# Smallholder Innovation in Ethiopia: Concepts, Tools, and Empirical Findings

by

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## Abstract

Agriculture in Ethiopia is increasingly characterized by new players, relationships, and policies that influence the ways in which knowledge is used by smallholders. This growing complexity suggests opportunities and challenges for smallholders. However, little is known about how technological, organizational, and institutional innovations affect rural livelihoods and poverty reduction in the country. Part of the problem lies in the near absence of robust tools and methods with which to study how the small-scale, resource-poor farmer innovates, i.e., how he or she generates, obtains, and uses new and existing knowledge to improve his or her livelihood. To develop keener insight into the smallholder innovation process, this paper examines the topic by looking beyond the traditional unit of analysis—the smallholder household—to study the wider innovation system, i.e., the set of interrelated agents, their actions and interactions, and the institutions that condition their behavior. The paper introduces tools and methods from a variety of disciplines to isolate and analyze components and linkages within local innovation systems, and draws several conclusions from empirical analysis of 10 local systems from across Ethiopia



**Keywords:** Ethiopia, agricultural innovation systems, methodology, social network analysis

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## 1. INTRODUCTION

Agriculture in Ethiopia is changing. New players, relationships, and policies are emerging in the sector and influencing the ways in which information is generated, exchanged, and used by smallholders. This growing complexity, characterized by many new technological and institutional innovations, suggests opportunities for small-scale, resource-poor farmers throughout the country. But too little is known about how smallholder innovation will ultimately affect agricultural sector growth, rural livelihoods, and poverty reduction in Ethiopia.

Conventionally, the pathways that foster smallholder innovation are viewed as fairly linear. Technologies developed by public research organizations are passed on to public extension agents and disseminated to smallholders. But modern realities increasingly suggest that smallholders innovate by obtaining information and technology from a wide range of actors, and modify these inputs to create knowledge that meets their particular needs in the institutional context within which they operate. This suggests a complex, iterative learning process tied to multiple actors and sources.

The innovation systems framework provides a useful means of studying these somewhat messy realities. The framework draws attention to the many diverse actors that contribute to innovation in the agricultural sector—public research organizations, private companies, non-governmental organizations, civil society organizations, and smallholders themselves—and emphasizes their roles and relationships as well as the social and economic institutions that condition their interactions.

The purpose of this study is to analyze the determinants of smallholders' capacity to innovate; the processes and systems that contribute to enhancing their capacity to innovate; and the organizational, institutional, and policy options that can strengthen smallholders' innovative capacities and enhance pro-poor innovation processes in Ethiopia.

This paper proceeds as follows. Section 2 sets forth key terms and concepts used throughout the study. Section 3 describes the tools and methods used in the study. Findings are provided in Section 4, followed by conclusions in Section 5.

## 2. KEY TERMS AND CONCEPTS

The innovation systems framework is an increasingly popular method of studying how society generates, exchanges, and uses information and knowledge, and how systems can be strengthened to improve innovation processes and the distribution of benefits from these processes. The innovation systems literature represents a significant change from the conventional, linear perspectives on agricultural research and development by emphasizing the analysis of complex relationships and processes that occur among multiple agents, social and

economic institutions, and endogenously-determined technological and institutional opportunities.

Before applying this framework to the case of smallholders in Ethiopia, it may be helpful to define several key terms used throughout the paper. An *innovation* is defined herein as any knowledge (new or existing) that is introduced into and utilized in an economic or social process (OECD 1999) An *innovator* is thus someone who introduces or uses such knowledge, a process that entails seeking information from various sources and integrating the information's elements into social or economic practices that somehow change behaviors and practices among individuals, organizations, or society (Ekboir, 2002).

An *innovation system* represents the set of interrelated agents, their interactions, and the institutions that condition their behavior with respect to the process of generating, exchanging, and utilizing knowledge. The term *agents* includes a variety of actors, including:

- public sector entities, international and national research organizations, agricultural extension and education services, state marketing agencies, state-owned enterprises, and institutes of higher learning;

- the private sector, e.g., foreign and domestic private firms engaged in various agriculture-related activities, industry associations, producer cooperatives and unions, and entrepreneurs;

- civil society organizations such as non-governmental organizations, farmers' organizations, or other community/solidarity-based groups; and

- farmers, farm households, agricultural laborers, and rural communities.

