ISSN 0798 1015

REVISTA ESPACIOS

Vol. 38 (Nº 47) Year 2017. Page 35

Agricultural knowledge and innovation system in South Kazakhstan Region: Sustainable agricultural intensification of innovation enterprises

Sistema de conocimiento e innovación agrícola en la región del sur de Kazajstán: intensification agrícola sostenible de las empresas de innovación

V. SEITOVA [1]; K. STAMKULOVA [2]

Received: 26/09/2017 • Approved: 06/10/2017

Content

1. Introduction
2. Integrated soil fertility management
3. Conceptual framework
4. Materials and methods
5. Data collection and analysis
6. Results and discussion
7. Conclusions and recommendations
References

ABSTRACT:

Agriculture remains the backbone of the Kazakhstan economy, yet land, the deterioration severely hampers agricultural productivity. Over the past decades, scientists and development practitioners have protected integrated soil fertility management practices to improve soil fertility. However, their acceptance levels are low, in part because many farmers in the South Kazakhstan Oblast are not fully aware of the principles of these systemic innovations. This was attributed to the wide communication gap between farmers and other agricultural agents in agricultural knowledge and innovative systems. We add to the literature, applying innovative system approaches to integrated awareness processes of soil fertility management. This study seeks to assess if agricultural knowledge and innovative

RESUMEN:

La agricultura sigue siendo la espina dorsal de la economía de Kazajstán, pero la tierra, el deterioro dificulta gravemente la productividad agrícola. Durante las últimas décadas, los científicos y los profesionales del desarrollo han protegido las prácticas integradas de manejo de la fertilidad del suelo para mejorar la fertilidad del suelo. Sin embargo, sus niveles de aceptación son bajos, en parte porque muchos agricultores en el sur de Kazajstán Oblast no son plenamente conscientes de los principios de estas innovaciones sistémicas. Esto se atribuyó a la amplia brecha de comunicación entre los agricultores y otros agentes agrícolas en el conocimiento agrícola y los sistemas innovadores. Agregamos a la literatura, aplicando enfoques innovadores del sistema a los

systems effectively disseminate an integrated knowledge of soil fertility management by the results of Kazakhstan. Social networking measures and statistical methods were used, using data from key formal agents and farmers. Our results suggest that the presence of weak knowledge links is important for awareness of integrated management of soil abundance at both sites of the study. However, in Kazakhstan agricultural knowledge and innovative systems are more effective, since there is a network of knowledge links, crucial for not only dissemination, but also the acquisition of knowledge about complex innovations.
Keywords Actor ties; Agricultural knowledge and innovation systems; Ego networks; Integrated soil fertility management

procesos integrados del conocimiento de la gerencia de la fertilidad del suelo. Este estudio busca evaluar si los conocimientos agrícolas y los sistemas innovadores diseminan efectivamente un conocimiento integrado de la gestión de la fertilidad del suelo por los resultados de Kazajstán. Se utilizaron medidas de redes sociales y métodos estadísticos, utilizando datos de agentes formales clave y agricultores. Nuestros resultados sugieren que la presencia de enlaces de conocimiento débiles es importante para el conocimiento de la gestión integrada de la abundancia de suelo en ambos sitios del estudio. Sin embargo, en Kazajstán los conocimientos agrícolas y los sistemas innovadores son más efectivos, ya que existe una red de enlaces de conocimiento, cruciales para no sólo la diseminación, sino también la adquisición de conocimientos sobre innovaciones complejas.
Palabras clave actor corbatas; sistemas de conocimiento e innovación agrícola; redes ego; gestión integrada de la fertilidad del suelo

1. Introduction

The importance of agriculture to Kazakhstan national economy and farmers’ livelihoods has been a major driving force for efforts fostering its sustainable intensification (Vanlauwe et al. 2010). It is well known, however, that many of Kazakhstan soils are characterized by inherent low soil fertility mainly due to a lack of volcanic or glacial rejuvenation and prolonged nutrient mining, a problem aggravated by extremely low fertilizer use. Diminishing farm sizes in many regions of Kazakhstan have resulted in continued cropping of the same parcels of land thus leading to the depletion of essential soil nutrients, land degradation and low productivity. This calls for innovative and sustainable forms of agricultural practices to raise or at least maintain and not just exploit soil productivity. Integrated soil fertility management (ISFM) is one such approach and it aims to take into account the array of often site-specific biological, chemical, physical, socio-economic and political processes that determine the effectiveness of soil fertility management. However, system innovations such as ISFM, agroforestry and conservation agriculture (CA) are knowledge-intensive, complex and involve risks, which often lead to low adoption. Low ISFM awareness is often a result of communication gaps between farmers (the primary producers and end-users of ISFM knowledge) and other agricultural stakeholders (Sanginga and Woomer 2009). Early models of innovation transfer such as the linear(pipeline)and induced innovation models, which focus on delivering technologies to the supposed users (farmers), have failed to improve agricultural productivity in Kazakhstan (Ro ¨ling 2009b, 2010). Unfortunately, agricultural scientists as well as policy makers and development agents are still much in favor of these approaches despite their limitations (Friederichsen et al. 2013; Ro ¨ling 2009a). The more recent innovation systems approaches are systemic in nature and emphasize mutually interactive learning between diverse actors in an agricultural system, in effect providing multiple pathways for problem solving (Klerkx et al. 2012; Ortiz et al. 2008; Pascucci and De-Magistris 2011; Ro ¨ling 2010). Hence they are viewed as a viable means of fostering innovation in small holder farming systems. Acritical examination of multi actor driven innovation processes that underpin knowledge search and utilization and their interaction with farmers’ social networks is hence vital in unraveling weaknesses in the sequence of system innovation awareness, learning, and uptake. Due to the complex nature of the innovation process previous research employed network perspectives to analyze linkages between informal farmer and formal actor networks (Crespo et al.2014; Esparcia 2014; Hoang et al. 2006; Isaac2012). While these studies reveal important network processes underpinning knowledge transfer between actor networks in an innovation system, such as embeddedness (Hoangetal.2006),centrality(Crespoetal.2014) and ties (Isaac 2012), the relationships between informal networks of smallholder farmers and overarching formal actor networks are still not clear. To close this gap, we use a mixed methodology to shed light on processes governing knowledge exchange in Agricultural Knowledge Innovation Systems (AKIS) within a developing-country context, and subsequent relation to innovation awareness. Such studies have rarely been done for South Kazakhstan Region (SKR). Furthermore, to our knowledge, no empirical study of this nature has been done for system innovations such as ISFM. To this end, we compare results from two sites located in South Kazakhstan Region that are comparable in terms of their farming systems, but differ in information availability and adoption levels. Key questions address the extent to which existing AKIS support ISFM innovation and whether interfaces for exchange or dissemination of knowledge between formal and informal networks are effective. Currently, there is an acute need to address the fledgling agricultural innovation systems of Kazakhstan, which have long been encumbered by weak institutions. It is imperative to assess the nature of interactions between smallholder farmers and supporting institutional actors, and how this contributes to the innovation process. The AKIS framework can help address the discrepancy between the prolific generation of agricultural knowledge on one hand, and minimal awareness and application of that knowledge by smallholder farmers, on the other. This framework is appropriate as it highlights the key actors in a given agricultural system, their roles and interaction, and how these facilitate change, learning and innovation. This study thus aims at comparatively assessing the efficacy of two AKIS in communicating and disseminating ISFM knowledge.

2. Integrated soil fertility management

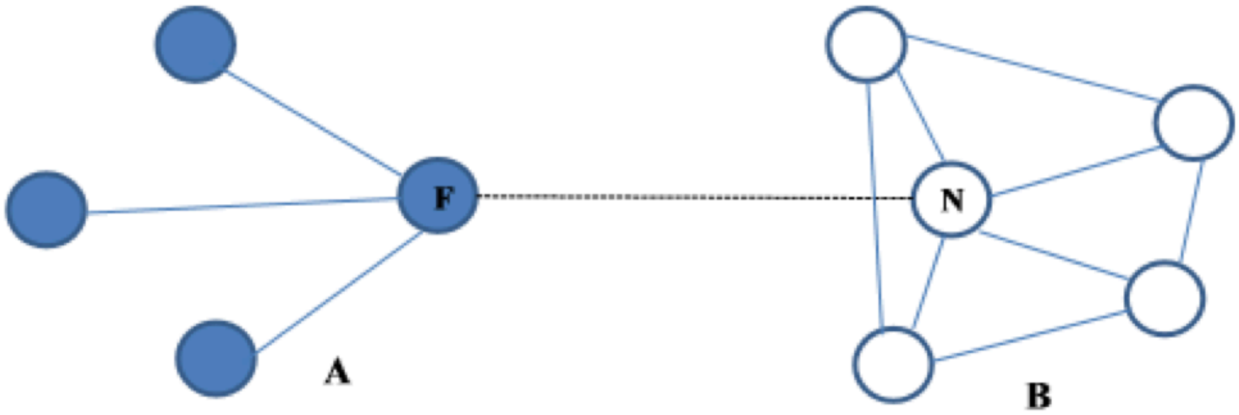
ISFM is a soil fertility management paradigm developed to help mitigate soil fertility decline in Kazakhstan. Integrated systems of nutrient management have been advocated in SKR and elsewhere over the last two to three decades. The implementation of the holistic strategy of ISFM, which addresses both biophysical and socioeconomic constraints faced by farmers, can effectively break the vicious cycle of soil degradation in many parts of Kazakhstan. ISFM is defined as a set of soil fertility management practices that include the use of mineral fertilizers, improved germplasm, and organic soil amendments combined with the knowledge on how to adapt these practices to local conditions in order to maximize agronomic use efficiency of the applied nutrients and enhance soil productivity (Vanlauwe et al. 2010). The practices involved are conceptually linked in a series of steps that starts with the use of mineral fertilizers and improved germplasm, followed by the second step when organic soil amendments are added and finally the third step of local technology adaptation, such as targeted manure application, construction of terraces to prevent soil erosion and incorporation of crop residues to recycle nutrients. Central to the ISFM paradigm is that no single component of soil fertility management can on its own lead to sustainable soil fertility management and that it is knowledge-driven rather than being input-intensive. ISFM aims to a) replenish soil nutrient pools, b) maximize on-farm recycling of nutrients, c) reduce nutrient losses to the environment, d) improve the efficiency of external inputs, e) make use of local, traditional and scientific knowledge, and f) integrate these into technologies that enable sustainable natural resource management.

