
Farmer's Indigenous Agricultural Knowledge in Gamo Highlands, South Western Ethiopia: Characteristics and Sustainability

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As part of government policy to curve food insecurity and bring sustainable livelihood to smallholder agricultural communities, the contribution of indigenous agricultural technologies is undeniable. This research uncovers the indigenous agricultural technologies that need promotion and support, to achieve the intended food security in densely populated highlands of Ethiopia in general and the Gamo Highlands in particular. This study is, therefore, intended to assess the status and sustainability of indigenous agricultural knowledge in Gamo Highlands. The research depended on data collected from 193 sample farm households through intensive household survey, focus group discussion, participant observation and key informant interview. The results indicate that crop production and animal husbandry are the major occupations of the Gamo people in the Gamo Highland. Indigenous soil fertility management techniques such as organic manure, application of tree leaf (mulching), crop rotation and indigenous cultivation mechanisms were still utilized to improve production.

Keywords: Indigenous Agriculture, Indigenous Knowledge and Conservation.

Introduction

Moreover, farmers use indigenous stone bund, soil bund and drainage ditches as their major soil conservation mechanisms. Rapid population growth, declining number of livestock due to lack of open grazing land, lack of manure and heavy weather variability are the threats for the sustainability of indigenous agricultural knowledge in Gamo Highlands. Agricultural experts and rural development agents should give attention to this problem side by side to the introduction of modern agricultural technologies.

In Ethiopia, agricultural policies are largely focus on increasing food production by introducing modern inputs such as improved seeds, chemical fertilizer, pesticides and related inputs. It is testified that there have been improvements achieved in areas of good soil and favourable climatic condition (Dasalegne, 2009). These modern agricultural inputs are purchased and need

some money to invest (Abera, 2014). On the other pole, there is little or no attention has been given to local agricultural practices, which can easily be improved without large investment. Although improved agricultural technologies are essential to enhance production in order to satisfy the needs of rapidly increasing population with the annual growth rate of 2.6 (CSA, 2007), it is wise to conduct extensive research at such instances to improve the indigenous agricultural knowledge side by side to the expanding modern agricultural technologies. This in general will help to recognize and/or incorporate the indigenous knowledge with the introduced scientific agricultural technologies.

Static agricultural systems with declining landholdings due to land transfer from father to sons created indigenous agricultural practices unsatisfactory. Moreover, the number of domestic animals whose waste product is significant to organically fertilize the farmland is also declined to the point that some poor farmers are none of them. As a result, not only average output per unit of input is very low but also the farming practices applied contribute to the soil degradation that seriously affects sustainability. Although traditional technologies may have, their values under subsistence conditions, most of the indigenous practices applied on very small plots of land are definitely not adequate for increased production to meet the food needs of the rapidly growing population. Therefore, it is not too late to improve the indigenous agricultural technologies to enhance productivity.

Like most other rural areas of Ethiopia, the prevailing farming system in Gamo Highlands is dominantly traditional small scale with no significant change over times. The rapid population growth added on to the already existing small landholding made life challenging for the rural households. They found it difficult to feed themselves and their families depending on indigenous agricultural practices. Mixed farming, crop production using livestock manure and homemade compost and livestock rearing, is the major livelihood strategy of the Gamo people to sustain their families. The two sub-systems support each other in order to supplement the livelihood of the rural household. Therefore, this research assesses the status and sustainability of indigenous agricultural knowledge in Gamo Highlands, South Western Ethiopia.

Materials and Methods

This study was conducted in Southern Nations Nationalities and Peoples Region (SNNPR), South-western Ethiopia. Similar to that of the federal division, the SNNPR is divided into 14 administrative zones and three special districts (*woredas*) based on ethnic and language identities. Gamo Highland is located in GamoGoffa administrative zone, which is the third largest zone in the region in terms of area, with its administrative centre at Arba Minch Town. The Gamo Highland lies within eight districts, namely Chench, Dita, Doroda, Mirab Abaya, Daramalo, Bonke, Arba Minch Zuriya and Gerese. Specifically, this study was conducted in Chench, Dita and Bonke.

