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Indigenous Knowledge and Practices for Soil and Water Management in East Wollega, Ethiopia

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Abstract

The study was conducted in western Ethiopia in order to identify local soil and water management related knowledge and practices of the farmers in order to utilize the output in further research and development interventions in the area. The awareness about the existence and extent of land degradation and nutrient depletion; and its contributory factors are pre-requisite for farmers to undertake any effort to arrest the problem. Farmers in the study area recognized soil erosion and nutrient depletion, and established cause and effect relationship between factors. The major causes of land degradation and nutrient depletion are soil erosion, intensive Tillage, exhaustion of nutrients by crops and deforestation. Apparently, crop type and crop management were emphasized particularly with respect to soil erosion. Small cereals like tef (*Eragrostis tef*), which require highly intensive tillage and smooth seedbed are considered detrimental while legumes and oil crops contribute positively to the land quality. On the side of the solution to these over-riding problems, they have various options ranging from simple mechanical or agronomic to integrated; and from a field level to a watershed scale. Some of the indigenous soil and water management practices identified in the area are consistent with similar practices found in different parts of the country (AZENE, 1997; MILLION, 1996; KEBEDE *et al.*, 1996), while some are unique to the area. *Joro* for soil conservation and nutrient management, and *Ciicata, Kolaasaa* and their integration with crop rotation for soil fertility maintenance and weed control are among the unique practices in the area. The practices are widely used in the study areas, and are appreciated by all the farmers. Detail description and rationale of every practice is discussed in this paper.

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1. Introduction

The Ethiopian land mass is generally categorized in to the highland (above 1500 m asl) and the lowland (below 1500 m asl). The highlands comprise about 44 % of the total landmass and accounts for 95 %t of the cropped land. About 88% of the human population, at an average density of 64 persons per km^{2,} and two-thirds of the livestock is accommodated in the highlands (Kruger *et al.,* 1996).

Serious erosion is estimated to have affected 25% of the highland area. According to some estimates four percent of the highlands are now so seriously eroded that they will not be economically productive again in the foreseeable future (Kruger *et al.,* 1996). The Soil Conservation Research Project (SCRP) has estimated an annual soil loss of about 1.5 billion tons from the highland. According to the Ethiopian Highlands Reclamation Study (EHRS) soil erosion is estimated to cost the country 1.9 billion US$ between 1985 and 2010. These call for external interventions based on the local socio-economic and technical potentials if the country is to continue as a nation.

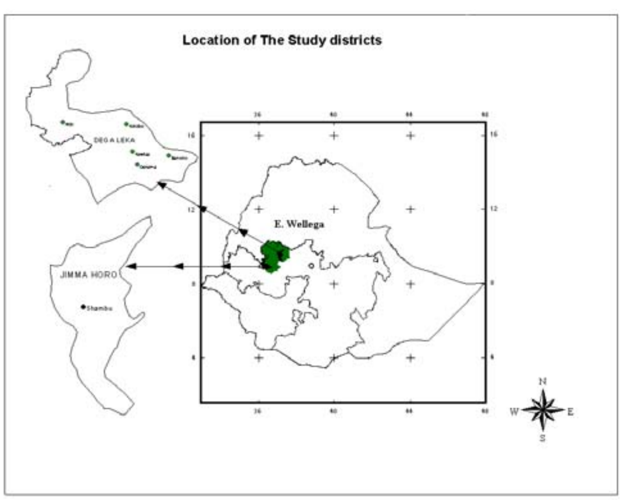
During the 1980s the Government of Ethiopia launched a massive program of soil conservation and rehabilitation. The effort, which involved heavy external support culminated in the mobilization of peasant associations with over 30 million workdays per year (Hurni, 1986). During this period, it was normal to follow any technical guideline developed and tested else where without integrating it into the local socio-economical or environmental conditions. Nevertheless, the achievements fell far below expectations and the country still loses a tremendous amount of fertile topsoil, and the threat of land degradation is alarmingly broadening.