The key input linking these agents is information. But information itself is rarely in a form that can be immediately introduced into some social or economic practice. The ability to do so—to translate information into functional *knowledge*—is referred to as *absorptive capability* and is unique to each actor or to groups of actors (Cohen and Levinthal 1990). *Individual absorptive capabilities* represent the foundations of an innovation system, and belong to individual actors, e.g., scientific researchers, post-secondary educators, extension agents, entrepreneurs, and smallholders (Renzulli 2003). But since individuals rarely innovate in isolation, their capabilities must be augmented by cooperative systems—e.g., private firms, professional associations, or innovation networks—embedded with *collective absorptive capabilities* (Rycroft and Kash 1999; Dosi et al. 2000). These systems provide formal and informal organizational structures, routines, procedures, and behaviors to create environments that allow individual and collective expressions of innovative capabilities.

Although knowledge is often difficult to characterize, we can assign to it several key properties for the purposes of this paper. 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 may be more tacit or implicit. It may original from foreign sources of discover, or emerge from the use or reorganization of internal and indigenous practices and behaviors at the local level (Malerba 2002; Clark 2002).

Next, since 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 include spot market exchanges of goods and services that embody new knowledge or technology; costless exchanges of knowledge through 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 that govern the exchange process. The study of how agents structure their interactions in the exchange of knowledge is what gives the approach its definitive systems perspective.

An important set of interactions revolve around social networks that limit membership or participation, and thus access to information and knowledge (Conley and Udry 2001). Smallholder innovation often emerges from such networks, and are conditioned by social and economic institutions that condition their form and function. Here, the term *institution* is defined as the rules, conventions, traditions, routines, and norms of a given social or economic system.

Included among these institutions is the set of *innovation policies*, an area that covers policies in agriculture, industry, trade, finance and investment, education, science and technology, and so on. Innovation policies focus on enhancing a country's capacity to discover, imitate, adapt, exchange, and otherwise utilize knowledge in social or economic processes (Arnold and Bell 2001). For present purposes, innovation policies are relevant in two specific areas: (a) supporting and facilitating innovation among smallholders or groups of smallholders; and (b) integrating and intermediating between public, private, and civil society actors.

The former includes efforts to build the absorptive capabilities of individuals and groups to innovate, including education, extension, and capacity building programs; support to emerging knowledge networks among smallholders and other actors; services to enhance input supply and market linkages; efforts to empower communities and stimulate collective action; and so on. The latter includes efforts to strengthen linkages and networks between key actors in the innovation system, science and technology policies, public and private financing services and mechanisms, or science and business education.

The conceptual framework described above is useful not only as an academic exercise. It can also assist policymakers, researchers, entrepreneurs, donors, and others to identify new ways of encouraging innovation at both the national and local levels. It does so by offering insight into the complex realities of how innovation actually occurs, and how attitudes, behaviors, and policies can affect innovation at a systemic level.

To this end, the study examines how social networks influence innovation processes among smallholders. The study hypothesizes that smallholder innovativeness is positively determined by network size and density, and argues that the livelihood-improving effects of social networks can be strengthened by policies that encourage the entry of actors in a greater number and diversity than the current situation permits.

## 3. TOOLS AND METHODS

Due to the complexity of these innovative processes, a variety of tools is required to better understand and analyze it. This study collected both qualitative and quantitative data using survey research, semi-structured interviews, participatory methods such as institutional ranking and Venn diagrams.

The first step of the study involved secondary data collection through document analysis and semi-structured interviews with key informants to better understand the changing innovation system in Ethiopia. This included collecting information on the key technological, organizational, and institutional innovations in smallholder agriculture from the perspective of key system actors.

Data from the semi-structured interviews and document analysis were used to select key "innovation sectors" that suggested scope for further analysis. The term "innovation sector" is meant to capture more than a specific crop or crop technology. It represents an attempt to identify crops where the interplay between technological applications, commercialization and market value, and knowledge-sharing between different individuals and organizations all bear relevance to the production choices make by smallholder. The identification of innovation sectors also allows for analysis that ranges beyond the conventional, linear process of research-extension-adoption.

Having identified key innovation sectors, the study team then turned to the 2005 Ethiopia Rural Smallholder Survey conducted by the Ethiopia Strategy Support Program (ESSP) and the Central Statistical Authority (CSA) to identify sites and households to study smallholder innovation practices in further depth.

Ten case study sites were selected based on the following criteria: (a) different agro-climatic or agro-potential regions (high-low agro-potential areas; high-low rainfall risk areas; etc; (b) innovation with respect to different types of crops (high value/food staple crops); (c) multiple innovation sectors existing in a single *woreda*; (d) different administrative regions; and (e) physical accessibility given available survey resources.

After selecting case study households, an "innovativeness proxy index" (IPI) was developed to capture household-level innovativeness among the smallholders using several equally-weighted variables measured by the survey, as follows:

- *Crop diversification*: the number of innovation sectors that the household was engaged in, divided by the total number of innovation sectors (six sectors: oilseed, apiculture, potatoes, onions/leeks/garlic, beans, and fruit trees).

