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Interaction patterns determining improved information and knowledge sharing among smallholder farmers participating in field-based learning alliances in eastern Zimbabwe

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Abstract

Limited access to timely and adequate information has been identified as a major impediment to the growth of smallholder agriculture in most parts of sub-Saharan Africa. This has negatively affected the socio-economic welfare of smallholder farmers resulting in high numbers of food insecure households. The potential of smallholder farmer social interactions for improved integrated soil fertility management (ISFM) information and knowledge access and sharing, was explored by understanding the smallholder social network structural layout and the role of social interactions on innovation learning cycle in the context of field-based learning alliances established by the Soil Fertility Consortium for Southern Africa (SOFECSA). Smallholder farmers within learning alliances had a denser network structure of social interactions. Closeness centrality indices were generally higher for participatory action research (PAR) participants than non-participants suggesting that field-based learning alliances facilitate improved social interactions subsequently shortening the innovation dissemination horizon.

Keywords: adoption cycle; farmer perceptions; integrated soil fertility management; learning alliance; social network analysis

Introduction

The declining trends in soil fertility within smallholder farming systems of sub-Saharan Africa continue to hamper agricultural productivity and food security in the region (Sanchez et al., 2009). Several research paradigms, including the Soil Fertility Consortium for Southern Africa (SOFECSA)'s integrated soil fertility management (ISFM) research and development thrust, have been tested and promoted at farm level to address the problem of soil fertility decline (Mapfumo, 2009). Despite field-based evidence of most of the technologies in increasing yields, adoption levels by smallholder farmers has been low (Damisa and Igonoh, 2007), and this can partly be attributed to the wide communication gaps between researchers

and farmers (Odento et al., 2006). Increasingly, trans-disciplinary research has been identified as appropriate fora of research in search for contextualised solutions with a high degree of complexity, uncertainty and controversy (Rist et al., 2007).

A study by Mashavave et al., (2011) on smallholder farmers participating in ISFM field-based learning alliances established by SOFECSA in eastern Zimbabwe showed that close to 70% of participants had adopted components or modified components of the ISFM package promoted to suit their circumstances. The study then concluded that this adoption could have been influenced by the social dynamics created through the frequent interactions of these farmers. This has generated scope for an improved understanding of technology adoption from a social network perspective with focus on the relationships among target groups rather than the attributes of the actors which is often the focus of most adoption studies (e.g. Kaliba et al., 2000, Abdulahi and Huffman, 2005). The network perspective assumes that actors (individuals or groups) have a network of interrelationships with other actors providing opportunities and constraints which maybe the causal forces for the uptake of new innovations (Halgin, 2009). Attitude formation occurs primarily through social interactions as individuals compare their own perceptions with those of others, especially 'similar' others (Galaskiewicz and Burt, 1991).

Sustainability of agricultural innovation is largely dependent on the action of farmers and their decision making abilities given the level of knowledge and information that is available to them (Boz and Ozcatalbas, 2010). Communicative learning takes place when farmers exchange views and share insights during group sessions such as field days, farmers' workshops, exchange visits among many (Hagmann et al., 1998). Essentially, innovation implies an alteration to the existing network structure of farmers or the formation of entirely new networks (Hartwich, 2010). Actors within a network can be connected on the basis of similarities, social relations, interactions and/or resource/information flows (Borgatti et al., 2009). Interaction and communication can be intended and purposeful or can be unintended and more or less constrained by factors external to the actors (Brass 1995a). However, little or no research has attempted to explore the influence of smallholder farmer social networks on the adoption of ISFM technologies which is the main thrust of this paper.

This paper gives findings following SOFECSA's initiatives for access and utilisation of ISFM information and knowledge in the context of field-based Learning Centres (LC) in eastern Zimbabwe. These initiatives sought to facilitate the spread of ISFM technologies by bridging the knowledge gap between farmers, agro-service providers and researchers (Mapfumo, 2009). Application of participatory action research (PAR) approaches in these initiatives has generated scope for understanding how farmer interrelationships with other agro-stakeholders can translate to competitive advantage through diffusion of information and shortening the adoption cycle horizon. This present study was guided by the hypotheses that learning centre approaches reduce the learning cycle through increased farmer interactions leading to higher adoption of ISFM technologies. Specifically, the study sought to: (i) assess the structural layout of smallholder farmer networks within field-based learning alliances; (ii) determine the role of social networks in the diffusion of ISFM innovations.

