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Status of implemented traditional and improved soil conservation practices in selected districts of Sidama,Gedio and Halaba Zones.

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Abstract: *Soil and water conservation is the only way to protect, control, and manage the influence of water, wind, and farming activities on soil erosion. Many introduced and traditional soil and water conservation techniques were implemented using various approaches in many places of Ethiopia, particularly the Southern Region. However, many traditional and introduced SWC techniques have yet to be investigated and identified. The overall goal of this study was to identify traditional and introduced SWC techniques, as well as their implementing system, function, category, and implementing season. The cropping system and its function were also evaluated, as were the difficulties of implementing SWC methods. The research was carried out in three SNNPRS districts. Based on the SWC practices status, two kebeles were chosen from each district. LayignaArisho and M/gortanichokebeles of WeraZuria district; TanakakaUmbullo and Kajima Umbullo of HawassaZuria district; and Tutitti and worabikebeles of Yirga Chafe district were among the kebeles. The study's data was gathered from both primary and secondary sources. The data was collected via a farmer's interview and questionnaire, a focus group discussion, and a transect walk. The findings demonstrate that both traditional and introduced SWC practices were practiced in all of the studied kebeles. Individual SWC practices' area share varied from one area to the next. Different traditional customs were practiced in different districts.*

Keywords: *Soil erosion, traditional soil and water conservation measures, introduced soil and water conservation measures, transect walk*

Abbreviations: GOs;Governmental organization, NGOs; Non-Governmental Organization, SCRP;Soil Conservation Research Project, SWC;Soil and Water Conservation., US$; United states dollar, ^{0}C;.Degree cent grade.

1. INTRODUCTION

Soil erosion is a global environmental concern that causes the loss of fertile top soil, reduces land productivity, and raises the danger of global food security. It reduces agricultural output and degrades water quality. Soil erosion is expected to cost the world approximately 10 million ha of agriculture each year, with the Mediterranean and China being particularly vulnerable. The Soil Conservation Research Project (SCRP) estimates that the Ethiopian highlands lose roughly 1.5 billion tons of soil each year. Due to extensive cultivation on steep and vulnerable ground, the Ethiopian highlands have experienced decreased soil fertility and considerable soil erosion (Abegaz, 1995). Ethiopian authorities claim. Ethiopia losses around 2 billion tons of fertile soil and subsequently losses 2% of the annual grain production, which is roughly equivalent to 120, 000 tons of cereal per annum (Mesfin, 2004).Ethiopia loses around 2 billion tons of fertile soil per year, resulting in a 2% loss of yearly grain production, which is roughly equivalent to 120, 000 tons of wheat each year (Mesfin, 2004). Mesfin (2004) estimates that the annual loss in grain output due to erosion was 170,000 tons in 2000. This represents a $150 million loss in income due to decreased agricultural productivity. Modeling studies also predicts that soil erosion in Ethiopia will diminish land potential productivity by 10% in 2010 and 30% in 2030. As a result, the agricultural sector's value contributed per capita per year falls from US$372 in 2010 to US$162 in 2030 (Sonneveld and Keyzer 2003). Thus, reversing soil erosion is a top priority in order to attain food security, poverty reduction, and environmental sustainability in the country (Bewket and Teferi, 2009; Abate 2012).

The only known technique to protect productive land is through soil conservation (Panda, 2007). It can be accomplished by exploiting and maintaining the land based on its capabilities, incorporating the implementation of optimal management techniques, and resulting in lucrative crop production without land degradation (Panda, 2007). After the famines of 1973 and 1985, the government (GOs and NGOs) initiated many programs, including the food-for-work program, which was implemented for a long time in Ethiopia (Hoben, 1996). Following this approach, community collective action and farmers' personal trials were used to develop various physical and biological soil and water conservation techniques. On the other hand, various land-improvement technologies and techniques have been introduced in the region by research institutes, extension agents, and other development practitioners (Wagayehu and Lars, 2003).

Traditional soil and water conservation is a practice used by farmers to maximize productivity from a particular piece of land while reducing soil loss below a certain level. The rate of erosion at which soil fertility may be maintained for at least 25 years is defined as the soil loss tolerance value (Hurni, 1983). Traditional soil and water conservation methods are frequently neglected or undervalued by development agents, researchers, soil conservationists, and government personnel (IFAD, 1992). Although the goals of learning traditional soil and water conservation strategies help us comprehend farmers' perspectives on the measures (Hudson, 1992). Farmers use a variety of traditional soil and water conservation measures to minimize soil erosion. Cut-of-drains, leaving crop residues in the field, manure distribution, contour farming, fallowing, planting root crops by preparing bunds, tree planting on slope farm, use of trash lines on contour, row planting, alley cropping, intercropping, strip planting, and plantation of Sisal (Agave sisalana Perrine) and Euphorbia (Euphorbia classenii) on the farm, etc. According to Genene M. and Abiy G. (2014), most farmers in south western Ethiopia perform introduced and traditional soil and water conservation activities such as contour farming, furrow creating, residue leaving, agronomic methods, putting garbage lines on contour, and so on. Appropriate soil and water conservation technologies are those which offer for a given production situation an optimal solution for using the land for sustainable and productive agricultural purposes. Appropriate technologies are not necessarily “simple” technologies. However, in the context of many developing countries, the appropriate technologies will be ones which are not capital-intensive and which use local resources and the existing labor force in an optimal way.

