Farmer Innovation: An Approach for Narrowing the Gap Between Research, Extension and Farmers in Ethiopia

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Abstract

One hundred and ninety farmers of three districts in Ethiopia were interviewed about their strategies of using indigenous innovations for the survival of their farms. Two workshops were also conducted to make the main actors part of the study, to communicate the findings to farmers, extension agents, districts leaders, researchers and traders, and get their feedbacks. The major findings were that farmers find it difficult to access modern technologies suggested by the extension agents. As a result, farmers use more of their indigenous knowledge and innovations to keep the costs of inputs down and find compromised solutions when they are confronted with a clash of factors influencing the farming situations. This has been in spite of the fact that the actual effects of indigenous knowledge and innovations are not proven by formal research studies. Despite all challenges, various local innovations have been identified in agriculture and natural resource management. The most conspicuous farmer innovations maintained for generations are the "Broadbed and Furrow" and "Open Ridge and Furrow" that are in use to drain excess water from the farmlands. Farmers have also been applying environmentally safe practices to control damage on crops caused by rats. Thus, there is a need to build good reciprocal partnership between researchers and farmer innovators for joint experimentation based on agenda set by farmers. This would also help researchers to communicate with farmers with due recognition as equally innovators, and to listen to and learn from farmers to improve the linkage between research, extension and farmers.

Keywords: Innovation, Vertisols, broadbed and furrow, joint experimentation and partnership

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Introduction

In recent years, the System of Innovation (SI) approach has become more popular both in the scientific and policy arena (Mytelka, 2000; Carlsson *et al.*, 2002; Hall *et al.*, 2006). According to the SI approach, innovation is an interactive, non-linear process in which actors interact with manifold of organizations. Reciprocity (something done is mutually done) and feedback mechanisms determine the success of innovation (Freeman, 1987, 1988; Lundvall, 1992; Nelson, 1993; Edquist, 1997). By identifying the interactions between actors and institutions, the SI approach uncovers the actors and mechanisms that lead to successful innovation that were left untouched by the market imperfections' approach, thereby offering a greater potential for identifying where public support should go (e.g. which actors to address), and is more helpful for policy makers from a practical and specific point of view (Edquist *et al.*, 1998). Considering farmer innovations as integral part of innovation system framework would offer a way to identify new rationales for research work and government intervention.

Innovation does not take place in isolation. Interaction among actors such as research, universities, firms, end-users and intermediaries is central to the process of innovation. Both cooperation and interactive learning are the central concept of interaction (Lundvall, 1992). But low interactive learning of actors and systemic imperfections may slow the innovation system as a whole. Various authors (e,g. Carlsson and Jacobsson, 1997; Smith, 1997; Johnson and Gregersen, 1994; Edquist *et al.*, 1998; Malerba, 2002) paid attention to these systemic imperfections, leading to the following list of system imperfections as external innovations are not implemented effectively and efficiently.

- Infrastructural failures (Smith, 1999; Edquist *et al.*, 1998) refer to problems in the physical infrastructure that actors need to function (such as IT, telecom, and roads) and the science and technology infrastructure.
- Transition failures (Smith, 1999) concern the inability of firms to adapt to new technological developments.

- Lock-in/path dependency failures (Smith, 1999) refer to the inability of complete (social) systems to adapt to new technological paradigms. NB: Edquist *et al.* (1998) address the same failure but do not distinguish so strictly between transition and lock-in failure.
- Hard institutional failure involves failures in the framework of regulation and the general legal system (Smith, 1999). These institutions are specifically created or designed (Edquist *et al.*, 1998) for which reason Johnson and Gregersen (1994) refer to them as formal institutions.
- Soft institutional failure concerns failures in the social institutions such as political culture and social values (Smith, 1999; Carlsson and Jacobsson, 1997). These institutions evolve spontaneously (Edquist *et al.*, 1998) for which reason Johnson and Gregersen (1994) refer to them as informal institutions.
- Strong network failures (Carlsson and Jacobsson, 1997) are the 'blindness' that evolves if actors have close links and as a result miss out on new outside developments.
- Weak network failures (Carlsson and Jacobsson, 1997) concern the lack of linkages between actors as a result of which insufficient use is made of complementarities, interactive learning, and creating new ideas. Malerba (2002) refers to the same phenomenon as dynamic complementarities failure.
- Capabilities failure: Smith (1999) and Malerba (2002) both refer to the phenomenon that firms, especially small firms, may lack the capabilities to learn rapidly and effectively and hence may be locked into existing technologies, thus being unable to jump to new technologies.

In addition to the above system imperfections, the top-down approach we often use does not exploit farmers' potential for providing practical guidelines for policy and decision makers. This study, therefore, aims at developing a clear-cut categorization of farmer innovations that can serve as a rationale for innovation policy design. Better policy framework can be formulated by discussing examples of the farmer innovations being practiced currently.

The objective of the study was to get a better understanding of farmers' innovations and practices, and the problems they are meant to tackle. Studying farmer innovations as a part of innovation system helps us narrow the gap between research, extension and farmers.