Investigation of differential social network effects across smallholder farmers could inform the design of extension and other poverty alleviation initiatives. On the other hand, the methodological approach may serve as a point of departure for other studies on ISFM technology adoption.

Methodology

Study site

The study was conducted in Chinyika smallholder farming area of Makoni district, Zimbabwe ($32^0$20'E - $18^0$11'S), 250 km east of the capital, Harare. The soils are predominantly sandy derived from granite (Arenosols and Lixisols). The area has unimodal rainfall pattern receiving between 650-750 mm annum^{-1} between November and March. Dominant crops include maize (*Zea mays* L.) and grain legumes that include groundnuts (*Arachis hypogaea* L.), cowpea (*Vigna unguiculata* [L.] Walp) and Bambara groundnut (*Vigna subterranea* (L.) Verdc.) with a strong livestock component, particularly cattle (Mtambanengwe and Mapfumo, 2005).

Selection of study sites and formation of learning alliances

Three villages (Village 19, 20 & 38) in Nyahava ward of Chinyika were targeted based on background information on commercial orientation, in terms of availability of road infrastructure; existing farmer groups, existence of farmer supporting institutions and previous interactions with SOFECSA. Joint visioning exercises initiated in 2009 in each of the villages led to the formation of farmer groups to participate in ISFM learning alliances (PAR participants) on a voluntary basis. A comparison group of non-participants was drawn from some villages located approximately 30 km away where no similar innovations had been tested to counter contamination. Wealth ranking procedures were used to categorise these farmers by resource endowment using attributes that included number of cattle, asset ownership, interactions with extension agents and land sizes. A full description of the different farmer categories by resource-endowment is given by Mtambanengwe and Mapfumo (2005). The farmers were categorised as: (i) resource group (RG) 1-resource endowed, (ii) RG2 comprised of intermediates and (iii) RG3 for resource constrained farmers.

Analytical framework and Data collection

The framework of social network analysis and data collection was guided by social network literature. Most researchers explain the outcomes of social networks on the basis of flows of resources (Podolny, 2001). However, actual transfers within networks are rarely measured but, rather proxies like frequency of interactions or strength of relationships (Borgatti and Cross, 2003). A 'roster' method was used to track linked information sources using the farmer as the *ego* and his/her *alters* (Borgatti, 2006). These ego-networks captured horizontal and vertical ties through sources and platforms for access and sharing of ISFM information

and knowledge (Scott, 2000). Social network analysis (SNA) was done using UCINET 6 software (Borgatti et al., 2002). Typical interaction maps for both PAR-participants and non-participants were created using NetDraw in UCINET. The purpose of the ego-network survey was to capture the changes, if any, in the interaction patterns with or without a new innovation. Network structure visualisation techniques were then used to analyse the interaction maps for both participant and non-participant farmers.

Given all actors are not equally important for dynamics and stability of the system, the importance of actors is usually quantified using centrality indices (de Nooy et al., 2005). Different sociometric measures of centrality have been developed to assess what it entails for an actor to be 'central' to a network. Among them is degree centrality indexing an actor's connectivity to others, betweenness centrality measuring an actor's control and closeness centrality measuring communication efficiency (Freeman, 1979). For this study, closeness centrality indices based on geodesic distances were employed on the observed interaction maps as a proxy to the role of farmer interactions on the adoption cycle (Brass, 1995a). Closeness centrality (CC) measures how fast it will take to spread information from a focal actor *i* to all other actors in the network sequentially. Closeness centrality of *i* is calculated as:

$$\mathrm{CC}_i = \sum_{j=1; i \neq j}^{n} \left(\frac{\mathrm{d}_{ij}}{n-1} \right)$$

where n is number of actors, and d_{ij} is the shortest distance (geodesic distance) between actors i and j measured in number of connections. Closeness centrality is computed as the inverse of the sum of the shortest distances between each individual and every other person in the network (Freeman, 1979; de Nooy et al., 2005). This implies that actors with high CC values have the potential to rapidly affect other actors in the network and vice versa. Here, the underlying assumption is that whatsoever flows through the network only moves along the shortest possible paths (Borgatti, 1995). In order to keep the structures comparable we limited our CC assessment on common sources and platforms for both groups.