3. Conceptual framework

The approach used in this study is based on the AKIS1 framework and is underpinned by the strength of weak ties (SWT) theory proposed by Granovetter (1973), which is closely related to the more recent theory of structural holes (Burt 1992). Both theories address the aspect of non-redundant ties that lead to the acquisition of new information in networks. We use the AKIS framework to illustrate the core concept to be addressed. The SWT theory allows conceptualization of the underlying processes affecting the network effectiveness in promoting innovation uptake and learning. The AKIS framework allows a systemic approach that incorporates suitable dimensions of agricultural innovation systems (AIS) into agricultural knowledge and information systems. Roling (1990) defines agricultural knowledge and information systems as a set of agricultural organizations and/or persons and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, and utilization of knowledge and information that work synergistically to support decision making, problem solving and innovation in a given country's agricultural domain. The three functional levels or roles within AKIS comprise primary producers, intermediaries, and end-users (Klerkx et al. 2012). Primary producers in this context are actors or organizations that collect data or carry out research and end-users are decision makers in agricultural entities. Intermediaries are concerned with collecting, translating and adding value to agricultural information to service decision-support needs of end-users. In a dynamic knowledge system, actors are not limited to one particular role and a farmer can thus be concurrently a primary producer and an end-user of information (Pascucci and de-Magistris 2011). Here we refer to an AKIS comprising multiple actors linked formally or informally through exchange ties of explicit or tacit knowledge. Explicit knowledge or information can be systematized, written, stored and transferred, whereas tacit knowledge is implicit, local, context-dependent, inherently intangible resulting from talents, experience and ability (Klerkx and Proctor 2013; Ro ¨ling 1990). The two forms of knowledge are complementary as they may transform into one another through different types of interaction or social processes (Klerkx and Proctor 2013). Following an innovation actor is defined as someone who uses or introduces innovative knowledge. Innovation actors range from public sector entities (National Agricultural Research Stations (NARS), International Agricultural Research Centers (IARC), agricultural extension, universities, and state-owned enterprises or parastatals to collective action entities such as farmer associations, Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs) and private sector actors such as marketers, traders, creditors, companies, as well as farmers and members of farm households. Innovation actors may fall under either institutional or organizational structures. Prell et al. (2010) describe institutions as established norms, rules, and practices that guide and constrain human behavior and actions. Institutions are classified as either formal or informal, with the former relating to laws, written contracts or other codified objects and the latter refering to social networks, beliefs, conventional practice, cultures and other similar norms (Casson et al. 2010; Prell et al. 2010). A social network is defined as a pattern of advice, friendship, communication or support that exists among members of a social system (Thuo et al. 2014). In literature a distinction is also made between institutions and organizations, where the latter is defined as a group of individuals with clearly defined roles and a common purpose (Prell et al. 2010). Nonetheless, formal organizations such as government and non-government agencies, farmer associations, and universities are interlinked with institutions as they often take advantage of opportunities created by the latter (Prell et al. 2010). Individuals (in our case farmers) and organizations typically integrate into networks with other actors to optimize resource and expertise utilization, since no single actor can possess all the neceSKRry knowledge and resources (Rycroft 2007). As mentioned earlier, farmers, for instance, will most likely integrate with other farmers in close social networks. Similarly, formal actors would be expected to integrate among themselves following patterns of homophily, that is, their similarities with respect to behavior (Borgatti et al. 2009, 2013). Network effectiveness hinges on the capacity of the networks to facilitate knowledge exchange. Thus knowledge exchange at the interfaces of two or more networks is a critical contributory factor to the enhancement of network efficacy. Klerkx and Proctor (2013) point out that actors can optimize information delivery by engaging in knowledge exchange through different institutional interfaces. It has been established that new opportunities for learning that drive the innovation process often occur at the boundaries of two or more networks through weak ties (Crona and Bodin 2006; Granovetter 2005; Klerkx and Proctor 2013; Matuschke and Qaim 2009; Thuo et al. 2014). Weak ties are linkages between actors characterized by infrequent contact, communication or interaction in terms of knowledge exchange (Granovetter 1973, 2005). Typical for such weak ties are those between farmers and researchers, extension agents, NGOs, financial agents, and agro-dealers (Thuo et al. 2014). Conversely, strong ties are characterized by dense networks of mutually interconnected and often homophilous actors that interact frequently (Fritsch and Kauffeld-Monz 2010; Granovetter

1973). The first premise of Granovettor's theory is that information circulating in 'strong-tie' networks of closely connected actors is often redundant. The second premise is that weak ties (also referred to as bridging ties) can be a potential source of new ideas (Fig. 1).

Fig. 1
A pathway for innovation flow: weak 'bridging' tie from actor/node F in network A to actor/node N in network B. Source: Adapted from Borgatti and Halgin (2011)



Several studies have shown that knowledge exchange can take place at the interfaces of networks (Klerkx and Proctor 2013; Prell et al. 2010). Others have demonstrated that strong ties are better suited for exchange of complex knowledge while maintaining that weak ties are suitable for the acquisition of novel, standalone technologies such as about fertilizer recommendations or seed varieties (Fritsch and Kauffeld-Monz 2010; Thuo et al. 2014). A well-functioning AKIS is thus characterized by network-based dissemination through both weak and strong ties as well as the embedding of actors within and outside their networks. In this context the questions our study seeks to answer are two-fold:

1. Is there is a relationship between complete awareness of ISFM as a scientific innovation and formation of four different types of knowledge ties with AKIS actors? 2. Is there is a relationship between awareness of the different components of ISFM as a scientific innovation and formation of different types of knowledge ties with AKIS actors?

We thus want to know whether the interfaces for exchange of knowledge between formal and informal networks are effective and the extent to which the existing AKIS supports ISFM. Based on our conceptual framework we disaggregate the knowledge ties into either weak or strong, both of which may have positive implications for knowledge exchange. As mentioned earlier, weak ties are often more useful in transferring new information, whereas strong ties are relevant in internalizing newly acquired information. Moreover, weak ties become important in situations of information scarcity while strong ties foster innovation in cases where there is information abundance. A further level of tie disaggregation is based on whether interaction occurs between a formal actor (e.g., a researcher) or an informal one (e.g., a neighboring smallholder farmer). To answer these questions, we need not only to know from whom the smallholders learn or who their advisors are but also the affiliations of these actors and the nature of their interactions. To complete the picture, it is important also to capture information flows among formal actors, which helps formulate possible adjustments in case of weaknesses. Therefore, there is a need for primary qualitative and quantitative data from formal and informal system actors. From the main research questions we formulate the following hypotheses for this study:

1. Those farmers with more knowledge ties to other AKIS actors have a higher propensity for complete awareness of ISFM. 2. The more ties farmers have the more components of the ISFM paradigm they are likely to be aware of.

4. Materials and methods

Description of study sites

The study was conducted in Shymkent, Kyzylorda, all of them are administrative districts that contain urban and rural areas (Fig. 2).

Fig. 2
Map highlighting the two study regions;
Kyzylorda and Shymkent

Shymkent

The South Kazakhstan region is located in the south of Kazakhstan, within the eastern part of the Turan lowland and the western spurs of the Tien Shan. Most of the territory is flat, with the hummocky-ridged sands of Kyzylkum, the steppe of Shardar (in the south-west, along the left bank of the Syr Darya) and Moyynkum (in the north, along the left bank of the Chu). The northern part is occupied by the Betpak-Dala desert, in the far south - the Hungry Steppe (Myrzashol). The middle part of the region is occupied by the Karatau range (Mount Bessaz - 2176 m), in the southeast - the western outskirts of Talas Alatau, the Karzhantau ridges (elevation to 2824 m) and Ugamsky (the highest point is Sairam Peak - 4238 m).
The largest rivers, the Syr Darya (with the tributaries Keles, Kurukkeles, Arys, Bugun, etc.) cross the territory of the region from the south to the northwest, and the Chu River (the lower course), flowing in the north and lost in the sands of Moyynkum.
The region is located in a zone of sharply continental climate. The highest temperature in the south is + 52 ° C in the sun + 82 °C. The average temperature in the deserts is + 37 ° C in the sun 63 ° C. The fertile soils, the abundance of sunlight, extensive pastures create great opportunities for Development in this area of various branches of agriculture, primarily irrigated agriculture and pasture sheep breeding. High yields give crops of cotton, rice, as well as gardens and grapes.

Kyzylorda

The Kyzylorda oblast is located in the south of the republic in a zone of deserts with sharp and continental climate along the bottom current of the Syrdarya River, occupying a considerable part of the Turansk lowland. In the West its structure includes the Small Aral Sea, in the south - a northern part of the sandy Kyzyl Kum Desert - one of the largest deserts of the Old World, in the north - Priaralsky Kara Kum, Aryskuma and desert plateaus of the suburb of the Kazakh folded country or Melkosopochnik. In the extreme northeast on the right coast Syr-Darya the

extremity of ridge of Karatau being an extreme spur of mountains Tian-Shanya comes into area limits on small space.
The natural landscape of Kyzylorda oblast is composed by sandy and clay massifs overgrown with bushes and a saxaul, in a flood plain of the Syrdarya River wood tugayny thickets meet. Between the Kyzyl Kum Desert and a plateau of the Kazakh folded country extensive spaces of the ancient and modern river plains obliged by the formation of activity of Syrdarya were stretched. A left bank of Syrdarya - extensive sand Kyzyl Kum, in which territory the saksaul forestry largest in the republic.
Thanks to rather southern geographical arrangement of the territory of the oblast corresponding to the North Caucasus and an average zone of Italy, in considerable remoteness from water spaces (3-4,5 thousand km), the climate of the oblast differs sharp continentality and dryness. Absolute maxima of temperatures reach to 46 °, and at least to a minus 37 °, i.e. fluctuations reach 87 ° degrees that seldom meets on the globe.
Quantity of sunny days in a year is more than 300. The maximum air temperature makes 11 ° S.Period with air temperature higher 5 ° is the beginning of the vegetative period of wild-growing herbs, above 10 ° - the beginning of sowing of rice, and more than 15 ° - a cotton. Duration of the vegetative period fluctuates from 190 to 226 days in a year. The warm period proceeds till October inclusive. Snow drops out in November (steadily in December), and in March melts. The height of snow cover doesn't exceed 15 mm. Evaporation exceeds a precipitation in 10 and more times.
The number of days with strong winds on the most part of the territory of the oblast makes 2-22, around Zhusaly - 45-65. In a warm season dusty storms - on the average during the season are observed 2-20 days. Wind-shelter strips are necessary for protection against northeast winds along the rivers, on borders of fields of crop rotations and boards of the main channels.

