Interaction patterns determining improved information and knowledge sharing among smallholder farmers

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Abstract

Limited access to timely and adequate information has been identified as a major hindrance to 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. This paper explores the potential value of social interactions between smallholder farmers in improving integrated soil fertility management (ISFM) information and knowledge access and sharing, in the context of field-based learning alliances. With a particular focus on understanding the structural layout of the smallholder social network, the study quantified the connectedness of smallholder farmers along an innovation learning cycle. The study revealed that smallholder farmers within learning alliances had a denser network structure of social interactions. The magnitude of communication efficiency was generally higher for learning alliance participants than non-participants. Field-based learning alliances facilitated improved social interactions, subsequently shortening the innovation dissemination horizon and hence increasing the likelihood of ISFM adoption.

Keywords: information sharing; soil fertility management; social networks; learning cycle; Zimbabwe

1. Introduction

The declining trends in soil fertility in smallholder farming systems in 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 diminishing soil fertility (Mapfumo 2009). Despite field-based evidence that most of the technologies can increase yields, adoption levels by smallholder farmers have remained low (Damisa & Igonoh 2007). This can be attributed partly to the wide communication gaps between researchers and farmers (Odendo *et al*. 2006). Increasingly, trans-disciplinary research has provided opportunities for a search for contextualised solutions that respond to the challenges of complexity, uncertainty and sometimes conflict (Hurni & Wiesmann 2004; Rist *et al*. 2007).

A study by Mashavave *et al*. (2011) showed that about 72% of farmers participating in ISFM field-based learning alliances established by SOFECSA in eastern Zimbabwe had adopted components or modified components of the ISFM packages tailored to suit their circumstances. The study concluded that adoption could have been influenced by the social dynamics created through frequent interactions among these farmers. This therefore calls 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, as has often been the focus of most adoption studies (e.g. Rogers 1993; Kaliba *et al*. 2000; Abdulahi & Huffman 2005). This network perspective assumes that actors (individuals or groups) have a network of interrelationships with other actors that provide opportunities and constraints, which may be the causal forces for the uptake of new innovations (Borgatti *et al*. 2009; Halgin 2009). Attitude formation occurs primarily through social interactions as individuals compare their own perceptions with those of others, especially those with similar circumstances (Galaskiewicz & Burt 1991).

There is growing empirical evidence that farmers' decisions to innovate are not based only on economic and personal considerations, but also on the context of social interactions they maintain among themselves and with agents that promote change. Such agents may include buyers, input suppliers, agro-dealers, researchers, farmer associations and farmer groups (Bandiera & Rasul 2006; Hartwich & Scheidegger 2010). The 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 (Rahman 2003; Boz & Ozcatalbas 2010). Communicative learning takes place when farmers exchange views and share insights during group sessions such as field days, farmers' workshops, exchange visits, etc. (Hagmann *et al*. 1998). Other studies have shown how human and social capital formation has been integral in solving many natural resource management problems (Krishna 2001; Pretty & Ward 2001; Adler & Kwon 2002). Innovation, therefore, implies an alteration to the existing social network structure of farmers, or the formation of entirely new networks (Barley 1990; Hartwich & Scheidegger 2010). Actors within a network can be connected on the basis of similarity (same locality, affiliations or other similar attributes), social relations (kinship, affective or cognitive relations), interactions and/or resource/information flows (Borgatti *et al*. 2009; Grosser *et al*. 2010). Granovetter (1973) found that the strength of ties (connections) is a function of time, intimacy, emotional intensity and reciprocity. Interaction and communication can be intentional or unintentional and somewhat constrained by factors external to the actors (Brass 1995). Nevertheless, there has been little or no research that has attempted to explore the actual mechanisms of how smallholder farmer interactions can influence the adoption of ISFM technologies in southern Africa.

