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Rural Innovation Systems and Networks

Findings from a Study of Ethiopian Smallholders

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ABSTRACT

Agriculture in Ethiopia is changing. New players, relationships, and policies are influencing how smallholders access and use information and knowledge. Although this growing complexity suggests opportunities for Ethiopian smallholders, too little is known about how these opportunities can be effectively leveraged to promote pro-poor processes of rural innovation. This paper examines Ethiopia's smallholder agricultural sector to provide qualitative insights into the interactions between smallholders and other actors in the agricultural sector and the contribution those interactions make to the smallholders' innovation processes. Case studies of smallholder innovation networks in 10 communities suggest that public sector extension and administration exert a strong influence over smallholders' access to knowledge and information relative to market or civil society actors. Given the priority the Ethiopian government has placed on improving rural welfare by increasing market access among smallholders, the findings of this study may suggest the need to further explore policies and programs that create more space for market and civil society actors to participate in smallholder innovation networks.

Keywords: Ethiopia, Agricultural Development, Innovation, Technology, Social Networks, Social Learning

1. INTRODUCTION

Agriculture in Ethiopia is increasingly characterized by new policies, actors, and relationships that influence how smallholders access and use information and knowledge. This growing complexity suggests opportunities for Ethiopian smallholders, but little is known about how those opportunities can be effectively leveraged to promote pro-poor processes of rural innovation.

An analysis based on an innovation systems framework can contribute to closing the knowledge gap. The framework draws attention to the diverse actors that contribute to agricultural innovation processes—public research organizations, private companies, nongovernmental organizations, civil society organizations, and smallholders themselves—by shedding light on the roles and responsibilities, actions and interactions, and institutions that condition behaviors and practices.

This paper examines how Ethiopian smallholders innovate—how they make use of new or existing knowledge and technology in their livelihood decisions; how their social networks contribute to innovation processes; and how those decisions, networks, and processes are influenced by policy- and market-driven factors. This examination is particularly relevant in light of the slow rate of technological change in Ethiopia's agricultural sector and the slow emergence of alternative institutional and organizational arrangements to enhance growth and development in the sector.

This paper draws on data compiled from focus group discussions held with smallholders and from key-informant interviews with other innovation agents conducted at 10 purposively selected study sites in Ethiopia. Using tools drawn from social network analysis, the study analyzes the social and economic context within which smallholders innovate, the nature and structure of innovation networks among smallholders, and the relationship between these networks and their innovation decisions.

Findings from this paper suggest that public sector service providers are often the primary source of information and resources critical to smallholder innovation, while market and other non state agents and institutions play more marginal roles in innovation networks. The information and resources transmitted within these networks relate primarily to the supply of production-related factors (inputs, credit, and technologies), while the transmission of information and resources concerned with market-related factors is far less common.

This study does not focus on the question of how to make smallholders more innovative—for example, by promoting basic and technical education, improving access to rural credit, or developing more appropriate technologies. Research along those lines is important and should be the subject of continuous empirical investigation. However, the intent of this study is to provide insights and recommendations not on how to make a better farmer but on how to support farmers with better networks and therefore greater opportunities to innovate.

Given the government of Ethiopia's strategic emphasis on increasing the productivity and commercialization of smallholder agriculture, findings suggest the need for policies and programs that (1) encourage the entry of new actors in the agricultural sector, particularly private industry, as a means of introducing new sources of knowledge and technology to smallholders; and (2) strengthen the willingness and ability of public sector service providers to interact with new actors and networks in support of smallholder innovation. Those types of interventions are important to the development of a more dynamic agricultural sector in which innovation networks of smallholders respond effectively to rapidly changing market and technological conditions.

2. KEY TERMS AND CONCEPTS

2.1. Systems of Innovation

The innovation systems framework is an increasingly popular way of studying how society generates, exchanges, and uses information and knowledge, and how systems can be strengthened to promote innovation and distribute the benefits of innovation more widely (Dosi et al. 1988; Edquist 1997; Freeman 1987, 1988; Lundvall 1985, 1988; Nelson 1988). The framework represents a significant change from the conventional linear perspectives on agricultural research and development by emphasizing the importance of studying an *innovation system* as a single unit comprising the agents involved in the innovation process, their actions and interactions, and the formal and informal rules that influence their practices and behaviors.

We define here several key terms drawn from the innovation systems framework and used throughout the paper. An *innovation* is any knowledge (new or existing) introduced into and used in an economically or socially relevant process (OECD 1999). For the purposes of this study, the term *innovation* includes not only the adoption of a new production technology by a smallholder but also a range of other processes, such as the reorganization of marketing strategies by a group of smallholders, the use of a new learning and teaching method by agricultural extension agents, and the introduction of a new processing technique by an agro-industrial company.

Based on that definition, we define an *innovation agent* as someone who introduces or uses such knowledge—a process that entails seeking information from various sources and integrating elements of the information into social or economic practices that somehow change the behaviors and practices of individuals, organizations, or society. Innovation agents include various actors. For example, innovation agents in Ethiopia may include:

1. public sector entities, like national and subnational research organizations, agricultural extension and education services, state marketing agencies, state-owned enterprises, institutes of higher learning, international research centers, and foreign universities;
2. traders, brokers, and other entrepreneurial individuals and their associations;
3. for-profit companies, both domestic and foreign, as well as industry associations;
4. farmers' organizations, cooperatives, and cooperative unions;
5. nongovernmental organizations, professional associations, and advocacy/lobby groups;
6. civil society organizations, such as community- or solidarity-based groups; and
7. farmers, farm households, agricultural laborers, and rural communities.

The key commodity linking these agents is *knowledge.* Although knowledge is a difficult commodity to characterize, we can assign to it several key properties that are useful for the purposes of this study. Knowledge may be scientific or technical in nature, or it may be organizational or managerial. It may occur in a codified or explicit form, or it may be more tacit or implicit. It may originate from foreign sources of discovery or emerge from the use or reorganization of internal and indigenous practices and behaviors (Clark 2002; Malerba 2002).

Note, however, that knowledge rarely presents itself in a form that can be immediately introduced into some social or economic practice. An individual's or organization's ability to identify, translate, and use existing knowledge to create something new is referred to here as *innovative capability* and is central to the study of an innovation system (Cohen and Levinthal 1990).

Individual innovative capabilities represent the foundations of an innovation system and belong to individual actors, such as scientific researchers, postsecondary educators, extension agents, entrepreneurs, and farmers (Renzulli 2003). However, because individuals rarely innovate in isolation, their capabilities must be augmented by collective systems—for example, private firms, professional associations, or innovation networks—embedded with *collective* innovative capabilities (Dosi et al. 2000; Rycroft and

Kash 1999). These systems provide the necessary organizational structures, routines, procedures, and behaviors to create environments that allow individual and collective expressions of innovative capabilities.

Because innovation results primarily from the exchange and use of knowledge, the nature of *interactions* between and among agents is another important aspect for consideration. Interactions may be spot market exchanges of goods and services that embody new knowledge or technology; costless exchanges of knowledge conducted in the public domain; long-term, durable exchanges that incorporate complex contractual arrangements and learning processes; local- or community-level systems of knowledge sharing; or hierarchical command structures. The study of how agents structure their interactions in the exchange of knowledge gives the innovation systems framework its definitive systems perspective.

An innovation system is also characterized by *innovation policies*. Innovation policies focus on enhancing a country's capacity to discover, imitate, adapt, exchange, and otherwise use knowledge in social or economic processes (Arnold and Bell 2001). They include policies in agriculture, industry, trade, finance and investment, education, science, and technology and provide leverage points for strengthening an innovation system and the networks contained within it. Moreover, innovation policies apply to both the formal and informal sources of innovation. Thus, although innovation policies may target the development of formal national agricultural research and extension organizations, other types of policies may emphasize efforts to promote indigenous innovation by extending credit to small-scale entrepreneurs and artisans.

For the purposes of this study, innovation policies can be classified into three categories. The first category comprises policies designed to create and strengthen the formal organizations and institutions needed to generate and apply new or existing information, including research organizations and programs; universities, colleges, and training programs; intellectual property rights regimes; financing mechanisms such as research grants and awards; and other policies designed to promote innovative behavior. The second category comprises policies that support and facilitate innovation among smallholders or groups of smallholders; and the third category includes policies that integrate and intermediate between and among public, private, and civil society actors engaged in innovation processes. Thus, the essential policy question for research on smallholder innovation networks is how to design and implement policies that recognize the existence of multiple sources of innovation, integrate those sources through productive interactions, and influence the functioning and evolution of the system in a manner that is socially beneficial.

The introduction of the innovation systems perspective here is not just an academic exercise. It can also assist policymakers, researchers, entrepreneurs, donors, and others in identifying new ways of encouraging innovation at both national and local levels. It does so by offering insight into the complex realities of how innovation actually occurs and how forward-thinking policies can facilitate innovation at a system level.2

Social Networks and Social Learning

An important element of an innovation system is the *social networks* within which innovation agents interact with one another, or the sets of individuals or organizations in which each has connections of some kind to some or all of the other members of the set (see Malerba 2005; Mowery and Sampat 2005; Rycroft and Kash 1999). Social networks define or limit an individual's opportunities for social learning by defining or limiting membership or participation in a given innovation process, thereby limiting access to knowledge (Bandeira and Rasul 2006; Besley and Case 1994; Foster and Rosenzweig 1995; Munshi

2 However, applications of the innovation systems perspective to developing-country agriculture are fairly nascent. For a survey and critique of the innovation systems literature with respect to developing-country agriculture, see Spielman (2006). For a wider discussion of new directions in the innovation systems literature, including their application to the study of innovation in developing countries, see Balzat and Hanusch (2004).