Research Methods

Description of the Study Districts

The survey was conducted in three districts (*viz.* Ada, Gimbichu and Moretna-Jirru) (Fig. 1) of Ethiopia during the 2010/2011 cropping season.

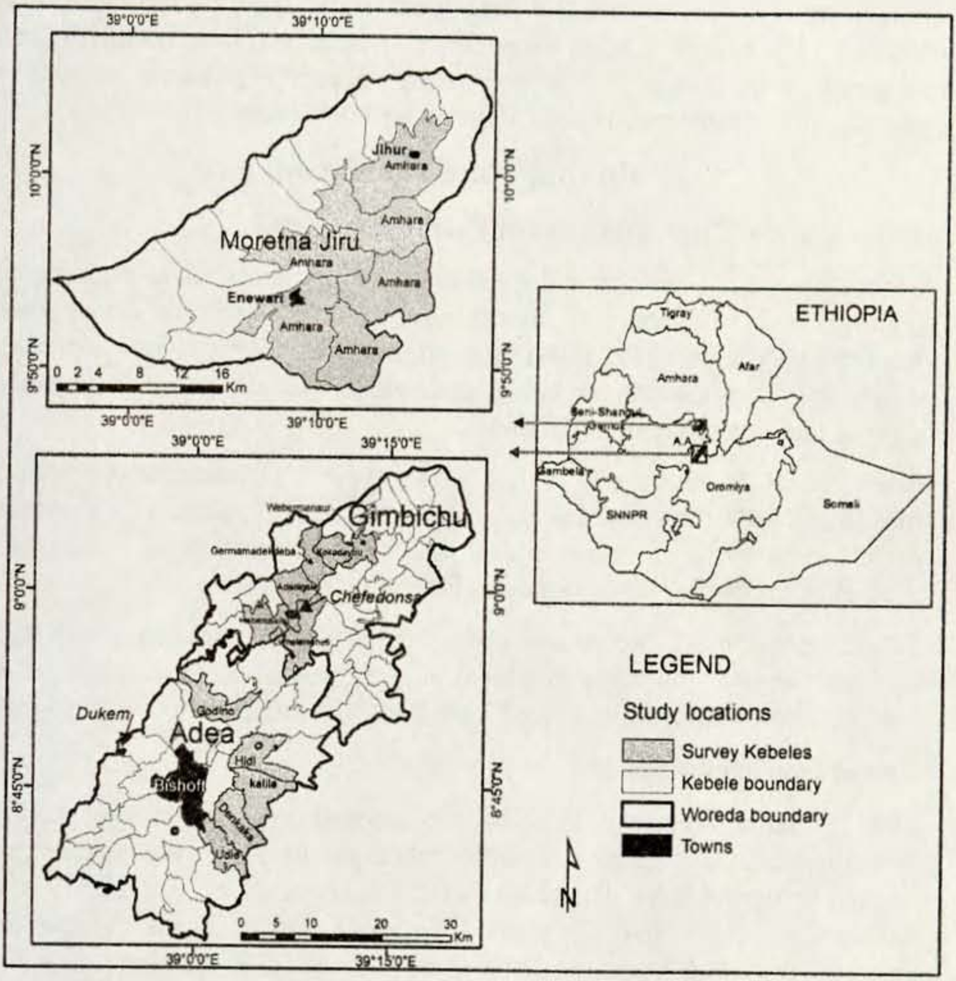
Survey Design and Sampling

In the first phase, farmers who were registered as innovators through the peasant associations were selected randomly from the three districts, and random samples of 190 farmer innovators were interviewed using semi-structured questionnaire.

In the second phase, group discussions were carried out with key actors (farmers, farmers' leaders, extension agents, and researchers) from each of the three districts. The group discussions made it possible to interpret the data and explore topics raised by farmers which had not been dealt with the individual interviews, because farmers complement each other during group discussion.

In the third phase, two stakeholders' workshops on farmers' innovations were carried out to make the main actors part of the study, to share the findings with farmers, extension agents, the district leaders, researchers and traders, and get their feedbacks.

Figure 1. Location map of the study districts



Source: Authors' construction, 2011

Data Analysis

Following data collection, the data were coded and entered into SPSS Version 11.5 computer software package for analysis. Data on the different variables were initially analyzed using descriptive statistics such as percentages, means, frequencies and standard deviations.

Findings and Discussion

Demographic Characteristics of Farm Households

Before discussing on the major findings of the study, it is necessary to highlight how innovation can successfully be adopted to rural development. According to Rogers (1995), an innovation is more likely to be adopted if it meets five characteristics: being observable, advantageous, compatible, simple, and reversible or verifiable.

Secondly, it is necessary to know the typical characteristics (pressing problems, gaps between the actual and the desired, access to resources, formal education, economic status and their connection to a variety of media) of the farmer innovators that innovate most readily.

Based on the basic theoretical and practical innovation associated issues outlined above, the demographical and physical characteristics of the sample farmer-innovators studied have been briefly presented as follows.

