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182

Highlights of Soil and Water Conservation Investments in Four Regions of Ethiopia

Zenebe Adimassu, Simon Langan and Jennie Barron

International Water Management Institute

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The authors: Zenebe Adimassu is Researcher - Agricultural Water Management at the West Africa Office of the International Water Management Institute (IWMI), Accra, Ghana. Zenebe was previously a Postdoctoral Fellow – Water and Landscapes at the East Africa and Nile Basin Office of IWMI, Addis Ababa, Ethiopia; Simon Langan is Program Director - Water at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. He was Principal Researcher and Head of the East Africa and Nile Basin Office of IWMI, Addis Ababa, Ethiopia, at the time this research study was conducted; and Jennie Barron is Professor – Agricultural Water Management at the Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. She was Strategic Program Leader - Building Resilience at IWMI, Colombo, Sri Lanka, at the time this research study was conducted.

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Contents

Acronyms and Abbreviations

ARTP	Agricultural Research and Training Program
BoA	Bureau of Agriculture
CIDA	Canadian International Development Agency (now Global Affairs Canada)
DA	Development Agent
DoA	Department of Agriculture
EHRS	Ethiopian Highlands Reclamation Study
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nations
FFW	Food-for-Work
GEF	Global Environment Facility
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoE	Government of Ethiopia
GTP	Growth and Transformation Plan
LLPPA	Local Level Participatory Planning Approach
MERET	Managing Environmental Resources to Enable Transitions
MoA	Ministry of Agriculture
NGO	Nongovernmental Organization
OoA	Office of Agriculture
ORDA	Organization for Rehabilitation and Development in Amhara
PD	Person Day
PSNP	Productive Safety Net Program
SAERAR	Sustainable Agriculture and Environmental Rehabilitation of Amhara Region
SART	Sustainable Agricultural Rehabilitation in Tigray
SCRP	Soil Conservation Research Project
Sida	Swedish International Development Cooperation Agency
SLMP	Sustainable Land Management Program
SNNPR	Southern Nations, Nationalities, and People's Region
SWC	Soil and Water Conservation
USD	United States Dollar
WHISA	Water Harvesting and Institutional Strengthening in Amhara
WHIST	Water Harvesting and Institutional Strengthening in Tigray
WB	World Bank
WFP	World Food Programme

Executive Summary

This paper provides details of soil and water conservation (SWC) investments in Ethiopia over the past 20 years. It presents SWC practices and estimates the level of SWC investments in different regions. The paper focuses on four principal agricultural regions: Amhara, Oromia, SNNPR and Tigray. Primary and secondary data were collected for the analysis, and consultations were conducted at regional levels. Primary data on diverse SWC practices, their numbers and areal extent were obtained from the archives of regional Bureaus of Agriculture (BoAs). The results of this study show that several projects involving significant financial investment have been implemented to reverse land degradation and improve land productivity in Ethiopia since the 1970s. The list of projects is not comprehensive due to a lack of documentation at all levels, but it does provide some insights into the scale of SWC investments and implementation. The projects analyzed in the four regions fall into the following categories: farmland management, hillside management and gully rehabilitation practices, including check dams and cut-off drains. The analysis shows that these practices involved both paid and unpaid labor, together representing an estimated investment of more than ETB 25 billion (or approximately USD 1.2 billion) per year over the past 10 years. It is clear that large investments have been made in SWC activities in Ethiopia. However, the outcomes in terms of impact on yield and livelihood benefits are yet to be fully understood. A comprehensive assessment is needed to measure the impact of SWC activities on farmers' livelihoods and the environment. A key recommendation arising from the analysis is that more data and information are needed on the successes and failures of SWC practices, which will assist stakeholders to better guide and target future projects and investments. An additional recommendation is to consider the biophysical and financial impact of soil erosion, both on and off farm.

INTRODUCTION

Land degradation through soil erosion and nutrient depletion is a major concern in Ethiopia, given the strong negative impacts on crop productivity, food security, the environment and quality of life (Bewket and Sterk 2002; Kassie et al. 2009; MoARD 2010). The impact of land degradation – particularly soil erosion – is experienced both on farmers' fields (on-site) and beyond (off-site) (de Graaf 1996). The on-site impacts of soil erosion include a decrease in soil productivity, decline in soil fertility and reduced availability of moisture (Falkenmark et al. 2009; Stroosnijder 2009). The most important off-site impacts of soil erosion include damage to infrastructure (such as roads, bridges, irrigation canals and water supply systems), and siltation of downstream natural and artificial water bodies and the ecosystems they sustain (e.g., lakes, irrigation dams and hydroelectric power-generating reservoirs) (Hurni et al. 2015; Pender and Gebremedhin 2008).

Land degradation has rendered vast areas of fertile land in Ethiopia unproductive (Bewket and Sterk 2002; Kassie et al. 2009), particularly soil erosion by water (Adimassu et al. 2014; Hurni 1988). Although estimates of the extent and rate of soil erosion vary, several studies have suggested the severity of the problem. The highest rate of soil loss occurs on cultivated lands ranging from 42 t ha^{-1} y^{-1} (Hurni 1988) to 179 t ha^{-1} y^{-1} (Shiferaw and Holden 1999).

Soil nutrient depletion has a severe negative economic impact because it reduces on-farm soil productivity (Haileslassie et al. 2005; Stoorvogel et al. 1993; Stoorvogel and Smaling 1990). Several studies have indicated the severity of soil nutrient depletion in Ethiopia. For example, Stoorvogel and Smaling (1990) estimated average national nutrient balances of -47 kg N ha^{-1}, -15 kg P_2O_5 ha^{-1} and -38 kg K_2O ha^{-1}. Similarly, Haileslassie et al. (2005) estimated national nutrient depletion rates of 122 kg N ha^{-1} y^{-1}, 13 kg P ha^{-1} y^{-1} and 82 kg K ha^{-1} y^{-1}.