2004). The form, function, and boundaries of a social network are often determined by social and economic *institutions*, conventionally defined here as the rules, conventions, traditions, routines, and norms of a given social or economic system (North 1990).

Of particular interest to the present study is how social networks facilitate the transfer of knowledge externalities—knowledge made available to an individual as a result of the practices or behaviors of other individuals—and how those externalities affect individual decisions to introduce something new into their agricultural practices or behaviors. An early model of information externalities and agricultural technology was described by Besley and Case (1994) in reference to the adoption of improved cotton cultivars. The model was later refined by Foster and Rosenzweig (1995) in a study of high-yielding varieties (HYVs) of wheat and rice in India during the Green Revolution. That study establishes the importance of distinguishing between the effects of learning by doing (a function of one's own innovative capabilities) and learning from others (a function of one's social networks) and concludes that while imperfect knowledge about HYV management is a barrier to adoption, the barrier decreases as farmers and their neighbors gain experience.

Several modifications to the social learning/social networks model have since entered the literature. Bardhan and Udry (1999) extend the model to examine wider development implications of social learning. By linking technological innovation to investment in human capital, they demonstrate that in the presence of imperfect labor markets, the absence of technological innovation and underinvestment in human capital are mutually reinforcing. Munshi (2004) adds further nuance to the social learning model by demonstrating how information flows related to a new technology are weaker in heterogeneous populations. Bandiera and Rasul (2006) add yet another twist by modeling social learning as a nonlinear process and testing it with a study of sunflower adoption in northern Mozambique.

However, few of these studies examine networks as a complete set of heterogeneous agents—smallholder farmers, extension agents, government officials, market traders, and so on. Even fewer studies examine technology adoption or household welfare as a function of such networks. This suggests the need for complementary tools and methods to study the complex relational data inherent in smallholder networks.

One such tool is *social network analysis (SNA)*. SNA allows for the study of relationships among multiple and diverse actors by providing tools with which to visualize, measure, and analyze the relationships (Borgatti 2006). In the context of innovation, SNA provides an understanding of how actors interact, how information and resources move between and among them, and how agent's roles and relationships are structured. Data for SNA are commonly based on measurements of relationships between actors and sets of actors, in addition to the attributes of individual actors.

SNA has introduced several useful concepts to the study of social learning and social networks. For example, the small-world theory—that any individual in the world can be linked to any other individual through no more than six acquaintances (only one of which is a personal acquaintance)—was empirically tested using experimental SNA methods by Milgram (1967). The "strength of weak ties" theory—that unique and non redundant information is more readily available through an individual's informal acquaintances than through close friends—was introduced by Granovetter (1973) and empirically tested in later studies.

These studies, among others, helped to launch a fast-growing field of inquiry with its own unique set of analytical tools. SNA studies are particularly abundant in research on social capital, social learning, and innovation processes in developing-country agriculture. For example, Raini et al. (2006) used SNA as a tool to detect disparities in information flows among Kenyan smallholders, agrochemical firms, nongovernmental organizations, governmental agencies, international development agencies, and universities in the development and application of integrated pest management (IPM) techniques to tomato cultivation. Within the social relations underlying the networks they studied, the researchers found significant differences that influenced the interaction behavior among IPM users.

Similarly, Clark (2006) used SNA to study the introduction of information and communication technologies in supply chains for chilies, coffee, and peaches in Bolivia. The study identifies key actors, information flows, and supply chain bottlenecks and recommends ways of improving supply chain

efficiency and market access for network actors. In conjunction with that study, Douthwaite et al. (2006) used SNA to develop an interactive tool for use with farmer groups in Colombia to improve members' understanding of the importance of network relationships and to strengthen their capacity to manage their networks more effectively.

Conley and Udry (2001) used SNA to map networks of 450 individuals in four clusters of villages in eastern Ghana to demonstrate how farmers' social learning processes are based on communications conducted through social networks that were not determined by geographic proximity. Similarly, Giuliani and Bell (2005) used SNA to examine clusters of wine producers in Chile to show that knowledge flows and connections, instead of being influenced by geographic proximity, are influenced by firm-level absorptive capabilities (measured in terms of human resources, experience, and experimentation) such that information tended to flow through a core group of firms with advanced absorptive capabilities and a similar knowledge base. Hoang et al. (2006) used SNA to study the influence of ethnicity, gender, socioeconomic status, and power relations in rice-farming communities in northern Vietnam; the influence of social networks on access to information; and the benefits of agricultural research.

Darr and Pretzsch (2006) applied SNA to the study of smallholder networks within agroforestry projects. Their study, based on an analysis of data from four sample sites in rural Ethiopia and Kenya composed of approximately 200 households each, revealed that group cohesiveness, group activity, and member motivation are positively related to technology adoption, in addition to persuasive interventions from the public extension system.

3. A TRANSFORMATION IN ETHIOPIAN AGRICULTURE?

3.1. A Strategy for Change

Before exploring the role of social networks and innovation processes among Ethiopian smallholders, it is useful to examine the wider strategies and policies related to agriculture and rural development in Ethiopia to provide context. This section summarizes the country's key strategies and policies and highlights some of their intermediate outcomes.

The government of Ethiopia gives high priority to agriculture and rural development as an engine of pro-poor growth, and efforts to enhance agricultural productivity, increase the commercialization of smallholder surpluses, and reduce rural poverty are a cornerstone of the government's economic growth strategy, Agriculture Development-Led Industrialization (ADLI; MoFED 2002, 2005).

The ADLI strategy argues for greater innovativeness in the agricultural sector to enhance productivity, increase commercialization, and reduce poverty (MoFED 2002, 2005). Key elements of the strategy include efforts to promote a market-led transformation of smallholder agriculture, the decentralization of rural services, new and enhanced technologies to conserve and manage scarce natural resources, and continued investment in the development and promotion of new crop technologies.

The strategy draws heavily on the resources and capacities of public sector agencies that are pillars of the country's formal innovation system: public sector research, extension, and education services, all of which are recognized as *the* prominent sources of information, technology, and inputs for the Ethiopian smallholder (Kassa 2005). However, the strategy also calls for active engagement with other potential sources of innovation, such as the private and civil society sectors, cooperatives and cooperative unions, domestic and foreign firms, rural investors and entrepreneurs, and nongovernmental and community-based organizations.[3]

3.2. Process or Progress?

Although the ADLI strategy implicitly recognizes that a more dynamic and competitive innovation system is critical to transforming agriculture in Ethiopia, it has yet to translate that notion into a system with the potential to improve rural livelihoods. The development of Ethiopia's innovation system faces several obvious challenges. The most critical challenges are the design and implementation of policies to create and strengthen the formal organizations engaged in the innovation process (universities, private firms, and research organizations); the policies needed to facilitate innovation among smallholders (e.g., cooperatives and extension services); and the policies designed to mediate between and among these actors. These challenges often boil down to the need for incentive mechanisms that promote greater cooperation and coordination between different public organizations at different levels (i.e., at the federal and regional levels) and between public organizations and newer players in the system (i.e., between public education, research, and extension on the one hand, and private companies and civil society organizations on the other; Spielman et al. 2007).

The public research and extension systems—in partnership with regional administrations, cooperatives, cooperative unions, and private industrial concerns—have recently chalked up several innovation successes in promoting high-value commodities such as pulses, legumes, oilseeds, bread wheat, and potatoes (Abate 2006). These successes demonstrate the viability of efforts aimed at facilitating cooperation among diverse actors and strengthening innovation networks. What remains to be seen is whether such experiences can be transferred to wider number of crops, technologies, farmers, and areas in Ethiopia.

[3] See Spielman et al. (2007) for an attempt to map the agricultural innovation system in Ethiopia and the roles played by the actors in that system.

Several prior studies suggest that Ethiopia's innovation policy regime is insufficiently robust to support such efforts. Gebremedhin et al. (2006) highlight these issues in a study focusing on the relationships among research, extension, and education in which they describe the links as largely top-down, supply driven, unimodal, and driven by state priorities, not necessarily to the benefit of smallholders and smallholder innovation. Spielman et al. (2007) similarly observe a weak culture of coordination, integration, and cooperation among key actors in Ethiopia's agricultural innovation system at the national level.

Two researchers (B. Kassa 2004a, 2004b; H. Kassa 2005) argue that Ethiopia's agricultural education system requires significantly stronger links among education, research, and extension to meet the country's development objectives, whereas Davis et al. (2007) point out that organizational behaviors, cultures, and incentives are dampening innovative capacity throughout the same system.

The International Organization for Knowledge Economy and Enterprise Development (IKED 2006) argues that university–industry–government relations in Ethiopia—the critical nexus that often defines innovative capacity within a system—similarly require significant strengthening. IKED recommends more autonomy and room for specialization in universities to improve conditions for entrepreneurship, financial and other incentives to encourage networks that bring together different actors and capabilities, and continued long-term investment and improvement in the educational and infrastructural foundations of an innovation system. Similar arguments are made by a country study conducted by the United Nations Conference on Trade and Development (UNCTAD 2002).