It should be stressed that before introducing a new technology, it is vital to determine whether existing local soil and water conservation methods exist, as well as why and how farmers use these traditional technologies. If such technologies exist and continue to be used by farmers, they can be regarded successful and, if not introduced and maintained by legal force and state authority, will be found to produce tangible benefits upon inspection. Understanding why farmers use such technologies, i.e. the production and conservation benefits they receive, is critical to the successful introduction of any "new" technology, which must at least match, if not improve, on the benefits obtained from existing ones (CARDI, 2010).

The effectiveness of soil and water conservation measures in decreasing soil loss varies according to soil type, land use, land cover, terrain, climate, and measure intensity. Among the key contributors to erosion reduction are farming systems in general and land use land cover in particular. The key elements in this regard are related to the day-to-day activities of landowners/farmers. As a result, they protect their land on their own for crop productivity. Many traditional soil and water conservation (ISWC) strategies that can prevent soil loss were assessed by many authors, but they were not grouped in a way that integrated their historical analysis, source, and property, technical, social, economic, and cultural characteristics. So, for this project, different Traditional and Imported that could provide value in reducing soil erosion and increasing moisture on farms were found and investigated. The study's aims were to identify, measure, and describe various traditional and introduced soil and water conservation methods, as well as to understand the purpose of implementation and the importance of identified traditional and introduced SWC activities.

2. METHODOLOGY

2.1. Description of study site

Southern nations,nationalities and peoples region is one of Ethiopia's nine regional states located in the south and south west. Geographically, it is located in 4027' and 8030' N and 34021' and 39011'E, with an altitude of 376 to 4207masl and a mean annual temperature of 150c to 300c. WeraZuria, HawassaZuria, and Yirgachafe districts, in particular, are located in the three center zones of the region's south nations, nationalities, and peoples. The districts are located in 7.49330N and 38.19000E, 07005.233'N and 038021.688 E, 38.19042N and 6.13628E, and 38.19042N and 6.13628E, respectively.Werazuria, Hawassazuria, and yirgachafe districts' agro ecologies are classified as midland, dry midland, and highland, respectively. The three districts' rainfall patterns are bimodal, with low rainfall during the dry season and heavy rainfall during the major rain season.

2.2. Data collection methods and Analysis

Data were gathered from both primary and secondary sources. Using an interview and a written questionnaire, primary data were collected from selected farmers in each kebele. To identify SWC practices, focus group talks were held with woreda's agricultural and natural resource management office. The conversation included agricultural experts from many areas. A transect walk was also conducted in order to identify, quantify, and describe various traditional and introduced practices in chosen kebeles. Secondary data were gathered from agriculture and natural resource management offices at the regional, zonal, and woreda levels, as well as various literatures. The collected data was analyzed using descriptive statistics and the SPSS 20.0 software package.

3. RESULT AND DISCUSSION

3.1. Rainfall and productionpatterns of study area

Farmers in WeraZuria and HawassaZuria areas grow agricultural crops twice a year, during the Belg and Meher production seasons. On average, the district receives medium to low rainfall in September and October; no rainfall in November, December, January, February, and March; and medium to low rainfall in April, May, and June. Maximum rainfall occurs in July and August. (Data from the 2022 survey).Yigachafe district, like WeraZuria and HawassaZuria districts, has two crop production seasons per year. Rainfall in the Yigachafe area, on the other hand, begins in March and finishes in November. The area receives a lot of rain in September, October, and November; very little rain in April, May, June, July, and August; and no rain in December, January, February, and March (Source: YirgachafeWoreda agricultural and natural resource management office, 2022).

3.2. Major agricultural crops and their erosion management practices in selected districts.

The three districts have the ability to produce a variety of agricultural crops. The following are some of the most prevalent crops recognized by district: Common crops grown in the WeraZuria district include teff, maize, wheat, pepper, sorghum, haricot bean, chit cabbage, and finger millet (Dagussa). Common crops grown in the HawassaZuria District include haricot bean, maize, coffee, inset, and pepper. The most often produced agricultural crops in the Yirgachafe district are barley, wheat, pea, cabbage, haricot bean, teff, and sweat potato. Farmers use several adaptation strategies for erosion management depending on whether the rain fall distribution of the lands is maximal or minimal. Some of them are the practice of early sowing during the scarce rainfall season, irrigation practices during the scarce rainfall season, use of open and close-ended tied ridges to conserve water during minimum rainfall, use of cut of the drain during excess water, contour terracing, physical soil, and water conservation bunds, and planting of different plants such as sugar cane, grass, banana, and inset at erosion expected positions.