(Figure 1).

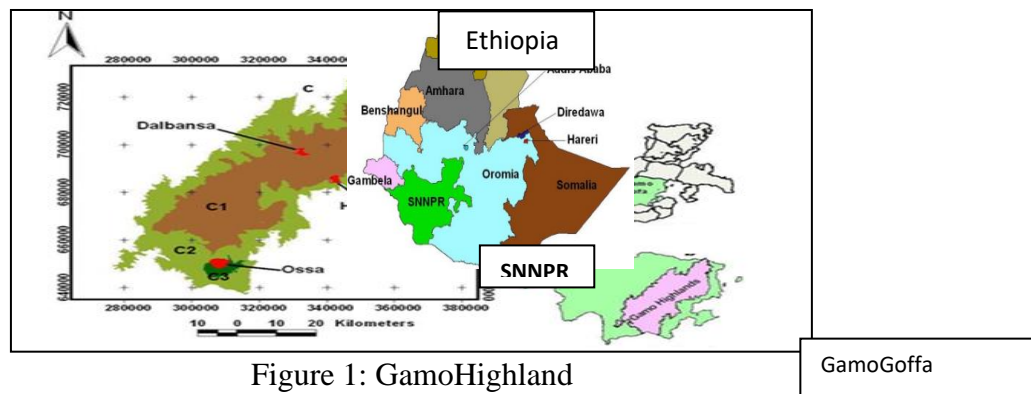


Figure 1: GamoHighland

Methods of Data Collection

All rural Peasant Administrations (PAs) that fall within the defined territory of Gamo Highlands were identified and stratified into three agro-climatic zones based on their previously recorded climatic data. These are, *Dega* (highland) constitutes an area above 2200 meters above sea level, *woynadega* (midland), areas between 1500-2200 meters above sea level and *qolla* (lowland) areas below 1500 meters above sea level (Woldeamlak, 2007; Alemneh, 2003; Shiferaw and Holden, 1998). Selection of sample PAs considered basic criteria: homogeneity of economic activities, geographic location, and distance from urban centres and placement of almost all boundary of the PA at the same agro-climate. Accordingly, one PA was selected from each agro-climate. Therefore, three PAs were purposely selected for this study.

List of all household head names of each category was obtained and alphabetically arranged. 20% of the total household heads were taken by using random numbers table, which according to Creswell (2009) is the most rigorous method for selecting the sample. The research depended on data collected through intensive household survey, focus group discussion, participant observation and key informant interview.

Data Analysis

Qualitative data generation of this study involved ethnographic approach through the understanding of everyday life of the respondents establishing a genuine trusting relationship (Kitchin and Tate, 2000). Firstly, all interviews and points in the group discussion that were tape-recorded were transcribed and documented in a notebook to link with the observation and household surveys. Specific focus was given to the observation by jotting down issues that are related to the day-to-day life setting of the community. Secondly, verbal responses, discussion results and observation memos, which were gathered during daytime, were carefully transcribed. The data were annotated immediately while both the interview and observations are still fresh in mind, which helped to categorise and connect to similar ideas. Sketches by participants and photographs were coded and categorized based on the issues they represented. Depending on the relationship, the sorted and categorized data were linked and connected to the contents they

belonged to. Quantitative data gathered through structured household surveys were coded, sorted, classified into themes and analysed.