Implicit in these studies is the argument that despite some forward-looking policies on science and technology, education, and private investment, Ethiopia is host to a weak innovation climate. This may be partly attributable to organizational cultures, particularly among public sector providers of rural services that are hierarchical, averse to change, and persistently focused on linear science. This is also evident in the shared beliefs that drive public sector programs and activities: (1) Food security and food self-sufficiency are largely synonymous, (2) the development and dissemination of new technologies to smallholders will generate the yield and output increases that are critical to achieving food security and reducing poverty, and (3) the innovation system's primary function is to develop and disseminate these new technologies. The approach eschews a more nuanced understanding of innovation systems and processes: Integration among heterogeneous actors is required for innovation to flourish. It also fails to recognize the need for new, more creative approaches to strengthening individual capabilities in the research, education, and extension systems; transforming organizational cultures into shared beliefs and practices that are more responsive to the changing need of the agricultural sector; and forging links among smallholders, extension agents, and actors in private industry and civil society.

The ultimate outcome of this weak innovation system is, by most measures, a stagnant agricultural sector. Agricultural GDP per capita grew at just 0.48 percent between 1996 and 2005 and displayed significant volatility year on year. Grain production per capita grew at just 1.38 percent, while cereal yields stagnated around 1.2 metric tons per hectare. The use of inorganic fertilizer is limited to just 37 percent of farmers, while their application rates remain at about 14 kilograms per hectare (Byerlee et al. 2007). Thus, rural incomes and livelihoods remain largely unchanged throughout the country, despite recent upswings resulting from several successive years of favorable rainfalls and some positive policy reforms.

4. METHODS, DATA, AND DATA SOURCES

4.1. Site and Household Selection

Geographic sites and households chosen for this study of smallholder innovation networks were drawn from the Ethiopia Rural Smallholder Survey (ERSS) conducted in 2005.4 This section describes the survey itself, and then defines the site and household selection criteria. Finally, the section provides an overview of the focus group and semi-structured interviews conducted for this study.

Ethiopia Rural Smallholder Survey

The ERSS was designed to collect data and information on the economic activities and behaviors of smallholders, with specific emphasis on efforts to improve rural welfare and incomes through increased market interaction. The stratified sample used in the survey comprised 7,186 households randomly drawn from 293 enumeration areas (each roughly mapping to a *kebele*)*5* from which 25 randomly drawn households were surveyed. The ERSS sample is considered representative at the national level as well as at the regional level for four of the main regions: Tigray; Amhara; Oromia; and the Southern Nations, Nationalities, and Peoples (SNNP) regional state. However, because the survey was not specifically designed for the study of topics covered by the present study, a purposive sub-sampling of enumeration areas and households was required to compile the necessary data for this work.

Geographic Site Selection

Using ERSS data, a set of 16 enumeration areas was initially identified based on evidence suggesting that multiple households within each enumeration area were engaged in what the research team identified as innovative cropping practices. These practices were associated with the adoption of the following crop/technology packages: oilseed (linseed, sesame, sunflower, canola, niger seed); apiculture (primarily modern beehives); nontraditional beans (mainly fasiola and haricot beans); potatoes (improved varieties); and onions, garlic, and leeks.

A total of 10 enumeration areas were selected for further exploration based on criteria designed to provide a heterogeneous sub-sampling of (1) agro-climatic or agro-potential regions, (2) one or more crop/technology packages being used in a given site, (3) administrative regions/regional states, and (4) physical accessibility of the site (Table 1). Although these criteria do not generate a nationally representative sub-sample, they do provide a basis for informative case studies with potential significance for national and regional policy.

4 The ERSS was designed and conducted by the International Food Policy Research Institute, the Ethiopian Development Research Institute, and the Central Statistical Agency of Ethiopia and was implemented as part of the Ethiopia Strategy Support Program (ESSP). This study is a component of ESSP.

5 In Ethiopia, *kebeles* or peasant associations (PAs) are the smallest administrative unit below the *woreda* (district) level. For purposes of comparison, *kebeles* correspond to a cluster of villages in most other sub-Saharan African countries.

Table 1. Selected sites for in-depth study

Woreda (region)	Crop/technology package	Agro-ecological zone[a]	Growth/ development potential[b]
Wemberma (Amhara)	Apiculture/onions	M1, M2	Medium potential, low risk
Janamora (Amhara)	Oilseed/apiculture/potatoes	M2	Medium potential, low risk
Hawzen (Tigray)	Apiculture/oilseed	SM2	Low potential, high risk
Hintalo (Tigray)	Apiculture/onions	SM2	Low potential, high risk
Ambo (Oromia)	Oilseed/potatoes	M2	Medium potential, low risk
Becho (Oromia)	Beans/oilseed	M2	Medium potential, low risk
Tikur Inchini (Oromia)	Oilseed	SH2, M2, H2	High potential, low risk
Kedida Gamela (SNNP)[c]	Beans/potatoes	SH2	Low potential, low risk
Badawacho (SNNP)	Beans	SH1	Low potential, low risk
Soro (SNNP)	Oilseed/potatoes	SH2	Low potential, low risk

Source: EIAR (pers. comm.)
[a] M1 is hot-to-warm, moist lowlands; M2 is tepid-to-cool, moist mid-highlands; SM2 is tepid-to-cool, sub-moist highlands; SH1 is hot-to-warm, subhumid lowlands; SH2 is tepid-to-cool, subhumid mid-highlands; and H2 is tepid-to-cool, humid mid-highlands.
[b] Source: World Bank (2004).
[c] SNNP: Southern Nations, Nationalities, and Peoples regional state.

Household Selection

Households for further study were selected from each enumeration area based on a rough index generated from the ERSS data. The index was composed of equally weighted values for (1) adoption of one or more of the identified crop/technology packages, (2) adoption of one or more complementary cultivation practices (e.g., innovative water management techniques or use of improved seed), (3) ownership of modern production assets (hand- or foot-operated mechanical water pumps and motorized (diesel) water pumps), and (4) contact with agricultural extension services. The five households with the highest index scores and the five households with the lowest index scores were selected for separate focus group interviews and were denoted (for convenience only) as innovators and non innovators, respectively (Table 2). This approach allowed the research team to identify groups that, according to ERSS data, were using agricultural practices different from those used by other members in their community, thus offering potentially valuable insights into the role of smallholder innovation networks.

Table 2. Social network analysis: Descriptive statistics for focus group participants

Characteristics	Innovators	Non innovators	Group mean difference test (*p* value)	
Number of observations	49	48		
Mean group size	5	5		
Female participants (%)	12	28		
Mean age (years)	45 (12.8)	46 (16.9)	0.7757	
Mean education (years)	3 (3.0)	1.8 (3.0)	0.0373	**
Mean land size (hectares)	1.84 (1.6)	1.23 (0.9)	0.0283	**
Participants who are household heads (%)	92	90		
Participants from women-headed households (%)	10	25		

Notes: Standard deviations given in parentheses.
* Mean between innovators and non innovators significantly different at confidence interval of 90 percent; ** 95 percent; *** 99 percent.

Focus Group Interviews and Semi-Structured Interviews

In mid-2006, the research team conducted a total of 20 focus group interviews (two at each of the 10 sites, one with innovators and one with non innovators) comprising five individuals each. Focus group interviews were conducted using pre-tested participatory rural appraisal (PRA) tools that focused on identifying sources of production knowledge and information, inputs and materials, credit and finance, and market links and price information (see the appendix for details).

Following the focus group interviews at each site, additional semi-structured interviews were conducted with key actors identified by the focus group participants. These interviews were used to further validate information provided by the focus group participants and included key informants in the immediate locality of the site (e.g., development agents,[6] cooperative managers, *kebele* officials, and leaders of community-based organizations); and in the *woreda* (district), zonal, or regional headquarters (e.g., Bureau of Agriculture and Rural Development officers, managers of credit and savings institutions, traders, brokers, staff at nongovernmental organizations, and others). Interviews were guided by questions similar to those posed to PRA participants (see the appendix for details). Data gathered from the PRA and semi-structured interviews were then used to conduct social network analysis of each site, as discussed in the following section.

4.2. Social Network Analysis

Here we examine the issue of smallholder innovation with an application of tools drawn from social network analysis (SNA). Because SNA is a relatively new application in this type of research, we describe it here in some detail (Table 3) and present the results in Section 5.1.[7]

In SNA, each actor in a network—whether an individual, organization, or some other entity of interest—is termed a *node*. The actor of interest within a network is known as the *ego*. Links between nodes, or *ties*, denote some form of interaction between nodes. In a tie linking an ego to another node, the other node is referred to as an alter. Ties can be analyzed with respect to their strength, frequency, distance, or other such measures depending on the focus of inquiry. Ties also reflect the key unit of analysis in SNA—the *dyad*, or a pair of nodes. Dyads may be direct ties between nodes, or indirect connections that pass through a series of interconnected nodes, or *walks*. Dyadic attributes can include the nature of social or economic relationships captured by the dyad, the characteristics of interactions in the dyad, or the ways in which information or resources flow in the dyad. Each network has a size—determined by the total number of nodes—and a boundary—a natural delineation between actors and relationships or an artificial limit set by the researcher.

Data for SNA can be collected through any number of conventional data collection tools, including household questionnaires, focus group interviews, and key-informant interviews. Data for the study of unimodal networks—for example, smallholder innovation networks—are compiled in a square $(n \times n)$ matrix of n actors (nodes) in which matrix element $n_{ij} > 0$ denotes the presence of a tie between actors i and j, while $n_{ij} = 0$ denotes the absence of a tie.[8] A simple non directional tie between two nodes is represented as $n_{ij} = n_{ji} = 1$ in the matrix. A directional tie—denoting, for example a flow of funds from node i to j but not from j to i—is represented as $n_{ij} = 1$ but $n_{ji} = 0$. Directed ties in a network graph are indicated by arrows, and an undirected graph shows only the lines between nodes. A valued tie in which matrix elements assume values in the set of real numbers $\left(a_{ij} \in \Re\right)$ can add further information to the analysis, with values assigned to each characteristic of the tie—for example, strength, frequency, or distance.