3.3. Cropping system and its use in specific districts

Cropping strategies such as monocropping and intercropping were the most common cropping systems used in the three areas. The intercropping system of maize and common bean was prevalent in three districts. Rotational cropping systems were widely used in two districts, namely WeraZuria and Yirgachafe. Agroforestry covered the majority of the area in Yirgachafe District. In WeraZuria district, there was a lot of talk about the maize producing method. Similarly, there was a coffee and maize Agroforestry system practiced in the HawassaZuria district. According to farmers' perceptions, the functions of the above-mentioned cropping systems vary depending on their kind, for example, intercropping and agroforestry systems can give improved production, minimize nutrient competition between crops, increase soil fertility and disease control, and so on. Crop rotation results in higher yield, disease control, improved soil fertility, and other benefits. Finally, an agroforestry system can deliver several benefits from a small plot of land by reducing nutrient competition, improving soil characteristics, and increasing land sustainability.

3.4. Common traditional soil and water conservation practices.

Traditional or intrinsic soil and water conservation practices are soil and water conservation measures used by farmers to control soil erosion. Aside from exotic soil and water conservation practices, individual farmers have undertaken traditional soil and water conservation activities with the goal of minimizing soil erosion, conserving soil moisture, and boosting soil fertility at the family farm level. The following are the identified Traditional SWC practices and their implication based on respondents attitude of the studied areas:-

Contour tillage: It means that cultivation takes place following the contour. The practice is critical for soil conservation. The approach was traditionally used in the three districts by farming the land horizontally along the contour on sloppy grounds. In terms of soil conservation, the farming technique was used to boost soil infiltration rate, regulate slope difference, decrease runoff velocity, and harvest water on furrows. (Survey data from 2022).

Manuring/compost application: The practice implies the use of animal excrement to boost soil fertility and moisture levels. Animal manure, such as that of cattle, goats, horses, donkeys, and sheep, was commonly collected near the farmer's dwelling in the three areas. They employ gathered animal excrement as an organic fertilizer on farming lands. Farmers in LayignaArisho, Kajima Umbullo, and Tuttitikebeles collect green plant residues, ash, animal feed remnants, and waste to utilize on croplands. The practice is useful to traditional peoples since it is simple to implement, increases soil fertility, increases crop yield, and improves topsoil resilience to erosion. Farmers can use it during crop planting and at various phases of crop growth. It can take the place of inorganic fertilizers. (Source: own survey)

Mulching: It denotes the covering of the soil surface with stubbles, plant residues, and plant remains/straw. The traditional SWC practice is common in LayignaArisho, Kajima Umbullo, Worabi, Tutitti, and TankakaUmbulloKebeles. Farmers believe that the method increases soil penetration rate, improves soil properties, conserves and retains water, and lowers raindrop influence on soil. (Survey data from 2022).

Tree planting: Represents the planting of perennial trees to mitigate soil erosion. This system is used in all of the study area's kebeles. Farmers repair abandoned, pasture, or common areas by planting various species of trees. In addition, trees are planted on sloppy lands to minimize runoff velocity and stabilize the land. (Survey data from 2022).

Enset, Banana and Sugarcane planting: Enset, banana, and sugarcane plantations are abundant in the research areas, particularly in TanakakaUmbullo, Kajima Umbullo, Tutitti, and worabikebeles. Farmers in those kebeles cultivate crops in eroding directions in order to reduce runoff velocity and stabilize the land. Farmers in TanakakaUmbullo and Kajima Umbullo also employ crops for gully rehabilitation, planting them at the top of crop land to protect it from erosion. (Survey data from 2022).

Crop rotation: It refers to the technique of producing a variety of crops in the same region over the course of several growing seasons. It lowers dependency on a single set of nutrients, pest and weed pressure, and the likelihood of acquiring pest and weed resistance. Crop rotation/alternative cropping systems are frequent in the three research areas, according to data collected about the area. Farmers in the areas can plant one crop kind during a specific season and the other crop type during the following cropping season of the year. In LayignaArisho and MirabGortanichokebeles, maize, common bean, and potato are planted exclusively in the belg season, and potato, maize/sorghum, and wheat are planted in the mehar season. Similarly, farmers in Kajima Umbullo and TankakaUmbullokebeles might plant maize crops in belg season on a specific plot of land, then plant common bean in meher season on the same plot of land in successive seasons. Farmers in the research areas use this cropping technique to boost crop to grain yield, reduce disease, minimize soil degradation, and improve soil quality. (Survey data from 2022).

Intercropping: This is the cultivation of two distinct annual crops on the same plot of land during the same cropping season. This is a prevalent practice throughout the three study districts. Planting maize and common bean on the same plot of land, for example, was prevalent in kajimaumbullo, tankakaumbullo, layignaarishokebeles, and M/gortanichokebeles. Farmers in Tuttiti and Worabikebeles planted maize with peas and maize with beans on the same area of land. They used this cropping strategy to receive two benefits/outputs from a specific piece of land at the same time, to limit nutrient competition between crops, to reduce disease, to improve soil qualities, and to safeguard soil quality. (Survey data from 2022).

