

# Knowledge networking among actors of the Rahad Agriculture Scheme, Gedarif State, Eastern Sudan

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## Abstract

*The Establishment of the Rahad Agriculture Scheme in Eastern Sudan in the 1970s established an agricultural innovation system where different actors including research, extension, investment, and agro-pastoral farmers network in order to provide better livelihoods within the irrigated scheme area. This investigation focuses on the question of how knowledge of farming has been networked among the actors in the scheme so as to facilitate an innovation process within Rahad Scheme area.*

*System thinking was suggested as a methodology to analyze knowledge networking among actors in Rahad. Accordingly, Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) was conducted to identify roles and objectives of relevant actors in Rahad. It was used to define knowledge sharing among actors, and finally RAAKS is to be used to suggest future strategies to improve knowledge networking among actors of Rahad Agriculture Scheme. Essential to achieving the objectives of the study is to understand the structures of the relations among different actors in the Rahad Agriculture Scheme; accordingly Social Network Analysis has been used to study the connections between the defined Rahad Scheme actors.*

*The focus of the paper is to present the structure of what we call the Rahad Scheme formal network; direction, centrality, and density of connections among actors are discussed.*

## Introduction

The Rahad Agriculture Scheme was established in 1977 and situated within 14° 23 – 13° 30 north and 34° 22-35°55 east. It is located 260 km south east of Khartoum, the capital of Sudan, and El-Fau City is the headquarters of the scheme. It is irrigated from two sources, the Rahad River from autumn to summer and the Blue Nile River during winter. The total cultivated area in the scheme is 147,698 hectares (Benedict *et al.*, 1982) (Rahad Agriculture Corporation, 2010).

One of the reasons for establishing of the Rahad Scheme was to shift the sustainably based economy of indigenous agro-pastorals surrounding the area of the scheme to a more intensified cultivation, so the government of Sudan anticipated that the standard of living – income, housing, nutrition, education, and values of those people – would be improved (Benedict *et al.*, 1982). In accordance with that planning, tenants were settled and allotted farming units of 9.2 hectares to plant cotton, ground nuts, and fodder crops. The Ministry of Agriculture in Sudan appointed the Rahad Agricultural Corporation to be the responsible institution for managing the Rahad scheme; the corporation was responsible for providing agriculture inputs and assessing costs against profits, while tenants were responsible for farming the land and would receive profits from their production (Benedict *et al.*, 1982). Crop combination in the Rahad Scheme was modified according to farmers' needs and economical viability. Therefore, sorghum, sweet corn, wheat, and sunflower were introduced into the scheme (Benedict *et al.*, 1982) (Rahad Agriculture Corporation, 2010).

The scheme had undergone many changes since its foundation up until the time of the research study (2010/2011). Shifting the finance of inputs from government to banks and inadequately providing maintenance requirements for the scheme assets "canals and machinery" had let to increasing farmer debt and fluctuating productivity (primary data, 2010). Presently a private company has been invited by the government of Sudan to share farming the scheme with the farmers. By the end of the farming season, the cost of production will be calculated at the farm unit level, and net profit will be distributed 50% for farmers, 40% for the company, and 10% for the improvement of social services within the scheme area (Ministry of Agriculture and Forestry, 2009).

## Innovations and Social Networks

Rogers (1983) , Beal and Bohlen (1955) cited by Valentine (1995) had earlier stressed that diffusion of innovations is a communication process, because innovation is communicated through certain channels over time among members of a social system. The time factor is essential in these types of innovation models; innovativeness (output of innovations) is correlated by time of adoption with the level of education, level of income, cosmopolites, and contact with change agents) (Valentine, 1995). The role of actors, and their interactions in the settings of innovations had been neglected on those linear models (Valentine, 1995; Spielman *et al.*, 2010).

Rural sociological research has developed this classic model of innovation diffusion to other subsets of diffusion known as network models of innovations (Valentine, 1995). According to Valentine (1995),

the network is a pattern of relations that could connect members of social systems; friendship, advice, communication, or supports existing between members are examples.

Therefore diffusion research employing a network perspective (Liu *et al.*, 2005) stems from viewing the structure of the relations among members of the social system as a factor that shapes or constrains the spread of new ideas and practices in the social systems (Burt, 1987; cited by Liu *et al.*, 2005).

Thus network models explain innovation diffusion in accordance with the structure of the social system and the communication pattern (who talks to whom) in the social networks (Valentine, 1995). These models are also used to decide the flow of personal influence (who influences whom) (Valentine, 1995).