Age of Household Heads

This variable measures age of the household head in years. It is hypothesized that age of household heads can be positively or negatively related to innovations. The results of the study revealed that 20.5% of the farmers are older than 50 years. The mean age of heads for the three districts was 44.6 years, and the three districts did not show significant differences in mean age of the household heads and all other household age structure characteristics considered (Table 1). However, Ada and Gimbichu appeared to have slightly higher (7.8 and 8.2 persons, respectively) household size than Moretna-Jirru (7.0 persons).

Farming Experience

Farming experience of household heads could affect their confidence. With more farming experience, farmers can avert risks by adopting alternative solutions; hence, this variable can positively or negatively affect the adoption of innovations. As depicted in Table 1, the overall average number of years of farming experience for the three districts was 21.3 years, and there were no significant differences in years of farming experience among the three districts.

Family Size

Farm labour availability depends on household size. Large households may be able to provide the labour required for planting, weeding, harvesting and threshing, whereas small households may encounter shortage of labour during peak periods. Based on the study, household size differs in accordance with the farm sizes. The size of households of all farmer-innovators ranged between 2 and 20 persons. On average, 7.6 persons live permanently in a household (Table 1).

Table 1. Age structure and family size of farm households surveyed in the three districts, 2010/2011 cropping year

Description	Moretna-Jirru (n = 65)		Ada (n = 65)		Gimbichu (n =60)		Total (n =190)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age of household heads (years)	43.5	8.5	44.8	9.1	45.4	8.6	44.6	8.7
Farming experience (years)	19.1	9.3	21.1	10.3	23.8	9.6	21.3	9.8
Household size (persons)	7.0	2.1	8.2	2.9	7.8	3.0	7.6	2.7
Adults between 15-60 years	2.1	1.0	2.3	1.4	2.1	1.3	2.2	1.3
Children less than 15 years	3.1	1.3	3.1	1.4	3.3	1.5	3.2	1.4

Source: Survey data, 2010/11

Level of Education

This variable represents the level of formal schooling completed by the household heads. The level of education of the household heads is assumed to increase the farmers' ability to adopt innovation, and use information relevant to farm productivity and efficiency. Education is, therefore, expected to increase the adoption of innovation of the sample farmers.

Concerning the level of education, 8.4% of the sample farmers were illiterate and 91.6% were literate, and of the latter 24.2% can read and write and 29.5% and 34.2% reached junior and senior high school, respectively (Table 2).

Table 2. Education level of household heads in the study districts surveyed during the 2010/2011 cropping year

Education level	Moretna-Jirru		Ada		Gimbichu		Total	
	N	%	N	%	N	%	N	%
Illiterate	6	4.2	2	3.1	8	13.3	16	8.4
Read & write	14	21.5	17	26.2	15	25.0	46	24.2
Elementary (1-6)	13	20.0	22	33.8	21	35.0	56	29.5
Secondary (7-12)	28	43.1	23	35.4	14	23.3	65	34.2
Above 12	4	6.2	1	1.5	2	3.3	7	3.7
Total	65	100	65	100	60	100	190	100

Source: Survey data, 2010/11

Physical Characteristics of Farm Households

Landholding

This variable measures the area of land cultivated to crops by the respondents at the time of the survey. Increasing the production and productivity of crops depends on the land area allocated to each crop. Farmers in the study districts are expected to allocate land efficiently because the land is scarce and limited resource. Therefore, land size is hypothesized to positively or negatively influence innovation adoption by the sampled farmers.

Landholdings in the study districts are small, mainly due to high population density. The mean farm size per household is 3.74 hectares for the three districts, varying from 2.77 hectares for Moretna-Jirru to 4.88 hectares for Gimbichu, while the mean land holding for Ada is intermediate (3.66

hectares) between the two. Farmers allocate very limited area for grazing and fallowing; the mean area of grazing land was 0.42 hectares, while fallowing in recent years has become virtually non-existent due to land scarcity.

Basically, farmers grow multiple crops to satisfy family food and cash requirements. Cereals, particularly wheat and *teff*, predominate in the three districts, mainly due to the high proportion of favourable highland environments for the production of these crops. Chickpea, lentil and grass pea production follow wheat and *teff* in terms of importance (Table 3). Other crops such as faba bean, maize, field pea, linseed and fenugreek are cultivated to a lesser extent. Generally, the legumes are grown in rotation, two-three year rotation, with the cereals.

The survey revealed that there are variations in the distribution of crops across the districts. Wheat is the dominant crop, extensively grown in Moretna-Jirru (1.09 ha) and Gimbichu (1.70 ha) districts, whereas *teff* dominates in Ada (2.08 ha) district. Except for Ada district, farmers also reported that wheat is the most important crop for satisfying both the cash and food needs of the family. This fact is also apparent from the large proportion of the cropped land area allocated to wheat.