Additional qualitative information was generated through participatory observation of recurrent interactions, document analysis, group discussions, and informant interviews especially with all regular participants in the learning alliances (Sasovova et al., 2010). A structured questionnaire was then administered through interviews with a random sample of 70 farmers drawn from the PAR participating and non-participating groups. The questionnaire captured data on farmer perceived information pathways, participation at Learning Centre activities, and limitations to effective information sharing. Descriptive statistics were generated using the Statistical Package for Social Scientists (SPSS) version 16.0 (www.spss.com).

Results and Discussion

Characterisation of interviewed households by preferred information pathways

Generally, >80% of farmers were still oriented to the top-down approach for accessing and sharing ISFM information and knowledge as shown by their strong preference for government extension agents as their prime source of information. The least preferred sources of information were mass media (3%) and private extension (1%). The lack of preference for mass media especially print media was mostly due to non-availability. Private extension was the least preferred source as these only targeted specific crops and the information they availed was therefore seen as a misfit in their normal cropping programmes. Non-dependency on extension as sources of ISFM information by RG1 farmers could be attributed to the group's relative capacity to access and utilize information from a wider bracket compared to their RG2 and RG3 counterparts. The most preferred platforms for accessing and sharing ISFM information were field days and agricultural extension meetings with 34% and 33% respectively. Seed fairs (2%), Master Farmer Training programme (2%) and exchange visits with local farmers (1%) were the least preferred platforms. Whilst resource-endowed and intermediate farmers groups prioritised competitive platforms, the resource-constrained farmers usually had nothing to exhibit at such platforms. Generally, non-participating resource-constrained farmers did not attend extension training.

Perceived farmer social network structures

Identified sources of information for the non-participant group were inter-generational knowledge, universities, mass media, agro-dealers, players in produce markets, NGOs, local farmers, farmer unions, private and national extension agents, local leaders and research institutions (Fig 1).