Results and Discussion

The type of crops produced in Gamo Highlands varied from cereals and root crops specifically, barley, *enset* (*ensete ventricosum*) and potato as the major food crop in the upper limit of the high land to Maize and *tef* in relatively lower agro-climatic zone. The temperate agro-climatic zone locally known as *dega* produces additional crops such as wheat, beans, pea, lentils, and oats in smaller amounts. The entire crops produced in this agro-climate were annual crops except *enset*. There was crop rotation in order to produce twice a year. For example, after harvesting barley, farmers prepared the land for potato. A bit different seasonal crop that grew as weedy in all over the *dega* agro-climate was *Qoltso* (*Arisaemaschimperianum*). It is a root crop that grows and used as a food only in Gamo Highland. It grows as a weedy root crop where the land is often cultivated. The root is cut-off and purposely buried while plowing the land for barley, wheat or other cereals. It stays dormant for several months and starts to grow in mid-February and it is harvested from the beginning of July to the end of September. Very recently, the amount of *Qoltso* production has been observed remarkably declining. According to observations, *Qoltso* was very sparse in the farm plots.



Figure 2. While men were plowing collecting *Qoltso*, women were separating the Edible Bottom (Left) From the Top Root Part (Right), Photo, 2016

Another important crop produced in the Gamo Highlands is *enset*, a perennial crop which supports the survival of all households during food shortage. *Enset* could be harvested and consumed at any stage of 4-6 years of its maturity stage. Farm households at *dega* saw *enset* as backbone of their life though it occupies land for several years. Farmer's attitude toward *enset* was twofold. Primarily, *enset* was a crop to rely on in times of food crises. The availability of *enset* at a reasonable number and in a good stage (at least more than 4 years of age) indicates that the household might not face serious food shortage although it was difficult to confidently say such household might be food secure.



Figure 3. *Chadhe* (chopped *enset*) at Dalbansa was spread-out on sun to dry to decrease water holding during cooking: photo, 2016

The very importance of *enset* was its availability as food item at any season and at any stage of development. At its very smaller stage, *enset* was simply chopped and cooked with cabbage to appear as a delicious food, which is locally called *chadhe*. However, it was considered as the food of the poor when it was consumed during harvest season of other crops such as barley. This indicates that *chadhe enset* was reserved to be consumed during the time of scarcity of other food items, particularly from April to November. Most of the time, *Chadhe enset* was cultivated at a separate plot of land either along the house next to the main *enset* plantation or in a specific land far away from home. Cabbage was usually planted along with *chadhe enset*, perhaps to use the land for dual purpose.

The major constraint of *enset* production was bacterial infestation that caused wilt and root rotting of the plant. The problem was very serious at Hirpho where almost about 17% of the farm households reported that they lost their plantation. This was raised as one issue of a group discussion, which concluded that the life of any farm household was at risk at any time with the limited availability of *enset* around his/her house. Several measures that have been taken by farmers to solve the problem such as uprooting the attacked *enset* including its root and burying it including the instrument used to uproot it, was fruitless. What one can argue in this case is that although farmers' knowledge can be appreciated and acknowledged, it could not have prevented the distribution of the bacteria all over the locality and still needs scientific solution and political attention as the crop has considerable value in tackling food insecurity. Furthermore, the severity of the problem needs not only further study but also screening of promising tolerant clones.

Considering the amount of land covered, maize and *tef* were the main annual crops at Ossa. In this specific area, maize is cultivated in *belg* (short rainy season, late February to end of May) season and harvested in the summer to leave the land for *tef*, which was cultivated from mid-July to the start of September. This was also the time to sow *sila* (crops cultivate during the main cropping season (July – September) maize immediately after the harvest of the *gaba* (crops crop cultivation between March- April) maize. However, farmers learned that the erratic nature of rainfall affected the effectiveness of the production of this season. According to the interview results, the main objective of *sila* maize was not to collect good harvest but simply to collect feed for the oxen and cows for the coming dry season. One of the challenges of Ossa farmers was the animal fodder during the time of dry season from November to February. Farmers with reasonable landholding had the chance to do this but the poor households could not misuse the

land and/or the maize seed for such purposes. After maize the next important was *tef* which occupied the peripheral and relatively sloppy farm grounds due to the fact that the soil in the flat grounds log water during excessive rains. According to the survey data, *tef* was produced not for home consumption but for market purpose to fulfill household needs such as children’s clothes, pay land tax, cover schooling costs, pay fertilizer debt and other home consumption needs such as salt, oil, gas etc.