Agro forestry: The term refers to land-use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, and so on) are actively employed on the same land-management units as agricultural crops and animals, in some sort of spatial arrangement or temporal sequence. Farmers in the study locations planted annual crops inside perennial trees on a specific plot of land. Tuttiti and Worabikebeles, in particular, were well-known agroforestry system practiced parts of the region. Inside perennial trees, they plant enset, maize, pea, bean, barley, wheat, and other crops. According to the respondents' attitudes, the farming method was used to offer two or more outputs, reduce nutrient competition, illness, improve soil nutrient content, and raise land productivity. (Source: Survey data, 2022).

Traditional planting pit: This method entails the traditional preparation of several rainwater-collecting small traditional pits within the coffee farm. The preparation of small traditional pits to gather in-situ water inside coffee farms was widespread in Tuttiti and Worabikebeles. Farmers in the area used this technology to boost soil penetration rate, preserve water, raise groundwater potential, and improve water availability for crops such as coffee. (Survey data from 2022).

Fallowing: This is a farming strategy in which fertile land is left unplanted for one or more vegetative cycles. Its purpose is to allow the earth to recover and store organic matter while maintaining moisture and interrupting pathogen lifecycles by removing their hosts temporarily. Farmers could fallow their agricultural land for one or more years if the land's production capability begins to deteriorate from year to year. This was a common practice in the Tuttiti and Worabikebeles. Farmers in the area use this system for the following reasons: disease prevention, soil nutrient content improvement, soil sustainability, and increased land production. (Survey data from 2022).

Cut off drain: Excess water is carefully discharged into waterways. Cut-off drains are trenches excavated across a slope to collect surface runoff and securely transport it to an outlet such as a canal or stream. Farmers in Tuttiti, Worabi, LayignaArisho, and M/gortanichokebeles used this traditional technology to remove excess water from their agriculture fields. According to the respondents, they used the technique because it allows them to easily remove excess water from their farm fields without damaging the soil or crops, it protects the land from serious erosion by safely removing water, and it protects the land from water logging and siltation problems (Source: Survey data, 2022).

Table1. *Summary of identified traditional soil and water conservation practices of the study areas based on farmers response.*

No.	Name of SWC practices	Kebeles	Local name	Implementing system	Importance of the practice based on farmers response	SWC category	Implementing season
1.	Napier grass planting	LayignaArisho and M/gortanicho	Duffakaasu	Planting of Duffa grass at water flow direction.	- Helps to minimizes rain drops impact on soil by interception - It Prevents soil erosion by saving water and slowing flow.	Biological SWC practice	At wet/ summer season.
2.	Banana, enset	LayignaArisho and	Muza, weesitashonkoraKaasu	Planting of banana plant	- Used as	Biological	Wet/Summer

	and sugarcane planting.	M/gortanicho		at erosion prone or runoff flow areas.	a barrier for eroding water flow. - Reduce runoff flow velocity. - Stabilize the land.	SWC practice.	season.
		TankakaUmbullo and Kajima Umbullo	Shonkora,MuzenaWeeseKaasha				
3.	Manuring	LayignaArisho and M/gortanicho.	Shallaujju	Applying organic manure on farm lands.	- Retain water - Improve soil nutrient and increase soil productivity. - Increase infiltration rate.	Agronomic SWC practice.	Wet and dry seasons. Before crop planting.
4.	Contour farming	LayignaArisho and M/gortanicho	Zaabehoguta	Farming/ploughing the land across the slope along the contour.	- Reduce erosion rate and run off velocity. - Conserve water - Facilitate soil infiltration rate. - Manage slope difference.	Agronomic SWC practice.	During farming season.
		TankakaUmbullo and Kajima Umbullo	HawittoLoosa				
		Tuttiti and Worabi.					
5.	Mulching	LayignaArisho	Bonxategalabauju(Guzguaz)	Leaving different crop residues/remains on farm lands.	- Increase soil infiltration rate - Improves soil property. - Conserve and retain water. - Reduces raindrop effect on soil.	Agronomic SWC practice.	Wet and dry season
		Kajima Umbullo and TankakaUmbullo.	DaroDiba				
		Worabi and Tutitti					
6.	Brush wood check dam	LayignaArisho and M/gortanicho.	Kitir/haqiribrabuta	Placing different stem parts of tree cut inside gullies and rills.	- Used as a barrier for water flow on the gully. - Reduce runoff velocity and others.	Mechanical SWC practice.	Dry/off season.
7.	Intercropping	LayignaArisho and M/gortanicho.	Lammuta	Cropping two different annual crops on the same plot of land at the same season. Example: maize and common bean.	- Two benefits/outputs at the same season. - Reduce dnutrient competition between two different crops. - Reduce d disease. - Improves soil	Agronomic SWC practice	Wet/Planting season
		Kajima Umbullo and TankakaUmbullo.	Karsiisekaasa.				
		Worabi and Tutitti					