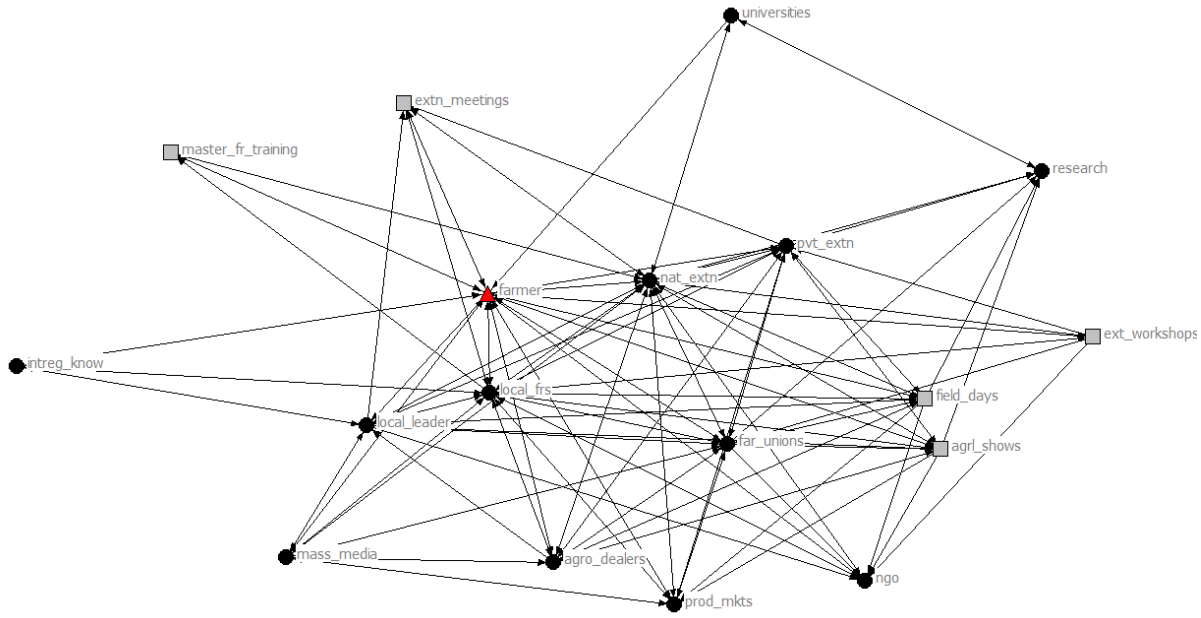

Fig 1: Structural layout for non-participant smallholder social network in Chinyika, Zimbabwe (black circles indicate sources of ISFM information and knowledge while grey squares indicate platforms for access and sharing ISFM information)

Inter-generational knowledge has been passed as 'folk' knowledge from previous generations. However, key informants revealed that much of the knowledge from this source could no longer be relied on and incomplete thus, needed to be updated in the face of current agricultural trends such as declining soil fertility and climatic changes.

Extension services were viewed as the media through which research-based knowledge passed on to farmers as evidenced by the lack of direct links between the farmer and research. Innovation dissemination was mainly through national/private extension agents (Roux et al., 2006) or farmer unions. There were few spaces where agro-service providers along value chains, local farmers and extension agents regularly met and collectively develop new knowledge and strategies. Exchanges with local farmers were mostly incidental and consisted informal dialogues void of sufficient information to constitute 'purposeful interaction' towards a specific subject matter e.g. ISFM. Generally, farmer-to-farmer interactions were along dimensions as age, religion and gender, a characteristic known as homophily in social network analysis (Leonard et al., 2008). Although some farmers showed interest to learn from each other, lack of confidence, misunderstanding, poor managerial skills and lack of clear purpose hindered them to meet. This type of network structure has been widely criticised for its general tendency to generate redundant information (Ingran and Morris, 2007) and lack of creativity which has been found to involve the recombination of different ideas or perspectives (Perry-Smith and Shalley, 2003). Besides extension meetings other identified platforms for access and information sharing included field days, agricultural shows, external workshops and for a few privileged farmers Master Farmer Training Programmes being run by AGRITEX (AGRITEX, 1985). However, involvement of farmers in most of the meetings was generally in the context of knowledge transfer activities characteristic of pipeline approaches to innovation known to discourage adoption of new technologies (Damisa and Igonoh, 2007). Field days and external workshops were usually organised by NGOs promoting conservation agriculture in the area. The composition of participants at field days was mostly farmers from within the community and very few outsiders, hence such activities were rarely conducted in this particular area. Weak collaboration within this network impacted negatively on farmers' production in that there was a lack of shared vision among the farmers and key agro-stakeholders. Whilst players in produce markets demanded critical mass production and consistency of supply, the farmers could not organise themselves for collective scaling-up of production.

The structural layout of the perceived interaction map for participant farmers (Fig 2) had a denser network compared to that observed for non-participant farmers (see Fig 1). Farmers within learning alliances had additional information sources such as organised farmer groups, farmers from outside the community, fertiliser companies and seed-houses. The farmers also interacted with district innovation platforms (DIP) and ward innovation platforms (WIP) established by SOFECSA in Makoni district. These IPs basically consisted of players in the banking sector, ministry of agriculture and service providers along agricultural value-chains.

Generally the composition of the IPs varied with the representation of a particular institution/organisation. However, at ward level, some organisations were not represented, as most of them had no establishment at this micro-level. Enhanced horizontal and vertical ties (bridges) have been found to provide novel information and different perspectives which can lead to creativity and innovation (Cross et al., 2003). Within this network, farmers' innovations were integrated for adaptive learning and testing at learning centres. Learning alliances provided space for intermediate (37%) and resource-constrained (47%) farmers to actively engage in soil fertility management problem solving (Mashavave et al., 2011).