Indigenous knowledge refers to the perception that farmers have about their natural and social environment, which they use to adopt, adapt and develop technologies to their local context. The rationale for undertaking certain traditional practices among others is recognition of problems by the local people. Indigenous practices are aimed at arresting the local priority problems. Although they survived the challenges of changing biophysical and socio-economic environments through a continuous responsive changes and adaptations, indigenous practices are not perfect. There are some who still argue that indigenous practices deserve little emphasis since "they cannot any longer go with the dynamics of the environments". They further suggest that modernization rather than the 'backward' local practices need to be pushed further. It is, however, believed that indigenous practices certainly fit into the local socio-economic situations and might be easily handled by farmers' knowledge and the resources at their disposal. The important issue should thus be the integration of indigenous practices and the western scientific technologies in such away that the positives sum produces optimum outputs. This study is therefore aimed at identifying the local knowledge and practices of farmers on soil and water management with the end goal of their fusion with the modern scientific knowledge and technologies for optimum output.

2. Methodology

The study was conducted at two districts (Jimma Horro and Diggaa Leeqaa) of the east Wollega zone of Oromia region (Map 1.). The two districts were selected as representative based on the secondary information acquired on rainfall erosivity indices and past experiences in indigenous knowledge and practices on soil and water conservation in the region.

Two Peasant Associations (*Tullu gurraacha* and *Laaftoo Boshe*) were selected from Jimma Horro district for the purpose of this study, one to represent areas with better external intervention and the other areas depending on indigenous practices.



One Peasant Association was selected from *Digga Leeqaa* district. Participatory Rural Appraisal (PRA) technique was employed to elaborate on the soil resource use and management practices of the farmers. The method helped the researchers focus on issues particularly important for the farmers. Guided group discussions were made with groups of ten to fifteen farmers from each Peasant Association (PA) using a checklist prepared ahead of the field trip. The discussion was focused mainly on the characterization, analysis of potential and constraints of the soil resources. Among the major constraints, soil erosion and nutrient depletion were addressed in detail. Secondary information from literature and Ministry of Agriculture (MoA) Zonal Office, key informant interviews and discussion with the development agents at various levels were conducted to crosscheck and verify the validity of information.

3. RESULTS AND DISCUSSION

3.1 Experts at zone

According to the Soil and Water experts in east Wollega zone, two distinct approaches (the top-down and the bottom-up) in soil and water conservation planning have been exercised in the zone.

The top-down approach- refers to the situation where conservation planning decision made at higher level and implemented at grass root level. Farmers were compelled to implement regardless of their will. Since their views and interest was not considered in the process, they developed a negative attitude towards the interventions. As they were not convinced about the usefulness of the measures they implemented, they did not feel responsible for the maintenance. Also appropriate technical design and implementation was lacking since there was an acute shortage of trained professionals in the area of soil and water management.

The bottom-up approach – In this case planning was made at local level but aggregated to make a regional plan. The plans were often prepared by the development workers at the district levels and submitted to zones for approval. Participation of farmers still remains minimal. This was also not successful mainly due to manpower and budget constraints in addition to the structural problems where the project regulatory and extension departments are separated and which created difficulty to synchronize efforts. As a consequence, still indigenous soil conservation practices are playing a significant role in the region.

3.2 Experts at Jimma Horro

According to the development workers in the area, three major soil types (Red, Black and Brown) are recognized across the district. Agro- climatologically highlands (*Baddaa*) mid altitude (*badda daree*) and low lands (*gammoojii*) represent 43, 56 and 1% of the area, respectively. Close to 74% of the arable land, which represents 62% of the total land area, is cultivated. The rest of the land is used for forest, grazing land and settlement, while some land is also considered as wasteland (Table 1). The landscape is described as undulating (Table 2). Consequently, a considerable proportion of the area is prone to soil erosion by water.