Estimates suggest that soil erosion costs farmers about USD 4.3 billion per year (Gebreselassie et al. 2016). This estimate considers only provisioning and regulating ecosystem services, so it may be an underestimate. This value would substantially increase if cultural and supporting ecosystem services affected by soil erosion are included. Sedimentation affects dam capacity and water storage, causing additional water losses (El-Shazli and Hoermann 2016).

The occurrence of soil erosion is visible in most parts of the country. Most cultivated land in the hills and mountains suffers from topsoil loss, leaving bare stones. Gullies are apparent in the deep soils throughout the country (Beshah 2003). Further proof of the severity of soil erosion includes thick masses of soil, and high suspension and bed loads of sediment in major rivers, such as the Nile, Awash, Omo and Baro (Beshah 2003). During the rainy season, the water in rivers is the color of dun due to soil erosion from their catchment areas. Awulachew et al (2008) estimated that 302.8 million tonnes of soil have been lost annually from the Nile Basin in Ethiopia, about 45% (136 million tonnes) of which was deposited in the river system. Recent estimates indicate that annual deposits in the Grand Ethiopian Renaissance Dam range from 250 to 319 million tonnes of soil (Hurni et al. 2015).

Since 1974, the Government of Ethiopia (GoE) has made huge investments in soil and water conservation (SWC) practices in response to severe land degradation (Berhe 1996). SWC practices are agronomic, vegetative and structural measures that control land degradation, and enhance productivity and/or other ecosystem services (WOCAT 2017). A soil and water conservation division was established in the Ministry of Agriculture (MoA) following the 1973/1974 drought, and was the first SWC investment in Ethiopian history (Berhe 1996). During that time, activities began in drought-prone areas using a food-for-work (FFW) approach, mainly funded by the World Bank (WB), World Food Programme (WFP) and the Food and Agriculture Organization of the United Nations (FAO) (Rahmato 2001). Since the 1980s, the GoE has carried out various SWC practices with financial support from international donors involving the mass mobilization of rural communities (Holden et al. 2001). The largest SWC investment occurred during the *Derg* Regime (1974-1991), when the government invested more than USD 1 billion per year (Rahmato 2001). International donors, governmental organizations and local nongovernmental organizations (NGOs) have all invested substantial resources in SWC since the 1990s (Beshah 2003).

In addition to development efforts, research efforts have sought to support SWC interventions in Ethiopia. The Soil Conservation Research Project (SCRP) was initiated in 1981 under the MoA, and was jointly financed by the GoE and the Swiss government (Grunder 1988; Hurni 1988). This project established six research sites in different parts of the Ethiopian Highlands to assess the extent of soil erosion and test the effectiveness of different SWC practices (Hurni 1996). The Ethiopian Highlands Reclamation Study (EHRS) invested substantial resources to assess land degradation and management in the Ethiopia Highlands (Constable 1985; FAO 1986a, 1986b). Moreover, various national and international research institutions have been conducting studies on SWC practices in different parts of the country which are also funded by development partners and international NGOs. Despite such efforts, no comprehensive assessment of SWC investments in Ethiopia has been conducted. Thus, the main objectives of this study are to: (i) document SWC-related projects, and (ii) assess the extent of SWC investments by region.

METHODOLOGY

This study reviewed SWC investments at national and regional levels utilizing data from four regions in Ethiopia: Amhara, Oromia and Tigray regions, and the Southern Nations, Nationalities, and People's Region (SNNPR) (Figure 1). Most SWC projects have taken place in those regions because they host large populations of smallholder farmers (Gebregziabher et al. 2016). Moreover, these regions cover a large proportion (about 60%) of Ethiopia's landmass.

This study obtained primary data from the archives of regional Bureaus of Agriculture (BoAs). As shown in Figure 2, data is usually collected at the *kebele* level (subdistrict community as the lowest administrative unit) by development agents (DAs) every year. The *woreda* (district) level Office of Agriculture (OoA) compiles data from the *kebeles* and sends it to the zone level Department of Agriculture (DoA). The DoA then compiles the data at the zone level and sends it to the regional BoA, which summarizes the data and reports to the MoA at national level. That said, there are some limitations in the flow of information. For example, in the Tigray region, the zone levels are currently not functional. Consequently, BoA receives data directly from the *woredas*.

Another challenge for the analysis is that data are not collected in a consistent format or unit of measurement. This study obtained data from the various regional BoAs which are presented in different formats and units of measurement. For example, some regional BoAs reported the length of the structures put in place for SWC (e.g., terraces, dams), while others reported the area covered by SWC practices. This study standardized the measurement units to enable comparative analysis. To do so, it converted investments in SWC practices into person days (PDs) based on available work norms (Desta et al. 2005b; MoARD 2010; MoA and WFP 2000). The average number of working days was calculated by considering the economically-active proportion of the rural population. Sum mary statistics and graphs describe investment trends over the years.

FIGURE 1. Map of Ethiopia highlighting the study regions.