Table 3. Average household landholding in the three study districts surveyed during the 2010/2011 cropping year

Description	Moretna-Jirru		Ada		Gimbicuh		Total	
	N	Mean	N	Mean	N	Mean	N	Mean
Farm size, ha	65	2.77	65	3.66	60	4.88	190	3.74
Cultivated area, ha	65	2.68	65	3.59	60	4.33	190	3.51
Wheat area, ha	63	1.09	62	0.84	60	1.70	185	1.20
*Teff** area, ha	65	0.75	65	2.08	60	0.81	190	1.22
Chickpea area, ha	16	0.32	29	0.82	57	0.73	102	0.69
Lentil area, ha	58	0.63	28	0.38	54	0.86	140	0.67
Other crops area, ha	36	0.42	35	0.35	51	0.42	122	0.40
Grazing land area, ha	33	0.18	20	0.23	40	0.64	93	0.42

Note : * Small-seeded grain indigenous to Ethiopia
Source: Survey data, 2010/11

To alleviate land shortage, farmers rented-in land for crop production through a contractual arrangement for 2-3 years, and the rent rate depends on the soil fertility. Share-cropping arrangements are also common in the study districts.

After making rigorous focus group discussions, the major crops grown in the three districts were identified and ranked based on weighted consideration of area coverage, total production, productivity, and economic importance including contribution to household food security. This was also cross-validated by taking the actual area, production and productivity statistics of the crops from the bureaus of agriculture of the respective districts. Accordingly, the major crops were listed in order of their importance as given in Table 4.

Table 4. Dominant crops grown in the districts as ranked by farmers during focal group discussions

Rank	Moretna-Jirru	Ada	Gimbichu
1	Wheat	*Teff*	Wheat
2	*Teff*	Wheat	*Teff*
3	Lentil	Chick pea	Lentil
4	Chickpea	Lentil	Chick pea
5	Grass pea	Field pea	Grass pea

Source: Survey data, 2010/11

For the production of these crops, farmers use both local and introduced innovations. There are limited introduced technologies that *inter-alia* include varieties, crop management technologies like fertilizers and disease management methods. Deterioration of the performance of improved varieties was mentioned to be a pressing challenge. The supplies of improved seeds for all crops are inadequate and the seeds are not true-to-type. They all consist of mixtures and are contaminated by weed and other crop seeds and particles. Farmers suggested that this is the area where the research centers and seed enterprises should take the utmost care to supply pure seed to the farmers. Farmers also suggested that an improved variety should be renewed or replaced by a new one after using for 4-5 cycles.

Changes in Farm Size

The high level of population pressure in the study districts has resulted in periodic changes in farm size. During the last three years, on average, 4,450 new households per year were formed in all the three study districts. Thus, periodic adjustments of landholdings were made by the peasant associations (PAs) in response to demand for land by the newly formed families.

In the past, there were many options for providing land to newly formed families. One option was to supply them from the communal grazing land or reserved land. Another option was to bring new land into cultivation. A third one was to take part of an existing farmer's land, and reallocate it to new farmers. All these options were used in land redistribution, but the first and the second options have now become exhausted, and at the present the only possible option available is the third one.

Regarding farmland size changes, over the last three years (2008-2010), nearly 23.7% and 12.6% of the farmers reported that their farm size had increased (gained some land) and decreased (lost some land), respectively, while 63.7% of the respondents indicated no changes in their farmland sizes (Table 5).

Table 5. The status of farmland size of households for the last three years (2008-2010) in the three study districts

Types of change	Moretna-Jirru		Ada		Gimbichu		Total	
	N	%	N	%	N	%	N	%
Increased	16	24.6	22	33.8	7	11.7	45	23.7
Decreased	4	6.2	10	15.4	10	16.7	24	12.6
No change	45	69.2	33	50.8	43	71.7	121	63.7
Total	65	100	65	100	60	100	190	100

Source: Survey data, 2010/11

Soil Types of the Farmlands Owned by Households

The soil type strongly influences the production decisions of a farm household. It is an important technical factor for determining the crop species or variety the farmer plants. To provide an overview of the different soils in the study districts, farmers were asked to give their views on the types of soils on their farms.

Traditionally, farmers in the study area classify the soil into three main groups (Table 6). The dominant soil type is the heavy black clay soil, locally called *Merere* soil *(Vertisols)*, followed by light black clay soil known as *Bushola,* and *Areda* soil. As perceived by farmers, the *Merere* soil type is the most productive type on which all crops can be grown. During the 2010/11 cropping season, the majority (80%) of the farmers produced cereals on the *Merere* soil. Most farmers in the study districts have a field of *Merere* soil (Table 6).

Table 6. Soil types and their characteristics as perceived by selected farmers in the three districts, 2010/2011 cropping year

No	Soil type	Characteristics
1	*Merere*	Heavy black soil Grows all types of crops, but preferred for cereal crops Most productive except for the water-logging problem
2	*Bushola*	Light soil Grows all types of crops except chickpea and lentil Slight water-logging problem
3	*Areda*	Found around homestead area Grows all types of crops except wheat and *teff* Weed problem

Source: Survey data, 2010/11

Livestock production

Many of the farmers have small numbers of animals such as oxen, donkeys and cows. Most farmers keep poultry, usually ranging birds, and only feeding on insects/worms or waste grains (wheat) from fluff processing (wheat chaffs) or harvesting and threshing. Some farms keep a few sheep, which are tethered (tended in principle by children) on crop residues and small grazing land. Farmers keep sheep mostly for sale and home consumption during holidays and other ceremonies. During the focus group discussions, farmers underlined that traditionally livestock production constitutes an important source of household income in their districts. Furthermore, domestic consumption and special celebrations are other reasons for keeping small animals.

