

Diversifying cropping systems in the mountainous landscape of Galessa, Ethiopia

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Abstract

Crop production is the mainstay of rural Ethiopians, including the mountainous landscape of Galessa. Its outputs have been very low, due to various biophysical and socio-economic setbacks with limited diversity of crops and cropping systems. Factors like low soil fertility, frost and other climatic hazards constrain the productivity of few traditional crops, such as barley and potato. In such mountainous and degraded areas, the systems of crop production are complex and more prone to risk. Consequently, some efforts are underway to improve the incomes and livelihoods of smallholder farmers through the diversification of crops that are suitable for effective integration of soil, nutrients, feeds and livestock management system, with better marketing opportunities. Diverse crops (potato, barley, linseed, triticale, legumes and forage crops) can thus bring various benefits to Galessa farmers in view of the integrated management of watersheds and landscape niches to meet multiple needs of the stakeholders. By doing so, more uptakes of improved technologies, increased productivity, incomes and livelihoods of small-scale farmers can be expected. Approaches would be possible for scaling out and up of outputs, and thus empowering smallholders for meaningful impacts from research and development efforts on the integrated management of crops, soil nutrients and livestock system. To this effect, the research for development efforts and/or approaches needs to focus on strong scientific and action-oriented activities. In this paper, attempts are made to discuss these and other related issues, which are required to support the livelihoods of farmers living under such difficult environments in a sustainable manner.

1. Introduction

Mountainous landscape is prevalent in the Galessa area of the central highlands of Ethiopia, exposing the topsoils to heavy erosions that deplete soil fertility from time to time. The cropping pattern and system of Galessa has mainly included barley/fallow/few crops and their interaction with farm resources, enterprises and the available technology that determine the feature of the area. Under such conditions, crop production conditions are often complex and prone to risk. Factors like low soil fertility, frost and other climatic hazards reduce the productivity of few traditional crops, such as barley and potato. Moreover, the availability and/or access to agricultural inputs (capital, land, labor, fertiliser, water, etc.) are generally limited, more expensive and more variable due to rough road systems and remote markets, since farmers live on cold and rugged mountains with limited access to agricultural inputs.

Crop production has been the mainstay of the Galessa watershed site. The same has been true for the remaining rural population of Ethiopia (Adugna *et al.* 2004). Nevertheless, the sector's output has been very low, due to the biophysical and socio-economic challenges, inadequate interventions, limited use of crop diversity and their poor production practices. Owing to this situation, the shortage of food at Galessa is high from April to November, with reduced shortages from December to March (Kindu *et al.* 1997). During these periods, farmers depend only on few crops like potato and enset (*Ensete ventricosum*) to overcome this problem. Food shortages are attributed mainly to limited crop diversity. Earlier surveys have indicated that the major problems of the Galessa area are: poor diversification of crops, deforestation, soil erosion, depletion of soil fertility, feed and food shortages, water shortage, high human population growth and low price of farm produce, which actually require integrated solutions (Kindu *et al.* 2002).

The major considerations are therefore what options and opportunities of crop diversity are adaptable or available to this area and how these are best exploited to increase the income and the livelihood of Galessa farmers. In other words, the ultimate goals are to improve livelihoods of smallholder farmers by availing a diversity of improved varieties of crops and their production practices. Options of crop diversity are required for an effective integration of soils, nutrients, feed and livestock management with better market opportunities. By doing so, better income generation, poverty alleviation and food security could prevail and subsequently farmers would be capacitated and motivated to invest in the integrated management of the natural resources.

This discussion paper tries to emphasise the strategies of poverty reduction and agricultural development in the central highlands of Ethiopia by improving the productivity and sustainability of crops through diversification and natural resource management as key elements in the drive to meet the different needs of farmers. Attempts will be made to analyse the possibility of diversification and enterprise-development of smallholders, while maintaining the natural resource base. When these are considered in an integrated approach, we believe that they can offer better and viable opportunities for poverty reduction and natural resource conservation in a sustainable manner.