- *Cultivation practices*: the number of improved cultivation practices applied by the household divided by the total number of cultivation practices. Two cultivation practices were identified: irrigation (micro-dam, river diversion, pond, water harvesting, and wells) and the application of improved seed.

- *Production assets*: the number of modern production assets owned by the household divided by the total number of production assets. Here, two assets were identified: mechanical water pumps (hand- or foot-operated), and motorized (diesel) water pumps.

- *Receiving extension advice from extension agents or other sources*. Here, two sources were used, based on the questions "Have you received any visits by extension agents in the past year" and "In addition to the DA [Development Agent] visits, did you receive advice or training on agricultural production from other sources in the past year?"

The IPI was used to stratify households (n = 97) in each site, based on the assumption that smallholder innovativeness is closely related to higher levels of crop diversification, greater application of improved crop practices, ownership of modern production assets, and receiving of extension services from official or other sources. Such smallholders were in a relatively better position to innovate than those with lower levels of the aforementioned indicators. From each site a total of five households with the highest level of IPI were identified as innovators, while five with the lowest level of IPI were identified as non-innovators. Note that the term "innovator" and "non-innovator" is used here with the understanding that all smallholders are innovative to some degree, although some may be more innovative than others degree.

While the IPI proved useful in identifying households with different innovative attributes, it is by no means a perfect measurement tool. First, several of the chosen variables proved to be inconsequential in number (e.g., hand, treadle, and motorized pumps; irrigation; and improved seed application), absent in the data (e.g., broad-bed makers), or statistically insignificant between the innovator and non-innovator groups (irrigation and improved seed application). Second, the selection of households was not designed to estimate population parameters; rather, it was done to identify patterns of innovative behavior. Thus, the sample does not have a statistical design and the results cannot be extrapolated to the population.

Third, the "extension" variable included in the IPI raised the issue of causality. Do smallholders innovate because they receive extension advice, or do they receive extension advice because they are innovative? Of course, both are accurate statements. Smallholders innovate because extension agents provide them with the knowledge, inputs, and credit needed to change their farming practices and behaviors. But extension agents often work with "target," "model," or "demonstration" farmers who possess a distinct capacity to make use of extension advice. In the end, this latter explanation was found to be a more accurate reflection of the situation on the ground, and was further confirmed in several interviews where extension agents clearly stated that they work most closely with "model" farmers. Thus, the introduction of the "use of extension advice" variable in the IPI was deemed to be a reflection of innovative capacity.

Key to gathering information on the innovation networks of smallholders was a series of participatory rural appraisals (PRAs) conducted at each of the 10 sites with separate groups of innovators and non-innovators. Each group was comprised of approximately five participants, all of whom were members of households covered by the ESSP survey. The two groups (innovators and non-innovators) were convened separately at each site and engaged in the PRA exercise for approximately two hours. Each PRA was conducted by three members of the research team,

accompanied at various times by a representative of the Central Statistical Authority, the *woreda* bureau of agriculture, or local administration (i.e., a development agent (DA)).

The PRA was conducted as follows. First, semi-structured group discussions were held, focusing 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 to feel comfortable speaking openly about the issues at hand.

The group discussions were followed by the Venn diagramming exercise. The diagramming exercise allowed participants to illustrate their sources (organizations and individuals) of knowledge/information, inputs/materials, credit/finance, and market linkages/price information, and the relative importance of different sources (Figure 4). Participants were given circles of colored paper in three different sizes (small, medium, and large) to represent the relative importance of each source, and then asked to place the circle in proximity to a point representing themselves (the smallholder).

The Venn diagramming exercise was followed by an institutional ranking exercise based on the list of sources constructed in the previous activities. Smallholders were asked as a group to rank the importance of each source in terms of their contribution to providing knowledge/information, inputs/materials, credit/finance, and market linkages/price information. Valid responses (and ranking scores) were: Very important (3), important (2), not important (1), or not applicable (0).

The research team's last step at the case study sites was to interview local innovation agents identified by the PRA participants at each site. These interviews were used to further validate information provided by the PRA participants and to gain further insight into the role played by various organizations and individuals in the provision of knowledge/information, inputs/materials, credit/finance, and market linkages/price information. Key informants included those in the immediate locality of the site (e.g., development agents, cooperative managers, administrative officers, and leaders of community-based organizations), in the *woreda*, zonal, or regional headquarters (officers and extension agents from the bureau of agriculture, cooperative managers, managers of credit and savings institutions, traders, brokers, non-governmental organization (NGO) representatives), and others. Interviews were guided by questions similar to those posed to PRA participants.