3.3 Focused Group Discussion at Jimma Horro

3.3.1 Tullu gurraacha

This peasants' Association (PA) represents the area exposed to external interventions for soil and water conservation. The area is characterized by a variable slope, ranging from level to very steeply sloping (26-35%). Farmers distinguish four soil types' *Biyyo gurraacha* (Black soil), *Boolalee* or *biyyoo diimaa* (red soil), *Kooticha* (Vertisol) and *Lafa Cirracha* (sandy soil) in the area. In the nomenclature of the soils, color and texture are the most important parameters. *Biyyo* means soil while *diimaa* and *gurraacha* refer to the color, red and black, respectively. *Lafa* means land while *cirracha* stands for large grain size, coarse sand or gravel. These soils occur in the top sequence as: *Lafa Cirracha, Biyyo diimaa, Biyyo gurraacha* and *Kooticha* from the top well-drained steepest slope to the level waterlogged bottomland, in that order. They ranked the soils depending on their area coverage, fertility and response to fertilizers (Table 4).

Table 1. The land use situation of Jimma Horro District in 1999/2000

Cultivated			**Uncultivated**		
	Land use type	Area (ha)	Land use type	Status	Area (ha)
Rain fed	Field crops	44638	Grazing land	Private	645
	Vegetables	328		Common	7,987
	Fallow	1870		Sub total	8,632
	Sub total	46835	Forest land	Natural	6754
Irrigated	Field crops	124		Plantation	1,774
	Vegetables	260		Sub total	852,886
	Fallow	625	Construction		4,022
	Sub total	1009	Land for future development		7,364
Perennials	Coffee	22	Waste land		40,820
	Geshoo and Caati	210			
	Fruits	22			
	Sub total	254			

Source: Jimma Horro District, MoA office.

Table 2. The landscape of the Jimma Horroo District

Landscape	**Area (ha)**	**Percent of the area**
Mountain	5,880	5
Level land	38,458	33
Steep slope	32,585	27
Gullies/Valleys	5,872	5
Temporary marshy	12,979	11
Others	21,681	19

Source: Jimma Horro District, MoA office.

Table 3. Level of soil erosion hazard in the district

Erosion status	Area (ha)	Percent of the area
Sever	12,533	11
Medium	16,114	14
Low	46,986	40
Not exposed	41,822	35

Source: Jimma Horro District, MoA office.

Table 4. Major soil types and their relative importance in terms of area coverage, fertility and response to fertilizer

Soil type	**FAO equivalent**	Relative importance (Rank)			
		Area coverage	Ferti lity	Response to fertilizer	Over all rank
Boolalee (Biyyoo Diimaa)	Nitosols	1	3	1	1
Biyyo gurraacha	*'Molislos'*	2	1	3	2
Kooticha	Vertisol	3	2	4	3
Lafa Cirracha	Sandy soil	4	4	2	4

3.3.1.1 Characteristics and limitations of the soils

The texture of the surface layer has some influence on many other soil properties, and gives farmers a clear indication as to whether a soil can be cultivated after the first rains of the season (Mark, *et al*. 2000). Soil color, texture and its position in the landscape are important criterion for farmers, to evaluate their soils.

Biyyo gurraacha (Mollisol) – Refers to dark topsoil with high organic matter content. It is the most fertile soil situated at the lower section in the toposequence between *kooticha* and *Boolalee* or on the summit under forest or newly deforested areas. It is suitable for all crops growing in the region even without fertilizer, but *Eragrostis tef* suffers from lodging some times even under no fertilization indicating high level of N content. This is thus considered the best among the four soils (Tables 4 & 5).

Biyyoo Diimaa (Nitosol) – some times also called *Dimmillee or Boolalee* describes red soils with low organic matter content, low fertility and in extreme cases sub-soil exposed due to soil erosion and intensive tillage with out fallowing. They commonly occur on steep slope areas where cultivation practices are easier due to the light texture and sufficient drainage. Only *Noug* (*Guizotia abyssinica)* and Linseed (*Linum usitatissimum*) can grow on these soils well with out fertilizers, while other crops like Tef (*Eragrostis tef*), wheat (*Triticum spp*.) and Mainze (*Zea mays L*.) grow only with fertilizers. Poor soil fertility and erosion by water are the major limitations of these soils.