Therefore, the relations of a given actor or actors in the network (leadership model) (Colman *et al.*, 1966; cited by Liu *et al.*, 2005) or relations and positions of all actors in the network structural models (Burt, 1987; cited by Liu *et al.*, 2005) can influence the adoption of innovation.

Considering social network structure as a factor influencing the diffusion of innovations means that this diffusion can be searched as a relational context in addition to time influence. Researchers believe so as Freeman (1984) argued, social network analysis would study how the social structure within the innovation contexts emerged, how it evolved, and how the structure of relations exhibit consequences for behavior. Using social networks as a dimension to study innovations is a way to explain complexities in the innovation processes, which leaner models failed to explain (i.e. heterogeneity of actors and their relations) ( Spielman, *et al.*, 2010).

Researchers in this study examine the innovation process within the Rahad Scheme by looking at the information flow between different actors that form the social network of the Rahad Scheme (Spielman, *et al.*, 2010). This flow of information goes through links connecting actors in the scheme network (Valentine, 1995; Engel, 1997). Actors' prominence in the network (Liu, *et al.*, 2005) and the content of their contacts is assumed by the researchers as the factor that influences the innovativeness in the scheme context (adoption of irrigated farming by agro-pastoral communities). In other words, network structures within the Rahad Scheme influence information flow between actors of the scheme and thus influence innovation output (Valentine, 1995; Coulon, 2005).

Two networks have been developed to work with the research problem. First there is a network consisting of 15 actors that communicate using codified information on irrigated farming management, livestock keeping, credit management, irrigation water management, forest conservation and management, environmental health management, and other social and administrative issues within the scheme area. This network also consists of representatives of farmer organizations in the scheme area.

For more information, see the attached appendix showing the array of actors, their contacts (who talks to whom), the content of discussion, and frequency of contacts.

The aim of this paper is to present the network structures the 15 relevant actors within the Rahad Agricultural Scheme (called the Rahad Scheme formal network); direction of connections, density, and centrality of the network are also discussed.

## **Methodology**

### **Knowledge and Information System Thinking**

System thinking is an approach developed by scientists to study the world and how to intervene in it; more specifically, it is an approach to studying agricultural innovations as settings where knowledge and information interact and are exchanged by different stakeholders or actors (Engel, 1997). System thinking may not be the only valid way to do so, but it has been widely adopted by many disciplines (Engel, 1997; see also Röling, 1992). Although there is no agreed definition on what system thinking is in literature, it is referred to as '*an image or metaphor of the adaptive whole, which may be able to survive in a changing environment*' (Scheckland and Scholes, 1990 cited by: Engel, 1997).

Knowledge system thinking is a diagnostic approach that would either aim to implement better interventions, or an investigator would learn more about the function of the system (Engel, 1997).

There could be many methodologies for understanding the process of innovation in the Rahad Scheme; choosing knowledge system thinking will help one understand the nature of knowledge held by different actors. RAAKS or Rapid Agricultural Appraisal Knowledge System is an empirical methodology to question innovation systems (Scheckland and Scholes, 1990; cited by Engel, 1997). RAAKS is a tested, participatory action research methodology used to approach agricultural innovations with change, but it does not give direct answers to innovation problems (Salomon and Engel, 1997). This approach to change begins by forming a team to diagnose the social organization of a certain innovation.

According to Hulsebosch (2001), the team of RAAKS in the investigation processes will aim to better organization, decision making, and information exchange among actors. RAAKS also aims to increase