					properties. - Protect soil quality.		
8.	Crop rotation	LayignaArisho and M/gortanicho.	Doransu.	Cropping of one crop at one season and other at the next season at the same plot of land.	- Reduces disease. - Increases crop yield. - Improves soil quality.	Agronomic SWC practice.	Planting season.
		Kajima Umbullo and TankakaUmbullo.	WitaSoranWita				
		Worabi and Tutitti	EyekayayaruMazirat.				
9.	Plantation of Sisal (Agave sisalana Perrine).	Kajima Umbullo and TankakaUmbullo.	Argissa/Kanche	Planting of sisal at erosion prone areas.	- Stabilize the land. - Reduce runoff velocity.	Biological SWC practice.	Wet/summer season.
10.	Tree planting	LayignaArisho and M/gortanicho.	Haqqakaasu	Planting of different tree species on sloppy and degraded lands.	- Stabilize the land. - Rehabilitate the area. - Reduce runoff velocity. - Improves soil errodiblity.	Biological SWC practice.	Wet/summer season
		Kajima Umbullo and TankakaUmbullo.	HaqqeKayisa				
		Worabi and Tutitti					
11.	Agro forestry	Worabi and Tutitti	Timir Dan	Planting of different annual crops inside the perennials. Example: maize and coffee. Maize and warka tree.	- Provide two or more outputs. - Reduce nutrient competition. - Reduce disease - Improve soil nutrient content. - Increase land productivity.	Biological SWC practice.	Wet/summer season
12.	Traditional pit.	Worabi and Tutitti	Gudguad	Preparation of different water harvesting small traditional pits inside the coffee farm.	- Increases soil infiltration rate. - Conserve water. - Increase ground water potential. - Improves water availability for crops like coffee.	Physical SWC practice.	All seasons.

13.	Cut off drain.	LayignaArisho and M/gortanicho	ZoofiBoyita.	Farmers prepare drainage way/cut off drain to remove excess water from farm field at sloppy areas.	- It helps for easily removal of excess water from the farm field without affecting the soil and crop. - It protects the land from serious erosion by safe removal of water. - It protect the land from water logging and siltation problems.	Physical SWC practice.	Summer/ rainy season.
		Worabi and Tutitti	Boyi				
14.	Fallowing.	Worabi and Tutitti	Masadar	Staying the land for one or two years without crop production/farming.	- Prevent disease. - Improve soil structure and nutrients. - Improves soil sustainability. - Increases land productivity.	Agronomic SWC practice	All seasons.

Source: survey data, 2022.

3.5. Traditional SWC Practices' Area Share

According to the graph below, sisal, banana, enset, and sugarcane plantation practices predominate in TankakaUmbullokebele of HawassaZuria district, followed by contour farming, tree planting, mulching, and intercropping. Tree planting, banana and enset planting, and contour farming practices predominate in Kajima Umbullokebele of HawassaZuria district, followed by mulching, sisal plantation, intercropping, and cut-off drainage. Manuring, intercropping, tree planting, brush wood check dam, mulching, cut-off drain, and contour farming are the major methods at LayignaArisho in the WeraZuria district, followed by banana and enset planting, Napier gass planting, and contour farming. Similarly, banana and enset planting, as well as Napier grass planting, are dominant Traditional SWC methods in the WeraZuria district's MirabGortanichokebele, but are followed by brush wood check dam, manuring, intercropping, mulching, tree planting, contour farming, and cut-off drain. Agroforestry and tree planting predominate in Tutittikebele of Yirgachafe district, followed by contour farming, intercropping, mulching, fallowing, traditional pit, and cut-off drain. Similarly, in Worabikebele in Yirgachafe district, agroforestry and tree planting are prevalent, followed by contour farming, intercropping, mulching, fallowing, cut-off drain, and traditional pit. (Survey data from 2022).

3.6. Commonly implemented soil and water conservation strategies in the research locations.

Soil and water conservation methods that have been implemented are current practices learned through training or with the assistance of agricultural specialists. Physical/mechanical, biological, and agronomic soil and water conservation strategies may be used (survey data, 2019). Soil and water conservation practices have been introduced and implemented by government organizations, primarily the regional Bureau of Agriculture, from the region to the district level. Furthermore, several voluntary groups, including bilateral and multilateral organizations, have implemented soil and water conservation strategies in highly degraded areas to slow the rate of land degradation, particularly soil erosion.(Survey data from 2022).

Soil bund: A soil bund is a structural measure that forms a soil embankment beneath a ditch. Soil bunds were introduced to all kebeles in each district based on data obtained from all study districts' farm and natural resource development offices. This structure was mostly built in response to public complaints each year. It was accomplished by drawing and excavating a line between two places along the contour and depositing the excavated earth beneath the ditch. This edifice was built on terrain with a slope of 3-30%. It measured 10m in length, 30-70cm in breadth, 30-60cm in depth, 20-25cm in burm width, 40-60cm in embankment height, and 30-50cm in embankment width. This was done to retain moisture, promote soil infiltration, reduce erosion by reducing runoff velocity, and gather water from the ditch. (Survey data from 2022).

Fanyaaju bund: It refers to the structural measure of forming a soil embankment above a dug ditch. It was also built on farmland by watershed management public complaint effort. It was accomplished by planning and excavating a space between two contour points along the contour, then dumping the excavated earth above the ditch. This edifice was built on terrain with a slope of 3-50%. The proportions were similar to soil bunds in that they were 10m long, 30-70cm wide, 30-60cm deep, 20-25cm burm width, 40-60 embankment height, and 30-50cm embankment width. This was done to retain moisture, promote soil infiltration, reduce erosion by reducing runoff velocity, and gather water from the ditch. (Survey data from 2022).