Data from the PRA exercises and semi-structured interviews were analyzed using social network analysis (SNA). SNA provides both visual mappings and measurable indicators that help characterize networks (Scott 2000). It is a novel and unique tool because it extends beyond conventional comparisons of actors and their attributes. Rather, SNA emphasizes the relationships between actors and the patterns that underlie these relationships.

The key unit of analysis in SNA is the node (a single actor within a network), the ties (links between the nodes), and the dyad (pairs of actors). Dyadic attributes of interest include the socioeconomic roles assumed within a dyad; the form and nature of the dyadic interactions; or the flows of information, knowledge, and materials within a dyad.

The boundary of a network is determined by natural delineations between actors and their relationships, or by artificial limits set by the researcher. A network may be a complete network (inclusive of all possible nodes) or an ego network (a single node of interest and its direct ties only). Key SNA measures include:

- Network size, or the total number of nodes in the network.

- Network density, or the proportion of potential ties that are met between actors.

- Ego network density, or the total number of ties unconnected to the ego, divided by the total number of possible ties in the complete network.

- Closeness centrality, which captures the "global centrality" of the network by measuring the distance of an actor to all other actors in the network, typically by summing the geodesic distances between pairs of actors to calculate a "farness" measure.

- Closeness, the reciprocal of farness normalized relative to the most central actor, which measures the "walk" or figurative distance for an actor to reach all other actors in the network. A high closeness score, i.e., shorter walks to all other actors, suggests greater relative access to other actors and the resources they may possess.

- Degree centrality, or the number of ties that each actor has. Degree centrality is often depicted showing the actor's relative share of degree centrality, which is the actor's centrality as a proportion of the entire network's degree centrality.

- Network centralization, representing the degree to which the entire network is focused around a few central nodes, and based on the ratio of the difference of the degree centrality score of the most central node to the maximum possible sum of differences of the degree centrality score for the other nodes.

SNA is not often used to compare networks between, say, innovators and non-innovators; much of the social network analysis literature deals with measures within one network. The comparison problem stems from the fact that measures such as density are a function of network size, implying networks of significantly different sizes generate measures that do not immediately lend themselves to comparison Scott (2000). In the present study, however, network sizes for innovators and non-innovators are not very different, thereby allowing for comparisons of density and other measures across networks.

## 4. EMPIRICAL FINDINGS

The social network analysis (SNA) and institutional ranking exercise (IRE) reveal several interesting findings. While the statistical properties of the sample used in this study do not imply nationally representative findings, they are nonetheless fairly robust: SNA and IRE results for each of the 10 sites (a total of 20 networks) reveal similar and consistent findings across all sites. Findings are as follows.

***Diversity and size.*** First, there is a diversity of actors operating in innovation systems at both the local and national level, the most prominent of which are government administrative, extension, and input services; cooperatives and cooperative unions; non-governmental organizations; traditional community-based organizations; and smallholders themselves (Figure 1). Private sector agents, including traders, brokers, input supply companies, or agribusinesses, are far less common across all sites.

***Innovators vs. non-innovators.*** Findings suggest that innovators and non-innovators differ in several important ways. Here, results from the SNA offer some useful insights. Figures 2 and 3 provide a generalized overview of the "typical" networks for innovators and non-innovators based on aggregated data from the 10 case study sites, while Table 1 provides descriptive measures for both networks.

The analysis reveals that innovators are typically members of networks that are larger in size and characterized by higher degree centrality. They tend to have more ties to traditional institutions such as *iquob* or local moneylenders than non-innovators. Innovators also display a higher ego network density.

**Table 1. Descriptive measures of generalized networks**

| Measure | Innovators | Non-innovators |
|---|---|---|
| Ego network size (no. of nodes) | 17 | 14 |
| Ego network density | 30.88 | 40.66 |
| Network centralization (%) | 42.59 | 43.23 |
| Closeness centrality[a] | 71.80 | 66.67 |
| Degree centrality[b] | 0.09 | 0.08 |

Note: Figures are calculated for complete network except for ego network size.
[a] Measured as Freeman's normalized closeness centrality.
b Measured as the relative share of degree centrality.

These descriptives suggests marked differences between innovators and non-innovators. Because innovators are typically members of larger networks that involve greater numbers of ties and shorter walks to other actors, they are more likely to have better access to necessary inputs and services. This would suggest that innovators have relatively greater access to information, inputs, credit, and markets than non-innovators; as well as relatively greater access to formal and informal substitutes for such inputs.