This article is based on findings following SOFECSA's initiatives in eastern Zimbabwe to promote access to and utilisation of ISFM information and knowledge by smallholders in the context of field-based learning alliances. This research on development initiatives sought to bridge the knowledge gaps among farmers, agro-service providers and researchers (Mapfumo 2009). This study sought to explore how institutional innovations to empower farmers could enhance adoption through farmer's social interactions. Specifically, the study sought to: (i) assess the changes in the social structural layout of smallholders within field-based learning alliances; (ii) investigate changes in central players with a new innovation and (iii) quantify the communication efficiency of farmer interactions in the diffusion of ISFM technologies or innovations. An 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 further studies on the adoption of ISFM technology.

2. Methodology

2.1 Study site

The study was conducted in the Chinyika smallholder farming area of Makoni district, Zimbabwe, 250 km east of the capital, Harare. Dominant crops are maize and grain legumes, which include groundnuts, cowpea and Bambara groundnut, with a strong livestock component, particularly cattle (Mtambanengwe & Mapfumo 2005). The soils are predominantly sandy, and are derived from granite. The area has a unimodal rainfall pattern, receiving between 650 and 750 mm per annum between November and March. Farmers in Chinyika have poor access to both input and output markets. The nearest market is in Rusape, about 60 km away. However, the farming community is dependent primarily on cropping for their livelihoods, and therefore commercially oriented in their production objectives. In the pre-SOFECSA phase, access to agricultural information was predominantly through national extension agents, regarded as the major source of post-1980 agricultural information currently being used by most farmers (Hagmann *et al*. 1998).

2.2 Selection of study sites and formation of learning alliances

This study builds on the activities by SOFECSA, which has been operating in Chinyika for more than five years. The integration of participatory approaches into these initiatives prior to the 2009/10 cropping season led to the formation of ISFM field-based learning alliances (learning alliance participants) in three villages (Villages 19, 20 and 38) of Nyahava ward in Chinyika. These villages were selected using criteria that included: evidence of previous interactions with SOFECSA initiatives, existence of farmer support institutions, and accessibility of the areas in terms of road infrastructure. A control group of non-participants was drawn from villages in Maire ward of Chinyika, located approximately 30 km away, where no similar interventions had been undertaken. Prior to the interventions, the two places generally shared a number of characteristics and the farmers operated under similar circumstances. These two groups of learning alliance participants and non-participants provided a sampling frame from which random samples were drawn for questionnaire administration in 2011. A systematic random sample of 70 farmers was extracted from the available lists of participant (30) and non-participant (40) farmers for the interviews.

2.3 Analytical framework and data collection

Data collection and analysis was guided by the social network analytical framework (Borgatti *et al*. 2002; Borgatti 2006), and informed by social network literature. Most researchers explain the outcomes of social networks on the basis of resource flows (Podolny 2001). However, actual transfers within networks are rarely measured, but rather proxies such as frequency and/or intensity of interactions (Borgatti & Cross 2003). Snowball methods were used to track linked ISFM information sources and platforms, using the farmer as the focal actor (*ego* in network analysis) and his/her *alters* (other actors with whom *ego* has direct relationships) (Borgatti 2006). These ego-networks captured horizontal and vertical ties through sources and platforms for access to and sharing of ISFM information and knowledge among learning alliance participants and non-participant farmers (Scott 2000). Due to the nature of the study, only 'human' sources were asked to name some of their ties who could be reached by the focal actor, whilst other sources were taken as given by the ego. In order to counter contamination in the interaction map for non-participants, a counterfactual sample was drawn from some villages located approximately 30 km away from Nyahava where no SOFECSA activities had been conducted. The collected data for both groups was subsequently subjected to social network analysis (SNA) using UCINET 6 software (Borgatti *et al*. 2002). Typical interaction maps (socio-grams) for both farmer groups were constructed using NetDraw in UCINET. The purpose of the ego-network survey was to capture the changes, if any, in the interaction patterns and players in the presence or absence of a new innovation. The observed interaction maps were subsequently subjected to sociometric measures so as to identify central players in the network and assess the level of farmer connectedness.