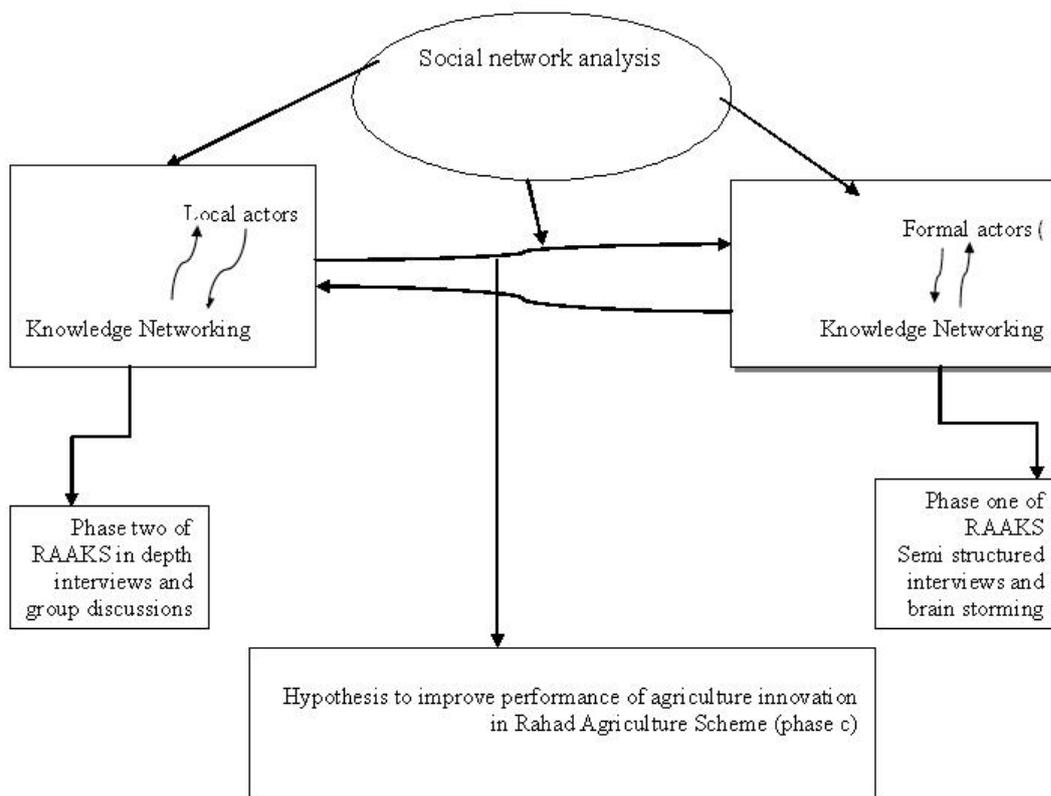
awareness among actors with respect to opportunities and constraints that affect their performance. Finally a RAAKS study will aim to identify actors and potential actors who act or could act effectively to remove constraints and use opportunities to improve innovative performance (Salomon and Engel, 1997).

RAAKS is implemented in phases; each phase has its constructed images or windows to diagnose and better organize innovative performance of studied actors. (Salomon and Engel, 1997; see also Hulsebosch (2001).

### How RAAKS was conceptualized by researchers in the Rahad Agricultural Scheme

In the following sketch we thought that within the Rahad Agriculture scheme, information flows among and between different social actors within the scheme. This flow of information materializes in certain communications and relations among the actors. This networking has characterized the actors' performance in the innovation over time. That the Rahad scheme is an innovation that has been implemented by formal institutions for agro-pastoral communities to practice irrigated farming is in fact a situation that by necessity poses an interesting question on how communication and coordination have been taking place between those different actors in order to realize the Rahad Scheme.

Since the focus of the paper is to present the structure of the Rahad formal network, in this methodological part we will show the methods used to collect information on its structure.



**Figure 1 :** a diagram showing how researchers conducted RAAKS in Rahad Agriculture Scheme; formal actors in Rahad means Rahad Scheme Administration, Ministries, research institutes, education institutes, investment, and private sector. Local actors in Rahad Scheme are Individuals and associations of agro pastorals. Understanding flow of information within and among both actors will improve the performance of agriculture innovation. Social network analysis is used to analyze part of RAAKS research study

### Sampling

Purposive sampling was conducted, as the researcher aimed to include actors concerned with innovations achieved by the Rahad Agricultural Scheme (Bryman, 2001). After approaching the Rahad Scheme administration, researchers decided to conduct snowball sampling in order to interview actors within the scheme (Bryman, 2001). Snowball sampling allowed the researchers to move from one

actor to the next during interviews by asking Who else do you think is involved with agricultural innovation in the Rahad Scheme. A structured questionnaire was used with 15 actors defined by the snowball sampling in order to collect information on their connections: whether actors recognize each other, how many times do they meet, and what is content of their discussion.