Kooticha (Vertisol) - This is a black clay soil occurring in valley bottom. Moisture content is the major problem since it is too hard when dry and too heavy when wet. Only *Tef* and *Noug* can grow with out drainage, while other crops like Barley (*Hordeum* *vulgare*), *Triticum spp* and *Zea mays L*. can grow on drained beds. It is explained that crops respond to fertilizers poorly due to the standing water that washes it away before it joins the root zone. It could also be due to the poor aeration and denitrification induced by the standing water, since the flat topography rarely allows runoff to wash the nutrients away.

Lafa Cirracha (Sandy soil) - This occurs on the summit or where there is high rate of erosion. It is exposed after the removal of the red soil (sub soil) due to erosion and extensive tillage for a long time. In this case it is likely that the parent materials are being exposed.

Table 5. Crops commonly grown on the different soil types with their management options

Soil type	Suitable for	Management required
Biyyo gurraacha	All major crops of the area, except Tef	Unfertilized
Boolalee (Biyyoo Diimaa)	Noug, Linseed	Unfertilized
	Tef, Wheat, Maize.	Fertilized
Kooticha	Tef, Noug	Drainage
	Barley, Wheat, Maize	Drainage
Lafa Cirracha	Noug, Linseed	Unfertilized
	Maize, Wheat, Tef	Fertilized

3.3.1.2 Indicators of soil erosion

Farmers in the district perceived the existence of soil erosion due to its felt effects over time. It was explained that the proportion of the different soil types is changing with time. In the past *Biyyo gurraacha* was dominating. However, currently the situation is fast changing that the area covered by *Biyyoo Diimaa* is increasing while that of *Biyyo gurraacha* is decreasing. Such change is attributed mainly to soil erosion and tillage intensity. The high rate of erosion is caused mainly by vegetation clearance and intensive tillage. In the region, 7-9 times tillage and packing of the fine seedbed by animals is a common practice for tef. This reduces infiltration, smoothens the land surface and consequently low surface storage leading to high runoff and soil loss.

Exposure of the sub-soil, reduced soil depth, reduced yield, high input requirement, changes in stream water quality and quantity and climatic change are among the farmers' indicators for soil erosion. Apparently farmers have the concept of soil profile (Box 1).

They explained that when *Biyyoo Diimaa* is exposed, it means that the top soil *(Biyyo gurraacha)* was removed and when *Lafa Cirrachaa* is exposed, *Biyyoo Diimaa* was removed due to the same agents.

Box 1. Although most top soils are black, there is a red layer beneath. When we were digging a grave ground, we used to penetrate through the black soil to the red soil, and some times to the sandy soils."
An old farmer from Tullu gurraacha

They elucidate this by the fact that fertilizer was not common in the past, but yield was good since the soil was naturally fertile. Recently, however, most crops give very low yield, if any at all, without fertilizers on most soils.

When the steep slopes and mountains were covered by vegetation, clean water could be obtained from streams during the rainy seasons (Box 2), and good quantity of water in the springs during the dry seasons. Presently, however, the color of water in streams and rivers turn brown due to the high sediment load. During the dry season some springs dry out or the volume of water reduces significantly. This indicates that surface runoff and soil erosion is increased, reducing the annual recharge to the ground water, and hence reduced water yield of springs.

Box 2
Few decades ago, we could get clean water in the spring during the rainy seasons as forests covered the areas above the springs. Today, we drink 'brown water' due to runoff.
A farmer at Tullu Gurracha

Formerly highland (*baddaa*) areas were used to grow only few crops including Barely and cool season grain legumes due to the low temperature. At present, however, Maize and Tef, which were considered to be low and mid altitude crops are grown on the high altitude areas showing the change in climate. This was particularly attributed to deforestation (Box 3). The soils vary in their vulnerability to erosion from the highest for *Biyyo gurraacha* to *Lafa Cirrachaa, Boolalee* and *kootichaa*, respectively.