Further insight is revealed in a comparison of the network data to the institutional ranking scores given by innovators and non-innovators for the various services and service providers.[1] Figures 4

[1] As described earlier, ranking scores for the services and providers were: Very important (3), important (2), not important (1), or not applicable (0). The four services were knowledge/information, inputs/materials, credit/finance, and market linkages/price information. Therefore, each service provider could receive a score from 0 (if they were

and 5 illustrate the importance that innovators and non-innovators place on different network actors with respect to the provision of key inputs and services.

Findings suggest that innovators place greater importance on all actors than non-innovators, suggesting that innovators have relatively better access to these inputs and services, particularly with respect to credit.

Furthermore, innovators place greater importance on the government administrative, input, and extension services than non-innovators. This includes the BoARD, *kebele* administrations, cooperatives, and credit and savings institutions.

In terms of service provision, both innovators and non-innovators view the BoARD and cooperatives as relatively more important than the *kebele* administrations and credit and savings institutions.

All in all, these findings are fairly intuitive: innovative smallholders are simply better connected than non-innovative smallholders. But further examination of networks at both the generalized and local levels reveals several additional findings of interest.

***Government services and centrality.*** Government organizations are ubiquitous throughout local innovation networks. Their interactions are highlighted by multiple roles that revolve around the provision of information, inputs, credit, and market linkages. They typically operate around an interwoven network of agencies: the *woreda* BoARD, its development agent at the *kebele* level, and the *kebele* administration; along with the government-supported cooperatives and credit and savings institutions. The BoARD typically acts as a central node or "gatekeeper" in most local innovation networks, and manages the supply of extension services, credit, and most other inputs or services.

Cooperatives are common in most local innovation networks, and are generally accessible to both innovators and non-innovators. Their role in supplying inputs is typically greater than their role in marketing crop surpluses for their members.

NGOs, both international and local, typically operate as highly-integrated members of these networks. International NGOs appear prominently in several networks across the sample site, although they are most concentrated in the Oromia and the Southern Nations, Nationalities, and People's (SNNP) regions. The high degree centrality displayed by NGOs suggests that they function at the center of their networks, facilitating linkages among smallholders, *kebele* officials, development agents, local NGOs, and agricultural research centers.

Private sectors agents, on the other hand, operate with far fewer ties to government organizations. Their role is typically confined to the purchasing of crop surpluses from smallholders.

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not applicable in each of the four categories) to 12 (if the smallholders said they were "very important" for each of the four categories).

In summary, local innovation networks in Ethiopia are relatively complex systems that revolve around the provision of production inputs and services by government or government-supported agencies. Realization of the advantages conferred by these networks, whether by NGOs, private sector agents, or smallholders themselves, seems to hinge on integration into the existing structures.

## 5. CONCLUSIONS

By combining quantitative and qualitative methods of analysis, this study attempts to provide some insight into the technological, organizational, and institutional innovations occurring in Ethiopian agriculture. These methods prove particularly effective where local innovation systems are relatively complex and characterized by interwoven relationships between diverse actors, changing public policies, and intricate institutional structures.

Most importantly, these methods help identify key relationships within local innovation systems and important differences between innovative and non-innovative smallholders in these systems. While results may not be immediately generalizable to a national level, similar and consistent findings from a sample of 20 networks in 10 case study sites suggest some important findings.

First, local innovation networks in Ethiopia are relatively complex systems that revolve around the provision of production inputs and services by government agencies. There is a near-absence of alternative sources for inputs and services, implying that smallholders and other network actors—NGOs and even private sector agents—must integrate into existing government structures to effect livelihood changes.

Second, the configuration of (and relationships within) these networks affect smallholders' ability to benefit from necessary inputs and services such as information, materials, credit, and markets linkages, and thus livelihood improvements. More specifically, because innovative smallholders are typically members of larger, more centralized networks that involve greater numbers of ties and shorter walks to other actors, they are more likely to have better access to necessary inputs and services.

These findings suggest several points for further consideration. Importantly, as the pace of rural development increases, the need for new actors and greater diversification of roles and responsibilities may become necessary. Government-led network structures may have to give way to the entry of more independent, but still integrated, network actors from the private sector and civil society. Forward-looking policy options to promote the entry of private agents and the diversification of existing government roles are needed.