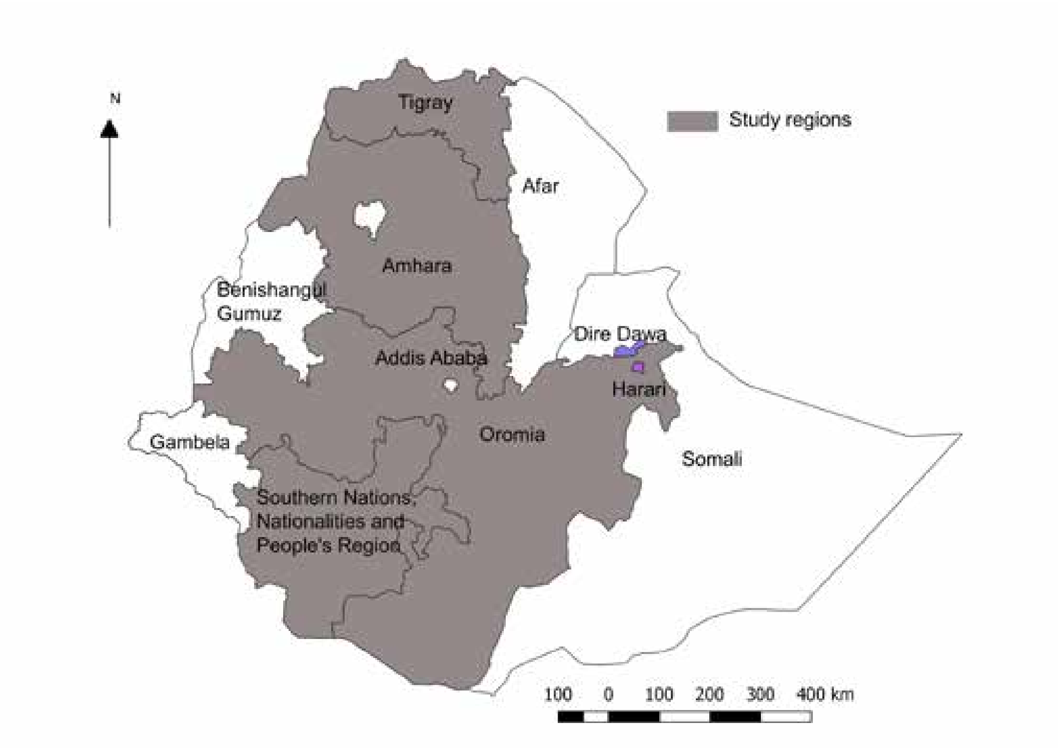
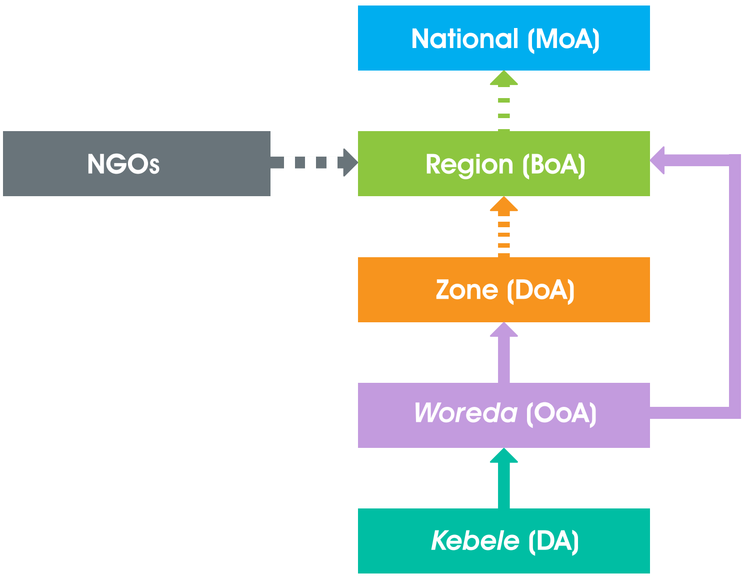


FIGURE 2. Data collection channels for SWC practices in Ethiopia.



Note: The broken lines indicate where data sharing is weak and/or limited as identified through interviews conducted with experts.

The study also collected secondary data related to SWC interventions in Ethiopia through a review of official documents available in local libraries. The document review was supplemented by informal discussions with experts (key informants) at the regional level. In each region, three key informants (experts) were consulted during the informal discussion. A checklist was prepared to guide these informal discussions (see Annex 1).

RESULTS AND DISCUSSION

Evolution of SWC Investments in Ethiopia

A range of projects funded by different institutions have been implemented over the years to reverse land degradation and improve land productivity, as indicated in Table 1. Selecting projects either directly or indirectly involved in SWC activities in Ethiopia helps to identify changes in approach, level of investment and sources of funding. Project information available suggests that donors, in collaboration with the public sector, are the primary investors at the national and subnational levels (e.g., Gilligan et al. 2009; Danyo 2014). Public sector organizations, in partnership with local and/ or international NGOs, generally carry out project implementation.

TABLE 1. Examples of projects/programs related to SWC activities in Ethiopia.*

Years	Projects/programs	Amount of investment (in USD millions)	Major donors/sponsors
2008-2013	Sustainable Land Management Program (SLMP-1)	37.79	World Bank (WB), Global Environment Facility (GEF), Government of Ethiopia (GoE), Food and Agriculture Organization of the United Nations (FAO)
2014-2019	Sustainable Land Management Program (SLMP-2)	94.65	WB, GEF, GoE, FAO. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
2005-To date	Productive Safety Net Program (PSNP)	500 per year	Multilateral
2005-2011	Water Harvesting and Institutional Strengthening in Tigray (WHIST)	6	Canadian International Development Agency (CIDA)
2005-2011	Water Harvesting and Institutional Strengthening in Amhara (WHISA)	6	CIDA
1998-2005	Agricultural Research and Training Program (ARTP)	60	WB
1997-2008	Sida-Amhara Rural Development Program	108.2**	Swedish International Development Cooperation Agency (Sida)
1988-1997	Peasant Agricultural Development Program	88	WB
1975-1985	Rangelands Development Project	27	WB
2004-2009	Integrated Watershed Management in the Amhara Regional State	3.4	Netherlands government

Sources: Key informant interviews; Gilligan et al. 2009; Danyo 2014.
Notes:
* List of projects/programs is not comprehensive due to a lack of documentation at all levels.
** USD 1 = SEK 8.65 in August 2016).

As noted above, SWC investments in Ethiopia began in the mid-1970s, soon after the 1973/1974 drought. The Food-For Work (FFW) project, which took place over a period of 15 years (1980-1994), is the most widely known SWC intervention. The FFW project was modified to become the Local Level Participatory Planning Approach (LLPPA) and later the Managing Environmental Resources to Enable Transitions (MERET) project. Under the MERET project alone, approximately 1 million hectares (Mha) of farmland and 0.3 Mha of hillside were covered with different types of SWC structures, such as farmland and hillside terraces (MERET 2013; Nedassa et al. 2011). In addition, 0.7 Mha of land were cultivated with trees and 1.4 Mha of degraded lands were rehabilitated using area exclosures (MERET 2014; Nedassa et al. 2011). Another substantial program is the Productive Safety Net Program (PSNP) (Box 1), which has been implemented continuously since 2005 with an annual budget of USD 500 million (Gilligan et al. 2009). The Sustainable Land Management Program (SLMP) (Box 2) under the MoA has also made large investments in SWC interventions.