Box 3.
Maize and tef are climbing to the mountains, and forest is disappearing. It has become difficult to get hordaa and gindii (parts of the local plough).
A farmer from Tullu gurraacha

3.3.1.3 Erosion control measures

In an attempt to tackle the problem, they have developed several indigenous technologies since antiquity. Among these are cut-off -drains locally called "*Boraatii* and drainage furrows called "*Bo'oo*' or '*yaa'a*" (similar to *Golenta,* but smaller, *and Boi*, respectively, as described by Azene, 1997 for Central Ethiopia). Both structures are constructed mainly by oxen drawn plough, but depending on the runoff expected, which depends on the slope length and gradient, intensity of rainfall and the type of crop planted upstream of the field, re-enforcement by hoeing may be necessary. If *tef* is planted upstream, the cut of drain (*Boraatii*), which is constructed at the upper most end of the field to divert all the runoff before it enters into the field, should be reinforced by stones, wood, blocks of soils with grass, especially across depressions.

The type of crop planted is also important factor determining the type and intensity of the structures. In fields planted to small cereals, since the seedbeds are fine and even packed for tef, higher runoff rates are expected. Thus to prevent the seed, fertilizers and soil loss due to runoff, semi-parallel drainage furrows known as "*Bo'oo*' or '*yaa'a* are constructed at relatively closer interval depending on the slope.

The spacing and gradient of *Bo'oo* depends on several factors like slope gradient and length, and land use or crop type of the upstream area. When the slope is steep and long, or when the upstream field is planted to tef and the crop to be planted on the field to be protected is also tef*,* the furrows spacing should be narrow and some times needs to be intercepted by perpendicular furrows such that a net of furrows be formed.

The quality of these measures indicates whether or not the farmer is active. An active farmer monitors what happens at the up stream or neighborhood of his field. He should follow what crops are sown and the direction of *Bo'oos* and *Boraatiis* of the neighboring farmers and up stream of the field in order to implement necessary measures. If his neighbor is directing the runoff to his field, he should receive and rely it to the next or send it to main drains. It is also customary to alert neighbors about the direction of the drainage furrows, so that he may take a necessary measure for his own. It is thus apparent that in the traditional soil and water management system in the area, watershed approach is prevalent and hence, any external intervention should make use of the advantage.

3.3.1.4 Soil fertility Maintenance

In addition to the commercial fertilizers, several traditional soil fertility maintenance techniques have been identified in the area. These include "*Ciicata*" or manuring, crop rotation, fallowing and *Kosii*. In the past since farmers used to have a large number of cattle and area of land, *Ciicata* and fallowing were the major practices for soil fertility maintenance. However, due to population pressure, which resulted in reduced land holding and hence, limited grazing ground, keeping a large herd and leaving a land fallow, have gradually become difficult. Hence, the use of such practices is highly challenged. Nevertheless, some of the practices are still visible as a persistent means.

Ciicata/Jijjiirra – Refers to the process of kraaling cattle at night and rotate the position of the barn regularly in order to uniformly distribute manure to crop fields. In this case not only manure, but also urine that is with high N content is distributed. All the farmers in the region want to practice *Ciicata* alone or in combination with inorganic fertilizers. However, herd size is a necessary condition to practice it. In this region cattle spend the nights in the barn. They drop their manure with their urine in the barn that rotates to new plots after 3 to 7 days depending on the season, crops to be planted and density of the herd. Longer kraaling is exercised during the dry seasons. For heavy feeder crops such as maize, sorghum and potato, longer kraaling are required. Shorter kraaling is often exercised during the rainy season for tef and other small cereals. Since grazing lands including crop stubbles are communal, a farmer with larger herd size benefits more through *Ciicata*. As a consequence, farmers still tend to keep a larger herd of their own or relatives. *Ciicata* avoids the major problems of transportation and distribution of manure, which is one of the major constraints of manure use in the other parts of the country. In East Shoa for instance, use of manure is limited to backyard mainly due to the problems of transportation and distribution as well as its limited availability since it is used as fuel. The other advantage associated with this practice is that crop residues and other herbs can easily be incorporated. Hence, in addition to soil fertility improvement, weed is also well controlled.