2. Methodology

The methodology combines the analyses of both primary and secondary data, with activities based on strong scientific designs and action-oriented applied research. Its innovative component was the inclusion of participatory on-farm research that has provided results of immediate use to the participating farmers and farmers' support groups (i.e. research and development organisations). A representative number of field trials were conducted in Galessa watersheds. For example, for linseed

informal seed multiplication 33 and 100 representative and willing farmers were selected in 2005 and 2006, respectively. Poor farmers who are largely dependent on food and feed crops, as well as their products were involved in these studies. Improved varieties and practices of potato, barley, linseed, triticale, faba bean, field pea, vetch and oats, which were developed at Holetta Research Center, were jointly tested by researchers and farmers on the farmers' fields in accordance with the needs and interests of the latter. In general, the activities have involved the following three steps:

a) Joint reviews and planning: assessment of past and current works in the Galessa area, refining well-adapted crops and their practices, consultation of relevant stakeholders (donors, researchers, development workers, non-government organisations and farmers). By doing so, the exchange of knowledge and experience is facilitated for a better planning and implementation of the study. Training and experience sharing was also undertaken whenever necessary.

b) Participatory implementation and evaluation: scientific and participatory on-farm investigations of different crops and their best practices were studied in a participatory manner. Views and evaluations by farmers were included in all investigations. The stakeholders also jointly conducted the monitoring and evaluation.

c) Synthesising and scaling out/up of promising results: compiling and spreading the best-adapted varieties and their practices of crops was carried out together with the users. Actually, these have currently been in progress for potato, barley, linseed and forage crops.

Generally, the activities were focused on analyses of the biophysical and socio-economic conditions in relation to crop diversity and the cropping systems

of cereals (barley, triticale), legumes (faba bean, field pea), oilseed (linseed), forage crops (oats, vetches), tubers and vegetables (potato, garlic). Efforts were made to use past experience (research, development works and indigenous knowledge from across the area and elsewhere) to establish viable options. Group discussions and stakeholder consultations were used to assess the most feasible options. An intensive review and a joint analysis were also applied in the selection of diverse crops and their varieties with respect to economic, social and ecosystem opportunities, specifically with soil and plant nutrition management strategies. Data on crops management practices and their growth conditions were collected in accordance with the initiators' initial plans. After that, evaluations were carried out to identify communication and knowledge sharing approaches that are appropriate for increasing the uptake of results or for scaling out/up activities.

3. Results and discussion

3.1 Diversity in traditional cropping systems

Whether it is within one crop or among many crops, diversity has been very important (Tables 1, 2, 3) for farmers to cope with both internal and external factors like climate, soil conditions, pests, market, etc., which are often difficult to control, and to deal with the limited use of capital and labor resources (Adugna *et al.* 2004). The traditional agriculture systems, such as the ones in Galessa, involved a high degree of crop diversification by taking advantage of local resources and thus have been moderately productive, stable and sustainable (Altieri 1987, Adugna 2002). The components of such agro-biodiversity have long been known to offer an array of benefits to agriculture and the ecosystem by reducing risks and contributing to resilience, food security and income generation (Beets 1982, Altieri 1987). These benefits were well recognised

by traditional farmers in Galessa (Adugna *et al.* 2004) and elsewhere in Ethiopia (Tilahun 1995, Adugna 2002).

According to earlier surveys, barley was the most prominent crop in the Galessa area, followed by potato and enset (Kindu *et al.* 2002). The major cropping system was barley, followed by fallow. Barley yields are reported to have declined over the past 25 years. Farmers associated these yield reductions to the lack of high yielding varieties, moisture shortage, reduced soil fertility, increased soil erosion, imbalance in amount and distribution of rainfall, severe frost and desiccating dry winds during the grain filling periods of the crop. They also indicated monocropping of barley as one of the causes for yield reductions.

Table 4 shows better yield advantage of the barley-fallow cropping system as opposed to the continuous or monocropping system. However, monocropping of barley was reportedly due to the unavailability of adaptable and diversified crops in the Galessa area. Farmers were unable to keep their land fallow, since the size of their landholding dwindled as a result of population growth. Hence, barley monocropping has been predominant in Galessa. In spite of this there has been tremendous variability within the local cultivars that could enrich future genetic resources, given that proper collections and preservations were accomplished. For example, Galessa farmers identified four barley cultivars locally known as *balami*, *guracha*, *adi* and *shamareta* in the Galessa area, *balami* (two-rowed) being the most dominant one (Kindu *et al.* 1997, Adugna *et al.* 2004). *Guracha* is black-seeded, while *adi* is white-seeded. *Shamareta* is often an early maturing type.