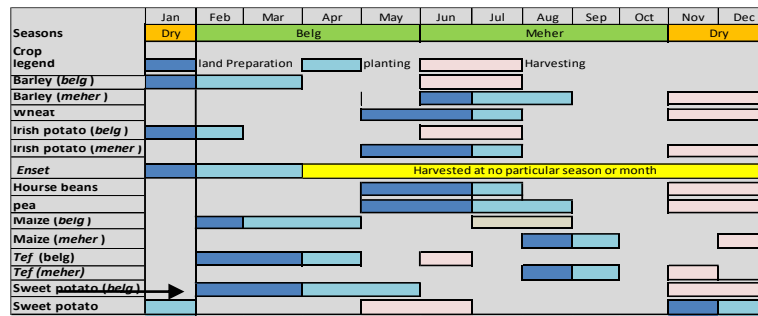


Figure 4. Agricultural calendar of the main crops in Gamo Highlands, 2015- 2016

Indigenous Soil Fertility Management Practices

Most of the cultivated soils in Gamo Highlands experience high degradation, which resulted in loss of primary micronutrients: nitrogen, phosphorus and potassium (Abren and Abera, 2010). Limited crop diversification combined with low or non-fallow period contributed to the decline of organic matter contents. Farmers of the highlands sustained permanent crop cultivation on these soils because there has been an effective indigenous soil fertility management practice in maintaining a reasonable level of organic matter and primary nutrients (Belay, 1998b). The physical set up of the farmland at Gamo Highland is characterized by ups-and-downs with steep slopes in its northeast direction. About 88% of the sample households had at least one plot of farmland in this step slope. Soil erosion happened to be common phenomena in this part of the study area, where there were few scattered transhumance houses constructed for two purposes primarily, to feed livestock on the upper part of the mountain that is a communal grazing land and secondly to store manure to apply on the nearby plots. The main indigenous soil fertility management practices applied in Gamo highlands are discussed as follows.

Organic manure

This is a kind of fertilizer applied on cultivated fields to improve both physical and chemical fertility of the soils. There are two types of organic manures: fresh manure and compost manure. According to the farmers’ accounts, fresh manure (*Ho’opitho* or in some localities called *Igisa*) is prepared by mixture of dung, urine and straw or leaf litter that was purposely strewn to feed animals during night time as a dinner and/or to prepare a good and safety sleeping place. After several weeks or few months of storage, the hot manure directly put in a large basket from its original place to be transported by human power (usually women) or in rare cases by horses and directly applied on the field. Such application was mostly practiced on potato fields.

On the other instance, compost manure was prepared outside the house to provide enough time for the mixture of cattle dung, urine, and strew together with some ash, kitchen waste and household rubbish. As it was stored outside the house, it was exposed to sunlight and rainfall, which altogether helped to ferment and made it ready to use during *belg* cropping. This type of manure is applied on barley and sometimes on wheat fields. All of the surveyed farm households prepared this manure to apply on the cereal fields. In both cases, the transported manure is dropped at a considerable distance, throughout the field and manually spread on the field as evenly as possible.

From their long experience, farmers knew that there are differences among the livestock manure. According to farmers account, sheep dung is the best manure for a good yield of barely, potato, and for other few crops produced in the area. This is scientifically supported, as phosphorous requirement level of cereals, including barely is low; but the optimum amount of phosphorous needed for better growth and productivity of potato is higher (FAO, 1990).



Figure 5. Preparing compost manure to carry to the field: photo, 2016

The same document explains that other conditions being satisfied, maximum productivity of barely, one of the major crops at Dalbansa and Hirpho, would be attained if nitrogen content of the soil is “high,” but the best potato yield can be obtained with “medium” level of nitrogen supply. In contrast, the cultivation of potato requires high amount of exchangeable potassium in the soil (Booker Tropical Soil Manual, 1991).