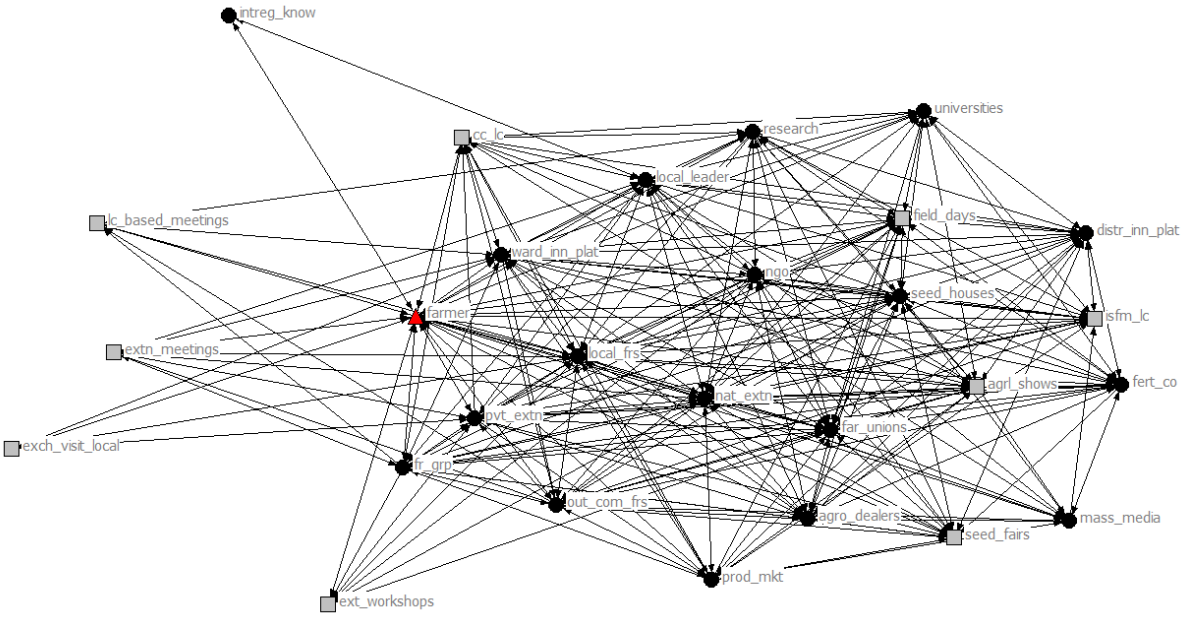

Fig 2: Social network structural layout for learning alliance participant in Chinyika, Makoni District, Zimbabwe (black circles indicate sources of ISFM information and knowledge while grey squares indicate platforms for access and sharing ISFM information)

Beside general agricultural extension meetings, the farmers were also exposed to regular learning centre based meetings for joint learning on ISFM. These meetings included participatory action planning (PAP) meetings usually conducted during the pre-season months of September or early October, followed by implementation of planned activities as the season commences, and subsequent monitoring and evaluation during the mid-season and post-season periods between January and July/August. The activities generally proceeded through an iterative cycle of action and reflection (action-learning). Studies showed that repeated interactions foster relationships that are easier to maintain and more likely to result in stable links (e.g. Borgatti and Cross, 2003). Field days drew participation from diverse groups within and outside the community where, ISFM and climate change information and knowledge were shared through songs and drama. Key informant interviews revealed that field days and agricultural shows had become non-existent before the inception of SOFECSA initiatives in the year 2007 due to depressed agricultural production. Beside field days and learning centres, the farmers also interacted through seed fairs, exchange visits with local

farmers and agricultural shows. Recurrent interactions within learning alliances were also found to foster mutual understanding and trust, broader comprehension of key ISFM issues, improved collaboration for better solutions as well as promote a market-oriented culture among smallholder farmers.