After *Ciicata* all cereals can be planted. The common practice is to plant maize, followed by sorghum or wheat and faba bean (*Vicia faba*) or tef. Thus *Ciicata* is integrated with crop rotation, which is often practiced in many parts of the country.

Crop rotation - The major cereals, after legumes or oil crops are rotated mainly for soil fertility maintenance, weed and disease control. In the rotation pattern, Vicia faba, field pea, linseed and barely are considered to improve soil fertility while tef and wheat are said to exhaust soil nutrients.

Fallowing- is a practice of abandoning land for rejuvenation when the nutrients are exhausted. Fallow land is commonly used as a grazing ground for five to seven years depending on land holding of the farmer and the nature of the land to recover. This practice is diminishing and becoming only things of the past.

Kosii - is a practice of spreading households' wastes to the field for soil fertility maintenance. '*Kosii*, which literally means waste, consist all kinds of human and livestock residues/leftovers in and around the residence. In the farm household, cleaning grains before grinding is among the daily practices. This leaves weed seeds as a residue to be cleaned away as any waste and distributed to the field as *Kossi*. Consequently, the practice is criticized for inducing weed infestation to the field. Therefore it is recommended that pretreatments, like composting be carried out before it is applied to the field.

3.4 Focused Group Discussion at Diggaa Leeqaa District

Diggaa Leeqa district is characterized by high altitude, high rainfall (total and intensity), low temperature, and undulating landscape. In this district, the MoA has introduced several Soil and Water Conservation works. The works have been demonstrated for the last ten years in order to transfer the practice to the farmers. Terraces are the most commonly used measures in the area. As has been claimed by the MoA staff, due to the improvements made to the design and construction, farmers accept the measures.

Although most farmers agree with the improvements made on the structures compared to the conventional terraces, they still complain that the new terraces stumble their tillage operations and incur wastage of land; hence the importance is gradually diminishing.

Soils- Similar to *Jimma Horro*, farmers perceive four types of soils: (*Biyyo gurraacha*, *Biyyo diimaa, Lafa Cirrachaa/goordana/Shaakii* and *Kooticha*).

Table 6. Soil types and their location in toposequence, constraints and advantages

Soil type	Location in top sequence	Constraints/advantage
Gurraacha	Valley bottom and upper	Lodging for some crops, limited are/Fertile
Diimaa	Middle and upper	Productive, workable/Requires more fertilizer
Kooticha	Valley bottom	Water logging, less fertile/less erosion
Cirracha/goordana	On the summit	Very poor

Source: PRA result

The composition of the soils is changing gradually from black to brown, down the top sequence. Farmers attribute the change to continuous and intensive tillage, particularly for tef, which requires 5-6 tillage and soil erosion. Similar to Jimma Horro *Biyyo gurraacha* stands to be the most productive followed by *Biyyo diimaa*. However, *Biyyo diimaa* is perceived to be the most productive soil under sufficient fertilizer input. *Biyyo gurraacha* is available in limited quantity. Kooticha is said to be less productive and mainly used for Barley (*Hordeum vulgare)* production. *Cirracha* is a very poor soil that may not be preferred for any crop in the farming system.

4. Summary and conclusion

Farmers in the study areas have a wealth of knowledge about their land resources, its characteristics, limitations and potentials, and management options. *Biyyo Gurracha, Biyyo Diimaa, Kooticha* and *Lafa Cirracha* are among the dominant soils identified by the farmers. These soils are situated in the top sequence from well-drained steep slope to the level waterlogged bottomland. Their coverage varies from place to place depending on the landscape, intensity of cultivation, and the parent materials. It is also remarkable that the proportion of the soils is changing from the most fertile dark soils to less fertile light colored soils.