[6] Development agents are trained extension agents who are employed by the regional bureaus of agriculture, managed by *woreda*-level offices of these regional bureaus, and posted directly to the *kebeles*.

[7] For further details on the methodology, see Borgatti (1998), Hanneman and Riddle (2005), and Scott (2000).

[8] SNA data can also be used to study bimodal networks in which nodes are tied by affiliations (e.g., memberships of actors in different types of associations) and are compiled in nonsquare $(n \times m)$ matrixes in which matrix element a_{ij} denotes actor i's tie with association j.

Several useful measures drawn from these relational data are discussed here. Network density *(D),* for example, measures the number of nodes that are actually tied to other nodes in the network and is expressed as a proportion of all the possible ties in a network or

$$D = \frac{\lambda}{N(N-\lambda)/2} \tag{1}$$

where λ denotes the total number of lines (ties) present and N is the number of nodes in the network.

Degree centrality (C_d) measures the number of ties that a node has relative to the total number of ties existing in the network as a whole, or

$$C_d(n_i) = \lambda_i(n_i)/(N-1) \tag{2}$$

where n_i denotes the i^{th} node in the network, $\lambda_i(n_i)$ denotes the number of ties to n_i, and $N-1$ represents the size of the network less the node of interest.

Closeness centrality (C_c) measures the reciprocal of the geodesic distance (the shortest path connecting two nodes) of node n_i to all other nodes in the network, or

$$C_c(n_i)^{-1} = \sum_{i=1}^{N} d(n_i, n_j) \tag{3}$$

where $d(n_i, n_j)$ denotes the number of ties in the geodesic paths linking n_i and n_j.

A clique denotes the maximum number of nodes that have all possible ties present among themselves. Coreness, a related indicator, measures the degree of closeness of each node to the network core, where the network core is defined as the cohesive subgroup of nodes in which the nodes are connected in some maximal sense. Network cores are a function of network structure, meaning that identification of a core is easier in some networks (e.g., in a hub-and-spoke configuration) than in others (e.g., in a network with evenly disbursed ties or multiple cliques).

Whether a node is a member of a network core is determined as follows. Each node is assigned a coreness score based on how close it is to the network's maximally connected subgroup. The coreness score is normalized so that the sum of squares is equal to 1. Concentration measures are then obtained by testing the model for different sizes of the core. This is done by first placing only the node with the highest coreness score in the core and all other nodes in the periphery. The model continues testing for different sizes of the core, from 1 to *N*. For each different size of the core, concentration scores are given for each node along with a correlation score that correlates the given coreness scores with the ideal scores of 1 for every core node and 0 for every peripheral node. A core size of *x* nodes that generates the highest correlation score identifies the core membership. Core members are identified as those with the highest coreness scores.

Structural holes denote weak connection areas between two or more densely connected subgroups in a network. A test for the existence of structural holes measures the network's effective size, or the number of ties between an ego and all its alters minus the average number of ties that each alter has to other alters (i.e., ego network size minus redundancy in the network). The larger the effective size of the network, the more chances an ego has to act as a broker between two unconnected alters. A broker is the middle node of a directed triad. It may occur, for instance, when in a triad *(N = 3)* of nodes n_1, n_2, and n_3, n_1 has a tie to n_2, and n_2 has a tie to n_3, but n_1 has no tie to n_3. In other words, there is a lack of ties among an ego's alters.

Therefore, a node's brokerage position is the number of nodes not directly connected to it. If a broker in a network with a relatively high effective size is removed from the network, a large number of other nodes also become separated from the network. Note that unlike coreness, there is no particular value against which to determine whether structural holes exist or whether a node is a broker; certain network structures may indicate the possible existence of structural holes, and certain nodes may have an effective size that indicates the possibility of greater chances to act as brokers.

Table 3. Social network analysis elements

Element	Definition
Node	Any discrete individual, actor, or collective unit
Ego	Node of interest or analysis
Alter	Node directly connected to an ego
Ego network	Network that only shows direct ties to the ego and not between alters
Dyad	Pair of nodes linked by a tie
Walk	Sequence of lines in a graph
Path	Walk where each node and line is only used once
Geodesic distance	Shortest path connecting two nodes
Network	Graphical representation of relationships that displays points to represent nodes and lines to represent ties; also referred to as a graph
Network boundary	Natural delineation between actors and relationships, or artificial limit set by a researcher
Network size	Total number of nodes in a network
Network centralization	Degree to which a network revolves around a single node
Network density	Nodes that are actually tied as a proportion of all possible ties in a network
Centrality	Structural attribute of nodes in a network determined by their structural position in the network; centrality measures include degree, closeness, and betweenness
Degree	Number of ties a node has to other nodes
Closeness	Inverse of the sum of the length of the geodesic distance from a given node to every other node in the network (i.e., the inverse of farness)
Betweenness	Number of times a node occurs along a geodesic path
Cliques	Maximum number of nodes that have all possible ties present among themselves
Core	Cohesive subgroup within a network in which the nodes are connected in some maximal sense
Periphery	Nodes that are only loosely connected to the core and have minimal or no ties among themselves
Coreness	Degree of closeness to the network core of each node
Structural hole	Weak connection area between two or more densely connected subgroups in a network, measured by either effective size or redundancy
Effective size	Network size of an ego minus the average degree centrality of its alters
Redundancy	Average degree centrality of an ego's alters, not counting their ties to the ego

Source: Authors; Borgatti (1997, 1998); Davies (2004); Hanneman and Riddle (2005).

5. SMALLHOLDER INNOVATION NETWORKS

5.1. Overview of Findings

Findings from this study are based on qualitative data gathered from the focus group discussions and key-informant interviews previously described, and from social network analysis of data compiled from those discussions and interviews.

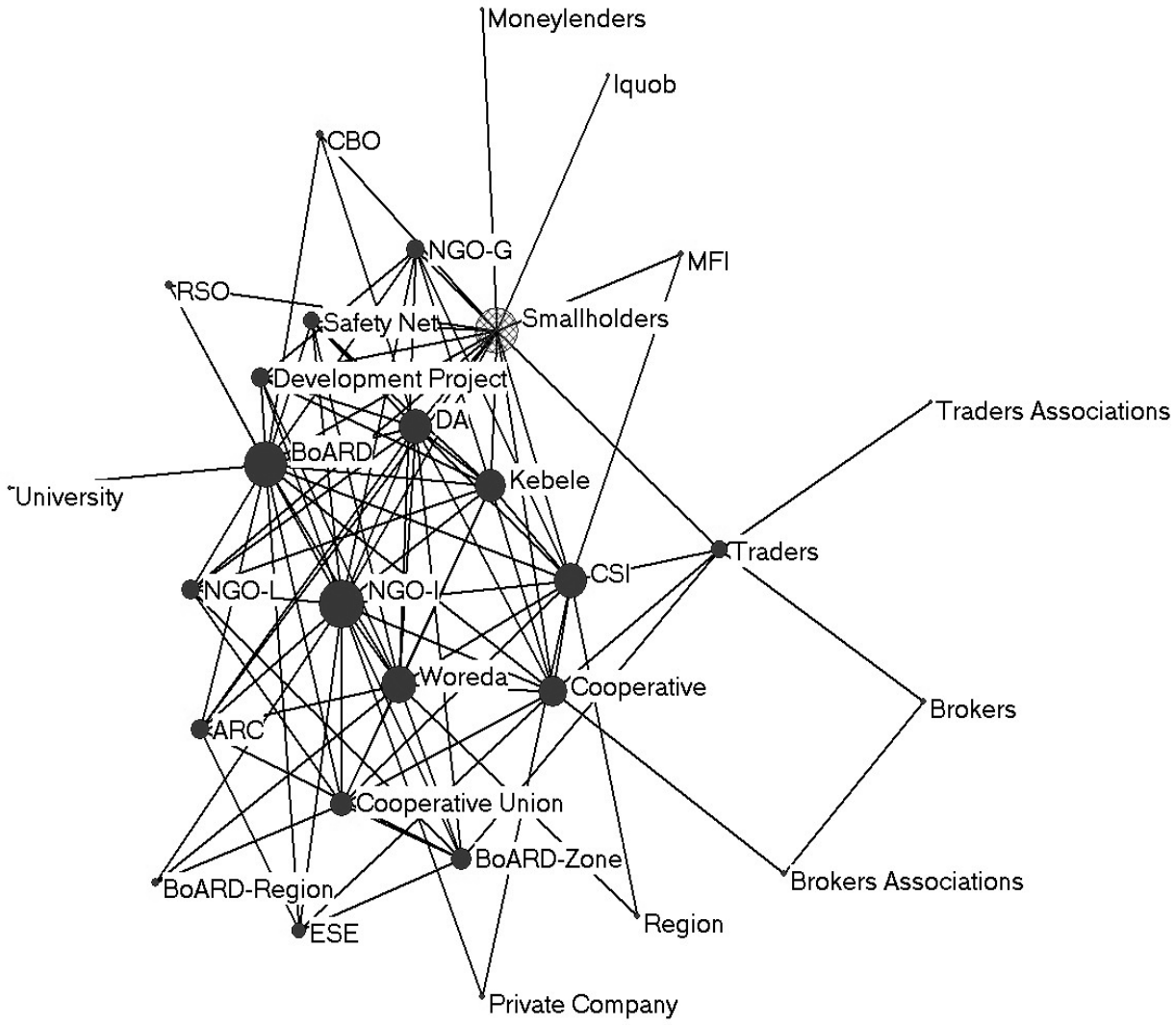
First and foremost, findings from this study suggest that smallholder innovation processes combine a diversity of public, private, and civil society organizations, the hypothetical extent of which is illustrated in Figure 1. The ties in this figure (and in the other figures presented in this section) indicate that the node interacts with another node in relation to the exchange of production knowledge and information, inputs and materials, credit and finance, or market links and price information.