The number of days with a precipitation makes 40-60, and in all territory a rain precipitation prevails over snow in 1,5-2 times. In exclusive years the sum of a precipitation can fall to 30 mm or increase to 220 mm. A precipitation has mainly storm character and their duration is, as a rule, insignificant in the summer. The greatest daily amount of precipitation in June makes 40-50 mm (1 time in 40 years) and 30-40 mm (1 time in 80 years) in July and August. The minimum of an atmospheric precipitation falls on summer months (10-25 mm), at most on spring - 30-60 mm. Generally the annual amount of precipitation insignificant also decreases from the southeast on the northwest - from 90 to 160 mm.
Summer precipitation entirely evaporates, autumn and spring is completely spent for a superficial drain and only winter a little souse the soil, creating conditions for development of early-spring vegetation.
Grain crops - wheat, barley, oats, millet - for ripening demand till 115 days and the sum of temperatures for this period about 1600 °, for olive (sunflower, mustard), commercial crops (a sugar beet, early ripening varieties of a cotton), and also some grades of the corn, which vegetative period of 120-140 days, the sum of temperatures - from 2000 ° to 3000 °.
Therefore the temperature mode of the oblast allows cultivation of all listed above crops, first of all rice, as leading grain culture.

---

5. Data collection and analysis

Interviews with key informants and social network analysis methods

Key formal organizations active in urban, peri-urban and rural agriculture were identified in Kyzylorda through a multi stake holder workshop facilitated by the Resources Centres for Urban Agriculture and Food Security under the Urban Food Plus project. In Shymkent, these organizations were identified with the help of key informants. A total of 25 actors representing 14 key formal organizations were interviewed in Kyzylorda from January to March, 2016. In

Shymkent, 17 actors representing 15 key formal organizations were interviewed from November 2014 to February 2015. Apart from collection of network data, in-depth interviews with these actors and a selected group of farmers were carried out to obtain further insights on the AKIS. All interviews were conducted by the first author.

In network terminology, a network is made up of actors or nodes and the relationship that links them is called a tie (Hanneman and Riddle 2005; Matuschke 2008). The number of actors/nodes in a network constitutes its size. The binary measures method is used to measure ties and shows not only the existence of a relationship between actors but also its direction (Matuschke 2008). This can be illustrated as follows: if actor j relates to actor k and vice versa, then $X_{jk} = X_{kj} = 1$. However, if j relates to k but the reverse is not true, then $X_{jk} = 1$ and $X_{kj} = 0$. Applying this logic, we followed the two-step procedure ego network analysis (Matuschke 2008) where the key actors (also referred to as "egos") were asked whom they discussed agricultural information and knowledge with to determine the size of their respective networks. Since our interest was in the information ties present in the network, we asked them whether they had received or given any information on an ISFM technology to those in their network. This approach enabled us to assess the direction of the ties. Questions were also asked on how frequently they communicated so as to elicit the strength of ties. A relative scale, described by Borgatti et al. (2013), was found suitable for rating, given the ordinal nature of the data. Thus a five-point Likert scale was applied: 5 (very frequently), 4 (somewhat frequently), 3 (moderate frequency), 2 (somewhat infrequently), and 1 (very infrequently). In previous research, the frequency of contact and in some instances also emotional intensity or closeness of a bond has been applied to measure the strength of ties (Collins and Clark 2003; Granovetter 1973; Reagans and McEvily 2003). In our case, as formal actors are for the most part homogenous, the use of frequency of contact is expected to be a reliable measure of tie strength. In the next step, actors in the respective networks of these "egos", referred to as "alters", were similarly asked the same set of questions to obtain a more concise picture of the overall knowledge network. Additionally, we integrated smallholder farmers into the formal actor network by using data from the farm household surveys, described in the next section. Each respondent in the survey was similarly asked whether they exchanged agricultural information with formal actors and if they had received information on any ISFM practice. Thus it was possible to determine which actors had knowledge linkages to smallholder farmers. Taking smallholders as a single node, this information was subsequently combined with the formal network data.

Some other important network measures considered include betweenness, pairs and density. Betweenness is a measure of the structural position or the embeddedness of an actor in a network to show whether that actor is in a favored position to receive or convey information (Hanneman and Riddle 2005; Isaac et al. 2007). This basically describes the extent to which a given actor falls between the paths of other actors as shown by the formula below:

$$C_B(i) = \sum_{j<k} g_{jk}(i)/g_{jk},$$

where CB denotes betweenness for node i; $g_{jk}(i) =$ is the number of shortest paths from j to k that pass through i; and g_{jk} is the number of shortest paths from j to k. Actors with high 'betweenness' scores are powerful as others depend on them to access other actors. In this way, they direct information flow in the system. Density (D) refers to the nodes that are actually tied as a proportion

of all possible ties in a network and is calculated using the formula of Spielman et al. (2011).

$$D = \frac{\gamma}{N(N-\gamma)/2},$$

where γ denotes the total number of ties present while N is the number of nodes in the network. Density can also be calculated by dividing the number of ties by the number of pairs (Hanneman and Riddle 2005). Pairs denote the maximum number of possible ties in each ego network. We used the networking software UCINET 6.0 to calculate these network measures (Borgatti et al. 2002). Two network diagrams for both AKIS were created with the aid of the Netdraw software package within UCINET 6.0.

Farm household survey

The analysis of informal networks as well as of the awareness and adoption of ISFM builds on a household survey among 285 stratified randomly sampled households in Kyzylorda and 300 households in Shymkent. The survey was carried out between July and October, 2016 in Kyzylorda and November, 2016 and February, 2016 in Shymkent. The households were stratified into participants, that is, those who had participated in previous ISFM-linked projects, and non-participants. Participants were sampled in a systematic random manner from compiled lists. In Kyzylorda, listings of participant farmers were drawn from the AGRA ISFM project, coordinated by the Agricultural Research Institute (ARI). An additional list comprised farmers who participated in ISFM trainings carried out by the Millennium Development Authority in conjunction with ARI around the same time. Similarly, in Shymkent participant farmers were also drawn from lists of ISFM projects funded by AGRA and coordinated by the Agricultural Research Livestock Organization (ARLO). Lists were also obtained from officials representing farmers that had been trained on ISFM by the International Centre for Agriculture (CIA). Non-participants were selected from a randomly generated list of farmers at both sites.

The face-to-face interviews conducted by the first author with the assistance of trained enumerators, were based on a structured questionnaire. Apart from network questions, it contained sections on farm characteristics, crop production and management, economic activities (including prices of inputs and outputs), marketing of agricultural products, the institutional context of agricultural production, information channels for value addition activities as well as socio-demographic characteristics of household members. The reference period for all economic activities was the last twelve months prior to the interview.

Informal networks

The ego network approach solves the boundary specification problem by allowing bounding of networks at two levels: the "ego" actor (bounding done by a random sample) and "alter" actor. In their study on social network impact on hybrid seed adoption, Matuschke and Qaim (2009) restricted their analysis to three alters by asking farmers to name a maximum of three persons they most communicated with about agricultural decisions and if they had exchanged ISFM information. Similarly in this study, farmers (ego respondents) were restricted to three actors (alters) with whom they most frequently exchanged agricultural information. In addition, they indicated the nature of relationship with alters named to elicit degree of emotional closeness, the professional affiliation or occupation as well as frequency of communication. These ties constituted the strong ties of farmers. However, Granovetter (1973) and others argue that novel information may be transmitted through weak links, that is, through interaction with actors outside tight-knit network structures. Therefore, we randomly matched the respondents with informal actors drawn from the same village and cluster (an administrative level higher than village such as ward, division or district) as well as selected formal actors as a proxy for the existence of weak ties. Three farmers each were randomly selected at the village2 and cluster level. They were asked if they had ever exchanged agricultural information with these actors. Additionally, the respondents indicated whether they had exchanged information with formal actors; three were local administrators (chiefs, sub-chiefs, and village elders) and six were at regional or national level and included extension agents, NGO officers, researchers, government agents, marketers3 and input dealers. It should be noted that unlike in Shymkent (exempting village elders), local administrators in Kyzylorda are better described as informal actors as they have very little connection with overarching government structures. Thus farmers were randomly matched with a total of 15 possible actors. T tests after cross-tabulation with the aid of the E-Net software (Borgatti 2006) and one-way analysis of variance (ANOVA) were carried out to compare farmers' knowledge ties at different awareness levels.

We asked the surveyed farmers whether they were aware of any of the principles outlined by Vanlauwe et al. (2010). Only those farmers who were aware of all the steps in ISFM were said to be completely ISFM-aware (Table 1). It is worth noting that indigenous traditional knowledge is embedded within the scientifically constructed ISFM paradigm. Thus some elements of ISFM are already local practice. In this paper we do not carry further analysis on adoption aspects but rather focus on disentangling the relationships between actor tie formation and awareness of the ISFM innovation.