## **Data analysis**

### **Social network analysis**

Social network analysis is a methodological perspective that has been developed within the social sciences. Social network analysis stems from the importance of the relations connecting interacting entities (Wassermann and Faust, 1994; Scott, 2000). It considers individual entities and the relations connecting them as the unit of the analysis (Wassermann and Faust, 1994). Those individual entities could be individuals, groups of the same type, or different types. Entities in social network analysis are called actors, who are connected to others with relations (Wassermann and Faust, 1994). Relations connecting actors are known as relational ties (there could be different kinds of relations connecting actors, i.e. biological relations, affiliations, behavioral interactions, etc.). Therefore, measurements of social network analysis are suitable for use in analyzing innovation systems based on a network perspective. The measurements used by the researchers in the analysis are described in the followed section.

### **Size of the network and direction of connections**

The size of the network is determined by the number of actors (Wassermann and Faust, 1994; Scott, 2000). Researchers determined the size of the Rahad network based on the number of actors defined by the snowball sampling (Bryman, 2001) used during the first phase of RAAKS. Then the researchers used semi-structured interviews to elicit information on who is talking to whom, how many times each year or month that this talking takes place, and what the content of their discussions is.

### **Density among the actors in Rahad**

Density is defined as the degree of dyadic connections in a population (Hannenman and Riddle, 2005). In other words, the more ties connecting actors with each other, the more complete the network will be (Hannenman and Riddle, 2005).

Density is calculated as  $T / n(n-1)/2$ , where T is number of ties and n is the number of individuals in the network (Scott, 2000). Density is measured between 0-1, where one is the highest density, nearly zero means a weakly tied network, and nearly one is a strongly tied network (Wassermann and Faust, 1994; Scott, 2000).

### **Centrality in Rahad**

Centrality is a measurement used to calculate the importance of actors in the network. The importance of actors could be measured according to number of relations they send or receive with other actors (degree measurement) (Bogratti *et al.*, 1999; see also Wasserman and Faust, 1994). In order to measure centrality, researchers used closeness centrality (global centrality as it gives an idea of the distance among actors in the whole network (Scott, 2000). Centrality closeness is the extent to which an individual is near other individuals in the network. The formula for closeness centrality is  $n-1/\sum dij$  where n is network size; dij is the number of ties in the geodesic distance between i and j (Freeman, 1979, in Scott, 2000). Geodesic distance means the number of relations in the shortest possible walk from one actor to another (Bogratti *et al.*, 1999; Scott, 2000).

## Results of the Rahad Scheme formal network

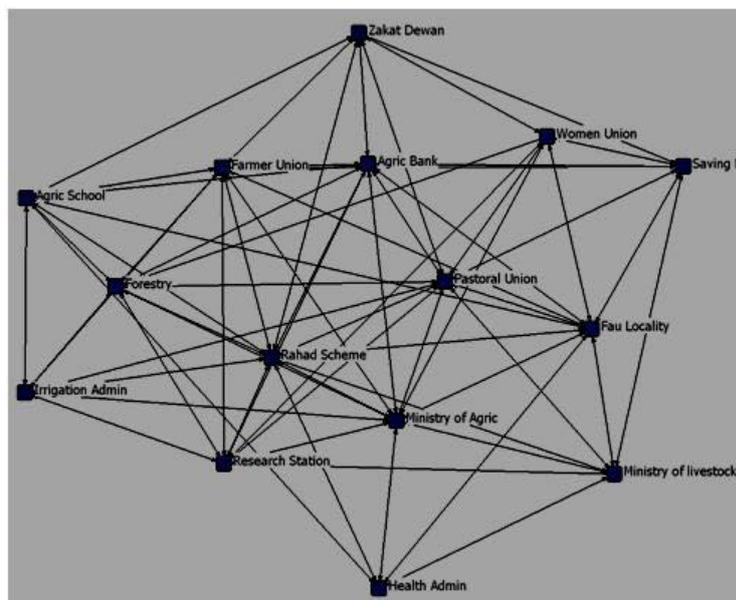
Rahad Scheme	The administration of agriculture scheme which was established to settle agro pastorals within Gedarif State and Gezira state – head quarter in El fau City
Rahad Research Station	A governmental research station to conduct agriculture research and specifically provide research findings to Rahad Scheme
Ministry of Agric	Ministry of Agriculture responsible to manage farmnig activities for rain fed farmers within El fau area
Ministry of livestock	Ministry of livestock responsible for health services and production activities of animal stocks in El fau area
Fau locality	El fau locality executive office that represents government authority in El fau area
Irrigation admin	Irrigation Administration Governmental inistitute responsible to manage water requirements for irrigation of Rahad Scheme
Farmer union	A voluntary organization represents Rahad scheme's farmers
Pastoral union	A voluntary organization representing owners of livestock in El fau area
Women union	A voluntary organization representing women in E lfau area
Saving bank	Saving and Social Development Bank, private financial Bank provide micro financial projects for farming society in El fau area
Agric Bank	Agriculture and trading Bank, a governmental financial Bank responsible to finance production inputs for farmers in Fau area
Heath Admin	Health administration in El fau locality responsible to monitor environmental health in El fau area.
Zakat Dewan	An Isalmic governmental institution responsible to manage donations from rich to needy people in El fau locality
Forestry	National Corporation for Forestry, a governmental institution responsible conserve and manage forest resources in El fau area
Agric school	El fau A agriculture school: a governmental higher school responsible for providing formal education in farming in El fau area.