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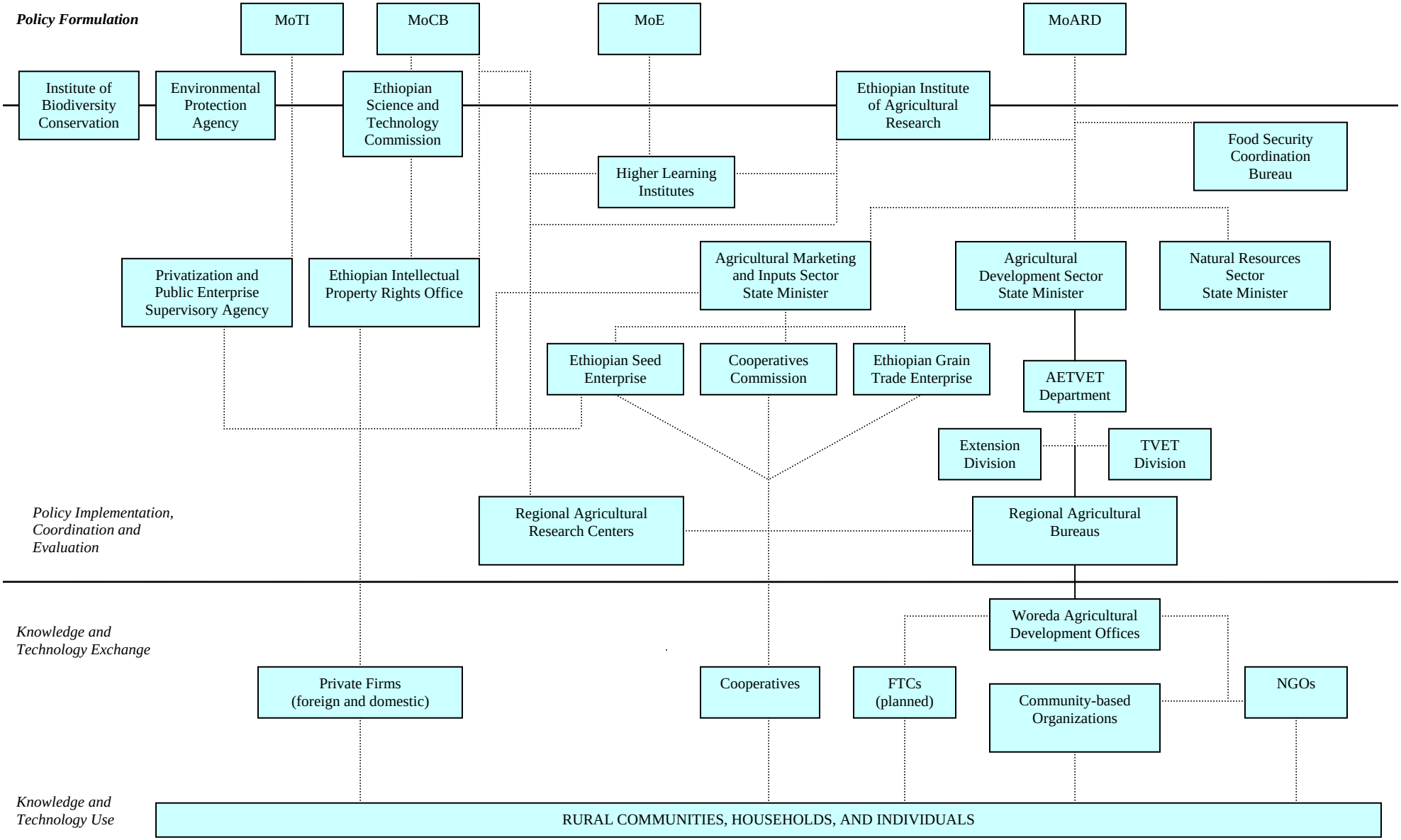