Table 1 Awareness and adoption of different ISFM components in Kyzylorda and Shymkent

Description	Kyzylorda (N = 282)		Shymkent (N = 300)	
	Awareness (%)	Adoption (%)	Awareness (%)	Adoption (%)
Control practice-traditional varieties and/or no fertilizer	n.a	85.85	n.a	16.00
Improved germplasm + fertilizer	64.89	2.13	99.00	8.67
Improved germplasm + fertilizer + organic amendments	53.55	3.19	97.67	7.67

Improved germplasm + fertilizer + local adaptation	44.33	4.61	92.67	23.33
Improved germplasm + fertilizer + organic amendments + local adaptation (crop residues and/or ridging)	40.43	4.26	92.67	25.86
Improved germplasm + fertilizer + manure/compost + local adaptation (lime and/or terraces)a	n.a	n.a	41.00	18.64

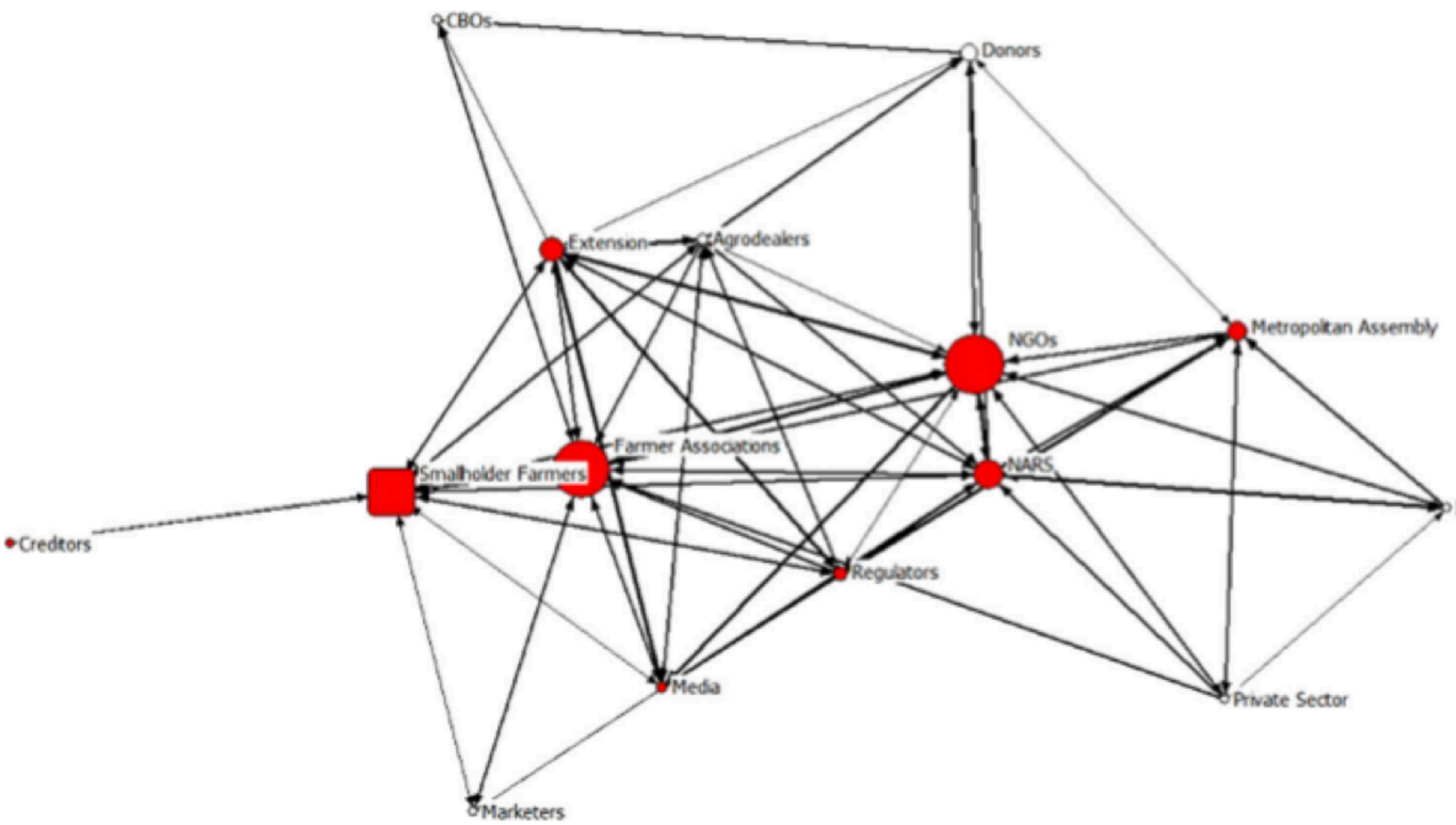
6. Results and discussion

A descriptive overview of formal AKIS networks

The network diagrams compiled with the UCINET software are shown in Figs. 3. Farmer associations, NARS, extension, agro-dealers, and NGOs are central in the Kyzylorda network while IARC, marketers and creditors are peripheral (Fig. 3). The activities of the Savannah Farmers Marketing Company, one of the few market organizations in the northern region, have been hampered by lack of funding and over-dependence on short-term projects.

Fig. 3

Graph of a directed formal AKIS network in Kyzylorda and Shymkent. Red/dark circles represent ego actors; node size is calculated based on betweenness; line thickness denotes strength of ties (color figure online)



An interview session with this actor revealed that they have been unable to relay market information to farmers due to the high costs of the short meSKRge service. IARCs, on the other hand, are less present as they often work through intermediaries such as NGOs. Farmer associations and NGOs are well embedded in the Kyzylorda knowledge network and are the most important intermediaries and brokers of information as shown by the relatively high betweenness measures (Table 2).

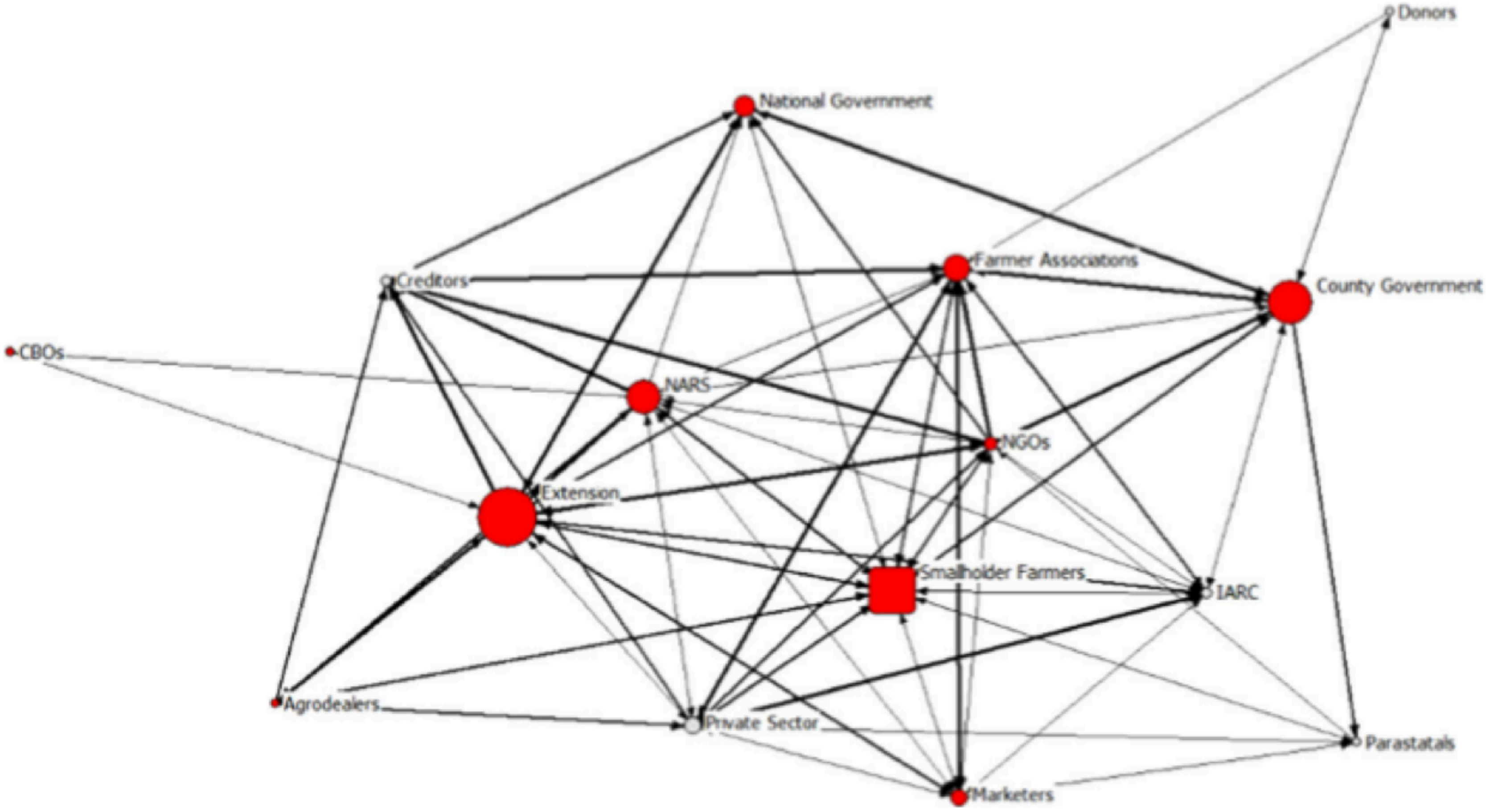
Table 2
Network measures for formal knowledge actors in Kyzylorda

	Size	Ties	Pairs	Density	Betweenness
Extension	9.00	41.00	72.00	56.94	7.42
Farmer associations	9.00	27.00	72.00	37.50	26.00
NGOs	10.00	42.00	90.00	46.67	26.70
NARS	9.00	35.00	72.00	48.61	10.62
Metropolitan assembly	6.00	17.00	30.00	56.67	6.00
Marketers	2.00	2.00	2.00	100.00	0.00

There are several NGOs in Kyzylorda such as the Urban Agriculture Network and Presbyterian Mile Seven that have played an active role in training farmers on group dynamics. The same NGOs have been used as platforms by several organizations to disseminate agricultural technologies to farmers. Their ties to different actors and their structural position in the network render them crucial intermediaries of new information in the system. Spielman et al. (2011) give a similar account of the importance of NGOs in an Ethiopian rural innovation system.

Farmer associations and NGOs are similarly well centered in the Shymkent AKIS (Fig. 4). Although actors at the other end of the value-chain like marketers still appear to be on the periphery, they have many more ties and are better integrated in the network.

Fig. 4
A directed formal AKIS network in Shymkent. Red/dark circles represent ego actors; node size is calculated based on betweenness; line thickness denotes strength of ties (color figure online



Market organisations such as Mumias District Federation for Soybean Organization, are actively engaged not only in disseminating market information to farmers but also information on soil fertility management, good agronomic practices, and value addition. They also frequently organize farmer field days and workshops and have close links with farmers; in fact most of their officials are farmers themselves. Here extension and county government, and to a lesser extent NARS, are the most important intermediaries and brokers of agricultural knowledge as shown by their higher betweenness measures (Table 3). A reason for this may be the strong presence of these two players, particularly the extension agents, in agricultural intervention projects funded by the national/county government (e.g., the "Njaa Marufuku" Kenya programme) or international donors.