The 15 actors are presented, and definitions of actors are provided in Figure 2.

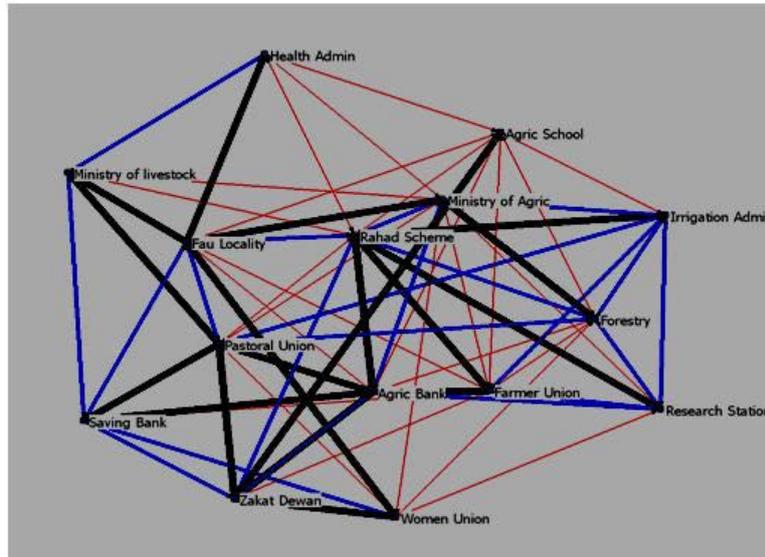
### Direction of connections in Rahad Scheme

In the Rahad Scheme formal network, two-headed arrows mean both actors are initiating contact with each other, and one-headed arrows mean only one actor initiates contact to another. There are variations in the structure patterns within the network (initiating contacts, Fig. 3, and frequency of contacts, Fig. 4); contacts in the Rahad Scheme formal network can be explained as follows:” the *Rahad Scheme administration* is the technical body managing farming operations in the scheme area. There are two ways contacts between the scheme administration and the *Agricultural Bank*, which is the credit institution within the scheme that facilitates funding inputs costs of farming, occur. The *Rahad Farmers' Union* representing farmers contacts both the scheme administration and the *Agricultural Bank* in order to facilitate technical supervision and access to credots for the farmers. The *Rahad Research Station* represents the source of agricultural research outputs for the *Rahad Scheme Administration*; both actors communicate with each other. In the same pattern, the *Irrigation*

*Administration* and the *Rahad Scheme Administration* communicate in order to facilitate irrigation water requirements for farming. The *Ministry of Agriculture*, which is the technical supervisor for rain-fed farming (outside the scheme area), contacts the *El Fau Locality Executive Office* and the *Agricultural Bank* in order to facilitate input funding and other administrative issues concerning rain-fed farming in the El Fau locality. The *Ministry of Livestock* and the *Health Administration* both contact the *El Fau locality executive office* in order to work on monitoring and supervising public health and livestock health within the locality. *Zakat Dewan* (Islamic Institution) in two directions of communication delivers donations to students and needy families by contacting the *El Fau Agricultural School* and the *Women's Union*. The *Pastoral Union* contacts the *Ministry of Livestock*, *El Fau Locality Executive Office*, and credit institutions (i.e. the *Agricultural Bank*) in order to monitor livestock health, access to pasture, tax reductions, and to plan micro-projects for livestock owners. The *Savings and Social Development Bank* is a private credit institution that contacts the *Women's Union*, and the *Pastoral Union* in order to organize the disbursement of micro-projects for women associations and livestock owners. The *National Forest Corporation* is a governmental institute that communicates with youth and public committees through the *El Fau locality Executive Office* in order to implement forest management and conservation programs within the El Fau locality. The above contacts represent the primary and frequent connections between actors (Fig. 4). The presence of weak connections in the network (when actors meet irregularly to discuss work) has been mentioned and discussed in discussion part of this paper.