Box 1. Productive Safety Net Program (PSNP) in Ethiopia.

The GoE launched the PSNP in January 2005 with support from development partners. The main objective of the program was to ensure that poor households in chronically food-insecure *woredas* were not forced to sell key assets during times of drought. Another objective was to build community assets by involving food-insecure households in public works. The program aimed to encourage households to engage in productive and investment activities to enhance their purchasing power and promote market development. A dual approach was developed: selected households took part in public works, such as SWC, for which they received payments in cash or in kind; and households lacking labor or support from relatives or those that could not participate in community activities (e.g., disabled persons and orphans) were eligible for direct support.

Sources: MoA 2014; Andersson et al. 2011.

In addition to projects led by the government with support from international funding agencies, NGOs, such as Sustainable Agricultural Rehabilitation in Tigray (SART), Sustainable Agriculture and Environmental Rehabilitation of Amhara Region (SAERAR), and the Organization for Rehabilitation and Development in Amhara (ORDA), have also made significant investments in SWC.

Although the list in Table 1 is not exhaustive, it illustrates that the Ethiopian government, NGOs and international donors are highly committed to arresting land degradation and enhancing land productivity in the country. Unfortunately, the lack of documentation on most of the projects and programs prevents a comprehensive impact assessment of those investments.

Box 2. Sustainable Land Management Program (SLMP) in Ethiopia.

The Sustainable Land Management Program (SLMP) was initiated in 2008 with the aim of reducing land degradation, increasing land productivity and improving farmer livelihoods in Ethiopia. The project has three major components (MoA 2013):

- **Watershed and landscape management.** The objective of this component is to support scaling up and adoption of appropriate sustainable land and water management technologies and practices by smallholder farmers and communities in selected watersheds and *woredas*.
- **Institutional strengthening, capacity development, and knowledge generation and management.** The objective of this component is to complement the on-the-ground activities under the first component by strengthening and enhancing capacity at the institutional level, and building relevant skills and knowledge among key stakeholders, including government agencies, research organizations and universities, the private sector, community leaders and smallholder farmers.
- **Rural land administration.** The objective of this component is to enhance the land tenure security of smallholder farmers in the project area, in order to increase their motivation to adopt sustainable land and water management practices on communal and individual lands.

Types of Practices and Work Requirements for SWC in Ethiopia

Types of SWC Practices in Ethiopia

Multiple SWC practices have been carried out at individual or community levels in Ethiopia (Adimassu et al. 2017; Desta et al. 2005a). Table 2 presents the most common SWC practices. These practices can be grouped into three broad categories: farmland management, hillside management and gully rehabilitation/stabilization. The use of these practices is flexible because a given intervention could fit multiple categories. For example, cut-off drains and waterways can be established in farmlands, hillsides and gully rehabilitations. Although several agronomic and biological SWC practices have been implemented by Ethiopian farmers, most SWC investments have thus far emphasized on physical structures, as shown in Table 2.

TABLE 2. Selected SWC practices widely implemented in Ethiopia (by category).

Farmland management	Hillside management	Gully rehabilitation/stabilization
Soil bund	Hillside terrace	Stone check dam
Stone bund	Diversion ditch	Brushwood check dam
Stone faced soil bund	Stone faced trench	Gabion check dam
Double stone faced soil bund	Micro-basin	Sediment storage dam
Fanya juu terrace	Bench terrace	Live check dam
Tied ridges	Semi-circular terrace	Stone Check dam
Bench terrace	Eyebrow basin	Gully reshaping and planting
Zai pit	Deep trench	Sand/soil filled check dam
Trash line	Terrace and trench	Cut-off drains
Cut-off drains	Cut-off-drains	Diversion ditch
Waterways	Waterways	

Work Requirements for SWC Implementation in Ethiopia

Work requirements represent the number of person days (PDs) needed to execute a given SWC practice (described in Annex 2). The number of PDs differs according to the difficulty or ease of construction and/or maintenance of a SWC structure. For example, 150 PDs are required to construct one kilometer of soil bunds, while 250 PDs are required to construct one kilometer of stone bunds, since the latter involves gathering stones and transporting them to the field. The work and design requirements for each SWC practice are established to control the quality and quantity of input labor for each planned intervention. The work requirements, as outlined in Annex 2, include the minimum design requirements that indicate how and where to apply each SWC practice. The responsible line ministry of the GoE provides design requirements for each type of SWC practice in technical guides, such as the Community Based Participatory Watershed Management Guideline (Desta et al 2005a, 2005b) and the Sustainable Land Management Technologies and Approaches document (MoARD 2010). These work and design requirements are then implemented throughout the country in projects and programs such as the PSNP, MERET and SLMP, as well as the Mass Mobilization Program.

The most important labor contribution comes from mobilizing communities: every capable family member between the ages of 15 and 65 years is expected to 'donate' at least 20 days to the implementation of SWC practices each year. Stated otherwise, SWC is undertaken through unpaid labor in all regions during the non-farming (i.e., dry season) period of the year. According to key informants, this approach is expected to create a sense of greater 'ownership' of the SWC structures by the community. To date, PSNP has utilized a large number of labor hours, though only paid beneficiaries may be involved in SWC implementation for that particular program.

Regional Investments in SWC Practices

Examination of case studies further enhances the understanding of SWC investments. This study considered cases in four major regions of Ethiopia: Amhara, Oromia and Tigray regions, and SNNPR. Cases vary by region, notably through different units of measurement. Therefore, the results are presented separately for each region.