**Figure 1. A schematic of Ethiopia's agricultural innovation system**

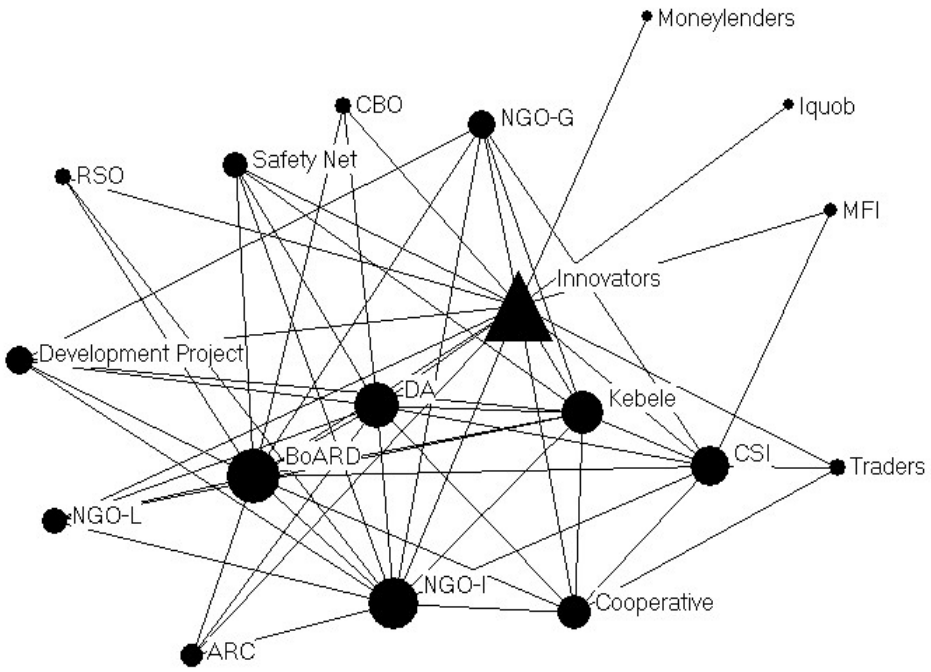


**Figure 2. A generalized innovator network**

Abbreviations/acronyms: ARC: Agricultural Research Center; BoARD: Bureau of Agriculture and Rural Development; CBO: Community-based Organization; CSI: Credit and Savings Institution; DA: Development agent; MFI: Microfinance Institution; NGO-G: Government owned non-governmental organization; NGO-I: International NGO; Kebele: Kebele Administration NGO-L: Local NGO; RSO: Religious or Social Organization.

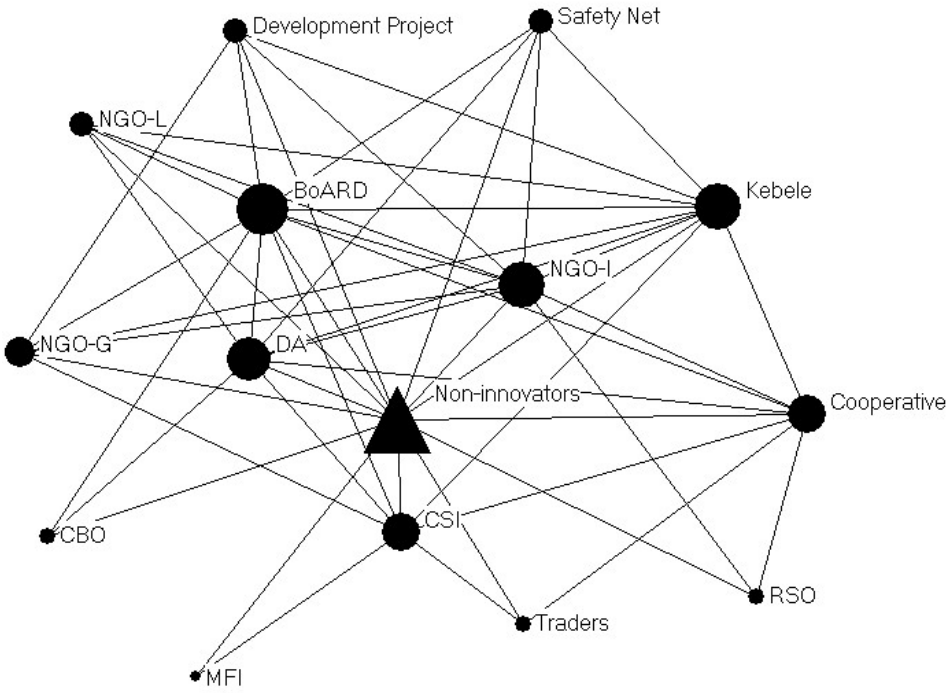


**Figure 3. A generalized non-innovators network**

Abbreviations/acronyms: ARC: Agricultural Research Center; BoARD: Bureau of Agriculture and Rural Development; CBO: Community-based Organization; CSI: Credit and Savings Institution; DA: Development agent; MFI: Microfinance Institution; NGO-I: International NGO; Kebele: Kebele Administration NGO-L: Local NGO; RSO: Religious or Social Organization.