Given that all actors are not equally important for the dynamics and stability of the system, the importance of actors is usually quantified using centrality measures (De Nooy *et al*. 2005; Estrada & Bodin 2008). Different sociometric measures of centrality have been developed to assess what it entails for an actor to be 'central' to a network. Among them are degree of 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 structures as a proxy for the role of farmer interactions in the adoption cycle (Brass 1995; Kilduff & Brass 2010). 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:

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

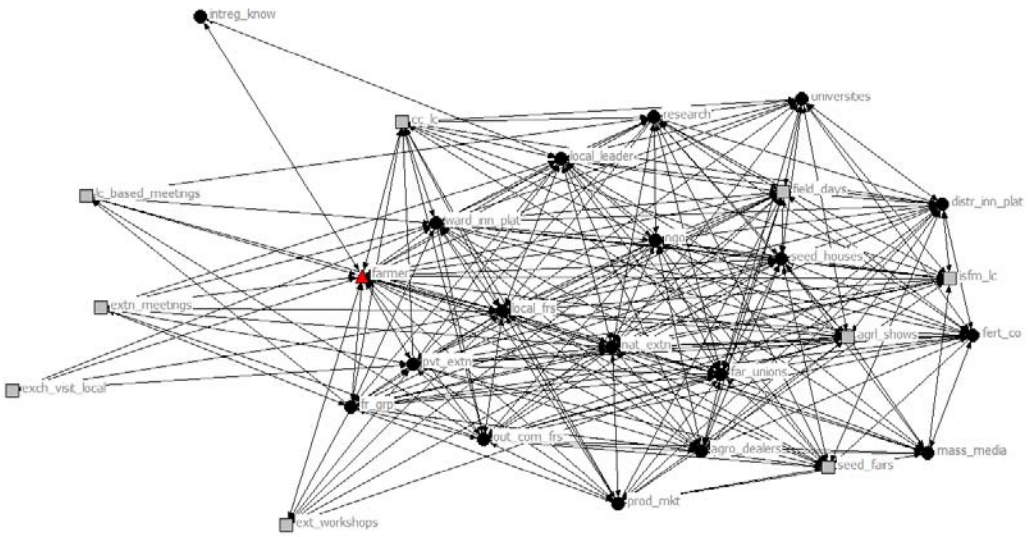
where *n* is the number of actors, and d_{ij} is the shortest distance (geodesic distance) between actors *i* and *j* measured in number of connections. Closeness centrality is computed as the inverse of the sum of the shortest distances between each individual and every other person in the network (Freeman 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 whatever flows through the network only moves along the shortest possible paths (Borgatti 1995). For this study, the CC assessment was limited to

common information sources and platforms so as to keep the structures comparable between learning alliance participants and non-participants.
Qualitative information was generated through techniques that included participatory observation of recurrent interactions, document analysis, group discussions and informant interviews, especially with all regular participants in the learning alliances (Bamberger 2000; Sasovova *et al*. 2010). A structured questionnaire was then administered in 2011 to a random sample of 70 farmers drawn from both the participants and the group of non-participants. The questionnaire captured data on the farmers' perceived information pathways, participation in field-based learning centre activities, and constraints to effective information sharing. Descriptive statistics were generated using the Statistical Package for Social Scientists (SPSS) version 16.0 (http://www.spss.com).