However, the number of sheep was significantly declined due to lack of grazing land. On the other hand, cattle or dairy dung was perceived less important for barley because of its lower content of primary nutrients compared to that of sheep and horse. Farmers, therefore, mostly used dairy manure at *enset* fields. As a result, *enset* crop was usually planted around the house where there is cow or horse manure to help *enset* mature timely with a considerable thickness and height. That is one of the reasons why all the houses were observed surrounded by *enset* plantation almost throughout Gamo Highland. Farmers were well aware of the longtime effect of organic manure and hence used two crops; barley followed by potato or vice versa continuously using manure applied once.

Crop production in Gamo Highlands has also been depended on fertilizing the soil by leaf litter (green manure or mulching). Trees are purposely left to grow around or at the boarder of farm field for their branches to be cut and thrown on the newly cultivated wheat, barely or any other cereal crop. Until the crop will have two or three leaves, the tree leaf starts to decompose as

intensive rain facilitates the process more quickly. This is the way how to keep the soil fertile in this part of the Gamo highland.

Another major organic fertilizer that has been used to restore soil fertility in Gamo Highlands is traditional compost. The preparation of this type of fertilizer is similar in all sample PAs leaves and grass are raw materials added up on the livestock dung and urine to be combined with other household wastes. Farmers applied this fertilizer to wheat and barley fields near and around the house whilst they adapted the application of artificial fertilizers on relatively far fields. Moreover, weeds and other plant remnants were widely used at the time of pre-preparation (*shalame*) period by which the land is thoroughly tilled at a considerable depth to bury what are found on the ground. After two weeks, the buried material is changed into humus and the land would be ready for final preparation. Minimum amount of animal manure is added if available on such a plot of land while preparing land to complete the soil fertility management process.

From farmers' point of view, indigenous soil fertility management has two strong positions. Firstly, if organic manure is applied in a specific plot of land, it would serve for two-term cultivation. For example, if potato is cultivated by applying manure then there is no need of adding manure for the next barley cultivation. This gave more time to store organic manure for further application. Secondly, the preparation of organic compost requires no financial expense because the raw materials needed for its preparation were obtained from domestic animal wastes, grass and leaf from surrounding environment and all unnecessary but decomposable trash of the house. Finally, applying manure helps to enhance the productivity of Qoltso, which depends on the manure applied for other cereal crops.

Crop Rotation

This is a mechanism by which nitrogen can be restored by crop types on the same cultivated field (Belay, 1998). Farmers' knew that including leguminous plants would recharge fertility to the soil. Having this knowledge in mind, therefore, farm household throughout Gamo Highlands cultivated barely, potato and horse bean sequentially. With regard to using the land twice a year, farmers regularly cultivate potato and barely interchangeably in a year which results in soil fertility depletion in terms of primary nutrients. Crop rotations were practiced only on annual crops, while *enset* fields most of the time did not have any of these activities.

Moreover, at Hirpho where the altitude is lower than that of Dalbansa, crop rotation was a common phenomenon. According to farmers report their small landholding and shortage of water during dry seasons not only forced them to rotate crops and vegetables but also mixing, that is cultivating different crops and vegetables and spices on one field at a time or continuously at different time. Harvesting a type of vegetable, for example green pepper, would not affect the life of cabbage or onion; and also planting garlic and potato at the same field would not affect the life of cabbage or onion. Hence, the entire homestead farm fields in this *PA* were occupied all the year round providing a diversified production at different time. Such type of agricultural activity was believed to be a good mechanism to avoid the risk of complete crop failure and to guarantee food and household income through purchase of varieties of agricultural products. However, the production of single food item was very small and results in earning of very small amount of money.