Findings also show that public service providers play what might be termed *the* central role in smallholder innovation processes. Bureaus of Agriculture and Rural Development and their development agents, *woreda* and *kebele* administrations, government-backed credit and savings institutions, and farmer cooperatives—all public, quasi-public, or state-supported rural service providers—are closely linked with smallholders, with each other, and with the process of promoting and financing the use of information and technology. This finding is not surprising in itself, but the magnitude and consistency with which these service providers are linked into smallholder networks draws attention to their role. Simply stated, extension and related public services are compelling forces in rural Ethiopia.

Findings further suggest that although these actors are key providers of information, inputs, and credit related to improving smallholder output and productivity, their role is far less evident with respect to developing marketing links or transmitting price information to smallholders.

Yet according the findings, private sector actors—market traders, brokers, moneylenders, and private companies—are also somewhat peripheral to smallholder innovation networks. In the case study sites where market agents did operate, their ties to smallholders, public sector service providers, and civil society organizations were typically weak or nonexistent.

Figure 1. Hypothetical innovators' social network



Note: ARC: Agricultural Research Center; BoARD: Bureau of Agriculture and Rural Development; CBO: community-based organization; CSI: credit and savings institution; DA: development agent; ESE: Ethiopian Seed Enterprise; Iquob: rotating savings and credit association; Kebele: *kebele* administration; MFI: microfinance institution; NGO-G: government-associated NGO; NGO-I: international NGO; NGO-L: Local NGO; RSO: Religious or social organization.

On the other hand, in the case study sites where civil society organizations operated, their ties to these same actors were relatively stronger. This finding applies to various organizations, including local and international nongovernmental organizations (NGOs), NGOs more closely associated with the government of Ethiopia, and community-based organizations established under the auspices of NGO activities. Moreover, NGOs were often tied not only to local public sector service providers but also to a range of other actors beyond the immediate locality, such as research institutes and universities.

Yet differences exist among smallholder innovation networks both within and between communities with respect to such elements as network size, network density, and distance from different nodes and with respect to the influence that these networks have on smallholder innovation. Thus, we dig deeper into these findings with several site-specific cases the subsections that follow.

5.2. Wemberma: The Importance of Being Core

The *woreda* of Wemberma is a highland district in the Amhara region where surpluses of maize and wheat are grown. Wemberma illustrates how innovation processes in the *woreda* combine technological changes (adoption of improved seed-fertilizer packages for maize and diversification into new crops/technologies such as onions and apiculture) with organizational changes (close strategic coordination among public service providers of inputs and credit) and institutional changes (individual marketing of crop surpluses through local market agents and collective marketing through cooperatives).

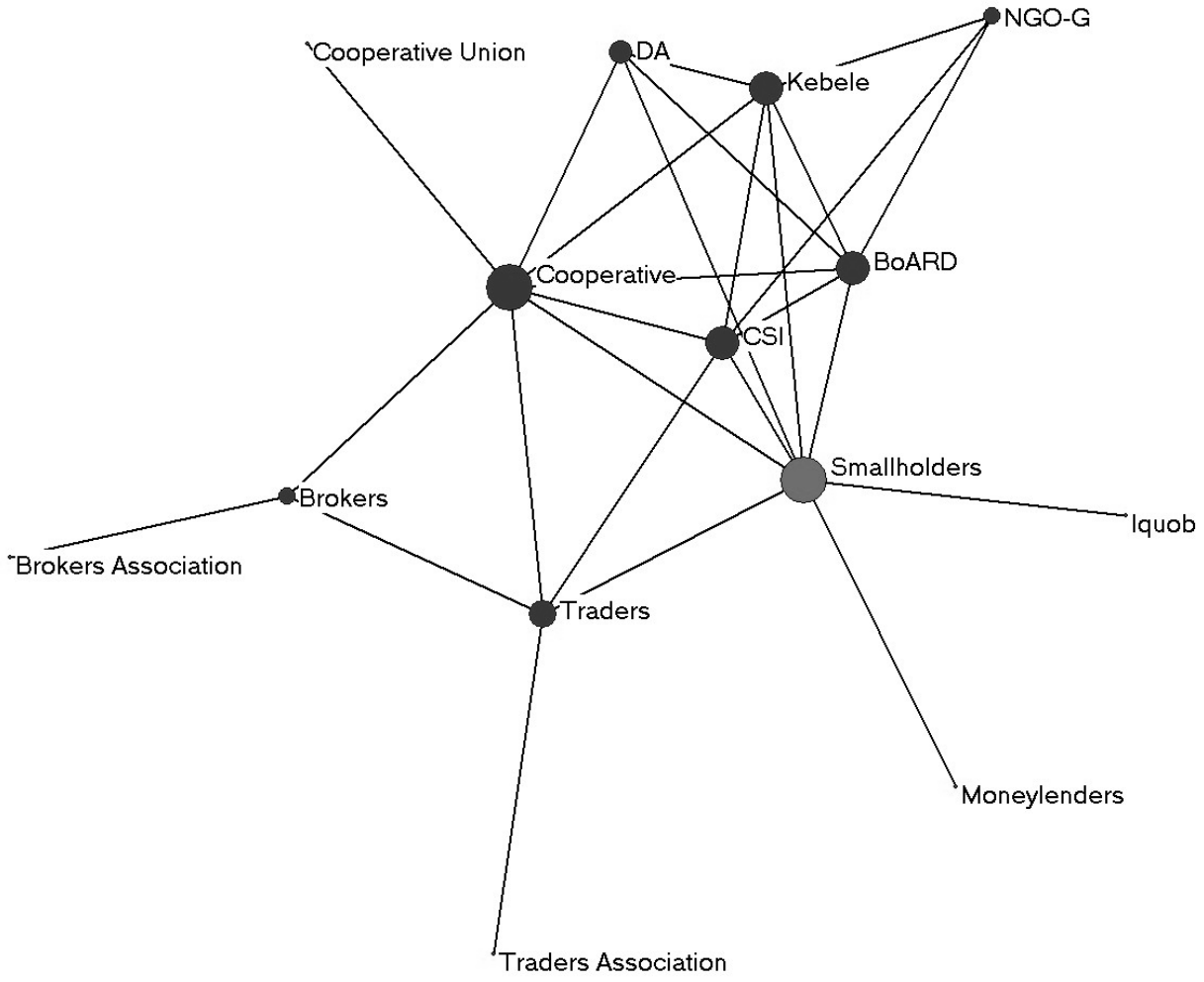
Wemberma also illustrates how smallholders depend on a small number of key nodes for production inputs, credit, and information—namely, the local Bureau of Agriculture and Rural Development (BoARD), the local cooperative, and the Amhara Credit and Savings Institution (CSI), as shown in Figure 2. These three institutions, along with the *kebele* administration, operate as a closely tied network for the smallholder: access to inputs from the BoARD requires access to credit from the cooperative or CSI, which in turn depends on a referral from the *kebele* administration. At the same time, smallholders in Wemberma depend on an even smaller number of key nodes for market information and links—nodes that are almost entirely delinked from the production-related network.

One way of representing this phenomenon is to examine the network structure in Wemberma in terms of cliques. An analysis of subgroups within the Wemberma network shows that three cliques exist, each with a minimum size of four:

1. Smallholders, BoARD, development agent, cooperative, and *kebele* administration
2. Smallholders, BoARD, CSI, and *kebele* administration
3. BoARD, CSI, government-associated NGO, and *kebele* administration
4. The BoARD and *kebele* administration are the closest actors to each other in the sense that they share membership in all three cliques. However, market-related actors (traders, brokers, and their associations) do not share any membership with these actors, indicating that market agents are relatively unconnected to other network actors.

Another way of representing this phenomenon is with an analysis of coreness in the network. As described earlier, coreness measures the degree of closeness of each actor to the network core. In Wemberma, smallholders, *kebele* administration, and the BoARD (all of which are nodes found in the network's three cliques) are closest to the network core, followed by cooperatives, the CSI, and the development agent (Table 4). This implies that core membership in the network consists of six nodes, none of which are market-related actors. In other words, key market agents can be viewed as peripheral to the network core.

Figure 2. Map of Wemberma *woreda's* innovation network



Note: The size of each node is determined by the node's degree centrality, or the number of ties that the node has relative to the total number of ties in the network as a whole. BoARD: Bureau of Agriculture and Rural Development; CSI: credit and savings institution; DA: development agent; Iquob: rotating savings and credit association; Kebele: *kebele* administration; NGO-G: government-associated NGO.

Table 4. Key network measures, Wemberma

Actor	Normalized coreness score	Possible core size	Correlation score
Smallholders*	0.468	1	0.441
*Kebele**	0.419	2	0.586
BoARD*	0.419	3	0.723
Cooperative*	0.361	4	0.802
CSI*	0.319	5	0.853
DA*	0.306	6*	0.910*
Traders	0.213	7	0.899
Government-associated NGO	0.201	8	0.896
Moneylenders	0.078	9	0.798
Iquob	0.078	10	0.712
Cooperative union	0.060	11	0.616
Brokers	0.037	12	0.495
Traders association	0.036	13	0.362
Brokers association	0.006	--	--

Measure	Innovators[a]	Noninnovators[a]
Ego network size (no. of nodes)	8 (13)	6 (11)
Ego density	35.71 (100)	66.67 (100)
Network centralization (%)	39.74 (100)	23.64 (100)
Freeman's normalized closeness centrality	68.42 (100)	64.71 (100)
Normalized degree centrality	61.54 (100)	54.55 (100)

* Network core and core members
[a] Highest possible value for each measure is given in parentheses
Note: BoARD: Bureau of Agriculture and Rural Development; CSI: credit and savings institution; DA: development agent; *Iquob*: rotating savings and credit association; *Kebele*: *kebele* administration.