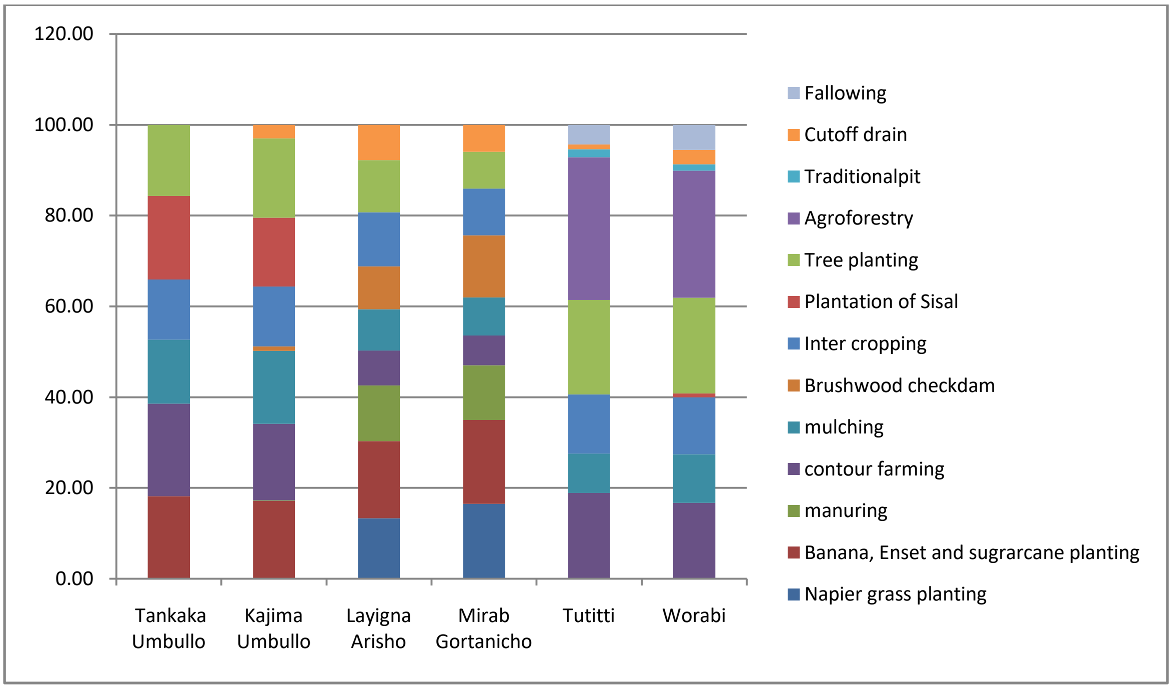

Fig1. *Area share of each traditional SWC practices per kebele*

Trench bund: Trenches were built in response to public outcry and by individual farmers. It was built along the contour. Trenches were not longer than 2-5m in length, and the depth of each trench was not less than 50cm. Different tree species were planted to support the bund and the region at Tuttiti, Worabi, and LayignaArishokebeles, but some of the planted trees were dried out. This was done to conserve moisture, harvest runoff water, rehabilitate degraded and closed areas, raise ground water potential, soil infiltration rate, and improve crop water availability. (Survey data from 2022).

Tied ridges: It is common practice to prepare water-saving ditches with ties that connect the ditches. The method was used on maize and sorghum farms, particularly in LayignaArisho and M/gortanichokebeles. This was done to boost agricultural water availability, soil infiltration rate, and in-situ water conservation. (Survey data from 2022).

Sand filled check dam: To some extent, the SWC approach was used to rehabilitate gullies at LayignaArisho, M/goritanicho, TankakaUmbullo, and Kajima unbullo. This procedure was carried out by filling bags with sand/soil and then erecting them horizontally as a gully flow barrier. It was done to control gully erosion and to act as a gully run-off barrier. (Survey data from 2022).

Gabion: This gully control measure was used to rehabilitate big gullies at LayignaArisho, Kajima umbullo, and Tankakaumbullokebeles. It was built horizontally on the gullies using stone and gabion mesh. This approach was used to rehabilitate huge gullies, reduce runoff velocity, and function as a barrier for runoff on the gully. (Survey data from 2022).

Farm pond and Improved pit: The term "farm pond" refers to the construction of a water collecting pond within or near an agricultural land. With government assistance, this technique was carried out to considerable extent in LayignaArisho and M/gortanichokebeles. This was done to water animals, irrigate crops during the dry season, and minimize water scarcity. In other words, in Tuttiti and Worabikebeles, improved pit was implemented by excavating a pit with the specified size of 50cm width and 50cm depth. It aids in improving agricultural water availability, particularly for coffee, and conserves both in-situ and flowing water. (Survey data from 2022).