Table 3
Network measures for formal knowledge actors in Shymkent

	Size	Ties	Pairs	Density	Betweenness
Extension	11.00	58.00	110.00	52.73	23.22
Farmer associations	7.00	28.00	42.00	66.67	8.50
NGOs	10.00	63.00	90.00	70.00	3.40
NARS	12.00	70.00	132.00	53.03	11.09
County government	8.00	27.00	56.00	48.21	16.83
Marketers	8.00	44.00	56.00	78.57	3.73

Nonetheless, extension agents have been known to focus on elite farmers who are often best placed to organize themselves in functional groups, at the expense of poorer, smallholder farmers (Hoang et al. 2006). Whether this high interaction of extension agents with other formal actors translates to increased filtering down of information to all farmers is not clear.

Following the phenomenon of homophily, informal actors (smallholder farmers) and formal actors (researchers, extensionists, agrodealers, etc.) are likely to be in different networks. In this study, we have formal actors encompassed within a single network (formal AKIS) interacting or linked with the individual ego networks of smallholder farmers. These ego networks were coalesced and integrated as a single unit or node within the formal AKIS for purposes of showing this hypothetical relationship (Figs. 3, 4). It is interesting to note that smallholder farmers in the Shymkent network are more closely embedded within the formal network than their counterparts in Kyzylorda. In order to observe the more detailed nuances of these relationships, subsequent discussion will shed light on how diverse actors interact and are mutually embedded through a combination of strong and weak ties.

Social networks of smallholders

In Kyzylorda, 50 % of the farmers mentioned three strong ties whereas in Shymkent their share was 73 % (Table 4). Overall, the majority share of strong ties was informal (i.e., farmer-to-farmer interaction) in both Kyzylorda and Shymkent farmer networks. This is expected as it has been widely noted that actors tend to form strong ties along homophilous lines (Borgatti and Halgin 2011).

Table 4

Strong network ties in Kyzylorda and Shymkent

No. of mentioned ties	Strong ties (Kyzylorda)			Strong ties (Shymkent)		
	Share of farmers mentioning ties (%)	Share of ties		Share of farmers mentioning ties (%)	Share of ties	
		Formal (%)	Informal (%)		Formal (%)	Informal (%)
0	8	n.a	n.a	11	n.a	n.a
1	17	47	53	6	10	90
2	25	24	76	10	17	83
3	50	19	81	73	9	91

With weak ties, a considerable share of farmers never exchanged information with informal actors in both AKIS, particularly at the cluster level (Figs. 5, 6). This is not surprising, since actors were selected randomly from the list of sampled farmers. At the village level in Kyzylorda, however, more than 50 % of the farmers had exchanged information with all of the three nominated actors (Fig. 5). This changed with formal actors as share of farmers reporting linkages were distributed almost equally across ties. In Kyzylorda, for example, 19 % of the farmers had none, 25% one, 23 % two, and 23 % three weak ties to formal actors (Fig. 5). The same was noted in Shymkent (Fig. 6), but some farmers at both locations reported having up to five formal ties. The relativelyhigherinteractionwithformalactorsisnotunexpected as most weak ties tend to be associated with formalized interactions (Thuo et al. 2014).

Fig. 5
Share of farmers with informal and formal weak ties with actors at various levels in Kyzylorda

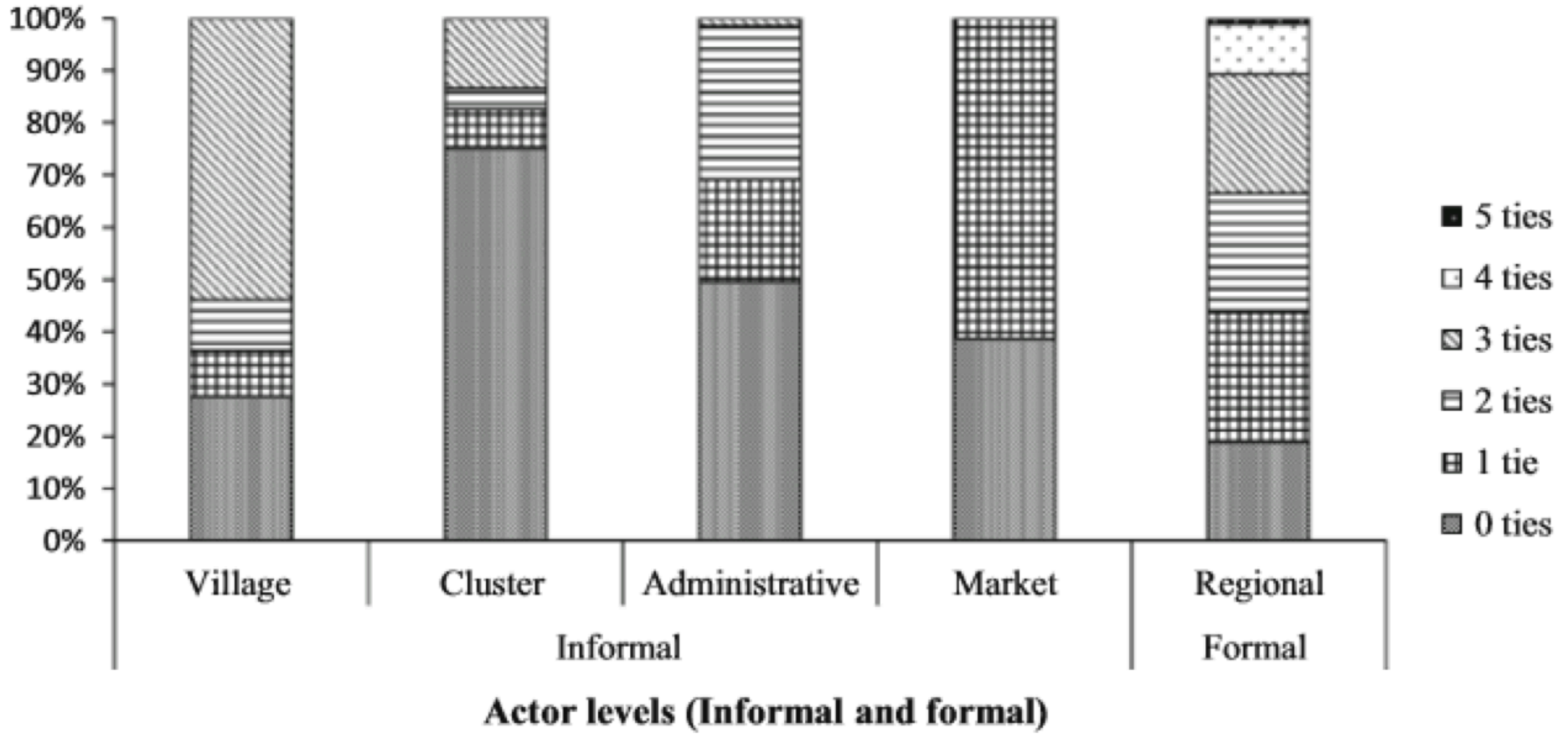
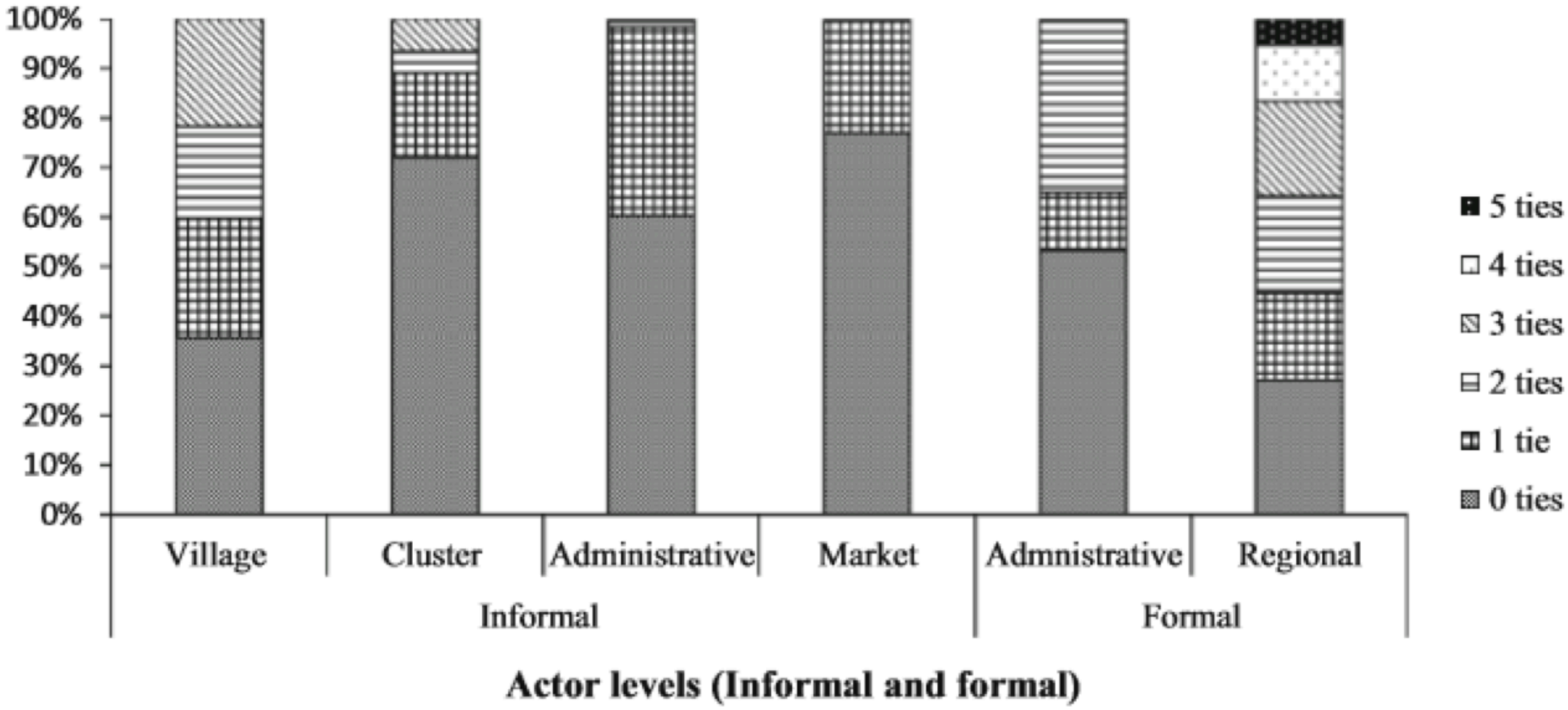


Fig. 6
Share of farmers with informal and formal weak ties with actors at various levels in Shymkent



The formal groups of actors farmers most interacted with were extension agents and NGOs in Kyzylorda, whereas in Shymkent it was chiefs followed by extension agents (Figs. 7, 8). There was no relationship between farmers' awareness of ISFM and their interaction with formal actors in Kyzylorda but the reverse was true in the case of Shymkent. This is not surprising given the close proximity farmers have to chiefs who act as government representatives at the grassroots in Shymkent.