SWC Investments in the Amhara Region (1999-2014)

The different SWC practices – most commonly farmland and hillside terraces – implemented in the Amhara region over the past 15 years are presented in Table 3. On average, 241,355 km (n[1]=16) of farmland terraces and 79,548 km (n=10) of hillside terraces have been constructed in the region each year since 1998. The construction of these structures required about 48 million and 20 million person days for farmland terraces and hillside terraces, respectively, each year. Building trenches and infiltration ditches is also a common practice in the region, requiring more than 6 million PDs for trench construction and 23 million PDs for infiltration ditch construction, each year. In addition, as seen in Table 3, the maintenance of SWC structures following initial construction is critical: 177,576 km (35.5 million PDs) of farmland terrace and 53, 000 km (6.6 million PDs) of hillside terrace were maintained each year during the period under study.

[1] 'n' is the number of years during which mean SWC investments was computed.

TABLE 3. Selected SWC practices in the Amhara region (1999-2014).

SWC practices	Average quantity ('000s) per year	Average person days ('000s) per year	Average cost of labor (USD '000s) per year*
Farmland management			
Farmland terrace construction (km)	241 (16)	48,270	45,857
Farmland terrace maintenance (km)	178 (16)	35,520	33,744
Farmland terrace stabilization with trees (km)	41 (9)	1,220	1,159
Cut-off drains construction (m^3)	6,611 (12)	9,440	8,968
Cut-off drains maintenance (m^3)	215,927 (5)	308,470	293,047
Waterways construction (m^3)	5,856 (12)	6,510	6,185
Waterways maintenance (m^3)	565,471 (5)	628,300	596,885
Tied-ridge construction (ha)	39 (5)		
Hillside management			
Hillside terrace construction (km)	80 (10)	19,890	18,896
Hillside terrace maintenance (km)	53 (6)	6,600	6,270
Area exclosure (ha)	202 (9)		
Moisture conservation structures			
Percolation ponds	0.3 (1)	610	580
Infiltration ditches	39 (6)	23,450	22,278
Micro-basin	6 (15)	1,240	1,178
Trench	10 (10)	6,060	5,757
Eyebrow basin	3 (8)	1,860	1,767
Zai pits	3,967 (6)	80	76
Gully rehabilitation/stabilization			
Check dam construction (m^3)	6,773 (14)	10,840	10,298
Check dam maintenance (m^3)	6,774 (14)	10,840	10,298
Stabilizing check dams with trees (m^3)	12 (8)		
Gully fencing (ha)	15 (11)		
Gully shaping and management (ha)	7 (7)		
Sediment storage dam construction (m^3)	89 (6)		
Total		1,119,200	1,063,243

Note: * The average exchange rate for the period 2010-2017 (USD 1 ≈ ETB 19). The cost of one person-day (PD) is estimated at ETB 20.

Figure 3 presents trends in selected SWC practices (in hectares) in the Amhara region. The annual rate of construction of farmland and hillside terraces was nearly constant until 2003, but increased significantly after 2004. The establishment of area exclosures started in 2006. Figures 4 and 5 show examples of SWC practices in the Amhara region.

FIGURE 3. Trends in selected SWC practices in the Amhara region.

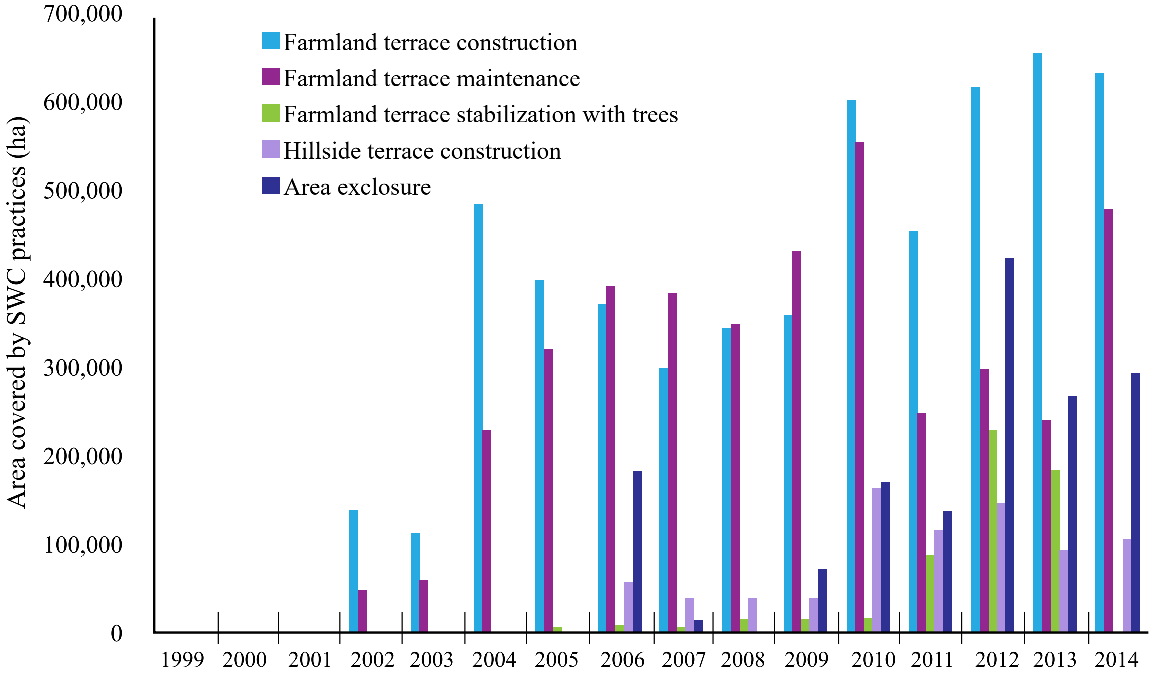


FIGURE 4. Farmland terrace in the Alekit-wonz watershed, Amhara region.

Photo: Zenebe Adimassu, IWMI.

FIGURE 5. Gabion check dam supported with elephant grass in Alekit-wonz watershed, Amhara region.

Photo: Zenebe Adimassu, IWMI.

SWC Investments in the Oromia Region (2005-2014)

Table 4 presents selected SWC practices carried out in the Oromia region over the last 10 years (2005-2014). As in the Amhara region, the most important SWC practices are farmland and hillside terraces. Farmland terrace construction covers 274,000 km which utilized about 55 million PDs every year over 10 years. In addition, 46,000 km of hillside terraces, corresponding to more than 9 million PDs (n=10), were used to construct and maintain hillsides in Oromia.