Microbezin and eyebrow bezin: These Physical SWC activities were used in the kebeles of TankakaUmbullo and Kajima Umbullo. The structures were built in the shape of a half moon along the contour, at communal lands and closure zones. These actions were taken to conserve/harvest water, enhance water availability for trees planted on the structure, and restore damaged land. (Survey data from 2022).

Grass Strip: Planting grasses horizontally along the contour of farmlands was typical in Kajima Umbullokebele. To combat erosion, elephant and desho grasses were utilized to grow grass strips on farm land. According to the responders, the approach was important for controlling soil erosion by minimizing the effect of raindrops and runoff velocity. In addition to preventing erosion, it provided a valuable supply of fodder for animals. (Survey data from 2022).

Table2. *Summary of identified implemented soil and water conservation strategies in the research locations based on farmers response.*

No.	SWC practice	Kebeles	Local name	Implementing system based on farmers reponse	Importance of the practice based on the farmers response	category	Implementing season
1.	Soil bund	LayignaArisho and M/ gortanicho.	Kaba	It was constructed by digging a line between two points which have equal elevation and throwing the excavated soil below the ditch.	- It helps to conserve soil moisture. - Reduce erosion by minimizing runoff velocity and harvesting water on the ditch. - Improve infiltration rate of soil.	Physical SWC practice.	Dry season
		Kajima Umbullo and TankakaUmbullo.	Irkane				
		Tuttiti and worabi	Irkan				
2.	Fanyaaju bund	LayignaArisho and M/ gortanicho	Kaba	It was constructed designing and digging a line along the contour by throwing excavated soil above the ditch.	- It helps to conserve soil moisture. - Reduce runoff velocity and conserve water. - Increase soil infiltration rate and increases ground water potential.	Physical SWC practice.	Dry season
		Kajima Umbullo and TankakaUmbullo.	Irkane				
		Tuttiti and worabi					
3.	Trench	LayignaArisho and M/	Trencha	It was constructed	- Harvest and control	Physical SWC practice.	Dry season

		gortanicho.		at different communal lands and closure areas by excavating a ditch with 2-5m length along the contour.	runoff water. - Increase ground water potential. - Helps to rehabilitate degraded lands. - Helps to conserve soil moisture, etc.		
		Kajima Umbullo and TankakaUmbullo.	Trenche				
		Tuttiti and worabi					
4.	Tied ridge	LayignaArisho and M/ gortanicho	tayrage	Constructed to harvest water and improve water availability for crops in farm field.	- Improves water availability for crops. - Conserve in situ-water. - Increases soil infiltration rate.	Physical SWC practice.	Wet season
5.	Sand filled checkdam	LayignaArisho and M/ gortanicho	Ashawikuntala	It was done by filling sacks with sand/soil and placing different sand filled sacks on the gullies.	- It helps to rehabilitate large gullies erosion. - It used as a barrier for run off on the gully.	Physical/mechanical SWC practices.	Dry season.
		Kajima Umbullo and TankakaUmbullo	Ashawaogorowonisha				
6.	Gabion	LayignaArisho	gabun	It was constructed by using gabion mesh and stone on large gullies.	- It helps to rehabilitate large gullies. - It reduces run off velocity and used as a barrier for runoff on the gully.	Physical/mechanical SWC practices.	Dry season.
		Kajima Umbullo and TankakaUmbullo	gabonete				
7.	Farm pond	LayignaArisho and M/ gortanicho	Haro/Kure	Constructed near to farm field to irrigate crops during scarce rainfall.	- It helps to irrigate crops at dry season. - Reduces water scarcity.	Physical/mechanical SWC practices.	Dry season.
8.	Improved pit	Tutitti and worabi	Gudguad	Excavating a pit with the specified size (50x50cm) inside coffee farm.	- It helps to conserve in-situ water. - It improves crop water availability especially for coffee.	Physical SWC practice.	Wet and dry seasons.
9.	Grass strip	Kajima Umbullo	Hayiso	Planting of elephant and desho grass horizontally along the contour on farm lands.	- It helps to control soil erosion by reducing rain drops effect and reducing runoff velocity. - In addition to erosion controlling effect it is forage for animals.	Biological SWC practice.	Wet season

10.	Micro bezin and Eyebrow bezin	Kajima Umbullo and TankakaUmbullo	-	It was constructed in half moon shape along the contour.	- It helps to conserve/harvest water. - It improves water availability for tree planted on the structure. - It is important to reclaim degraded area.	Physical/mechanical SWC practices.	Dry season.

Source: survey data, 2022.