Fig. 7

Occurrence of different formal actors in Kyzylorda farmers' networks. Chi square = 10.248, df = 11, P = 0.508

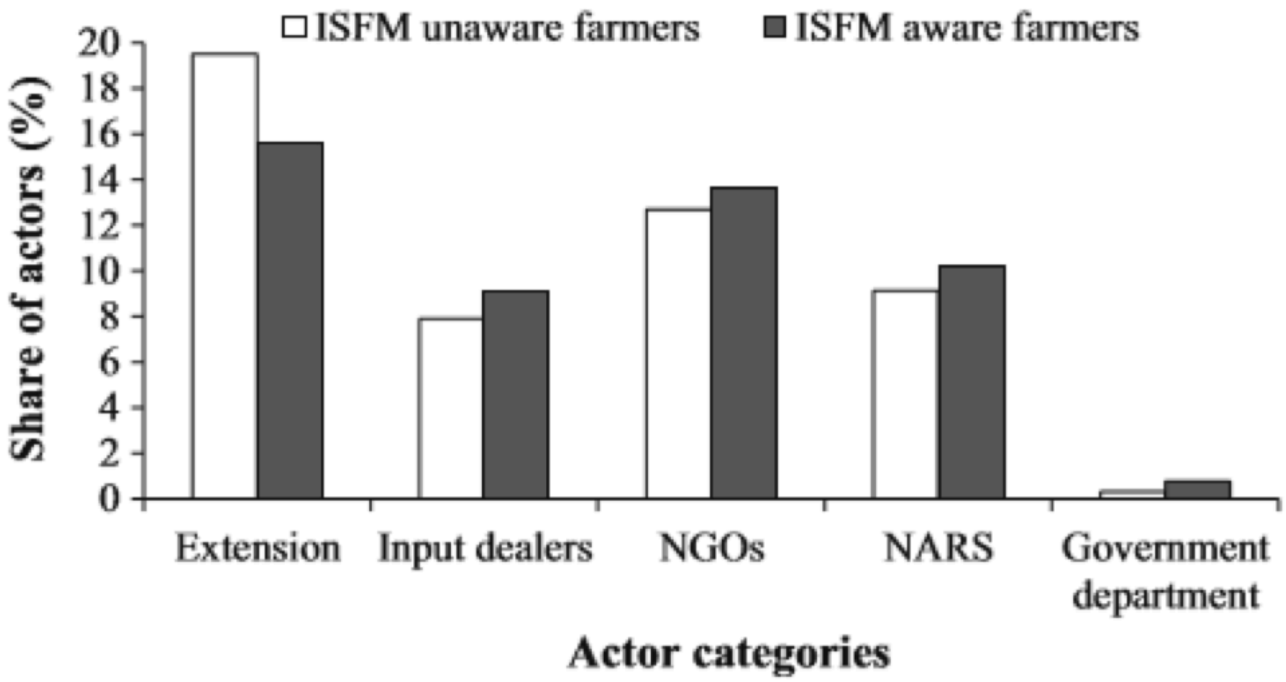
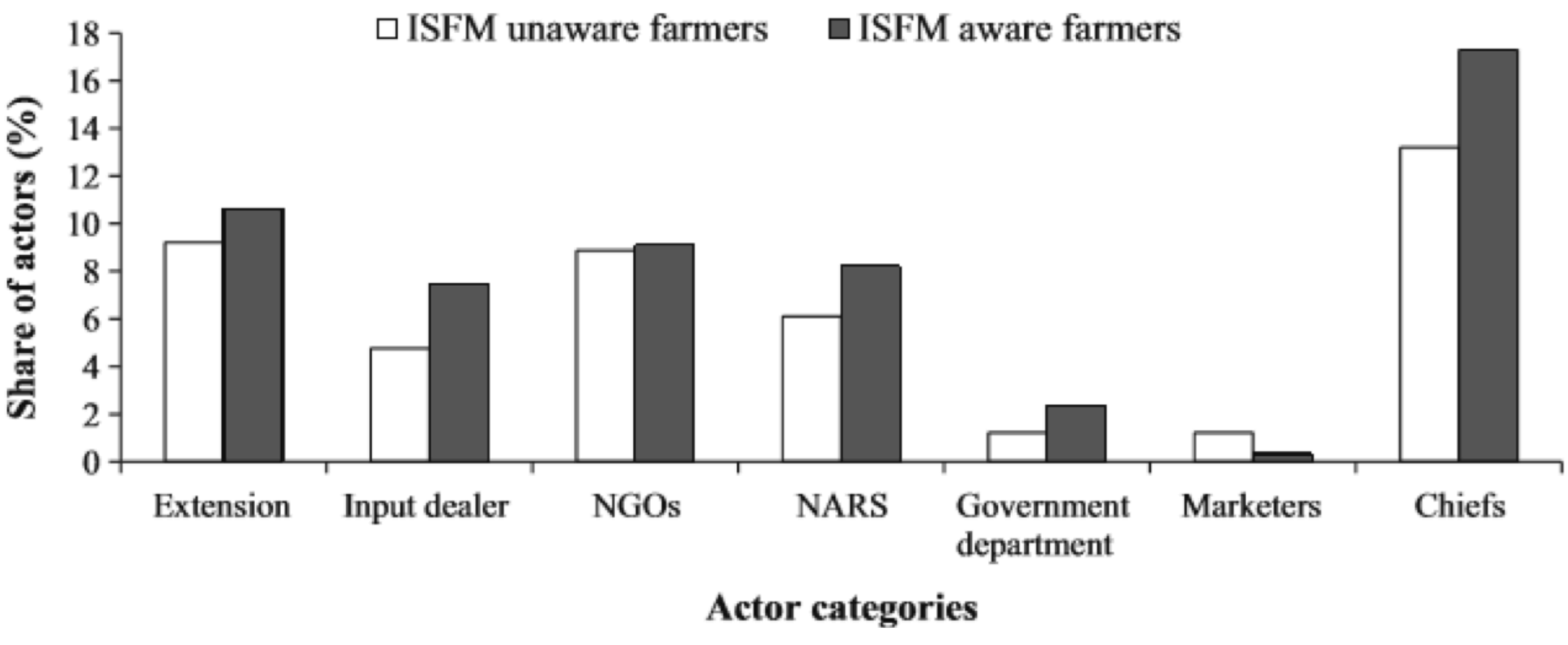


Fig. 8

Occurrence of different formal actors in Shymkent farmers' networks. Chi square = 22.659, df = 13, P = 0.046



Hoang et al. (2006) pointed out the important role of official and traditional leadership in anchoring research and development interventions. The important role of the county government in Kenya as an information broker supports this assertion (Table 3). However, the results also show that this varies with the context as chiefs and government representatives do not play this role in Kazakhstan.

At Shymkent, there was a significant relationship between awareness and farmer interaction with formal actors and a higher interaction among those who were ISFM-aware with formal actors (Fig. 8). The only exception was for marketers who in any case constituted a small share of formal actors in farmers' networks. Small-scale farmers are likely to benefit regarding the acquisition of new information by interacting more with formal actors such as extension agents, researchers and government officials who have been shown to be influential in directing information flow in agricultural knowledge systems (Table 3). Although the results in Figs. 7 and

8 imply an active interaction between extension agents and farmers at both study locations; the former have been widely castigated for being a hindrance rather than a driving force in the dissemination of agricultural knowledge in the rural context of developing countries (Fujisaka 1994; Hoang et al. 2006).

Farmers' social networks and ISFM awareness

Two main null hypotheses (Ho) were tested here:

1. Incompletely aware and completely aware farmers have equal number of knowledge ties, and 2. Mean knowledge ties are equal for the different awareness levels (unaware; IG + F- aware of improved germplasm + fertilizer; IG + F + OA- aware of improvedgermplasm+fertilizer+organicamendments; and IG + F + OA + LA (or complete awareness)- aware of improved germplasm + fertilizer + organic amendments + local adaptation).

There were varying levels of inter-dependency between tie formations on the one hand, and complete awareness on the other. In Kyzylorda, there was no significant difference between farmers with full knowledge on ISFM and those without regarding forming strong knowledge ties with formal actors (Table 5). However, there was a highly significant relationship between complete awareness of ISFM and weak ties to both formal and informal actors.

One-way ANOVA of strong informal ties grouped into different awareness levels showed that the groups were significantly different (F(3, 278) = 3.961, P = 0.009)).4 This result was somewhat surprising as there was no significant difference at 5 % level between completely aware and incompletely aware farmers (Table 5). Tukey post hoc tests revealed that strong informal ties for partially aware farmers (group: IG + F + OA) were significantly less than those for unaware farmers (P = 0.048) and those farmers completely aware of ISFM, that is, group: IG + F + OA + LA (P = 0.020). Thus it is reasonable to presume that grouping partially aware and incompletely aware farmers as was done in Table 5 would in overall reduce the significance of any differences. Also, the mean values for strong informal ties for unaware and completely aware farmers seem to be close (Table 6). Similarly, weak formal ties (F(3, 278) = 11.340, P \ 0.0005)) and weak informal ties (F(3, 278) = 4.733, P = 0.003) were different across groups. Tukey post hoc tests further showed that farmers who were completely aware of ISFM (group: IG + F + OR + LA) had significantly more weak formal (P\0.0005) and informal ties (P = 0.003) than those who were not ISFM aware (Table 6).