Another finding from Wemberma is that innovation networks vary within communities. Closer examination of networks associated with the two focus groups studied in Wemberma reveals important differences (Figures 3a and 3b). First, innovators' networks are less dense, denoting the presence of more actors than non innovators in the network; and innovators' networks are more centralized and closer, denoting greater proximity (shorter walks) to other actors (Table 5). This suggests that innovators have greater access to sources of knowledge/information, inputs/materials, credit/finance, and market links/price information, and that access gives them a potentially greater number of livelihood options and opportunities than non innovators have. Second, non innovators have fewer ties to traditional or informal institutions (such as *iquob* or local moneylenders) compared with innovators. This suggests that non innovators have less access to informal sources of credit, finance, and risk management.

The implications of the findings to smallholder innovation networks in Wemberma are (1) public service providers are key nodes with respect to the provision of production information and resources, (2) market agents are largely peripheral, and (3) within-community variations exist in terms of the structure and role of innovation networks. In a surplus output *woreda* such as Wemberma, those findings suggest that the network may be insufficiently configured to provide smallholders with ties to the marketing side:

neither market links nor price information are transmitted through the sub-network of public service providers to any significant extent, and the sub-network of private market agents is relatively disconnected from other actors relevant to smallholders. As a result, smallholders operate with little access to market-related information. The core–periphery structure suggested by a marketing network that is largely separated from the tightly linked production network can potentially constrain the ability of smallholders to innovate effectively—to change their on-farm practices and strategies—in response to changes in the market.

Figure 3a. Ego network of innovators, Wemberma

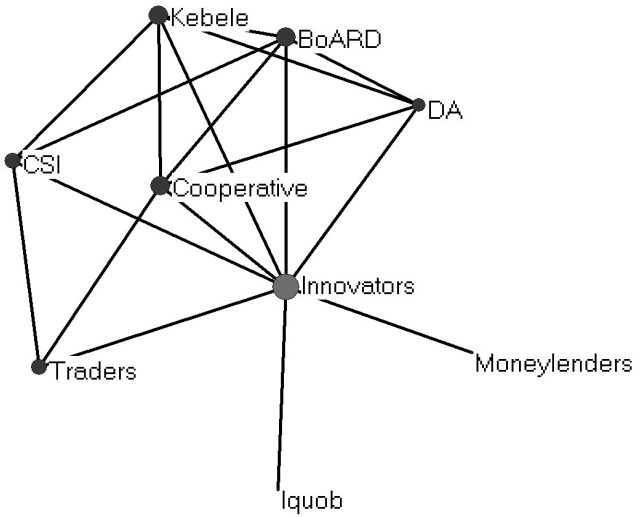
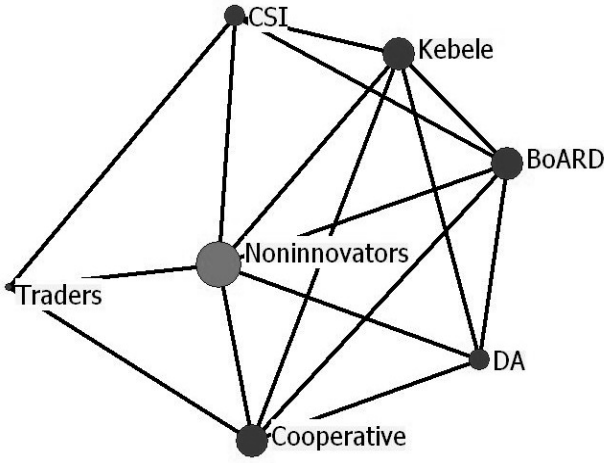


Figure 3b. Ego network of non innovators, Wemberma



Note: The size of each node is determined by the node's degree centrality, or the number of ties that the node has relative to the total number of ties in the network as a whole. BoARD: Bureau of Agriculture and Rural Development; CSI: credit and savings institution; DA: development agent; Iquob: rotating savings and credit association; Kebele: *kebele* administration.

5.3. Soro: A Case of Diversified Networking in Action

The Soro *woreda* in SNNPR is a major enset (false banana, or *Ensete ventricosum*) growing region. Food staple crops such as wheat, teff, and maize are also cultivated in the *woreda.* In recent years, Soro's BoARD has introduced several improved varieties of these cereals, along with higher-value crops such as oilseed and potatoes, and new water-harvesting techniques.

Findings from Soro indicate that its innovation network is more diverse than that of Wemberma in terms of the number and types of actors, with public service providers playing a less central role in the network (Figure 4). Although smallholders in Soro still depend on the BoARD for access to production information and inputs, it is the local and international NGOs and market-related agents who are particularly active in this network.

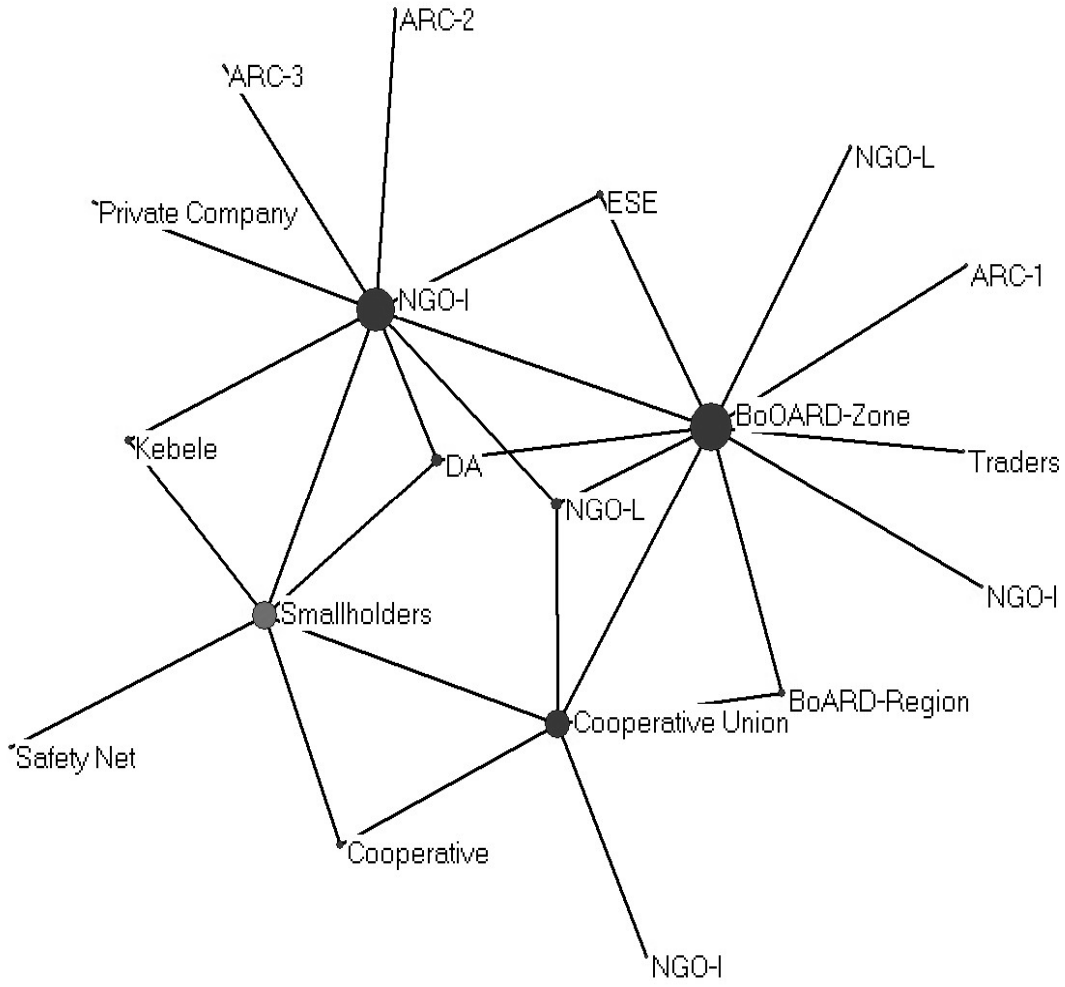
One way of illustrating these differences using SNA is to examine how key nodes form "bridges" between core network actors and more peripheral actors. In Soro, the bridges include an international NGO (World Vision), the BoARD, and the cooperative union. Without those bridges, the Soro network would break into separate networks. This implies that structural holes exist within the network, where single nodes lie along the *only* walks between one part of the network and another. Implicitly, this means that information and resources from peripheral actors (e.g., regional agricultural research centers) must pass through these bridges to reach smallholders

Measurement of the network's effective size (described earlier) provides a test for the existence of structural holes in a network. In the case of Soro, World Vision and the BoARD both have a relatively high number of ties compared with their alters (see Table 5). This indicates high effective sizes of their ego networks, suggesting that their locations are structural holes in the network. If World Vision and the BoARD were removed from the network, numerous other actors would also be lost.

Another way of testing this is to examine brokerage measures for these bridging actors. The Zonal BoARD, World Vision (NGO-I), the cooperative union, and smallholders show relatively high brokerage scores, implying that they play a relatively larger role in connecting other nodes compared with other actors (see Table 5).