**Figure 3:** figure shows connections of actors within the Rahad Scheme Formal actors. There is a core of actors in this network; *Rahad Scheme Administration*, *Ministry of Agriculture*, *Pastoral Union*, *Farmers Union*, and *Agriculture Bank* are the main actors that circulate communication on irrigated farming, rain fed farming, and credits for farming inputs.



**Figure 4.** Shows valued connections in Rahad Scheme formal network; Black lines shows strong related actors, actors would meet monthly to discuss specific working issues, blue lines indicated next strong related actors, which means actors meet twice a year, and red lines indicate weakly related actors, when actors meet irregularly or without schedule to discuss work.

#### Density and Centrality of the Rahad Formal Network

In our network we found the density to be 0.5981. Therefore, the number of isolated actors “that have fewer ties to the rest of the actors” in the Rahad network is almost equal to the number of actors that have a larger proportion of ties to each other. Therefore, we can describe our network as moderately dense.

In the Rahad network, the Rahad Scheme, Pastoral Union, Ministry of Agriculture, and El Fau Locality have the highest closeness (reach other actors most quickly); followed by the Farmer Union and Agriculture Bank; while the Women Union, Health Administration, and Agricultural School are peripheral actors in the network.

Actors' higher closeness centrality	Value	Actors' medium closeness centrality	Value	Actors' minimum closeness centrality	Value
Rahad Scheme Administration	87.500	Agriculture bank	73.684	Women Union	63.636
Pastoral Union	82.353	National Forest Corporation	70.000	Health Administration	60.870
El fau locality Executive Office Ministry of Agriculture, Rahad Farmers Union	77.778	Rahad Research Station Zakat Dewan, Saving and Social Development Bank, Ministry of livestock, Irrigation Administration	66.667	Elfau Agriculture School	48.276

**Figure 5:** table shows closeness centrality in Rahad Scheme formal network. Values of out closeness are presented.

## Discussion of Results

In the Rahad Scheme's formal network, researchers considered the density of all the connections within the network as one of the measurements of the Rahad network structure. In diffusion research, network density is associated with faster diffusion; higher network density indicates that there is a lot of communication among individuals within the network (Valentine, 1995). In line with this fact, Riana, *et al.*, (2005) found that the flow of information within the Tomato IPM (Integrated Pest Management) network in Kenya was low due to it being a less densely knit network. However, the sparsely knit network of the Tomato IPM indicated connections through weak ties to other sources of information outside the network (Granovetter, 1973). A study by Spielman *et al.* (2010) measuring how Ethiopian small holders innovate – how they make use of new knowledge and technology in their livelihood decisions – found that innovators have more ties to a large number of actors than non innovators. That makes the innovator network larger but less dense than that of non-innovators. Density among actors in the Rahad network was found to be 0.5646, meaning that connections among actors seeking information on farming, credits, and livestock keeping are moderate connections and not tightly knit. A densely knit network shows the cohesiveness of the community, but the flow of information can become fragmented and captured within the borders of communication (Granovetter, 1973). On the other hand, networks with less density indicate access to different sources of information through actors connected to outside sources of information (Granovetter, 1973; Riana *et al.*, 2005). Therefore the moderate density in the Rahad Scheme formal network illustrates the prominence of actors connected to outside sources. Findings of density in the Rahad network lead to discussions on the centrality of actors in the formal Rahad network. Centrality is the degree to which links between the networks are centralized within a group of individuals (Valentine, 1995). A centralized network contains a few members who are the locus of the contacts (Valentine, 1995).