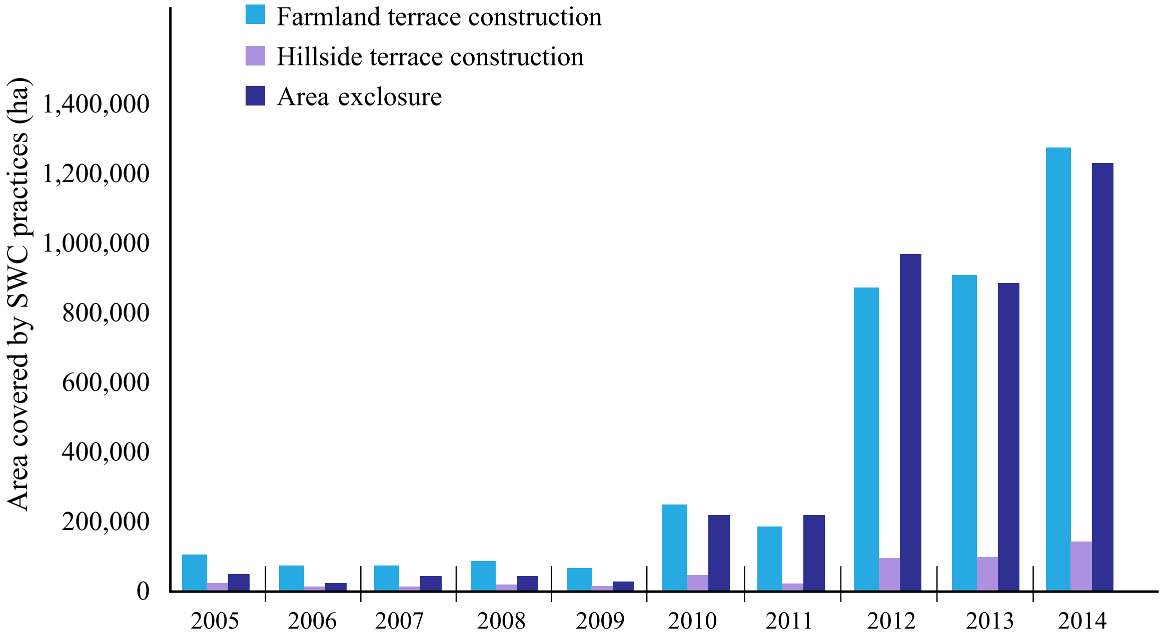
TABLE 4. Investments in selected SWC practices in the Oromia region (2005-2014).

SWC practices	Average quantity ('000s) per year	Average PD ('000s) per year	Average USD ('000s) per year*
Farmland terrace (km)	274 (10)	54,680	51,946
Hillside terrace (km)	46 (10)	9,150	8,693
Waterways and cut-off drains (km)	234 (10)	30	29
Area exclosure (ha)	368 (10)		
Check dams (m^3)	113 (9)	190	181
Moisture conservation structures	3,300 (4)	1,160	1,102
Total		65,210	61,951

Note: * Average exchange rate for the period 2010-2017 (USD 1 ≈ ETB 19). One person-day (PD) = ETB 20.

Figure 6 shows trends in SWC practices in the Oromia region between 2005 and 2014. The trend of constructing hillside terraces has been constant over the years (Figure 6). Before 2010, the construction of hillside terraces and area exclosures was not a priority for SWC. However, area exclosure interventions increased in 2010, while hillside terrace construction increased starting in 2012. Experts attributed the upward trend to Ethiopia's Growth and Transformation Plan (GTP) introduced in 2011, which led to significant mobilization of communities to undertake such activities.

FIGURE 6. Trends in selected SWC practices in the Oromia region.



SWC Investments in SNNPR (2004-2014)

Table 5 shows the extent of SWC practices in the Southern Nations, Nationalities, and People's Region (SNNPR). The most common SWC practice during the period 2004-2014 was the construction of farmland terraces, averaging 98,316 ha (n=11) per year; average terrace maintenance was 76,324 ha (n=5). This entailed 15.14 million PDs for construction and 11.75 million PDs for maintenance. More than 4 million PDs were also invested each year to construct and maintain cut-off drains and waterways, and more than 14 million PDs were used to construct and maintain check dams.

Figure 7 shows the trends in SWC practices in SNNPR. The construction of terraces occurred at a nearly constant annual rate from 2004 to 2010. However, terrace construction increased rapidly from 2011 onwards. The maintenance of terraces then started in 2010 and increased significantly after 2013. Similarly, the construction of area exclosures increased notably between 2010 and 2013. Examples of SWC practices in SNNPR are shown in Figures 8 and 9.

TABLE 5. Investments in selected SWC practices in SNNPR (2004-2014).

SWC practices	Average quantity ('000s) per year	Average PD ('000s) per year	Average USD ('000s) per year*
Farmland terrace construction (ha)	98,316 (11)	15,140	14,383
Farmland terrace maintenance (ha)	76,324 (5)	11,750	11,163
Area exclosure (ha)	52,783 (11)		
Cut-off drains construction (m^3)	2,045,772 (5)	2,050	1,948
Waterways construction (m^3)	1,763,044 (5)	2,520	2,394
Moisture conservation structures			
Micro-basin	2,534 (5)	510	485
Trench construction	1,399 (8)	840	798
Eyebrow basin	1,038 (5)	520	494
Gully stabilization			
Check dam construction (m^3)	23,411 (5)	7,800	7,410
Check dam maintenance (m^3)	20,958 (5)	6,990	6,641
Total		48,120	45,716

Note: *Average exchange rate for the period 2010-2017 (USD 1 ≈ ETB 19). The cost of one person day (PD) is estimated at ETB 20.

FIGURE 7. Trends in selected SWC practices in SNNPR.