The Soro case illustrates how a heterogeneous network provides smallholders with a greater diversity of options in accessing information, inputs, credit, or other resources, and how certain actors play critical bridging functions in making those options available to smallholders. Soro also illustrates how networks may be characterized not only by a greater variety and number of actors but also by more integration—that is, fewer separate sub-networks and less of a core-periphery structure. This heterogeneity potentially translates into a greater number of livelihood options and opportunities for smallholders in Soro, whereas integration can bring about greater stability in the network, even if an actor exits the network for some reason.

Figure 4. A map of Soro *woreda's* innovation network



Note: Ties indicate relationships between nodes. Node size is calculated based on degree centrality. ARC-1/ARC-2/ARC-3: three agricultural research centers active in the Soro network; BoARD-Region: Regional Bureau of Agriculture and Rural Development; BoARD-Zone: Zonal Bureau of Agriculture and Rural Development; CBO: community-based organization; DA: development agent; Kebele: *kebele* administration; NGO-G: government-associated NGO; NGO-I: international NGO; NGO-L: local NGO.

Table 5. Structural holes and brokerage measures in Soro *woreda* network

Actor	Effective size	Broker measure
BoARD-Zone	9.00	40
NGO-I	7.89	31
Cooperative union	5.17	12
Smallholders	5.00	12
NGO-L	1.68	1
DA	1.68	1
Cooperative	1.00	0
Kebele	1.00	0
Safety net	1.00	0
NGO-I	1.00	0
NGO-I	1.00	0
NGO-L	1.00	0
ESE	1.00	0
BoARD-Region	1.00	0
Private company	1.00	0
ARC-1/ARC-2/ARC-3	1.00	0
Traders	1.00	0
Measure	**Innovators[a]**	**Non innovators[a]**
Ego network size (no. of nodes)	5(10)	5(9)
Ego density	20.00(100)	20.00(100)
Network centralization (%)	45.10(100)	39.54(100)
Freeman's normalized closeness centrality	48.64(100)	51.54(100)
Normalized degree centrality	27.78(100)	27.78(100)

[a] Highest possible value for each measure is given in parentheses.

Note: ARC-1/ARC-2/ARC-3: three agricultural research centers active in the Soro network; BoARD-Region: Regional Bureau of Agriculture and Rural Development; BoARD-Zone: Zonal Bureau of Agriculture and Rural Development; CBO: community-based organization; DA: development agent; Kebele: *kebele* administration; NGO-G: government-associated NGO; NGO-I: international NGO; NGO-L: local NGO.

5.4. Ambo: A Case of Both Strong and Weak Ties

Ambo is a highland *woreda* west of Addis Ababa where teff is grown as the main crop, alongside improved varieties of wheat, barley, maize, linseed, and potatoes. The *woreda's* innovation network is relatively large and diverse compared to other *woredas* covered in the study. In addition to the usual public service providers, the network includes local and international NGOs, agricultural research centers, a private company, and several banks operating within the *woreda*.

This case offers an opportunity to examine how valued SNA data can be used to describe the strength of ties among network actors and with respect to the transmission of specific types of information or resources. Data gathered from the participatory rural appraisal exercise described earlier provide values for tie strength as follows: 1 = not so important, 2 = somewhat important, 3 = very important.

With respect to the provision of production knowledge and information, innovators in Ambo view their ties with the Oromia Credit and Savings Share Company (CSI) as stronger than other ties relating to the same services (see Figures 5a and 5b). The importance placed on the role of the Oromia Credit and Savings Share Company in Ambo is, according to feedback from smallholders interviewed for this study, a result of the share company's intensive engagement in the *woreda.* The company does more than disburse loans for purchasing oxen, seed, and fertilizer; fattening livestock; renting land for commercial cultivation; or engaging in petty trade. It also operates a training program to educate farmers on the company's various savings and loan programs, and on how to use loans effectively (e.g., how to engage in profitable livestock fattening). In short, the company provides both financial and training services in Ambo.

This finding is an interesting contrast to the observation at other sites that few smallholders, when asked about their key sources of production knowledge/information, consider their local credit and savings institutions as important as the BoARD or other public service providers. Thus, by examining individual actors' perceptions of the strength of ties, the study of the Ambo *woreda* shows that the roles played by actors in a network can vary. The provision of information and resources from farmers need not follow a set pattern that is consistent from site to site. Rather, different actors can play different, possibly overlapping or complementary, roles that may nonetheless contribute to increasing the number of livelihood options and opportunities for smallholders.

Figure 5a. Smallholder ego network for knowledge and information, Ambo

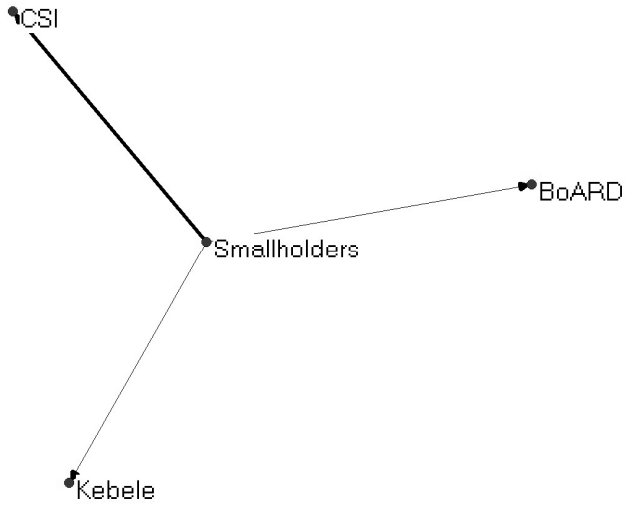
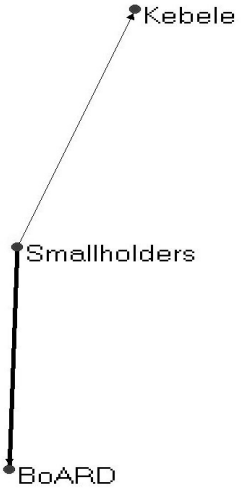


Figure 5b. Smallholder ego network for inputs and materials, Ambo



Note: Line thickness denotes the strength of tie on a scale of 1 to 3. BoARD: Bureau of Agriculture and Rural Development; CSI: credit and savings institution; Kebele: *kebele* administration.

6. CONCLUSIONS AND RECOMMENDATIONS

This study presents an analysis of smallholder innovation networks in rural Ethiopia. Using tools drawn from social network analysis, the study examines how various types of networks relate to the innovation practices of smallholders in case studies conducted in 10 localities across Ethiopia. In most cases examined, public service providers, particularly extension services, are the dominant network actors in the provision of production-related information and resources relevant to smallholder livelihoods. Bridges—ties that provide smallholders with indirect access to information and resources from actors in private industry or civil society—seem to be less common, although their appearance and importance vary between the localities covered by this study. Similarly, other network actors—traders, community organizations, and traditional institutions—exist but are of varying relevance to innovation, again depending on the site, crop, or technology.

These findings suggest that despite the changing dynamics of Ethiopia's agricultural sector, innovation tends to follow a linear path of supply-driven technology dissemination through the public sector, at least in the cases examined here. Public providers of extension, administration, and financing services are the sources of information and resources that smallholders accessed most often, particularly compared with non state sources. This suggests that the potential contributions of other innovation systems actors—private industry, entrepreneurs, civil society, and so on—remain largely untapped.

Given the priorities the government of Ethiopia has placed on agriculture and rural development, these findings suggest several points for further consideration. First, efforts to boost on-farm productivity and the commercialization of smallholders' surplus output might require a wider interpretation of the term *innovation*. Although the need for *technological* innovation in agricultural production obviously remains, additional consideration might be given to promoting *institutional* innovations in exchanging knowledge and information with smallholders and promoting agricultural technologies.

Second, further consideration might be given to the role assigned to public sector service providers. At present, the conventional role of public extension, administration, and financing services may be crowding out other innovation system actors or promoting innovation processes that are highly dependent on state interventions. Public service providers might consider repositioning themselves as *facilitators* of innovation networks in which their primary role is to accelerate the transmission of production information and inputs by connecting smallholders to private industry and civil society organizations. Given their central role in the rural economy, public service providers might also be better positioned to act as conduits for the transmission of price information and market links, particularly in light of the weak transmission mechanisms that currently exist.

Third, and given the Ethiopian government's strategic emphasis and sizable investment in increasing the productivity and commercialization of smallholder agriculture, consideration might be given to strengthening its innovation policies and programs. This includes interventions designed to encourage the entry of new actors in the agricultural sector, particularly private industry, as a means of introducing new sources of knowledge and technology to smallholders and interventions designed to improve the willingness and ability of public sector service providers to interact with new actors and networks in support of smallholder innovation.

This is not to say that the public provision of information, input, credit, and administration is unnecessary: rather, it will remain a critical component of an innovation network in which rural market failures are common because smallholders have poor access to markets, weak purchasing power, and asymmetrical access to market information. However, the absence of some degree of network heterogeneity *and* integration may also constrain the growth of innovation in the agricultural sector. Innovative responses to new market or technological opportunities often depend on a diversity of ties that link smallholders to other agents. Innovative responses also depend on both repeated interactions between agents well known to each other and more exploratory interactions with agents who are relatively new to a network. Highly dense networks that revolve around long-term relationships with a few central agents—

public sector service providers in the case of rural Ethiopia—offer few of these alternative links and thus less unique information and resources with which to innovate.