The awareness about the existence and extent of land degradation and nutrient depletion; and its contributory factors are pre-requisite for farmers to undertake any effort to arrest the problem. Farmers in the study area recognized soil erosion and nutrient depletion, and established cause and effect relationship between factors. The major causes of land degradation and nutrient depletion are soil erosion, intensive tillage and exhaustion of nutrients by crops, and deforestation. Apparently, crop type and crop management emphasized particularly with respect to soil erosion. Small like tef, which require highly intensive tillage and smooth seedbed are detrimental while legumes and oil crops contribute positively. On the side of the solution to the over-riding problems, they have various options, which range from simple mechanical or agronomic to integrated; and from a field level to a watershed approach.

The result indicates that some of the indigenous practices of soil and water management in the area are consistent with other practices found in different parts of the country (Azene, 1997; Million, 1996; Kebede *et al*., 1996), while others seem to be unique to the area. *Joro* for soil conservation and nutrient management, and *ciicata, Kolaasaa* and their integration with crop rotation for soil fertility maintenance and weed control are among the unique practices to the area. These are widely used in the areas, and are appreciated by all the farmers. Most farmers want to continue to use them alone or integrating with chemical fertilizers. There is a plenty of potential that needs to be exploited from this system. It is therefore, judicious that the practices be bio-economically evaluated in-situ, and adopted or adapted to other similar areas.

Boraatii and *Bo'oo* or *Yaa'a* are the commonly used indigenous technologies to arrest the problems of soil erosion. These are common practices in different parts of the country; nevertheless, their efficiencies are not well studied. Therefore, detailed characterization, evaluation and, if need be modification for best use might be necessary.

Most of the soil conservation and fertility maintenance practices are well integrated in to the existing farming system. Consequently, there may not be difficulty to adapt or adopt the practices in to other areas with similar biophysical and socio-economic situation. The use of *Joro* is highly limited by moisture availability and tillage frequency. Consequently, despite its uniqueness and technical suitability, use of *Joro* is diminishing and limited to localities where grasses are the major weeds. Tillage frequency, particularly when exercised early before the onset of rainfall, kills the grass weeds and leaves no thrush materials for Joro. Although most of the technologies are easy, but with tremendous potential, it is necessary to investigate and evaluate them both physically and socio-economically before opting for their promotion to other areas.

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Reference:

Azene Bekele-Tesemma (1997) A participatory agroforestry approach for soil and water conservation in Ethiopia. Trop. Res. Mgmt Papers 17, 1-229.

Hurni, H (1986) Guidelines for Development Agents on Soil Conservation in Ethiopia CFSCDD, Ministry of Agriculture, Addis Ababa

Kebede A., Kederalah I. And Mesfin S. (1996) The flexibility of indigenous Soil and Water Conservation techniques: a case study of the Harerge Highlands, Ethiopia In:Chris Reij, Ian Scoones and Camilla Toulmin (eds) Sustaining the Soil Indigenous soil and Water Conservation in Africa International Institute for Environment and Development

Kerr J. and Sanghi N.K. (1993). Indigenous Soil and Water Conservation in India's Semi Arid Tropics. Sustainable Agriculture Program of the International Institute for Environment and Development. Gatekeeper Series No. 34

Million A. (1996) Traditional ditches in northern Shewa, The Ethiopian highlands In:Chris Reij, Ian Scoones and Camilla Toulmin (eds) Sustaining the Soil Indigenous soil and Water Conservation in Africa International Institute for Environment and Development

Shaxon T.F, Hudson, N, Sanders, D, Roose, E and Moldenhauer, W (1989) Land Husbandary: A Framework for Soil and Water Conservation Soil and Water Conservation Society, Ankeny, IA