3. Results and Discussion

3.1 Perceived farmer social network structures

The exposure of farmers to field-based learning alliances resulted in a dense network structure (Figure 1) suggesting access to a wide range of information sources and platforms. Inter-generational knowledge (intreg_know), which is information passed as 'folk' knowledge from previous generations, was the most isolated source of ISFM knowledge and information. Key informants revealed that much of the knowledge from this source could no longer be relied on and often was incomplete, and thus needed to be updated in the face of current agricultural trends such as declining soil fertility and climatic changes. However, within this network, farmer's knowledge and innovations were integrated for adaptive learning and testing at field-based learning centres (LCs). Other identified information sources included organised farmer groups (fr_grp), farmers from outside the community (out_com_frs), fertiliser companies (fert_co), seed houses, universities and research institutions. The farmers also interacted with the district innovation platforms (DIP) and ward innovation platforms (WIP) established by SOFECSA in Makoni district. These DIPs basically consisted of members in the banking sector, ministry of agriculture and agro-service providers, including farmer associations. Generally, the composition of the IPs varied with the representation of a particular institution/organisation. This suggests that there exists scope for enhancing information and knowledge sharing as more organisations and actors are established, especially at the micro-level (ward level), thereby creating the potential to further increase the density of interactions. The IPs quickly hook up to new developments that can be shared with the farmers, thus enhancing their opportunities to access services. 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). Even if some members of the group fail to attend gatherings, fellow group members can pass on advice and training to their peers.



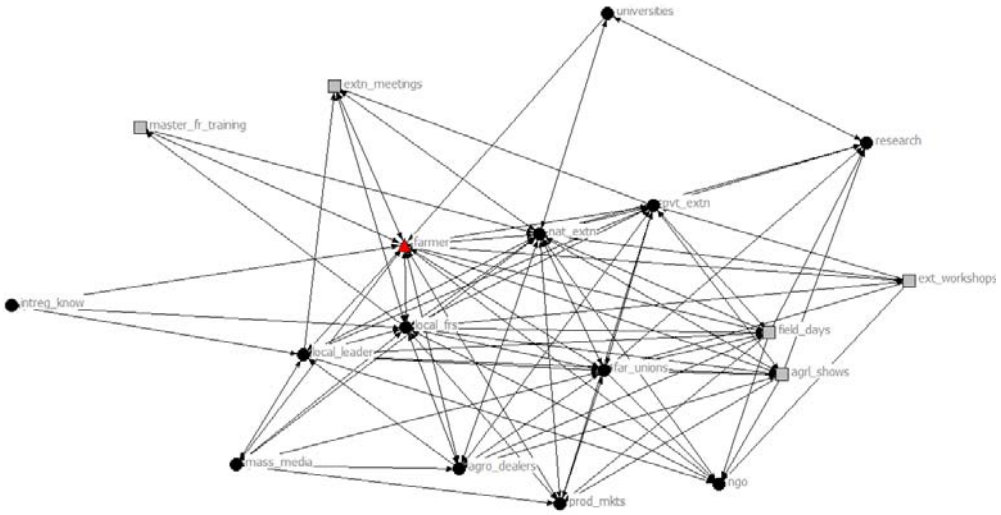
Note: Black circles indicate sources of ISFM information and knowledge, while grey squares indicate platforms for access to and sharing ISFM information)

Figure 1: Social network structural layout for learning alliance participants in Chinyika, Makoni District, Zimbabwe

The most outwardly projected platforms were exchange visits with local farmers (exch_visit_local,; external workshops (ext_workshops) and extension facilitated meetings (extn_meetings), suggesting that these platforms for access to and sharing of ISFM information were less preferred among these farmers. Learning centre-based meetings (lc_based_meetings) for joint learning on ISFM and climate change included participatory action planning (PAP) meetings, which usually are conducted during the pre-season months of September or early October, followed by the implementation of planned activities as the season commenced. Joint monitoring and evaluation then followed during the mid-season and post-season periods, from January to July/August. The activities generally proceeded through an iterative cycle of learning–action–reflection. Studies have shown that repeated interactions strengthen social coherence and trust within the group (e.g. Borgatti & Cross 2003). It is also much cheaper and easier to organise training and agricultural extension services for groups of farmers than for individual farmers (Hagmann *et al*. 1998). Field days drew participation from diverse groups within and outside the community, where ISFM and climate change information and knowledge were shared through poetry, songs and drama. Key informant interviews revealed that, as a result of depressed agricultural production, field days and agricultural shows had become non-existent before the inception of SOFECSA initiatives in the year 2007, and this could be attributed to declining soil fertility. In particular, maize grain yields were less than 2 t/ha.