Role of social networks on smallholder farmer innovation learning cycle

Non-participants

Table 1: Geodesic path closeness centrality for a non-participant farmer in Chinyika, Zimbabwe

Closeness Centrality Measures

		1 inFarness	2 outFarness	3 inCloseness	4 outCloseness
2	nat_extn	18.000	19.000	94.444	89.474
1	farmer_exp	19.000	19.000	89.474	89.474
8	local_frs	20.000	20.000	85.000	85.000
4	far_unions	23.000	23.000	73.913	73.913
18	local_leader	24.000	23.000	70.833	73.913
10	pvt_extn	24.000	24.000	70.833	70.833
17	agro_dealers	26.000	25.000	65.385	68.000
9	ngo	26.000	33.000	65.385	51.515
16	field_days	27.000	24.000	62.963	70.833
11	prod_mkts	27.000	28.000	62.963	60.714
15	agrl_shows	27.000	24.000	62.963	70.833
3	research	29.000	34.000	58.621	50.000
14	extn_meetings	29.000	31.000	58.621	54.839
5	mass_media	30.000	27.000	56.667	62.963
13	master_fr_training	31.000	32.000	54.839	53.125
12	ext_workshops	31.000	28.000	54.839	60.714
6	universities	33.000	31.000	51.515	54.839
7	intreg_know	34.000	33.000	50.000	51.515

Statistics

		1 inFarness	2 outFarness	3 inCloseness	4 outCloseness
1	Mean	26.556	26.556	66.070	66.250
2	Std Dev	4.475	4.810	12.405	12.510
3	Sum	478.000	478.000	1189.257	1192.498
4	Variance	20.025	23.136	153.875	156.492
5	SSQ	13054.000	13110.000	81343.711	81819.680
6	MCSSQ	360.444	416.444	2769.758	2816.857
7	Euc Norm	114.254	114.499	285.208	286.041
8	Minimum	18.000	19.000	50.000	50.000
9	Maximum	34.000	34.000	94.444	89.474
10	N of Obs	18.000	18.000	18.000	18.000

Network in-Centralization = 61.97%
Network out-Centralization = 50.72%

National extension (nat_extn) had the least inFarness value of 18.00 and a corresponding highest inCloseness value suggesting that national extension still dominated information dissemination in the network (Table 1). Low Farness implies information is able to move

over short distances accurately and timely whilst the opposite (high Farness) transmits information slowly and can distort the information (Opsahl et al., 2010). Intra-community sources of information and knowledge such as farmer's own experience (farmer_exp), other local farmers (local_frs), farmer unions (far_unions and local leaders (local_leaders) were integral to the dissemination of information within this network. Research institutions (research) and universities were among the least important sources of information with inCloseness indices of 58.62 and 51.51 respectively. There was a rather strong attachment to non-governmental organisations (ngo) possibly due to anticipation of perceived benefits such as free handouts. Produce markets (prod_mkts) were primarily a source of food supplements especially maize grain in the event of grain shortages. Intergenerational knowledge (intreg_know) had the largest sum of geodesic distances from other actors (inFarness of 34.00) and to other actors (outFarness of 33.00) implying that this information source maybe of less importance. The corresponding lowest inCloseness value of 50.00 was further evidence that this source had the least potential to influence this network. External workshops (ext_workshops) were the least important platform of access and sharing of information with an inFarness of 31.00 and inCloseness of 54.84. Summary statistics indicate that the distribution of outCloseness (50.7%) indices had less variability than inCloseness values (62%).

PAR participants

Local farmers (local_frs) and farmer's own experience (farmer_exp) were the most important information sources to this network with inFarness indices of 28.00 and 29.00 respectively and corresponding inCloseness values of 96.43 and 93.10 respectively (Table 2). Smallholder farmers were able to send and receive information from these sources progressing through the notion of an influence process whereby, through interaction, individuals effect changes in each other's beliefs or attitudes (Borgatti, 1995). This suggests that there is value in contextualised practical experimentation as demonstrated by farmer participation in ISFM field-based learning alliances. The more pronounced CC indices for research institutions (research) suggested that farmer participation in action learning alliances enhanced proximity to and from research initiatives. National extension was the third prioritised source of information within this network implying a shift from the traditional top-down information dissemination approach to an innovation systems approach where farmers take the lead in research initiatives whilst outsiders are facilitators. Improved vertical ties enabled access crucial marketing information for making decisions on crops to prioritise as well as the production methods to use to ensure high productivity thus enhancing the potential to create an entrepreneurial culture among smallholder farmers where they could produce what they can market rather than try to market what they produce.