3.7. Area share of Introduced SWC Practices

According to the figure below, the dominant introduced SWC practices in TankakaUmbullokebele of HawassaZuria district are soil bund, trench, and Fanyaaju, followed by gabion, improved pit, sand filled check dam, micro bezen, and eyebrow bezen techniques. Soil bund, trench, and Fanyaaju predominate in Kajima Umbullokebele of HawassaZuria district, followed by gabion, micro bezen and eyebrow bezen, tied ridging, grass strip, improved pit, and sand filled check dam. Tied ridging, soil bund, and trenchare the most common adopted SWC practices, followed by sand filled check dam, Fanyaaju, gabion, micro bezen, eye brow bezen, and farm pond in LayignaArisho in WeraZuria district.In contrast, soil bund, trench, and tied ridging are the most commonly used SWC practices in MirabGortanichokebele of WeraZuria district, but they are followed by Fanyaaju, sand filled check dam, farm pond, gabion, micro bezen, and eyebrow bezen. Trench, soil bund, and Fanyaaju predominate in Tutittikebele of Yirgachafe district, followed by grass strip, tied ridging, micro bezen and eye brow bezen, improved pit, sand filled check dam, gabion, and farm pond. Similarly, in Worabikebele of Yirgachafe district, soil bund, trench, and Fanyaaju are dominating, followed by improved pit, micro bezen, and eyebrow bezen.

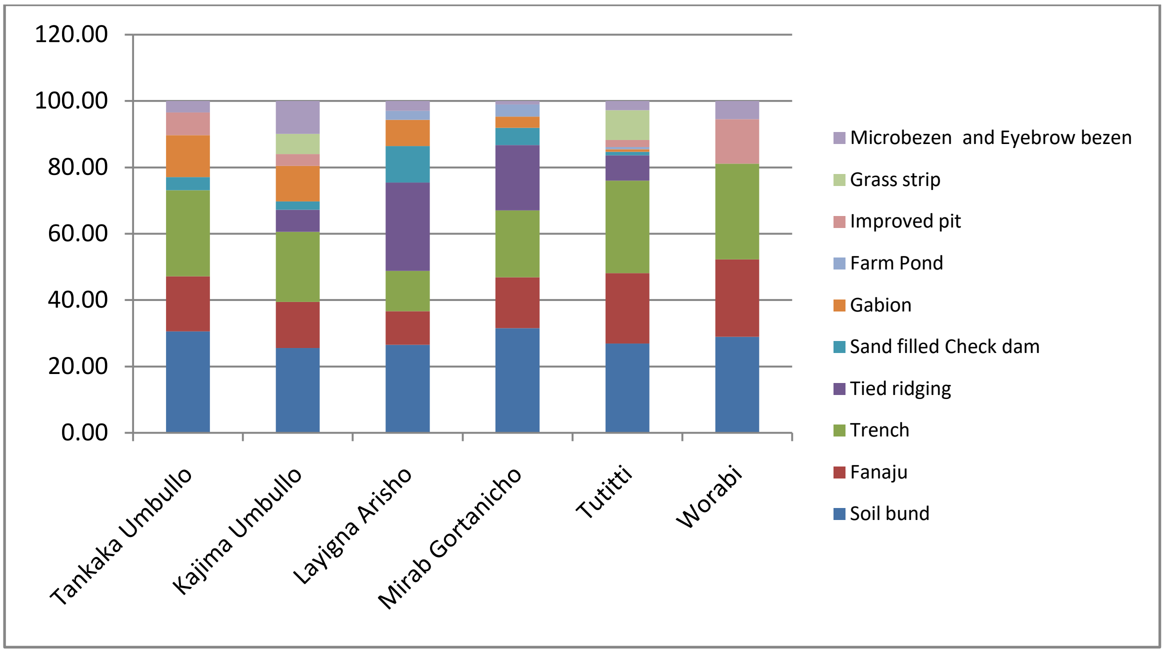

Fig 2. *Area share of introduced SWC practices per kebele*

3.8. Limitations in the research area's soil and water conservation initiatives.

We observed numerous site-specific issues with soil and water conservation operations during a transect walk with development agents. We saw several destructed constructions at MirabGortanicho, LayignaArisho, TankakaUmbullo, and Kajima UmbulloKebeles, which were built by free community involvement each year. According to the responses, farmers were unaware of the impact of physical soil and water conservation methods. According to the development agents, the destruction of the structures at MirabGoritanicho was also done in quest of cultivating land. Furthermore, during our transect walk, we noticed that various physical structures built by the public campaign were not properly constructed and excavated.The structures were not maintained on a regular basis. Biological stabilizers were not used to stabilize some of the bunds. However, due to social, economic, environmental, and political issues, the majority of farmers did not perform technically sound soil and water conservation practices. Among the significant factors mentioned were: Land size is highly related to farmers' perceptions of soil fertility and soil erosion, so farmers with larger farm holdings perceive soil erosion better than those with smaller ones. They practice traditional fallowing and provide adequate grazing pasture for their livestock, which helps to reduce soil erosion and fertility depletion.

4. Conclusion and Recommendation

We find and recommend based on this research that;

- Some physical structures adopted are of poor quality and were not constructed in accordance with the SWC principle.
- Traditional SWC techniques are fundamental for newly introduced practices. There were several traditional practices that were practiced in one district but not in another. As a result, all stakeholder bodies should promote to other areas.
- Even within the same district, the area share of practices varies from kebele to kebele.
- •There is a gap in physical structure implementation, evaluation, regular maintenance, and management. As a result, the task requires serious attention.
- Various research and pre-scaling up efforts on soil and water conservation are required to raise awareness, familiarize, and decrease intentional destruction of bunds by landowners.

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