Moreover, Galessa farmers select specific cultivars depending on their purposes, locations of adaptability and suitability of soil types for planting. For example, black- and white-seeded barley cultivars are grown on fertile and deep soils, while

balami grows on all types of soils and frost prone areas. *Balami* is preferred for *injera* (local bread) making, while black-seeded varieties are used for preparing *tela* and *arekie* (local beverages). White-seeded cultivars are preferred for the preparation of various local foodstuffs. Galessa farmers usually use qualitative characteristics related to morphological appearance, seed colour and maturity periods to distinguish one cultivar from the other. These experiences show that farmers' indigenous knowledge on the diversity of crops and their uses is valuable for germplasm collection and conservation. Solomon and Lemlem (1999) also indicated that germplasm collection can be more fruitful when a team of breeders, a population geneticist, a taxonomist and farmers is involved.

3.2. Alternative crops for diversification

In order to overcome low productivity and limited diversity of crops in Galessa, efforts have been underway by researchers from Holetta Research Center and other development agents. For instance, five released varieties of potatoes were evaluated on four farmers' fields, of which three varieties performed better, with yield ranges of 8-31 t/ha (Table 3). Informal potato seed production was also multiplied on farmers' fields and it was possible to produce a good quality potato seed, with yield ranges of 20-41 t/ha (Kindu *et al.* 2002). Likewise, 50 forage species (oats, medics, clovers, vetches) were evaluated for three seasons and it was possible to identify better performing ones. Oats and hairy vetch produced 17 and 7 t/ha dry biomass, respectively. Medics (*Medicago*) varieties and *Trifolium* species produced an average biomass of 2 t/ha (Kindu *et al.* 2002, Adugna *et al.* 2004). Similarly, five improved barley varieties were evaluated on different farmers' fields for two years. Three varieties were promising for further dissemination. Moreover, 33 farmers have evaluated a linseed variety known as Berene in 2005. 29 of them had good

yield and satisfactory seed filling quality (Figure 1 and 2). The farmers preferred the new variety to the local variety for its superior vegetative growth, better yield components, seed yield and seed quality. Thus, several farmers have been planning to expand their linseed farms and consequently demanded more seeds for the 2006 growing season. Accordingly, over one hundred farmers were involved in the scaling out of linseed, informal seed multiplication and variety adaptation tests (five varieties) in 2006. More than double of this figure is expected in 2007. In general farmers show great interest in different varieties of potato, barley, linseed, and forage crops for better diversifications and thus for greater economical benefits.

Diverse crops (Table 3) such as improved potato, barley, linseed, triticale, legumes and forage crops are believed to bring diverse benefits to Galessa farmers. They fit into the existing landscape or environmental niches, and also satisfy multiple needs of the local people. In fact, farmers and agricultural scientists have known for years that crop diversity via rotations can break insect and disease cycles, reduce weeds, curb erosion, supplement soil nutrients, improve soil structure and conserve soil moisture (Altieri 1987, Adugna 2002). Ecosystems with greater diversity are usually more stable and resilient. The more diverse the organisms that inhabit a farming system, the more diverse the populations of pest-fighting beneficial organisms a farm can support (Altieri 1987). For example, healthy soils enriched and revitalised by rotation and cover crops of leguminous nature can promote root development and better water infiltration, and thus contribute a lot to optimise the benefits from watershed ecosystems. The rationale behind crop diversification is the availability of a 'basket' of alternatives and opportunities (Tables 1, 2 and 3) to smallholders like the ones from Galessa. This refers to income generation, poverty alleviation and food security, and will enable farmers

to invest in the integrated management of natural resources. Bearing this in mind, researchers of Holetta research center have been empowering farmers of limited capacity with improved crop varieties. In a nutshell, diversity of crops can play a significant role in the following objectives: improving productivity; risk aversion; pest management (weeds, insect populations and diseases); enriching genetic resources (great values for future breeding); stabilizing ecosystem and nutrient cycling (Altieri 1987, Adugna 2002).

Diversification of cropping systems can improve the impacts on environmental resources, spread the farmers economic risk, exploit profitable market niches, create new agro-industries, strengthen rural communities and enable producers to grow crops that are more economical (Altieri 1987, Adugna 2002). Growing diversity of vegetables, cereals, legumes, oilseeds, and forage crops can expand market opportunities and offset price fluctuations. Consequently, profits will not depend exclusively on one commodity or market. Direct marketing of alternative crops creates local opportunities to process, package or sell new products. Galessa farmers could therefore benefit from diversified farming practices. Their economic picture can improve with such strategic diversification. For example, adding legumes (beans and vetches) to a rotation can reduce the need to purchase N fertiliser, as they fix N from the atmosphere. Moreover, rotations that include three or more crops usually have fewer problems with pests and less need for pesticides. Diverse crops can also reduce the economic risk associated with unfavorable weather or pest damage in a single crop. For example, Galessa farmers can successfully harvest crops like linseed and triticale that are tolerant to frost and low soil fertility. Farmers have an old saying which exemplifies the values of diversity by stating that *"a person with only one eye need not play with dust"*. Thus, by promoting various kinds of

crops that have different requirements of temperature, moisture, fertility etc. it is possible to provide benefits for farmers and the ecosystem as well.