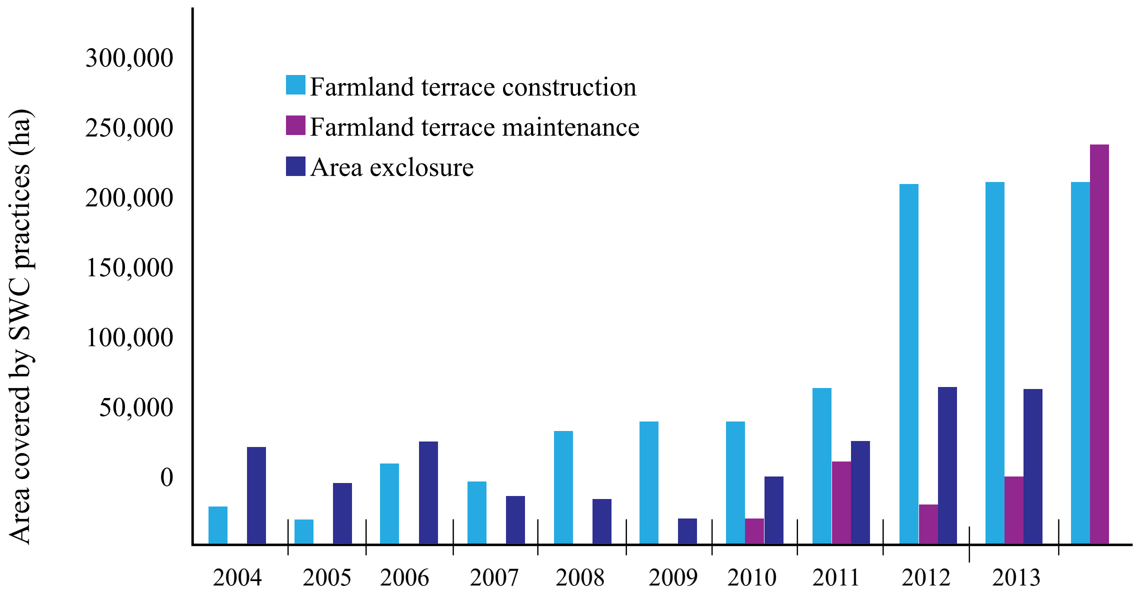


FIGURE 8. Bench terrace at Konso Special District, SNNPR.

Photo: Zenebe Adimassu, IWMI.

FIGURE 9. Rectangular basins from sorghum straw at Derashe Special District, SNNPR.

Photo: Zenebe Adimassu, IWMI.

SWC Investments in the Tigray Region (1995-2008)

According to data available from 1995 onwards, farmland and hillside terraces have long been constructed in the Tigray region, as shown in Table 6. In total, more than 10 million PDs have been invested for the construction of farmland terraces and about one million PDs for the construction of hillside terraces each year. More than 18 million PDs have been used to construct and maintain check dams and cut-off drains each year.

TABLE 6. Extent of selected SWC practices in the Tigray region (1995-2008).

SWC practices	Average quantity ('000s) per year	Average PD ('000s) per year	Average USD ('000s) per year*
Farmland terraces			
Stone bund construction (km)	20,591 (14)	5,150	4,893
Soil bund construction (km)	3,908 (14)	980	931
Trench bund construction (km)	5,456 (12)	1,800	1,710
Stone faced trench bund (km)	6,381 (8)	1,600	1,520
Stone faced soil bund (km)	330 (4)	80	76
Bund maintenance (km)	3,615 (8)	450	428
Hillside terrace construction	3,755 (10)	940	893
Check dam construction (m^3)	3,103,561 (14)	4,140	3,933
Cut-off drain construction (m^3)	9,709,073 (7)	13,870	13,177
Cut-off drain maintenance (m^3)	144,000 (1)	140	133
Deep trench (km)	15,222 (1)	10	10
Total		29,160	27,704

Note: * Average exchange rate for the period 2010-2017 (USD 1 ≈ ETB 19). The cost of one person day (PD) is estimated at ETB 20. Numbers in brackets represent the number of years during which mean SWC investments were computed.

Figure 10 shows trends in SWC practices in the Tigray region. Investments in farmland terraces were higher than investments in hillside terraces in all the years under review. The largest area of farmland terrace construction occurred in 2005 and 2008, while the lowest area was in 2003. Also, farmland terrace maintenance has been an important SWC activity in the region since 2000. Examples of the SWC practices in the Tigray region are shown in Figures 11 and 12.

FIGURE 10. Trends in selected SWC practices in the Tigray region.

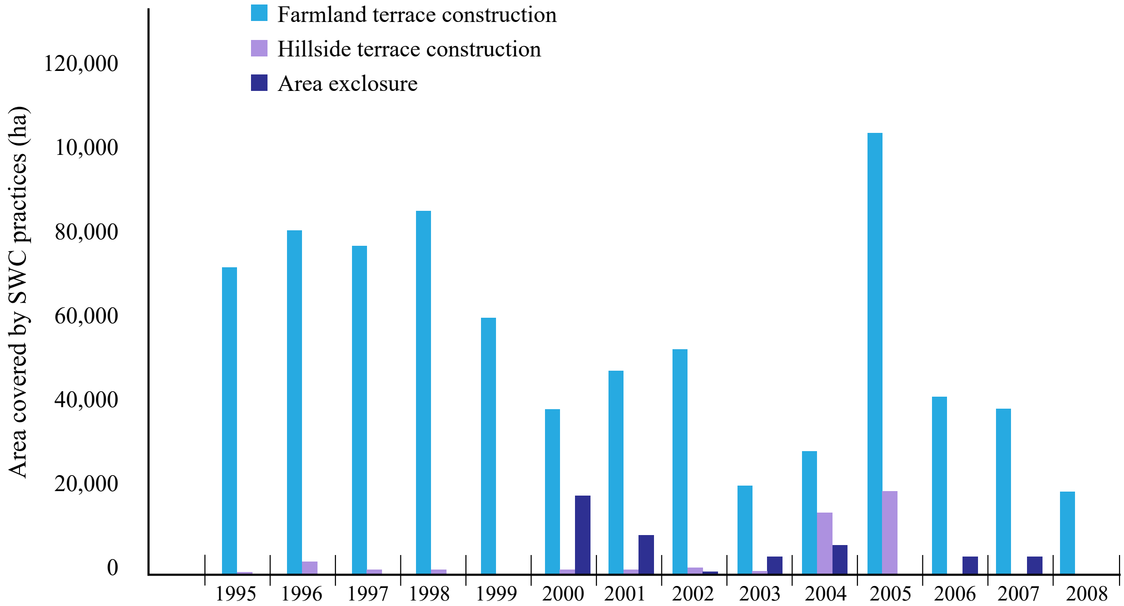


FIGURE 11. Micro-basin in the hillside of Tigray region.