In summary, the development of a more dynamic and competitive agricultural sector in Ethiopia may require development of a stronger rural innovation system in which local innovation networks respond effectively to rapidly changing market and technological conditions. This suggests the need for policies and programs designed to strengthen innovative capabilities among rural service providers from the public sector, and to create more space for both public sector service providers and other actors to participate and cooperate within smallholder innovation networks.

APPENDIX: PARTICIPATORY RURAL APPRAISAL GUIDE

The participatory rural appraisal (PRA) began with semistructured group discussions based on a set of questions that focused on the sources and impacts of technological, institutional, and organizational change in the participants' lives. These group discussions helped familiarize the participants with the purpose of the PRA and the research team, and helped the participants became more comfortable speaking openly about the issues at hand.

Group discussions were followed by a Venn diagramming exercise. The exercise allowed participants to illustrate their sources (organizations and individuals) of knowledge/information, inputs/materials, credit/finance, and market links/price information, and the relative importance of those sources. Each participant was given circles of colored paper in three sizes (small, medium, and large) to represent the relative importance of each source and then was asked to place each circle in proximity to a point representing the participant (smallholder).

The diagramming exercise was followed by an institutional-ranking exercise based on the list of sources constructed in the earlier PRA activity. Smallholders were asked as a group to rank the importance of each source in terms of it contribution to providing knowledge/information, inputs/materials, credit/finance, and market links/price information. Valid responses (and ranking scores) were 1 = not so important; 2 = somewhat important; 3 = very important.

The institutional-ranking exercise was useful in several respects. First, it served as a cross-checking instrument to validate data from the previous PRA activities. Second, it illustrated how participants perceived the role and influence of key institutions and organizations, thereby capturing their perspective and voice. Third, it provided a clear indication of the strengths and weaknesses of the provision of knowledge/information, inputs/materials, credit/finance, and market links/price information.

The PRA team comprised one technical officer (a PRA expert with extensive field experience and local language expertise) from the Ethiopian Institute of Agricultural Research (EIAR) and two researchers drawn from the EIAR, the International Food Policy Research Institute, and/or the Ethiopian Development Research Institute (EDRI). At each site, one researcher was a non-Ethiopian. When the team was accompanied by a representative of the Central Statistical Agency (CSA), the *woreda* Bureau of Agriculture and Rural Development, or the local administration, efforts were made to separate that individual from the team to avoid biased responses among participants.

TOPIC GUIDE FOR INNOVATORS

Date: _____ Interviewers: _____
Time: _____ _____
Location: _____ _____

HHID	Name of household head	Name of respondent, if different

The CSA people studied your community, and we understand you are doing some new things in agriculture. We would like to ask you questions about this.

OVERVIEW

Tell us about the new or different crops, technologies, and practices that you are using. (Probe if necessary to get the following information):

√ What new crops are you growing?
√ Where and when did you learn about these new crops?
√ How are you growing them? Are you doing anything different from past activities?
√ Where and when did you learn about new technologies or practices?
√ Have you adapted or changed these technologies or practices in any way?

√ Why are you doing things differently? Why are you growing new crops or using new technologies or practices?
√ What sort of problems/risks did you face in doing things differently? Did you face any problems/risk related to weather, finances, time, or reputation?

√ Who are the people in your community who have done things *most* differently?
√ How would you describe them? Are they leaders, business people, risk takers, etc.?
√ Did you learn from them? Have they demonstrated how to do things differently?

√ Why are some people not doing things differently?
√ How has your life changed since you started doing things differently?
√ What is needed to enable more people to do things differently?

VENN DIAGRAMS

- Remember: include indigenous knowledge/institutions
- Remember: allow respondents to place the circles on the chart by themselves
- Ranking: big = very important; medium = somewhat important; small = not so important

1. Which organizations/individuals were important for getting agricultural knowledge or information? How important are these contacts?
2. Which organizations/individuals were important for getting agricultural inputs or materials? How important are these contacts?
3. Which organizations/individuals were important for getting credit or financial services? How important are these contacts?
4. Which organizations/individuals were important for getting market access so you could do this differently? How important are these contacts?

INSTITUTIONAL RANKING

- Remember: include indigenous knowledge/institutions
- Remember: you can use stones for this exercise
- Ranking: 1 = not so important; 2 = somewhat important; 3 = very important

1. Please list the organizations/individuals that are related to your farming activities.
2. Please list the goods or services that these organizations/individuals provide (knowledge/information, inputs/materials, credit/financial services, market access)
3. Please rank each organization/individual in terms of the goods or services it provides.

Organization/institution	Knowledge/ information	Inputs/materials	Credit/financial services	Market access
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

TOPIC GUIDE FOR NON INNOVATORS

Date: _____ Interviewers: _____
Time: _____ _____
Location: _____ _____

HHID	Name of household head	Name of respondent, if different

The CSA people studied your community, and we understand people in your area are doing some new things. We want to ask you questions about that.

OVERVIEW

√ Are you using any new or different crops, technologies, practices? If not, why?
√ Do you know about the different/unusual practices that some of your neighbors are doing?
√ What sort of problems/risks did you face in doing things differently? Did you face any problems/risks related to weather, finances, time, or reputation?
√ What is needed to enable more people to do things differently?

VENN DIAGRAMS

- Remember: include indigenous knowledge/institutions
- Remember: allow respondents to place the circles on the chart by themselves
- Ranking: big = very important; medium = somewhat important; small = not so important

1. Which organizations/individuals were important for getting agricultural knowledge or information? How important are these contacts?
2. Which organizations/individuals were important for getting agricultural inputs or materials? How important are these contacts?
3. Which organizations/individuals were important for getting credit or financial services? How important are these contacts?
4. Which organizations/individuals were important for getting market access so you could do this differently? How important are these contacts?

INSTITUTIONAL RANKING

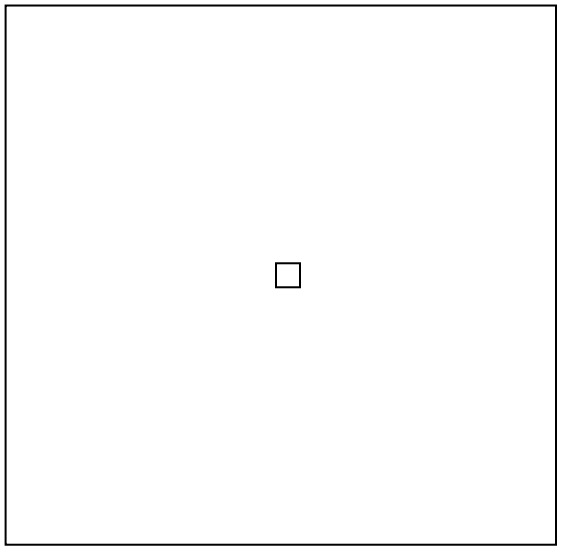
- Remember: include indigenous knowledge/institutions
- Remember: you can use stones for this exercise
- Ranking: 1 = not so important; 2 = somewhat important; 3 = very important

1. Please list the organizations/individuals that are related to your farming activities.
2. Please list the goods or services that these organizations/individuals provide (knowledge/information, inputs/materials, credit/financial services, market access)
3. Please rank each organization/individual in terms of the goods or services it provides.

Organization/institution	**Knowledge/ information**	**Inputs/materials**	**Credit/financial services**	**Market access**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Additional Instructions for Participatory Rural Appraisal Exercises

1. Venn Diagrams



Supplies:
Colored paper
Scissors
Markers
Pens
Flip chart paper
Writing paper

Instructions:
Using the paper, show all groups, government agencies, people, etc. that are involved with you regarding innovations. This is done by placing a card representing the farmer group in the middle of the flip chart. Write the name of the link on the circles of paper, where

Yellow = knowledge/information
Green = materials
Blue = credit/financial services
Red = market access

Then classify them by their importance.
1. Big = very important
2. Medium = somewhat strong
3. Small = less important

1. Which organizations/individuals were important for getting knowledge or information on how to do this differently? How often did you meet with them?
2. Which organizations/individuals were important for getting inputs or materials so you could do this differently? How often did you meet with them?
3. Which organizations/individuals were important for getting credit or financial services so you could do this differently? How often did you meet with them?
4. Which organizations/individuals were important for getting market access so you could do this differently? How often did you meet with them?

LOCAL INNOVATION AGENT INTERVIEW QUESTIONS

OVERVIEW

Tell us about the new or different crops, technologies, and practices that are being used in this area.

- √ Where and when did smallholders learn about these new crops?
- √ How are they growing them? Are they doing anything different than in the past?
- √ Where and when did they learn did you learn about new technologies or practices?
- √ Have they adapted or changed these technologies or practices in any way?
- √ Why are they doing things differently? Why are they growing new crops or using new technologies or practices?

- √ Who are the people in this community that have done things *most* differently?
- √ How would you describe them? Are they leaders, business people, risk takers, etc.?
- √ Did smallholders learn from them? Have they demonstrated how to do things differently?
- √ What sort of problems/risks did you face in doing things differently? Did they face any weather, financial, time, or reputational risks?
- √ Why are some people not doing new things differently?
- √ How has their life changed after they started doing things differently?

- √ What policy changes have affected the provision of services for knowledge/information, materials/input, credit/financial, or marketing?
- √ What is needed to enable more people to do things differently?

INSTITUTIONAL RANKING

What is your relationship, if any, with the following organizations/institutions?[9]

- Note: use the information from the Venn diagrams and institutional ranking
- Ranking: 0 = no relationship; 1 = knowledge or information services; 2 = materials/input services; 3 = credit or financial services; 4 = marketing services

Organization/institution	Relationship	Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

9 *Relationship* means that the respondent cooperates with the organization/institution.

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