Crop residues resulting from the cultivation of cereals and pulses are important feed sources. Farmers indicated that crop residues account for up to 90% of the livestock feed since they constitute most of the feed supply during the long dry season. The availability of feed in terms of both quality and quantity is the big challenge that farmers face in raising animals.

The contribution of cereal crop residue as livestock feed is very high compared to the pulse residues because farmers allocate a limited area to pulse crops. But, pulse residues have high crude protein content, improving the nutritional quality of the overall residues including that of the cereals as feed. Sale of crop residues in the area is also common. In addition, farmers who do not have livestock give crop residues to other farmers free of charge so that they can borrow oxen for ploughing.

The other problems farmers mentioned in livestock production are lack of improved breeds and forage supplies, and prevalence of diseases.

Many farmers can no longer afford to keep cows as they are forced to feed their entire animals with fodder at homesteads rather than letting them graze as before. Only 25% of the households keep one cow per family. Farmers believed that stabled livestock rearing involves improved cows which cost more to buy and need comfortable stalls, healthcare and controlled provision of the required dietary feeds. Fodder production for livestock on the scarce land may compromise production of food grains for humans.

The Major Problems Triggering Innovations

Both scientific knowledge and technical innovation have played a pivotal role in setting off what is often called the "great transformation." The single most important reason why prosperity spread and it continues to spread is the transmission of technologies and the ideas underlying them. Even more important than having specific resources in the ground, such as coal, was the ability to use modern, science-based ideas to organized production (Sachs, 2005).

The question what triggers farmers to innovation was included in the questionnaire, survey and it was also discussed upon with the farmers during the focus group discussions. Farmers reported that needs/necessities are the prime reason to innovate: these may be natural and/or man-made problems. The major reasons that farmers thought are those that make them innovate and/or adopt innovations have been summarized in Table 7. As per the farmers' opinions, the major factors that trigger them to innovate and/or use new innovations were in diminishing order water-logging problem (98%), scarcity of cultivated land (97%), escalation of input prices (83%), and decline in land productivity (76%).

Table 7. Major problems triggering farmer innovations as ranked by farmers themselves

Description	Moretna-Jirru		Ada		Gimbichu		Total	
	N	%	N	%	N	%	N	%
Water-logging problem	65	100	61	93.8	60	100	186	97.9
Scarcity of cultivated land	61	93.8	64	98.5	59	96.3	184	96.8
Escalation of input prices	49	75.4	52	80.0	56	93.3	157	82.6
Land productivity decline	47	72.3	49	75.4	49	81.7	145	76.3
Family size increase	32	49.2	58	89.2	42	70.0	132	66.5
Desire for more income	51	78.5	37	56.9	36	60.0	124	65.3
Erosion problem	42	64.6	31	47.7	44	73.3	117	61.6
Needs for technologies	32	49.2	52	80.0	32	53.3	116	61.1
Feed scarcity	32	49.2	36	55.4	40	66.7	108	56.8
Total	65	100	65	100	60	100	190	100

Source: Survey data, 2010/11

Farmers' Decision to Adopt Innovations

Research based development will bring food security only if it is farmers-centered, environmentally sound and participatory, and builds local and national capacity for self-reliance. These are the basic characteristics of sustainable development.

Farmers-centered agricultural development is a development that puts farmers and poor rural people first, that equitably distributes the benefits of growth, and that attacks poverty with opportunities and education. At every turn, the lesson keeps hitting us in the face that involving rural people actively in the defining, designing and decision-making stages of agricultural development is not optional, but essential. We see this missing requirement in many of the rural development approaches that failed because they adopted traditional top-down approaches, and they have grossly been based on narrow technical specializations.

Agricultural development does not merely come from introducing better crop varieties, new cattle breeds, more credit or rural cooperatives, as important as these may be. Rather, it is achieved by farmers working in every specific farm-household system. It must be based on the tasks, needs and aspirations of the farmers themselves, and on the dynamics and constraints they face not only in their farming but also in their domestic and non-farm activities. It must take account of their whole rural life situation, including real-world factors beyond the control of the household – the ecology and natural resources of the districts, the social-cultural environment in the community, and the policies, prices, services and infrastructure that affect rural prospects.

Whatever innovations are brought into consideration, how acceptable and sustainable they are will depend on farmers' perceptions and capacity. The crucial questions, as seen by farmers, are whether the innovations are or can be accessible and affordable, economically viable and technically simple, and adaptable to local conditions and culture. Everything else, including the responses of policy-makers and cooperating organizations, should follow from the answers to these questions.

Innovations are those that change the way smallholder and other rural people produce, invest and market their products; manage their assets; get organized, communicate and interact with their partners; and influence policy and institutions (IFAD, 2008). Literature offers a variety of definitions for innovation. This suggested that there is no perfect one definition. Thus, each organization needs a definition that has the greatest operational value from its own perspective. What remains appropriate is that innovation is essentially a means to achieve one's goals better. A technology, a product, an idea or an approach is not necessarily an innovation. That is the definition the researchers, development agents and farmers are often confused with.