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 broader comprehension of key ISFM issues, improved collaboration for better solutions, as well as promote a market-oriented culture among smallholder farmers. These collective actions provided an opportunity for the farmers to pool scarce resources, as well as to reduce transaction costs in the acquisition of requisite ISFM inputs by cutting out middlemen. In addition, the collective acquisition of inputs increases the farmers' bargaining power, which can contribute to lower production costs.

The network structure for non-participant farmers (Figure 2) had fewer dense connections (ties) compared to that for participant farmers (see Figure 1), suggesting weak collaboration within the network. Still, intergenerational knowledge was the most outwardly projected source of information. Within this network type, farmers' knowledge is usually viewed as 'know-how' and not acceptable by scientific research standards (Hagmann *et al*. 1998). Other less common sources of information were universities and direct research, as evidenced by their projection and few connections. Extension was viewed as the medium through which research-based knowledge was 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 along the value chains where farmers, extension agents and other agro-service providers met regularly to collectively develop/share new knowledge and strategies. This subsequently limited the farmers' ability to realise economies of scale and hindered the farmers from developing stable relationships with suppliers or traders. Currently, exchanges with local farmers were mostly incidental and consisted of informal dialogue devoid of sufficient information to constitute 'purposeful interaction'. Generally, farmer-to-farmer interactions were along dimensions such as age, religion and gender, a characteristic known as homophily in social network analysis (McPherson *et al*. 2001; Leonard *et al*. 2008).



Note: Black circles indicate sources of ISFM information and knowledge, while grey squares indicate platforms for access to and sharing ISFM information)

Figure 2: Structural layout for non-participant smallholder social network in Chinyika, Makoni District, Zimbabwe

Besides extension meetings, other identified platforms for access to and sharing of information included field days, agricultural shows, external workshops and Master Farmer Training Programmes being run by the national extension agency, AGRITEX. However, Master Farmer Training Programmes were the most isolated platform for access to and sharing of information and knowledge. Information on extension meetings would be conveyed through village chairpersons by verbal communication, mobile phones and/or school children. The composition of participants at field days was mostly farmers from within the community, with very few outsiders, hence such activities were rarely conducted in this particular area. Farmers in this network failed to organise themselves towards production and

marketing – this could be attributed to weak collaboration, as evidenced by the few connections. Whilst players in produce markets demand a critical mass of production and consistency of supply, the farmers could not organise themselves for collective scaling-up of production.

3.2 Communication efficiency of smallholder farmer social networks in innovation learning cycle

Smallholder farmers within field-based learning alliances generally had higher closeness centrality indices than their counterparts, implying relative communication efficiency of their network (Table 1). Higher communication efficiency implies that information can be conveyed accurately and timeously, whilst the opposite (low closeness) transmits information slowly and can distort the information (Opsahl *et al*. 2010). Non-participants had a more pronounced index for national extension (nat_extn) of 94.4 than that of the participants (81.8), suggesting that national extension still dominated information dissemination in the network. Local farmers (local_frs) and farmer's own experience (farmer_exp) were the most important information sources for participants, with closeness values of 96.4 and 93.1 respectively. Smallholder farmers were able to send and receive information from these sources, progressing through interaction processes whereby individuals effect changes in each other's beliefs or attitudes (Borgatti 1995). This suggested that there is value in contextualised practical experimentation, as demonstrated by farmer participation in ISFM field-based learning alliances. National extension was the third prioritised source of information within the network of participants, implying a shift from the traditional dissemination pathway, as dominated by the national extension service, to an innovation systems approach, in which farmers take the lead in research initiatives, whilst outsiders are facilitators.