Table 2: Geodesic path closeness centrality for a learning alliance participant farmer in Chinyika, Zimbabwe

Closeness Centrality Measures

		1 inFarness	2 outFarness	3 inCloseness	4 outCloseness
6	local_frs	28.000	32.000	96.429	84.375
1	farmer_exp	29.000	30.000	93.103	90.000
2	nat_extn	33.000	31.000	81.818	87.097
10	far_unions	33.000	33.000	81.818	81.818
28	ward_inn_plat	34.000	32.000	79.412	84.375
17	pvt_extn	36.000	39.000	75.000	69.231
19	field_days	37.000	38.000	72.973	71.053
8	seed_houses	37.000	34.000	72.973	79.412
22	agrl_shows	37.000	37.000	72.973	72.973
13	agro_dealers	37.000	38.000	72.973	71.053
7	out_com_frs	37.000	38.000	72.973	71.053
4	distr_inn_plat	38.000	37.000	71.053	72.973
9	fert_co	39.000	39.000	69.231	69.231
20	isfm_lc	39.000	46.000	69.231	58.696
26	seed_fairs	39.000	43.000	69.231	62.791
15	local_leader	39.000	34.000	69.231	79.412
3	research	40.000	36.000	67.500	75.000
21	cc_lc	40.000	46.000	67.500	58.696
16	universities	40.000	41.000	67.500	65.854
18	fr_grp	41.000	35.000	65.854	77.143
11	mass_media	43.000	43.000	62.791	62.791
14	ngo	43.000	38.000	62.791	71.053
12	prod_mkt	44.000	40.000	61.364	67.500
24	extn_meetings	46.000	47.000	58.696	57.447
23	ext_workshops	48.000	49.000	56.250	55.102
25	lc_based_meetings	48.000	50.000	56.250	54.000
27	exch_visit_local	51.000	50.000	52.941	54.000
5	intreg_know	53.000	53.000	50.943	50.943

Statistics

		1 inFarness	2 outFarness	3 inCloseness	4 outCloseness
1	Mean	39.607	39.607	69.671	69.824
2	Std Dev	5.833	6.247	10.427	10.621
3	Sum	1109.000	1109.000	1950.800	1955.068
4	Variance	34.024	39.024	108.727	112.804
5	SSQ	44877.000	45017.000	138959.328	139668.891
6	MCSSQ	952.679	1092.679	3044.352	3158.510
7	Euc Norm	211.842	212.172	372.772	373.723
8	Minimum	28.000	30.000	50.943	50.943
9	Maximum	53.000	53.000	96.429	90.000
10	N of Obs	28.000	28.000	28.000	28.000

Network in-Centralization = 56.56%
Network out-Centralization = 42.65%

Extension facilitated meetings (extn_meetings) were among the less prioritised platforms of information sharing with an inFarness index of 46.00 and inCloseness of 58.70 providing

further evidence that the interaction pattern is a digression from transfer of technology models of research. Field days (field_days) and agricultural shows (agrl_shows) were the platforms most likely to influence this network with inCloseness values each of 72.97. These platforms were highly interactive and promoted sharing of information with less similar others. Summary statistics showed that inCloseness indices had more variability than outCloseness indices. Network in-Centralisation was 56.6% and out-Centralisation was 42.6%.

Conclusions

Smallholder farmers within field-based learning alliances had a denser structural layout of social interactions than non-participants implying access to more horizontal and vertical ties than non-participants. Closeness centrality measures indexing the proximity of farmers to and from sources and platforms for access and sharing of ISFM information showed that participant farmers had a relative advantage in terms of ability to send and receive information quickly. These results suggest that exposure to field-based learning alliances led to increased opportunities through enhanced social interactions. This study has shown the important role of social networks in the diffusion of new innovations as the extent to which a farmer could reach/be reached by other agro-stakeholders can influence their technology adoption decisions.

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