With this reality on the ground, we asked farmers how they evaluate innovations coming either from the research or from the local innovations.

As depicted in Table 8, the most important parameters farmers use to accept innovations were economic advantage (97.9%), technical feasibility (87.9%), environmental validity (84.7%), capacity to absorb (81.6%) and social acceptance (58.4%). Farmers protect things that are useful for their survival (land and water), but they do not care much for environmental change. Farmers usually respect the environmental protection policies proposed to them, or imposed on them, if there are economic incentives that encourage them to protect the environmental factors.

Table 8. Farmers' main evaluation criteria to accept or reject innovation as ranked by farmers surveyed in the three districts

Description	Moretna-Jirru		Ada		Gimbicu		Total	
	N	%	N	%	N	%	N	%
Economic advantage	65	100	61	93.8	60	100	186	97.9
Technical feasibility	63	96.9	52	80.0	52	86.7	167	87.9
Environmental validity	55	84.6	47	72.3	59	98.3	161	84.7
Capacity to absorb	45	69.2	64	98.5	46	76.7	155	81.6
Social acceptance	42	64.6	39	60.0	30	50.0	111	58.4
Total	65	100	65	100	60	100	190	100

Source: Survey data, 2010/11

Limitations of Farmers' Innovations

The farmers' innovations in soil management and conservation in Moretna-Jirru district have still remained marvelous despite the fact that the experts claimed that the Ethiopian peasantry is strongly attached to its traditional ways even when these are shown to be less efficient and less productive. It is known that traditional farming methods have become increasingly inadequate to provide food security to the growing rural population. Sometimes, change is intensely or violently resisted and even considered immoral. It is, therefore, essential to obtain reliable data to briefly look at the conditions of peasant agriculture, its inherent dynamics and the potential it does or does not offer. In fact, this study made an attempt to explore some of the major limitations in transferring farmer innovations to wider areas of the country. Some of the limitations, as ranked by farmers, are listed in Table 9.

Table 9. Major limitations/constraints to transfer farmer innovations to wider areas of the country

Limitations of farmer innovations	Moretna-Jirru		Ada		Gimbichu		Total	
	N	%	N	%	N	%	N	%
Not evenly spread	55	84.6	48	73.8	54	90.0	157	82.6
Slow and not easy to spread	39	60.0	58	89.2	55	91.7	152	80.0
Researchers not fully integrated	40	61.5	55	84.6	56	93.3	151	79.5
Lack of institutionalization	45	69.2	54	83.1	51	85.0	150	78.9
Farmers don't want to share	48	73.9	32	49.2	44	73.3	124	65.3
Needs refinement	25	38.5	50	76.9	38	63.3	113	59.5
Not always attractive to others	22	33.9	34	52.3	32	53.3	88	46.3

Source: Survey data, 2010/11

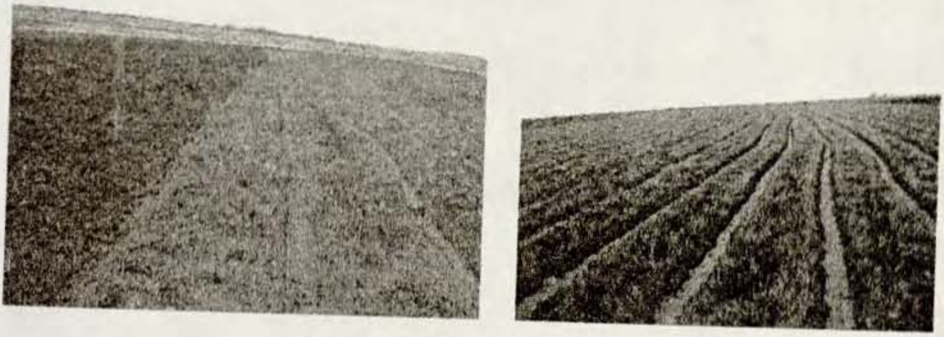
Conspicuous Farmer Innovations Maintained for Generations

Broadbed and Furrow and Open Ridge and Furrow

For the last several thousand years, farmers in Ethiopia produced most of their food by using their own knowledge and innovations. The most common farmers' innovations maintained for generations are the *Broadbed and Furrow* (Fig. 2) and *Open Ridge and Furrow* (Fig. 3) used in the three study districts. For years, farmers have been able to drain excess water from the Vertisols (black heavy clay soil) to increase yield per unit area.

The farmers were asked if they could replace the "Broadbed and Furrow" or "Open Ridge and Furrow" technology with new ones. After a few minutes of thinking, the farmers said that several studies have been carried out by researchers, but the results found were inconsistent and impractical to replace the traditional practices in the study districts due to the squelchy thick mud that hindered any earth moving during the raining seasons. "Open ridge and furrow" known as "*Shurbie*" is named after the traditional braided hair of rural women in the locality because of its similarity in form. The technique has improved household food security (higher land productivity) and has mitigated agricultural risk for many impoverished families in Ethiopia.