The discussion above shows that the significance of diversity is immense. Sufficient incentives are available for its implementation. Actually, the most motivating factors are the tremendous benefits the farmers have been securing for years. They are reflected by farmers' indigenous knowledge and from the new technologies and information being delivered to them from research and other development organisations. Favorable policies supporting these issues are also important. They create further awareness by using different forums and other communication mechanisms. This could take place during joint planning meetings, field visits and field days, focused discussions and presentations of results at various stages. The current communication and knowledge sharing strategies can ensure a two-way exchange and joint learning among various actors, including the policy makers.

3.3. Challenges of diversification and future courses of actions

One of the most challenging issues is whether to follow specialisation or diversification in areas like Galessa, where small-scale farmers are living with a lot of production constraints. Within the current circumstances and the context of the preceding discussion, crop diversification increasingly improves the sources of livelihood for farmers by preventing various economic risks that arise from specialising on specific crops. Gemechu and Adugna (2001) indicate that reasonable yields with fewer risks are preferable to high yields with high risks for resource-poor farmers living under highly vulnerable conditions. On the other hand, like many new ventures, diversifying crops may pose some challenges. However, being prepared and calling on experts for advice can help the farmers to overcome

most of the obstacles. Some common and challenging issues include:

a) Market information: One has to conduct substantial market research to get reasonable profits. Hence, sufficient knowledge of local businesses and infrastructure for handling, transporting, processing, storing and marketing are also vital. Price swings are expected for alternative crops. The more diverse crops are, the better are price buffers and less economic risks are expected.

Contract arrangements with buying agents can safeguard the farmers against price fluctuation and other marketing challenges. For example, contracts on malt barley can be arranged between Galessa farmers and malt factories to support the farmers.

b) Technologies and information: Improved varieties, agronomic and crop protection practices should be made available to the farmers by research and development organisations. Likewise, technologies and information associated with pests and pesticides should be available for different crops, although diverse systems are known to break the life cycles of pests.

c) Seed sources: Sources of seeds could be limiting and the current experiences with informal seed multiplication would be useful in addition to the efforts being done by the formal seed sector like the Ethiopian Seed Enterprise. Supplies of other inputs are also equally important.

d) Post-harvesting technologies: Post-harvest handling and storage information need to be available, especially for the new crops.

4. Summary and conclusion

Growing alternative crops at Galessa for diversification could increase profits for the farmers, while lessening adverse environmental impacts on the area.

Ecosystems with greater diversity have proved to be more stable; they withstand disturbances and recover better than less diverse systems. The more diverse the plants, animals and soil-borne organisms are that inhabit a farming system, the more beneficial are the organisms and their pest-fighting capacity. Thus, agricultural strategy based on a diversity of plants and cropping systems can bring moderate to high levels of productivity and can be more sustainable at a much lower cost and for a longer period of time. Therefore, crop diversification has been and will continue to be valuable both in traditional and modern agriculture for more productivity and sustainability, survival and profitability and for continued improvement (breeding).

Hence, diversity of crops has to be encouraged and maintained at all levels of research and development.

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Table 1: Mean value of various parameters for faba bean mixed cropped with field pea from 1991-1993 at Holetta, Ethiopia.

Mixed proportion (kg/ha)		LER			Monetary Value*	Competition ratio	Crowding coefficient		Relative crowding	
FB	FP	FB	FP	Total		FB	FP	FB	FP	
25	75	0.17	0.97	1.14	304.67	0.526	1.902	0.616	9.559	5.888
50	50	0.34	0.87	1.21	450.85	0.391	2.559	0.517	6.916	3.576
75	25	0.62	0.77	1.39	812.46	0.268	3.726	0.552	9.881	5.454

* = In Ethiopian Birr based on yield, adjusted downward by 10%

LER = Land Equivalent Ratio

FB = Faba Bean

FP = Field Pea

Source: Amare (1995)

Table 2: Effect of mixed cropping of barley and faba bean on different parameters from 2001-2003 at Holetta, Ethiopia.