Table 5

Tie differences between farmers with complete and incomplete ISFM awareness in Kyzylorda

	Completely aware (N = 114)		Incompletely aware (N = 168)	
	Mean	SD	Mean	SD
Strong formal ties	0.51	0.90	0.46	0.90
Strong informal ties	1.86	1.24	1.58	1.22
Weak formal ties	2.31	1.30	1.49	1.23
Weak informal ties	4.58	2.43	3.47	2.49

Table 6
Mean (SD) differences in number different knowledge ties at different ISFM awareness levels in Kyzylorda

	Awareness			
	Unaware (N = 99)	IG + F (N= 32)	IG + F + OR (N = 37)	IG + F + OR + LA (N = 114)
Strong informal ties	1.80 (1.21)a	1.34 (1.23)ab	1.19 (1.13)b	1.86 (1.24)a
Weak formal ties	1.36 (1.21)a	1.62 (1.29)a	1.73 (1.22)ab	2.31 (1.30)b
Weak informal ties	3.41 (2.21)a	3.72 (2.87)ab	3.41 (2.87)ab	4.58 (2.43)b

In contrast, farmers in Shymkent with complete ISFM knowledge had more strong formal ties in their close networks (Table 7). Since the number of ties was limited to three, what mattered most here was not the number of ties but rather who was in the network. There were striking similarities with Kyzylorda, however, with respect to weak ties. Farmers that were completely ISFM-aware had significantly more formal and informal weak ties than those not fully aware (Table 7). Strong formal ties ($F^*(3, 183.47) = 7.762$, $P = 0.0001$), weak formal ties ($F^*(3, 13.15) = 20.998$, $P = 0.0000$), and weak informal ties ($F^*(3, 6.58) = 4.542$, $P = 0.0490$) showed significant differences between groups5 (Table 8). Post-hoc tests showed that the significant differences were mainly between partially aware (IF + F + OA) and completely aware groups. Completely aware farmers had more ties ($P = 0.0020$) than partially aware (IF + F + OA) ones for strong formal ties. The same applied for weak formal ties ($P = 0.000$) and weak informal ties ($P = 0.010$). In most cases, those who were not aware of ISFM had zero ties to either formal or informal actors. In any case, for weak formal ties completely ISFM aware farmers had more ties ($P = 0.029$).

Table 7
Tie differences between farmers with complete and incomplete ISFM awareness in Shymkent

	Completely aware (N = 123)		Incompletely aware (N = 177)	
	Mean	SD	Mean	SD
Strong formal ties	0.37	0.83	0.14	0.48
Strong informal ties	2.14	1.19	2.28	1.10
Weak formal ties	3.57	2.00	2.08	2.00

Weak informal ties	2.80	2.11	2.01	1.98

* * *

The significance of strong formal ties with regard to awareness points to the embeddedness of formal actors in these farmer social networks. Strong ties are crucial to internalize the complex ensemble of technologies and management practices that comprise system innovations. Thus strong formal ties have the added benefit of reinforcing already existing knowledge in addition to providing new information. Altieri (2002) suggests that strong ties between farmers and external agents are crucial for agroecological improvements entailing knowledge-intensive soil and crop management practices. Furthermore, Agrawal (1995) citing Chandler (1991) mentions that farmer innovation and experimentation is facilitated through the combination of existing knowledge and new information. Farmers in Shymkent have had a longer period to interact with ISFM technologies and some of the actors involved in its dissemination (Vanlauwe et al. 2004). In the case of Kyzylorda, informal farmer and formal actor interviews revealed some gaps between what was communicated by formal actors and what farmers understood or perceived. For instance, a commercial vegetable farmer based in south area in the city was of the view that he did not receive information on new innovations from a formal actor, yet the latter claimed to have worked closely with farmers in various agricultural projects. Interactions between famers and formal actors were further constrained by lack of trust (emanating from farmers) and apathy on the part of the other actors, particularly the extension agents. Such perceptions are often replicated in other AKIS across Kazakhstan, for instance potato knowledge systems in Kazakhstan. Thus the idea that more strong ties lead to more interaction, which in turn results in higher awareness of complex knowledge among farmers is supported partly (for Shymkent) by these results, which are corroborated by previous studies of the implications of strong and weak ties (Hansen 1999). Although informal strong ties are also useful in reinforcing already acquired knowledge, this may not always be adequate when dealing with complex knowledge. In addition, farmer learning through informal village networks may not always be optimal due to acquisition of only partial information.

The differentiated interaction between formal actors and smallholders in the two study areas may also be considered from a policy perspective. The agricultural sector in Kazakhstan have been guided by similar agricultural policies (e.g., the structural adjustment programs) from the colonial to the present period, but there is one notable difference. The national agricultural innovation system in Kenya benefited from pioneering efforts of innovative actors, encompassing colonial-era administration and agricultural services officers and smallholder farmers, which generated institutional, organizational and policy innovations. Some of the outcomes included land transfer to small-scale farmers, cash crop production for export by smallholders and intensified maize production. This facilitated closer interconnections between the actors enabling increased awareness of technologies, such as improved maize varieties. This contrasts with policies in Ghana, particularly in the northern region, where there has always been an adherence to mainstream agricultural policy initiatives even when they were clearly unsustainable. Key informant interview sessions with a key actor shed further light on the structural weakness and constraints in the maize seed sector in Kazakhstan. Firstly, the Kazakhstan Grains and Legumes Development Board, which is charged with the production of foundation seed, was poorly resourced. Secondly, the seed inspection division charged with the inspection and certification of seed growers was constrained in terms of labor and finances. Finally, there was a tendency of rural farmers to use recycled seeds or “saved seeds” after receiving seeds from projects. Their counterparts in the city, however, used improved maize seeds more regularly, probably due to increased proximity to input shops. This state of affairs has contributed to the lower awareness and application of ISFM principles among Kyzylorda farmers in comparison to their counterparts in Shymkent (see Table 1).

As mentioned earlier, weak ties play a major role in the transmission of new information or knowledge. Weak ties between farmers and formal actors are often established through various research and development projects. Indepth interviews with farmers in Kyzylorda revealed cases where AKIS actors had transferred innovative approaches on soil fertility management to farmers.

Apart from the information network structure and the underlying aspect of tie interactions, socio-demographic factors are bound to influence the awareness and subsequent adoption of innovations (Dutta 2009). Education is one such important factor. Innovators in Kyzylorda differed quite significantly from non-innovators in terms of education (Table 9), with innovators having significantly more years of education than non-innovators. In the case of Shymkent, the differences between innovators and non innovators were less pronounced, but these farmers were more educated than those in Kyzylorda (Table 9). The higher education levels of farmers in Shymkent relative to their counterparts in Kyzylorda may have enhanced not only interactions with formal actors but also an understanding of the scientific format of such knowledge conveyed. Education is often a major underlying factor for the effective understanding of knowledge intensive innovations and their consequent adoption.

Table 9
Descriptive statistics for Kyzylorda and Shymkent

	Kyzylorda						Shymkent					
	All		Innovatorsa		Non-innovatorsb		All		Innovatorsa		Non-innovatorsb	
	Means	SD	Means	SD	Means	SD	Means	SD	Means	SD	Means	SD
Farm and location characteristics												
Total land area cultivated (acres)	7.52	9.13	8.60	9.94	7.34	9.00	2.42	5.56	2.53	5.97	1.88	2.62
Total maize area cultivated (acres)	3.66	3.50	4.57	5.76	3.50	2.96	1.21	1.34	1.25	1.37	0.98	1.19
Livestock unitsc	3.97	7.99	6.82	16.12	3.50	5.55	2.07	2.02	2.07	1.99	2.08	2.21
HH in urban/periurban area (%)	33.00	47.00	62.00	9.00	28.00	44.80	20.00	39.80	22.00	41.40	8.00	27.90
Land titled (%)	14.00	35.00	32.00	47.40	11.00	31.50	67.00	47.00	65.00	47.60	77.00	42.50
Household (HH) characteristics Age of HH head (years)	52.15	13.84	51.10	15.53	52.32	13.57	52.69	13.14	52.82	13.12	52.04	13.37
Gender of HH head is male (%)	95.00	22.50	100.00	00.00	94.00	24.20	81.00	39.00	83.00	38.00	75.00	43.80
HH head education level (years)	2.33	4.95	5.68	6.26	1.78	4.48	8.97	3.93	9.14	3.84	8.04	4.31
HH size (no.)	12.95	7.18	11.22	6.86	13.23	7.21	7.23	3.57	7.39	3.62	6.38	3.18
Adult members of HH (no.)	4.46	2.67	4.02	2.29	4.53	2.72	4.10	2.16	4.19	2.18	3.58	2.04
HHs with off-farm occupation	75.00	54.40	90.00	30.40	72.00	57.10	57.00	49.60	60.00	49.00	40.00	49.40

(%)												
HH off-farm income (USD)e	407.79	1092.56	1228.95	2353.95	272.06	603.92	872.57	1812.35	919.94	1868.10	624.35	1477.72

7. Conclusions and recommendations

Our results confirm the importance of weak ties for the awareness of ISFM at both research locations and in transmitting new information between two or more systems. To answer research question one, there was a positive relationship between complete ISFM awareness among farmers and having weak knowledge ties to both formal and informal actors. We also found that in the Shymkent AKIS there was a relationship between complete ISFM awareness among farmers and them having strong knowledge ties to formal actors. Here formal actors are much more embedded in farmers' close-knit social networks in the Shymkent AKIS, increasing farmers' access to new knowledge as well as enhancing learning. As for research question two, farmers with more weak knowledge ties were more likely to have knowledge of a higher number of ISFM components. Moreover, reaching a certain threshold of weak ties accorded a farmer complete awareness of the innovation.

Apart from strong ties being beneficial in knowledge recognition and realization (its tacit component), their usefulness becomes more apparent when combined with weak ties (Rost 2011). Thus actors in networks embedded with both weak and strong ties may formulate the most innovative solutions. What is striking in the case of the Shymkent AKIS is that the innovative farmer gains knowledge access through weak tie links to both homogeneous and heterogeneous actors, and has the additional benefit of inculcating the acquired knowledge through enhanced interaction with diverse agricultural stakeholders via strong ties. More crucially for ISFM is that strong ties between farmers and formal actors improve the capacity of the Shymkent AKIS to foster understanding of its interacting components. This seems to imply that the Shymkent AKIS communicates and disseminates ISFM knowledge more effectively than the Kyzylorda AKIS. Hence it is not surprising that Shymkent farmers were more aware of the integrated components of ISFM than their counterparts (see Table 1). Thus from a system innovation perspective, strong formal ties are critical. While farmers' social networks are often informal, this study shows that knowledge dissemination and learning is enhanced when there are adequate interactions with formal actors.