Fig. 2. Wheat grown on "Broad Bed and Furrow" at Moretna-Jirru district freshly made (a) and after 12 days of growth (b)



(a) (b)

Source: Authors' construction, 2010/11

Fig. 3. Open Ridge and Furrow (Shurbie) at Gimbichu district, freshly made (a) and lentil grown after 15 days (b)

(a) (b)

Source: Authors' construction, 2010/11

Broad Bed and Furrow, and Open Ridge ad Furrow have been practiced for generations, and they still have good farming potential today to drain excess water and maintain soil fertility. There is considerable evidence that research plot design known as broadbed and furrow (BBF) and made by a special oxen-drawn broad bed maker (BBM) is taken from farmers' knowledge of soil management, despite the fact that the peasantry, it is claimed, is strongly attached to its traditional practices (Fig. 4).

Fig. 4. Broad Bed and Furrow being practiced at Gimbichu Agricultural Research Station (a) wheat experiment at early stage, and (b) at harvesting stage, (c) chickpea at grain filing stage (d) lentil at maturing stage

(a) (b)

(c)

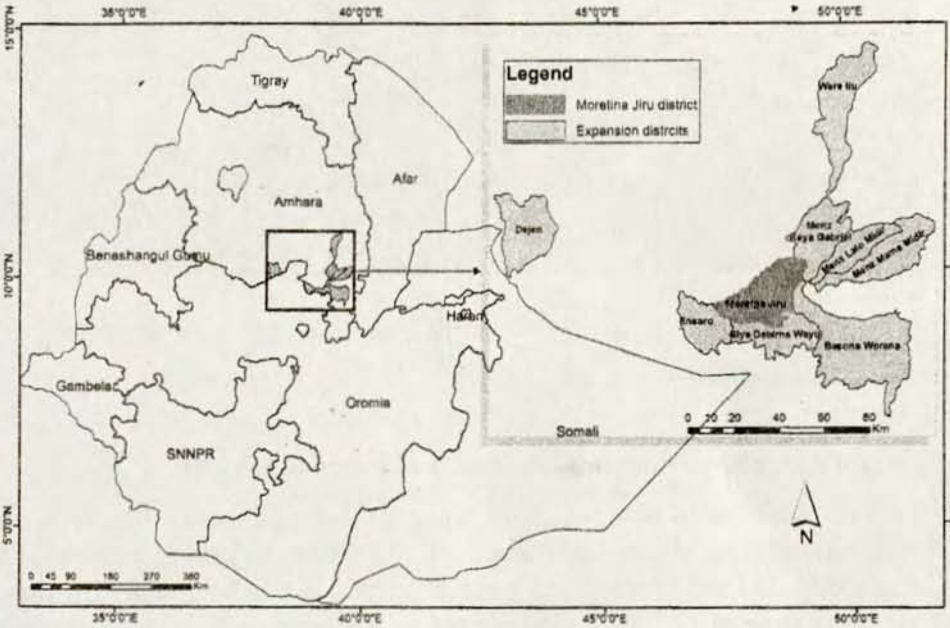
(d)

Source: Authors' construction, 2010/11

Origin and Expansion of Broadbed and Furrow System

Farmers were asked how long the local broadbed and furrow has been used, where it originated and the extent of expansion to other districts. They responded that the method has been practiced in the Moretna-Jirru district for many generations. It is now expanding to Dejen (with Broadbed making tool, BBM), Siyadebre, Ensaro, Menz, Basona and Wore Illu districts (Fig. 5).

Fig. 5. Origin and expansion of Broadbed and Furrow from Moretna-Jirru to other districts



Source: Authors' construction, 2011

Environmentally Safe Practices to Control Multiplication of Rats

Most of the farmers in Ethiopia regarded rodents as the number one pests because they cause considerable economic losses in staple crops, particularly cereals, pulses, and oil and tuber crops. As per the farmers reports, field damage and losses in maize damage were estimated at about 26 percent. In years with serious rodent outbreaks, the losses can be as high as 40 percent in some regions. In spite of the damage, farmers in many parts of Ethiopia are not yet using rodenticides to control rats because of fear of harmful effects on domestic and pet animals such as poultry, cats and dogs. Instead of using rodenticides, farmers use various techniques to control damage on crops caused by rats.

Ecology Based Rat Control

Farmers in Ethiopia consider rats as significant agricultural pests because they are responsible for damaging field and stored crops, damaging irrigation hoses and plastic jars, spreading diseases to people and livestock. As a result, farmers use ecologically-based rat control and specific techniques to minimize damage on crops caused by rats:

1) Rearing specific cats*:* The community usually rears specific types of cats to control rats. These specific cats blind the rats especially when the rats outnumbered the cats. Blinding the rats exposed them to different birds feed on rats. Farmers have been using this specific cat breeding for hundreds of years and have safe ingenious ways of controlling damage on field and stored crops caused by rats. One farmer says that the price of such specific cat increased from 10 to 80 Birr.