Year	Grain yield (kg/ha)		Total grain yield	Barley grain yield eq	Total biomass yield (kg/ha)		Partial and total LER values for grain yield		
	Barley	FB			Barley	FB	Barley	FB	Total
2001	2744a	1470a	4214	3790a	8650a	3001a	0.88a	0.39c	1.07b
2002	1488c	665b	2153	1979c	4448b	1666b	0.81b	0.55a	1.17a
2003	1896b	1320a	3216	3050b	5233b	2684a	0.85a	0.46b	1.16a
LSD0.05	213.91	201.66	-	200.68	808.83	376.7	0.04	0.06	0.06

FB = Faba Bean

eq = equivalent

Same letters in columns were not significantly different at $P < 0.05$

Source: Getachew *et al.* (2006)

Table 3: Alternative crops and their improved varieties introduced into Galessa for diversifying its cropping system since the 1990s.

Crop	Number of varieties introduced	Yield range (t/ha)	Farmers' variety (t/ha)
Barley	> 4	1.9-2.2	< 1.0
Potato	> 5	8.5-31.0	< 4.0
Linseed	> 5	0.4-1.0	< 0.2
Oats	> 4	4.7-8.8	< 3.0
Vetch	> 2	3.0-7.0	Nil
Total	> 20		

Table 4: Grain yield of winter barley (kg/ha) as affected by tillage and cropping systems from 1999-2002.

Tillage system	1999-2000		2000-2001		2001-2002	
	CC	BF	CC	BF	CC	BF
CT	859a	1442a	1409a	1475a	2599a	3096a
RT	457c	1693a	1188a	1347a	1782a	3021a
NT	633b	839a	902a	1242a	1386a	3578a

Same letters in columns were not significantly different at $P < 0.05$

CT = Conventional Tillage, RT = Reduced Tillage, NT = no tillage

CC = Continuous Cropping, BF = Barley-Fallow rotation),

Source: Moret *et al.* (2007)

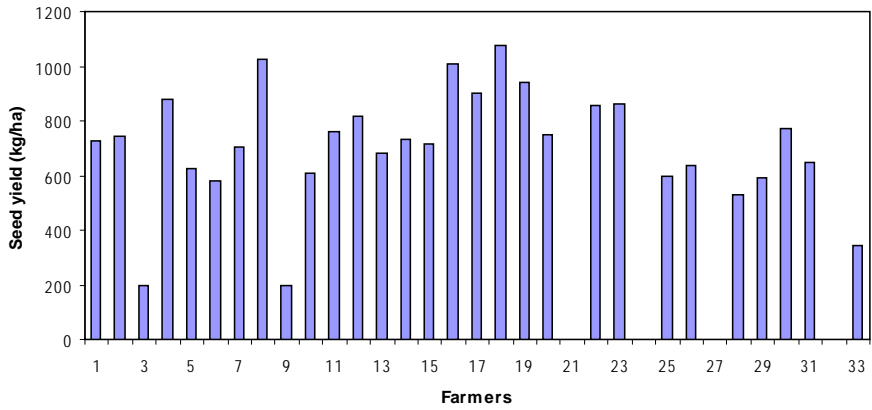


Figure 1: Seed yield of *Berene* linseed variety sown at Galessa, 2005/2006, shown per farmer (n=33).

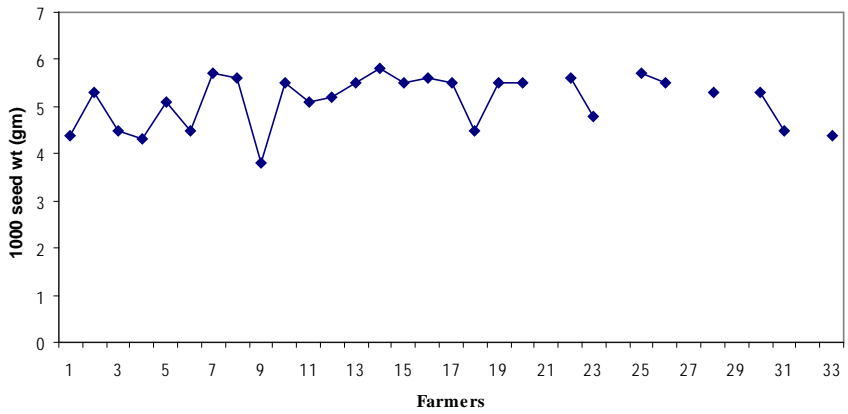


Figure 2: 1000 seed weight of *Berene* grown at Galessa, 2005, shown per farmer (n=33).