Individuals with high centrality closeness reach other individuals in the network more quickly or with fewer steps, and they can rapidly and influentially spread information concerning innovations to many others (Valentine, 1995). In contrast to other literature, Spielman *et al.* (2010) found that public sector actors were central to the network and had high centrality in the studied regions of Ethiopia. However, those government actors were unlikely to adequately meet their goal of commercializing small holder productions. There were other non-governmental organizations that had far-reaching ties that were most likely to bring new information and opportunities to innovate (Granovetter, 1973). Moreover, Riani *et al.* (2005), studying the information flow among tomato stakeholders, found similar results that the Ministry of Agriculture, non-governmental organizations, and small-scale farmers in the studied region were the central actors in the IPM network but did not maintain frequent contact with each other. Thus information flow in IPM practices was not consistent. In the RAAKS research conducted, the *Rahad Scheme Administration*, *Ministry of Agriculture*, and *El Fau Locality Executive Office* were the closest to be reached by other actors in the network. Therefore information on farming within the locality where the scheme is situated is mainly sourced from the Rahad Scheme Administration for information on irrigated farming and from the *Ministry of Agriculture* for rain-fed information. The *El Fau Locality Executive Office* represents the government authority in the scheme area, so administrative issues of farming such as tax collection or disputes between farmers are maintained by the locality officers. The *Pastoral Union* and *Farmer Union* are the secondary central actors in the network. The *Farmer Union* describes itself as a partner in management of the Rahad Scheme. The presence of the *Pastoral Union* as a central actor in the network is due to the actor's ability to reach other actors within the scheme (the representative of the *Pastoral Union* in the scheme area is a famous farmer with a considerable amount of livestock in the area, so he also has personal motives to research information on farming, livestock keeping, and credits). The *Agricultural Bank* is central in the network, since it represents the main credit institution for input costs for farmers within the Rahad Agricultural Scheme or within the rain-fed sector in the El Fau Locality. This would explain the peripheral role for the *Savings and Social Development Bank*, which is a private credit institution running micro-finance projects for animal owners and women groups within the El Fau Locality. The *El Fau Agricultural School*, *Health Administration*, and *Women's Union*, are peripheral in the Rahad Scheme formal network; they have fewer connections within the network of the scheme but are connected with other circles outside the Rahad Scheme formal network (Raini *et al.*, 2005; Spielman *et al.*, 2010)

The *Women's Union*, *El Fau Agricultural School*, and *Health Administration* are weakly connected with the rest of the actors in the Rahad Scheme (Fig.4). Consistent with literature findings, some of the mentioned actors have outside connections (Granovetter, 1973; Raini *et al.*, 2005; Spielman *et al.*, 2010). The *Women's Union* is a volunteer women's association working to improve the economic and social situation for women in the area. It is also connected with the federal women's union in the capital. The *Women's Union* in the scheme area is connected to other women's groups (i.e. workers on farms, Quran learning groups); however, no present extension programs are being directed at those groups by the *Rahad Scheme Administration* or *Ministry of Agriculture* in the area. The *El Fau Agricultural School* is not getting any support to train students in agricultural practices, but students

who study in the school are sons of farmers in the area with well-organized and equipped training in farming. In the long run, students can add further farming knowledge on innovations in the Rahad Scheme. The *Health Administration* does not exchange information on issues regarding livestock keeping with either the *Pastoral Union* or *Farmers' Union*; however, the *Health Administration* is a source on environmental health in the area (connected to the State Ministry of Health in Gedarf through the *El Fau Locality*). Building connections between the Ministry of Health and farmers' organizations in the Rahad Scheme can improve chances for innovation performance in the Rahad Scheme (Granovetter, 1973; Raini et al., 2005; Spielman et al., 2010).

### Concluding remarks

The paper had presented the structure of the Rahad Scheme formal network, the prominence of actors, and their patterns of communication (Valentine, 1995; Liu et al., 2005). It discussed how the structure of relations is shaping the current process of innovation among actors who exchange codified knowledge on farming, credits, livestock keeping, and other administrative issues related to farming within the Rahad Agricultural Scheme.

The structure of the Rahad Scheme formal network shows the prominence of actors central to the network who influence information flow within the formal actors; the *Rahad Agricultural Scheme Administration*, *Ministry of Agriculture*, and *El Fau Locality Executive Office* were the main actors. However, some central actors in the formal network such as the *Pastoral Union* and *Farmers' Union* could exploit the Rahad Scheme formal network with personal and political interests that may shift the innovation process in the scheme (information flow). The Rahad Scheme formal network also contains actors that have fewer connections within the network but are connected to outside sources of knowledge. The *Women's Union* and *El Fau Agricultural School* are examples. Maintaining such connections can bring better performance for agricultural innovation in the Rahad Scheme.

The next stage of research is to connect the Rahad Scheme formal network with local actors (farmers, women, youth, and local leaders) within the Rahad Agricultural Scheme. Understanding the relations between the Rahad Scheme formal network and local actors (under process) can bring more insights into the information flow among the actors, whereas maintaining the expected weak linkages will hopefully improve innovation within the Rahad Agricultural Scheme.

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