2) Identifying breeding time and place: The farming community knows that rat breeding time is always linked to food supply. Rat breeding reaches peak when plants start developing seed following the booting stage. Ecology-based rat control should be launched before and at this critical time. Farmers asserted that weeding the crops makes it difficult for rats to build nests, and cleaning up crop boarders and practicing good farm hygiene check rat breeding. Farmers explained further that non-weeded crops are prone to attack by rodents. Many farmers (82%) believe that rat breeding seasons are proportional to the number of crop harvests. For instance, if there is area with two crop harvests, there will be two rat breeding seasons. Farmers suggested that cropping vacuum (gap) is effective timing of rat control if the main cropping season is not followed by irrigation. But, so far, no relevant research has been initiated in Ethiopia to prove farmers' idea.

3) Planting rat-preferred crops/plants on the boarders: Farmers know that rats seem to have preference for certain crops, which differ in the hardness of the kernel. They usually plant rat-preferred crops on the boarder of the main crop. This system works well as a bait to catch rats by traps before they invade the main crops. Farmers are inclined to planting more of fenugreek, lentils and chickpeas on the boarder of the main crop. These crops were considered by 77% of the farmers to be the most susceptible crops to rats.

4) Leaving clean boarder space between farms and grain stores: Cleaning boarder spaces between farms and grain stores is considered to be good for preventing rats. Farmers keep the boarder space between farms and grain stores free of grass and stack stones to avoid damage by rodents. Keeping boarder space between farms and grain stores clean obstructs the movements of rats and exposes them to natural enemies. Farmers who can produce larger quantities of sorghum in a good year tend to store it for longer periods in underground pits. Farmers who prefer pits, do so mainly out of fear of rodents and theft. Fear of rodent and theft is augmented when rodent outbreak occurs and food becomes scarce. Farmers also keep grain in closed underground pits not to let others know how much they stored and not to let their wives sell the grain to buy salt and oil (which should be paid from cash income), and thereby in order to keep the cereal grains as long as possible.

5) Community action: Many of the farmers (90%) stated that rat can be controlled using the indigenous knowledge but community action should be coordinated. If community action is implemented successfully, it can reduce the great loss caused by rats.

Overall, considering farmer innovation could, therefore, be a powerful tool to fuel economic growth in agriculture. Research undertaking to study the actual methods, observations and measurements farmers use is knowledge production for the science and technology community. Researchers and policy makers would do well to bear such evidence in mind in the development of research-related policies. Without considering farmer innovation, national research alone does not affect economic development. By working together, we certainly obtain a lot to gain.

Conclusions and Recommendations

Conclusions

The most conspicuous farmers' innovations identified in this study are "Broadbed and Furrow" (BBF) and "Open Ridge Furrow" (ORF) to drain excess water from the farmlands, and environmentally safe practices to control rats. Over 95% of interviewees stated that BBF and ORF are important farmer innovations for crop production on Vertisols, which constitute the pre-dominant soil formation in the three districts.

Most of the farmers in Ethiopia regarded rodents as the number one pest because they cause considerable economic losses in major staple crops, particularly cereals, pulses, and oil and tuber crops. Thus, they use environmentally safe practices to control multiplication of rodents such as rats.

The major farmer innovations to control multiplication of rats are ecology-based rat control, rearing specific cats, identifying breeding time and place, leaving clean boarder space between farms and grain stores, and community action.

The production principles that farmers considered for accepting technology and innovation are economic advantage (97.9%), technical feasibility (87.9%), environmental validity (84.7%), capacity to absorb innovation (81.6%), and social acceptance (58.4%).

As per the farmers' opinions, the major factors that trigger farmers to innovate and/or use new innovations were water-logging problem (98%), scarcity of cultivable land (96%), escalation of input prices (83%) and decline in land productivity (76%).

The farmers who participated in the focus group discussions claimed that farm tools and land management systems have remained largely unchanged all through generations, except introducing high yielding varieties and fertilizers. Likewise, they claimed that post-harvesting problem and the livestock sector has remained grossly untouched by research.

Recommendations

In general, the following recommendations have been made based on the findings of the study:

- Integrating farmer innovations with research findings should remain fully intact for technological diversity and for winning farmers' trust and cooperation.
- An innovation is a collaborative and an interactive process that requires researchers and extension agents to work with farmer innovators for strengthening local innovation capacities.
- Considering farmer innovations, particularly those in soil conservation and in controlling water-logging and rats, could, therefore, be a powerful synergy to modern research to enhance economic growth in agriculture.
- Studying indigenous knowledge makes innovation repeatable, sustainable and profitable, and bridge the glaring gap between farmers, extension and research.
- Studies on indigenous knowledge and farmer innovations enhanced farmers' empowerment. This is one alternative way of marrying research and extension with farmers.
- Experience and knowledge sharing among farmers across various districts, as demonstrated among the three study districts, could speed up innovation transmission.
- The innovation system of a specific commodity such as wheat, *teff*, chickpea, lentil, and the likes has to be studied on wider areas of coverage. The results obtained from this study might be applicable to other areas in Ethiopia with similar socio-economic and agro-ecological conditions.

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