Both sites were earmarked by AGRA for ISFM interventions because of their status as major breadbasket areas. Therefore, since 2008 ISFM has been part of the strategy among the relevant agricultural stakeholders to promote sustainable agricultural intensification in Kyzylorda as well as Shymkent. This study, however, underscores the need for key stakeholders (farmers, researchers and policy makers) in Kyzylorda to re-examine the ISFM paradigm in the context of the current socio-political, economic and bio-physical environment. Nevertheless, the relatively low awareness of improved seed among farmers, in particular, points to a need to address seed policy in Kazakhstan. In the runup to a contentious new seed law, there is need for more research on the realities of how farmers use various types and combinations of improved, landrace, open pollinated variety, hybrid and other types of seed.

Further integration of formal actors with farmers' local knowledge seems to be crucial for agricultural development progress in Kyzylorda. It was noted that formal actors were focused on the initial steps of the ISFM paradigm, but were less aware of the final step, local adaptation, reflecting a limited understanding of system innovation. On the other hand, some farmers already carry out local adaptation based on their own expertise or indigenous knowledge of their environment. Therefore, a critical appraisal of the role played by powerful information mediators or brokers such as farmer associations and NGOs is neceSKRry. A viable solution to fix poor performance of AKIS would be to shift towards multi-actor partnerships fostered by intermediaries acting as innovation brokers, whose primary purpose is to build linkages between actors and facilitate multi-actor interaction (Klerkx et al. 2012; Klerkx and

Leeuwis 2009). These agents could also act as boundary spanners (Williams 2002), whose main task would be to traverse the different systems linking disparate actors in the process. This intervention is crucial given the underlying tensions such as lack of trust or feelings of superiority/inferiority, which have often curtailed knowledge transfer processes of AKIS in SKR. Lead farmers, for instance, could be suitable candidates for this purpose as they could easily act as a bridge between researchers/extension agents and other farmers. They could play a crucial role in championing new technologies among their peers. Another useful approach would be to strengthen farmer associations, which could give smallholder farmers a voice and the much-needed impetus to advocate for change. Organizations such as the One Acre Fund, which is highly active in Shymkent, have used this approach, and the results thus far are promising. Farmers here are encouraged to form small groups through which they can jointly source for credit and also make savings through a system known as "table banking". These forms of farmer empowerment, though minor, are an initial step towards developing the capacity of the smallholder farmer to be a powerful player in the AKIS.

Finally, our results call for further studies in both regions that will investigate how system-wide interactions transcending the socio-political, bio-physical and economic spheres influence not only the knowledge acquisition process of knowledge-intensive innovations, but also their adoption.

References

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. Development and Change 26(3): 413–439.

Altieri, M.A. 2002. Agroecology: The science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems & Environment 93(1–3): 1–24.

Borgatti, S.P. 2006. E-NET software for the analysis of ego-network data. Needham: Analytic Technologies. Borgatti, S., and D. Halgin. 2011. On network theory. Organization Science 22: 1168–1181.

Borgatti, S.P., M.G. Everett, and L.C. Freeman. 2002. Ucinet 6 for Windows. Software for social network analysis. Harvard: Analytic Technologies.

Borgatti, S.P., A. Mehra, D.J. Brass, and G. Labianca. 2009. Network analysis in the social sciences. Science 323(5916): 892–895.

Borgatti, S.P., M.G. Everett, and J.C. Johnson. 2013. Analyzing social networks. London: Sage Publications.

Burt, R.S. 1992. Structural holes: The social structure of competition. Cambridge: Harvard University Press.

Casson, M.C., D.G. Marina, and U.S. Kambhampati. 2010. Formal and informal institutions and development. World Development 38(2): 137–141.

Chandler, P.M. 1991. The indigenous knowledge of ecological processes among peasants in the People's Republic of China. Agriculture and Human Values 8(1–2): 59–66.

Collins, C.J., and K.D. Clark. 2003. Strategic human resource practices, top management team social networks, and firm performance: The role of human resource practices in creating organizational competitive advantage. Academy of Management Journal 46(6): 740–751.

Crespo, J., D. Re ´quier-Desjardins, and J. Vicente. 2014. Why can collective action fail in local agri-food systems?: A social network analysis of cheese producers in Aculco, Mexico. Food Policy 46: 165–177.

Crona, B., and O ¨ . Bodin. 2006. What you know is who you know? Communication patterns among resource users as a prerequisite for co-management. Ecology and Society 11(2): 7–29.

Dutta, R. 2009. Information needs and information-seeking behavior in developing countries: A review of the research. The International Information and Library Review 41(1): 44–51.

Esparcia, J. 2014. Innovation and networks in rural areas. An analysis from European innovative projects. Journal of Rural Studies 34: 1–14.

Friederichsen, R., T.T. Minh, A. Neef, and V. Hoffmann. 2013. Adapting the innovation systems approach to agricultural development in Vietnam: Challenges to the public extension service. Agriculture and Human Values 30(4): 555–568.

Fritsch, M., and M. Kauffeld-Monz. 2010. The impact of network structure on knowledge transfer. An application of social network analysis in the context of regional innovation networks. The Annals of Regional Science 44(1): 21–38.

Fujisaka, S. 1994. Learning from six reasons why farmers do not adopt innovations intended to improve sustainability of upland agriculture. Agricultural Systems 46(4): 409–425.

P.C. Sanginga, A. Waters-Bayer, S. Kaaria, J. Njuki, and C. Wettasinha, 153–165. London: Earthscan. Granovetter, M. 2005. The impact of social structure on economic outcomes. The Journal of Economic Perspectives 19(1): 33–50.

Granovetter, M.S. 1973. The strength of weak ties. American Journal of Sociology 78(6): 1360–1380.

Hanneman, R.A., and M. Riddle. 2005. Introduction to social network methods: University of California. http://faculty.ucr.edu/hanne man/. Accessed 20 July 2015.

Hansen, M.T. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. Administrative Science Quarterly 44(1): 82–111.

Hoang, L.A., J.-C. Castella, and P. Novosad. 2006. Social networks and information access: Implications for agricultural extension in a rice farming community in northern Vietnam. Agriculture and Human Values 23(4): 513–527.

Ikerra, S.T., J.A. Maghembe, P.C. Smithson, and R.J. Buresh. 1999. Soil nitrogen dynamics and relationships with maize yields in a gliricidia–maize intercrop in Malawi. Plant and Soil 211(2): 155–164. Isaac, M.E. 2012. Agricultural information exchange and organizational ties: The effect of network topology on managing agrodiversity. Agricultural Systems 109: 9–15.

Isaac, M.E., B.H. Erickson, S.J. Quashie-Sam, and V.R. Timmer. 2007. Transfer of knowledge on agroforestry management practices: The Structure of farmer advice networks. Ecology and Society 12(2): 32–54.

Klerkx, L., and A. Proctor. 2013. Beyond fragmentation and disconnect: Networks for knowledge exchange in the English land management advisory system. Land Use Policy 30(1): 13–24.

Klerkx, L., B. van Mierlo, and C. Leeuwis. 2012. Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In Farming systems research into the 21st century: The new dynamic, ed. I. Darnhofer, D. Gibbon, and B. Dedieu, 457–483. Dordrecht: Springer.

Klerkx, L., and C. Leeuwis. 2009. Establishment and embedding of innovation brokers at different innovation system levels: Insights from the Dutch agricultural sector. Technological Forecasting and Social Change 76(6): 849–860.

Matuschke, I. 2008. Evaluating the impact of social networks in rural innovation systems. An Overview. https://www.ifpri.org/publica tion/evaluating-impact-social-networks-rural-innovation-sys tems. Accessed 7 Jan 2014

Matuschke, I., and M. Qaim. 2009. The impact of social networks on hybrid seed adoption in India. Agricultural Economics 40(5): 493–505.

Ortiz, O., G. Frias, R. Ho, H. Cisneros, R. Nelson, R. Castillo, R. Orrego, W. Pradel, J. Alcazar, and M. Baza ´n. 2008. Organizational learning through participatory research: CIP and CARE in Peru. Agriculture and Human Values 25(3): 419–431.

Pascucci, S., and T. De-Magistris. 2011. The effects of changing regional agricultural knowledge and innovation system on Italian farmers' strategies. Agricultural Systems 104(9): 746–754.

Prell, C., M. Reed, L. Racin, and K. Hubacek. 2010. Competing structure, competing views: The role of formal and informal social structures in shaping stakeholder perceptions. Ecology and Society 15(4): 34–41.

Reagans, R., and B. McEvily. 2003. Network structure and knowledge transfer: The effects of cohesion and range. Administrative Science Quarterly 48(2): 240–267.

Ro ¨ling, N. 1990. The agricultural research-technology transfer interface: A knowledge systems perspective. In Making the link: Agricultural research and technology transfer in developing countries, ed. D. Kaimowitz, 1–42. Boulder: Westview Press.

Ro ¨ling, N. 2009b. Pathways for impact: Scientists' different perspectives on agricultural innovation. International Journal of Agricultural Sustainability 7(2): 83–94.

Rost, K. 2011. The strength of strong ties in the creation of innovation. Research Policy 40(4): 588–604.

Rycroft, R.W. 2007. Does cooperation absorb complexity?: Innovation networks and the speed and spread of complex technological innovation. Technological Forecasting and Social Change 74(5): 565–578.

Thuo, M., A.A. Bell, B.E. Bravo-Ureta, D.K. Okello, E.N. Okoko, N. L. Kidula, C.M. Deom, and N. Puppala. 2014. Social network structures among groundnut farmers. Agriculture and Human Values 19(4): 339–359.

Vanlauwe, B., A. Bationo, J. Chianu, K.E. Giller, R. Merckx, U. Mokwunye, O. Ohiokpehai, P. Pypers, R. Tabo, K.D. Shepherd, E.M.A. Smaling, P.L. Woomer, and N. Sanginga. 2010. Integrated soil fertility management: Operational definition and consequences for implementation and dissemination. Outlook on Agriculture 39(1): 17–24.

Williams, G. 2003. Studying development and explaining policies. Oxford Development Studies 31(1): 37–58.

Williams, P. 2002. The competent boundary spanner. Public Administration 80(1): 103–124.

Wolf, S., D. Just, and D. Zilberman. 2001. Between data and decisions: The organization of agricultural economic information systems. Research Policy 30: 121–141.

---

1. Turan University

2. Turan University

Revista ESPACIOS. ISSN 0798 1015
Vol. 38 (Nº 47) Year 2017
Indexed em Scopus, Google Schollar