Soil fertility management practice undertaken in Gamo Highland showed a slight variation in different agro-ecological zone. It is important to note here that the types of crops produced have their impact on soil fertility management. At Ossa where maize and *tef* were the major crops that interchangeably cover the land, manuring by animal waste had low importance. According to farmers' explanation and our observation, in order to restore soil fertility, farmers depended on the residue and remnants of previous harvest. Normally, crop rotation at Ossa was in between maize and *tef*. As a staple food, maize was cultivated during *belg* seasons of March, April and May (Figure 4.). Majority of the farm households at this PA (62%) cultivate *tef* immediately after harvesting maize while some farmers (18%) reserved *tef* field and cultivate only *tef* that result in relatively better yield. Farmers in this case stressed the fact that their soil has exhausted due to over cultivation because of small landholding. In spite of this, farmers were inclined towards the use of chemical fertilizer to restore fertility of their soil.

The survey result indicates that fallowing had become a history at Dalbansa where land scarcity was at its peak. All sample household heads responded that they never fallowed any piece of land in any season. On the other hand, we observed some pieces of land have been left uncultivated in different parts of Hirpho. According to informants and development agents, such land belongs to migrants to Addis Ababa for weaving because of very small landholding.

One-season fallow was a common activity at Ossa. After harvesting the *belg* maize on July and August, the land is kept free until the next *belg* cropping period comes. Farmers thought that during that time gap the land became free enough for the soil to restore itself back to its fertility. Of course, excessive temperature due to high solar radiation at one season and excessive rainfall at the other season might have facilitated the decomposition of materials on the surface to change into humus while the top soil was turned during tillage. However, such practices were restricted to those households who have relatively larger holdings.

Cultivation Procedure

Indigenous cultivation mechanisms that have been practiced through centuries creating production adaptive to local environment and apply ecological approaches to enhance agricultural production (UNEP-UNCTAD, 2008) are still important along the holdings at the Gamo Highlands. The preparation and use of organic manure and the practices of rotational cropping depended on indigenous knowledge rather than training and imports. Such practices, which were not guided by external experts, were cost effective, simple, easily implemented by farmers; and could be applied and suitable for any type of soil.

Farmers' Knowledge of Soil Conservation

In Gamo Highlands, in general, different land management practices that were well adapted to local ecological conditions have been developed through generations. Individual farm households practiced suitable measures that fit a specific plot of land at different locations with different biophysical characteristics such as soil type, slope and agro-climate. In light of this, indigenous land management practices that have been practiced in this highland can be seen within the framework of indigenous soil conservation (mechanical/ biological) methods.

Indigenous Soil Conservation Methods

Farmers in Game Highlands have been practicing combinations of mechanical strategies of soil conservation. This method has gained primary attention by farmers of all sample households. This was due to the fact that these methods basically protect the washing away of the upper soils including agricultural inputs such as seeds, manure and chemical fertilizers. It is also critical to note that these strategies created a better opportunity for the soil to hold moisture as the rainwater is prevented to run; and it is made widely practical structural soil conservation method in Gamo Highlands.

Stone Terracing (*Keela*)

Farm households throughout the Gamo Highlands where the raw material (stone) is available, practice stone terracing. Farmers' perception of *Keela* reveals that it had two purposes. Firstly, it protects the top soil from being washed away and secondly, it restores soil fertility by conserving water and hence creating soil moisture ability. However, its construction as well as maintenance requires physical strength, much input of family labor and construction and maintenance skills.

As observed during survey, lack of raw material (stone) was taken as a problem of *Keela* by about 18% and 4% of the households at Dalbansa and Hirpho, respectively. Farm households explained that sometimes in case of serious degradation they collect stones from river ways and carry it to the affected site to construct or maintain the structure. It appears important to add that *Keela* has to be weeded and maintained every two to three years to control the proliferation of dangerous running weeds such as *phedha* that may creep into the soil particles stored in the form of silt.