This finding suggested a strong shift away from the dominance of the national extension service, which is often associated with transfer-of-technology approaches (Hagmann *et al*. 1998). Improved vertical ties enabled approximately 73% of the participating farmers to access crucial marketing information for making decisions on crops to prioritise, as well as the production methods to use to ensure high productivity. These results indicate that mechanisms that improve information flows to farmers can significantly influence their decision-making capacities. Direct research (research) had a high closeness among participants (67.5) than non-participants (58.6), suggesting that farmer participation in action learning alliances enhances proximity to and from research initiatives. There was a rather strong attachment to non-governmental organisations (ngo) and produce markets (prod_mkts) among non-participant farmers, possibly due to the anticipation of perceived benefits, such as free hand-outs, or as a source of food supplements, especially maize grain in the event of grain shortages. Intergenerational knowledge (intreg_know) had the least closeness values across the two groups, providing evidence that information from this source had the least potential to influence these networks.

Table 1: Closeness centrality indices for non-participant and participant farmers in Chinyika, Zimbabwe

Non-participant		Learning Alliance Participant	
Source/Platform	**Closeness**	**Source/Platform**	**Closeness**
nat_extn	94.4	local_frs	96.4
farmer_exp	89.5	farmer_exp	93.1
local_frs	85	nat_extn	81.8
far_unions	73.9	far_unions	81.8
local_leader	70.8	ward_inn_plat	79.4
pvt_extn	70.8	pvt_extn	75
agro_dealers	65.4	field_days	73
ngo	65.4	seed_houses	73
field_days	63	agrl_shows	73
prod_mkts	63	agro_dealers	73
agrl_shows	63	out_com_frs	73
research	58.6	distr_inn_plat	71.1
extn_meetings	58.6	fert_co	69.2
mass_media	56.7	isfm_lc	69.2
master_fr_training	54.8	seed_fairs	69.2
ext_workshops	54.8	local_leader	69.2
universities	51.5	research	67.5
intreg_know	50	cc_lc	67.5
		universities	67.5
		fr_grp	65.9
		mass_media	62.8
		ngo	62.8
		prod_mkts	61.4
		extn_meetings	58.7
		ext_workshops	56.3
		lc_based_meetings	56.3
		exch_visit_local	52.9
		intreg_know	50.9
Statistics			
Mean	66.1		69.7
Std dev	12.4		10.4
Minimum	50		50.9
Maximum	94.4		96.4
No. of obs	18		28

Field days (field_days) and agricultural shows (agrl_shows) had higher indices among participants than their counterparts, implying that these highly interactive platforms were integral in promoting the sharing of experiences, ideas and information with other farmers and stakeholders outside the community boundaries. Extension-facilitated meetings

(extn_meetings) had almost equal closeness values in the networks of both the participants (58.7) and the non-participants (58.6). The lower preference for these meetings among participants could be further evidence that the interaction pattern (see Figure 1) is a digression from traditional models of technology transfer found in the research. External workshops (ext_workshops) were the least important platforms of access to and sharing of information within the networks.

4. Conclusions

Smallholder farmers within field-based learning alliances had a denser structural layout of social interactions than their non-participating counterparts. They therefore had access to more horizontal and vertical (bridging) ties, which strengthened their access to information and knowledge for use in decision making. Participant farmers had a relative advantage in terms of ability to quickly send and receive ISFM information in their decision-making processes, primarily due to their proximity to information sources and knowledge-sharing platforms. The results suggest that farmer exposure to field-based learning alliances led to enhanced social interactions and increased opportunities for ISFM adoption. The closeness centrality indices were considered as a suitable analytical tool for separating the participant and control groups. Overall, the study revealed the important role of social networks in the diffusion of new innovations, as explained by the extent to which the farmers could reach/be reached by agro-service providers, influencing their technology adoption decisions.

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