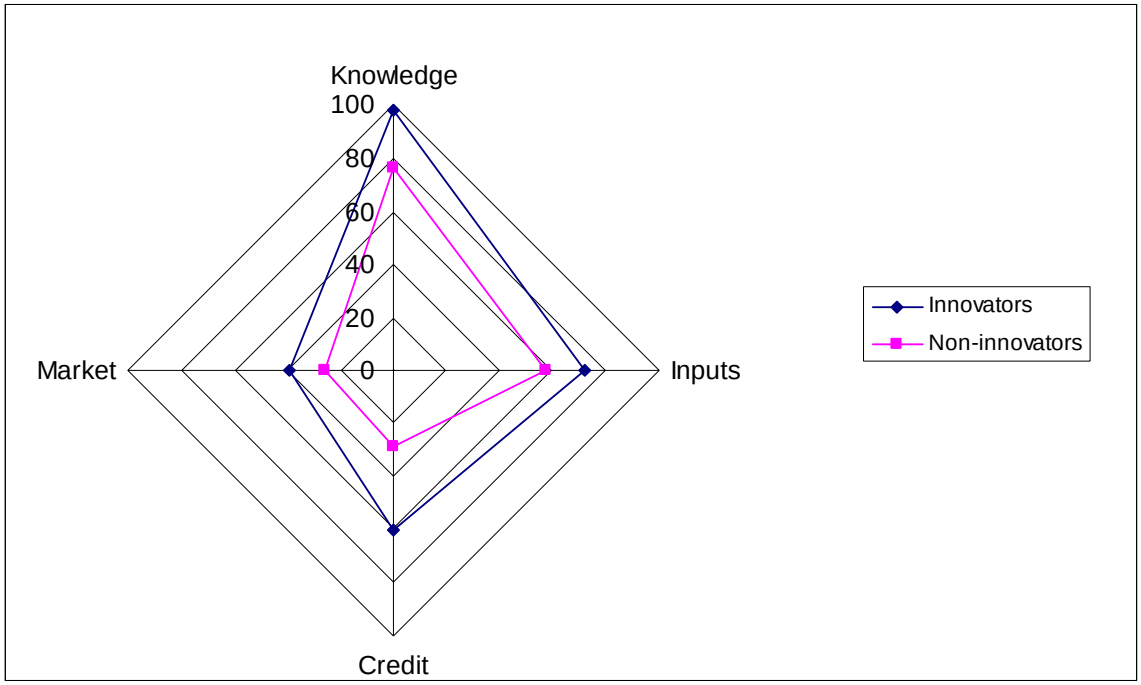


**Figure 4. Service rankings by smallholders**

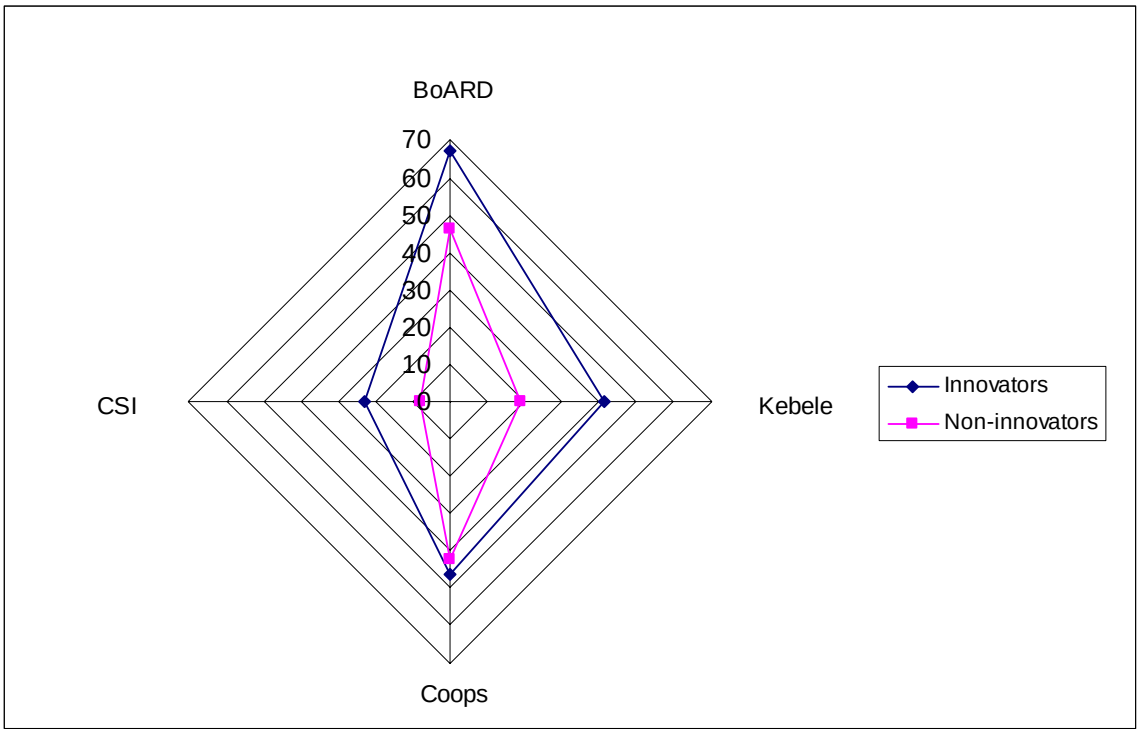


**Figure 5. Service provider rankings by smallholders**