality (link among farmers), out-degree centrality (influence), in-degree centrality (prestige/prominence), closeness centrality (proximity) and betweenness centrality (liaison/strategic position) and selected the nodes having greater than mean+2 SD centrality scores (in-degree scores wherever applicable). We have described the first four of these nodes for maintaining simplicity of the presentation.

Table 4 reveals that ego 9, 10, 11 & 12 (in-degree) and ego 20, 23, 47 & 67 (out-degree) in the SPM network are central actors. For FPP network central actors were 9, 10, 12 & 14 (in-degree) and 20, 23, 47 & 67 (out-degree); for I network 9, 11, 13 & 15 (in-degree) and 20, 23, 47 & 53 (out-degree); for AH network 9, 10, 12 & 30 (in-degree) and 1, 23, 60 & 67 (out-degree); and for M network 1, 5, 7 & 14 (in-degree) and 1, 2, 3 & 29 (out-degree). In terms of closeness centrality central actors in the networks are – for SPM and FPP networks

– 9, 10, 11 & 14 (in-closeness) and 54, 57, 96 & 97 (out- closeness); for I network – 9, 11, 13 & 15 (in-closeness) and 57, 59, 60 & 99 (out- closeness); for AH network – 9, 10, 12 & 30 (in-closeness) and 23, 56, 96 & 97 (out-closeness); and for M network - 5, 14, 45 & 90 (in-closeness) and 61, 63, 87 & 94 (out-closeness). Overall, for both degree and closeness centrality node 9, 10, 11 and 12 featured in more than one networks as central actor while other nodes were seeking information from these nodes (in-degree). For out-degree - 20, 23 & 47 were central actors, who sought information from others in the community. Further, SPM and FPP networks were closely related in terms of central actor, while I, AH and M networks were distinct in terms of central actors. In terms of betweenness centrality central actors in the network were – for SPM and FPP networks – 6, 11, 15 & 17; for I network 11, 15, 16 & 17; for AH network 4, 6, 15 & 30; and for M network 8, 14, 15 & 90. Overall, degree and closeness centrality were similar in terms of the central actors concerned, while betweenness centrality (liaison) were distinct in terms of central actors in the networks.

**Table 4: Centrality of selected actors in the five information networks**

Information networks	Degree Centrality				Closeness Centrality				Betweenness Centrality	
	In		Out		In		Out		Centrality	
	Ego (Sl no)	Score	Ego (Sl no)	Score	Ego (Sl no)	Score	Ego (Sl no)	Score	Ego (Sl no)	Score
Seed/planting material	10	48	23	5	10	72.833	57	13.433	17	1080.510
	11	42	47	4	11	56.259	54	12.750	6	768.716
	9	28	20	4	14	49.667	96	12.750	11	748.308
	12	22	67	4	9	49.550	97	12.750	15	666.005
Fertilizer/ pesticide, plant protection	10	48	23	5	10	72.67	57	13.433	17	1099.69
	9	28	47	4	11	55.59	96	12.750	6	796.73
	12	22	20	4	14	49.50	97	12.750	11	747.93
	14	13	67	4	9	49.00	54	12.750	15	687.92
Irrigation	15	51	23	5	15	72.67	57	13.100	15	824.33
	11	45	47	4	11	64.15	59	12.783	17	639.63
	9	28	20	4	13	51.00	60	12.483	11	626.81
	13	22	53	3	9	49.73	99	12.450	16	529.19
Animal Husbandry	30	47	23	5	10	67.42	23	13.100	30	1091.11
	10	45	60	4	30	63.85	96	13.083	6	786.46
	9	28	67	4	9	48.75	97	13.083	15	692.80
	12	21	1	3	12	48.08	56	12.876	4	533.39
Market information	14	17	1	3	14	39.82	94	19.116	14	2476.97
	5	7	2	3	5	30.95	87	18.727	90	1542.75
	7	5	3	3	90	27.13	63	18.517	15	1542.75
	1	5	29	3	45	26.64	61	18.283	8	1311.83



The central actors in SPM and FFP of the network can directly affect many of the actors. Hence, 23, 47, 20 actors had most influence (highest out-degree), 9, 10, 11 had most prominence (highest in-degree), and highest closeness (is closest to the others), and 6, 11, 15 had highest betweenness (the actor with the most favoured position) because many other actors depend on it to make connections with these actors. For other three networks these actors were different (refer to Table 4). These central positions made them more accessible to the farmers for specific agriculture related information. These actors can be considered as the most important channel for the diffusion of information and innovations in the community. Further, actors having highest betweenness may be specially taken care of for sustaining information flow and avoidance of practising vested interest within the network.

## CONCLUSION

Information is one of the most important inputs of livelihood sustenance and communication networks play an important role in sharing this information in rural society. Efficient flow of information related to farming ensures that social learning process in the community gets going and results in adoption of innovations. The present study explored the nature of communication networks related to agriculture and allied sectors in terms of five information domains - seed and planting material, fertilizer and plant protection, irrigation, animal husbandry and marketing of agricultural produce. SPM and FPP networks are similar in nature, both being tightly knit and having 3-4 central actors. I network has a strong core, but the whole of the periphery is independent of the core nodes. AH network is relatively sparse in

appearance with few central nodes. On the other hand, M network is clearly sparse in nature without any distinct core or even central actor. Although the degree centrality of network was low in the M network, the closeness and betweenness centrality was high in this network. For both degree and closeness centrality node 9, 10, 11 and 12 featured in more than one networks as central actor and for out-degree - 20, 23 & 47 were central actors. Further, SPM and FPP networks were closely related in terms of central actor, while I, AH and M networks were distinct in terms of central actors. Overall, degree and closeness centrality were similar in terms of the central actors concerned, while betweenness centrality (liaison) were distinct in terms of central actors in the networks.

The information networks at the grassroots, if plotted carefully, can act as an important input to extension agencies in reaching client system more efficiently. Extension professionals may have ideas on how agricultural information flows in a network, may understand the critical roles of important network nodes/actors, may get sensitized regarding the important role of small and resource-poor farmers in diffusion process. Capacity building of actors having high centrality scores may reinforce the information spread in social networks. There might be provisioning of alternative routes of information flow in sparse networks hinging heavily upon one or two liaisons. Moreover, the identified social networks can be used to support broader livelihood related information like health, information of development programmes etc. needed by the farming community, which is a challenge for broad based and diversified extension services in the third world countries (Goswami and Basu, 2011).

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