Soil Bunds

Soil bunds are structures constructed at higher altitudes and more steep slopes. According to owners of farmland with soil bunds, lack of stone was the main reason to construct soil bunds. At steeper slopes, permanent soil bunds were constructed because of the fear of landslide, while at relatively gentle slopes soil bunds were changed annually to use the fertile soil stored at the

structures. All steeper slopes in the study area are structured by soil bunds; especially at Dalbansa soil bunds supported much soil at very steep slopes from degradation.

Contour Plowing

Plowing the land horizontally was a common practice at all sample PAs. At steep slopes, farmers were forced to plough horizontally to avoid small landslides and gullies. However, farmers complained that cultivating horizontally using hoe results in back pain.

Farmers' perception on the Causes of Soil Erosion

In Ethiopia, under conditions of peasant subsistence agriculture in densely populated highlands, survival in the rural areas is solely linked to the exploitation of land-based resources resulting in the over exploitation beyond their capacity to regenerate (Belay, 2003). In the present study area, the levels of erosion whether it is very severe, severe or minor is determined by farmers' experience and perceptions and is therefore a relative term. The underlying issue in posing these questions is to ascertain the farmers' awareness of soil erosion. During the interviews, the farmers' view on the level of erosion was first raised and subsequently verified by observation of the farming plots.

Farmers were also asked to express their views about environmental degradation and the level of erosion on their main cropland. It was easier for farmers to remember the conditions on the cropland and other areas such as grazing areas, bare land and other small plots. It was also easier for us to verify the status of soil erosion through other indicators of degradation, such as soil depth and the level of stoniness, which were more easily observed on cropland. Therefore, farmers at the three sites seemed to be frank in expressing the incidence of erosion.

Accordingly, soil erosion was observed to be the problem with more than half of the respondents suffered severe soil erosion. At Dalbansa, more than 80% of the studied households found soil erosion out of their control as the indigenous soil conservation structures at steep slopes always damaged due to heavy rain. Farmers at Hirpho had similar problems although their traditional soil conservation structure (*Keela*) was far better and stronger than that of soil bunds of steep slopes of Dalbansa. On the other hand, only 5.5% and 32.9% of the respondents at Ossa expressed that soil erosion is severe and minor on their farm plots, respectively.

The soil erosion problem was perceived by the majority of the respondents in terms of decrease in the capacity of soil to grow a variety of crops, decrease in the depth of topsoil, decline in yield and decline in the water holding capacity of soils. About 51.8% of the respondents reported during survey that soil erosion is increasing on the farm plots either due to heavy rains, overgrazing or heavy sunshine that made the soil of the farm plot fracture and susceptible to erosion. Therefore, the major causes of erosion perceived by farmers were topography, high rainfall rates, and overgrazing. The rugged topography with steep slope farm plots facilitated high erosion rates at the seasons of torrential rains in the Gamo Highlands.

Moreover, scarcity of grazing area forced farmers to graze their livestock on the farm plot immediately after harvest. The land was open for grazing for the long dry season until land

preparation period (start of the rainfall). Livestock roam everywhere feeding on crop residues creating enormous stress on most fertile agricultural lands. This grazing results in soil breaking, which reduces infiltration and the ability of the soil to absorb moisture that ends up in soil erosion. According to the group discussion, this was one of the major causes of soil erosion in Gamo Highland though massive soil conservation practices have been taking place by the government.

As an additional experience, farmers evaluated soil fertility of each parcel before deciding to start conservation measures. Primarily, individual households categorized each plot of land into three fertility levels; *tolso* (very fertile), *modho* (fertile) and *tsalla* in some place also called *mela* (less fertile). Obviously, farmers expressed soil fertility in association with soil type. For example, if the soil type is *gobo* and the fertility level is *tolso*, then it is expressed as *tolso gobo*, *modho gobo*, etc.

Conclusion

Crop production and animal husbandry are the major occupations of the Gamo people in the Gamo Highland. Barley, potato, wheat and *enset* are the major crops produced at *dega* and *woynadega* agro-climate while maize and *tef* are the staple foods produced at *qolla*. As far as livestock is concerned, cattle and sheep are the dominant at *dega* and *woynadega* while only cattle dominate at *qolla* areas. Farmers developed their own strategies to respond to the production constraints.

To maximize crop production by reversing soil fertility, farm households in Gamo Highlands use indigenous soil fertility management techniques such as organic manure, application of tree leaves (mulching), crop rotation and different cultivation mechanisms. All of these strategies are under pressure due to observable constraints to achieve: small number of livestock, deforestation and the use of tree branches and leaves for fuel, weather variability, lack of labor and encouragement of government development agents to use introduced agricultural inputs were the confronting ones.

Indigenous soil conservation strategies are also the most appreciable mechanisms used by the Gamo community to enhance production. Some of the effective structures that have been used mostly to protect soil erosion were stone bund (*Keela*), soil bund (*pore*) and drainage ditches (*Zara*). Stone bunds were the most effective structures applied by all households at Dalbansa and Hirpho PAs (*dega* and *woynadega* agro-climate) while drainage ditches were common at Ossa PA (lowland) due to the influence of physical landscape and the availability of raw materials for the construction of structures. However, massive introduction of experimental soil conservation structures swallowed the indigenous soil conservation practices, which were affordable, simple and effective. Therefore, rural development agents as well as district agricultural experts who are the key player can reverse the limited use of indigenous agricultural technologies in Gamo highlands.

Reference

- Abren Gelaw and Abera Uncha (2010). The status of soil quality and indigenous management practices towards the sustenance of soil resource in Gamo Highlands, *South Western Ethiopia, Arba Minch University research report*.
- Alemneh Dejene (2003). Integrated natural resource management to enhance food security: The case for community-based approach in Ethiopia. Environment and *Natural Resources Service Research, Extension and Training Division Food and Agriculture Organization of the UN, Rome, Italy*.
- Belay Tegene (2003). Combining land capability evaluation, geographic information systems, and indigenous practices for soil conservation in North Ethiopia. *Eastern Africa Social Science Research Review, Vol.19(2), 23-53*.
- Belay Tegene (1998), Indigenous soil knowledge and fertility management practices of South Wollo Highlands, Northern Ethiopia, *Ethiopian Journal of Development Research 14*, 31-58.
- Booker Tropical Soil Manual (1991). A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics. In: J.R. London (Eds.). Booker Tate Limited Corbeels, M. Abebe, S. & Mitiku, H. (2000). *Farmers knowledge of soil fertility and local management strategies in Tigray, Ethiopia. Managing Africa's Soils No.10*.
- Creswell, J. W. (2009). *Research design qualitative, quantitative, and mixed methods approach*. (3rd ed.), Sage Publications Ltd, London.
- CSA (2007). Summary and statistical report of the 2007 population and housing census; *Federal Democratic republic of Ethiopia population census commission, Addis Ababa Ethiopia*.
- Desalegn Rahmato (2009). *The peasant and the state: Studies in agrarian change in Ethiopia 1950s-2000s*. Addis Ababa University Press.
- Ellis, F & Tasew, W. (2004). Ethiopian participatory poverty assessment (2004-2005) PPA Manual, Addis Ababa.
- FAO (1990). Guidelines for soil description: Soil resources, management and conservation; *Food and Agricultural Organization of the UN, Rome, Italy*.
- Kitchin, R & Tate, J. N. (2000). *Conducting research in human geography: Theory, methodology and practice*. Pearson Education Ltd, United Kingdom.
- Shiferaw, Bekele. and Holden, S. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian Highlands. *Agricultural Economics 18*,233-247.
- Woldeamlak Bewket (2007). Soil and water conservation intervention with conventional technologies in North Western Highlands of Ethiopia: Acceptance and adoption by Farmers. *Land Use Policy 24*, 404-416.