Photo: Zenebe Adimassu, IWMI.

FIGURE 12. Bench terrace to restore degraded lands in Embahasti watershed, Tigray region.

Photo: Zenebe Adimassu, IWMI.

Summarizing SWC Investments in the Four Regions

This study made a number of conclusions generally and across the four regional case studies. These are relevant for further analysis and can inform future studies. Key points are as follows:

- The units of measurement used to describe SWC practices differs across the four case study regions. The lack of a national standard for measurement makes comparison across regions difficult, and constrains the ability to undertake a national impact assessment. As such, one approach to assessing the investment in SWC is to use person days (PDs) to standardize data for each region, and then aggregate across regions. Once the total number of PDs per region and activity is computed, the cost to undertake the SWC activities can be calculated. Using that approach, the study summarized the investment in SWC practices by each region in PDs and monetary terms, as shown in Table 7. Terrace construction and maintenance were presented separately because the use of terraces is the most common SWC practice in all regions.

- The average annual monetary and human resource investment in PDs for SWC practices is highest in the Amhara region (> 1.119 billion PDs) and lowest in the Tigray region (29.15 million PDs). On average, the four regions support more than one billion PDs each year.

- Calculating PDs in monetary terms provides a better understanding of the investment costs in SWC, albeit many other costs are not included in this calculation. Therefore, it represents only a part of the total investment in SWC by the GoE and various donors. A shadow wage of ETB 20 per day (≈ USD 0.95) was used to calculate the labor cost, which is consistent with the average wage paid under the PSNP (MoA 2014). This is significant given the substantial underemployment in rural Ethiopia during the non-farming season (i.e., dry season). An estimate of more than ETB 25 billion (> USD 1 billion) has been invested in SWC practices, on average, every year in the four case study regions (Table 7) over 20 years (1995-2014).

TABLE 5. Annual investments in SWC in four regions of Ethiopia (1995-2014).

Region	Investments in SWC practices		
	Person days (thousands)	ETB ('000s)	USD* ('000s)
Amhara	1,119,190	22,383,800	1,063,240
Oromia	65,220	1,304,300	61,950
SNNPR	48,120	962,400	45,714
Tigray	29,150	583,060	27,702
Total	1,261,680	25,233,560	1,198,606

Note: * Average exchange rate for the period 2010-2017 (USD 1 ≈ ETB 19). The cost of one person day (PD) is estimated at ETB 20.

Views of Experts on SWC Interventions in Ethiopia

Key informants agreed that there is growing interest in SWC interventions at watershed scale in Ethiopia, correlating with the trends presented above. However, the sustainability of SWC practices and their adoption by individual farmers have not been well studied, largely because most SWC practices in Ethiopia have been implemented through disparate projects, public works and community mobilization programs. This section presents the views of experts on SWC interventions in Ethiopia. Experts mentioned three major challenges for SWC interventions in Ethiopia:

- *Turnover or reshuffling of SWC staff* at various levels affects the quality of the work and data handling, and implementation of programs and projects more generally.

- *Free grazing of livestock* particularly affects the Amhara, Tigray and Oromia regions. Free grazing destroys physical and biological SWC structures and results in the need for additional investments in maintenance, and replanting trees and grasses on bunds. Regulations and bylaws formulated to restrict free grazing have not been effectively implemented.

- Most of the *design specifications for SWC practices* are based on general parameters that are not always appropriate or adequately specific across areas. SWC practitioners need site-specific and contextualized design specifications to guide activities.

In addition to these three challenges, the experts also suggested that research support for SWC intervention is extremely inadequate. For example, more information on the returns on investment, and profitability for agriculture from the construction of bench and hillside terraces is needed to assess the actual value, particularly given the intense labor input required. The key informants also argued that biological SWC practices are not given due attention by most SWC projects, particularly relative to the size of investment in structures.

LIMITATIONS OF THE STUDY

Consistent documentation and standard metrics are needed to monitor activities and investments, as well as to assess the impact of SWC interventions at watershed, regional and national levels. This study attempts to document resource investment and funding sources for SWC activities. However, a comprehensive list of investments in projects and programs is not possible because of inconsistent and inadequate documentation. According to the documentation, the upgrading and maintenance of poorly constructed and highly damaged structures were considered as new constructions; and arithmetic values (e.g., summation) of the quantities of SWC practices could not tell us the total quantities of SWC structures constructed in the country for the last several years. In addition, soil fertility management (e.g., compost and manure application) and biological SWC practices, including area exclosures, were rarely documented in any region. Measurement units also differed from region to region and over time, which made it necessary to convert measurements into a standardized unit, in this case person days, to achieve proximate conclusions about investments. Through that approach, this study shows the amount of labor invested for the construction and maintenance of SWC practices annually, which can then be used to calculate an approximate monetary value of investment in labor. Getting information on the total investment over time and across funding sources was not possible given the limitations noted above.

CONCLUSION AND IMPLICATIONS

This report identified that investments in SWC from 1995 to 2014 totals more than USD 1 billion per year, based on an average of person days spent on SWC activities in four regions of Ethiopia. This is still well below recent estimates of economic losses due to land degradation, projected to be USD 4.3 billion per year (Gebreselassie et al. 2016). Adding up the past 3 years of SWC interventions (see Figures 3, 6, 7 and 10) across the four regions where most SWC practices are implemented, the total area covered by new farm and hillside terraces alone would total 6.4 Mha, or nearly 20% of Ethiopia's agricultural area, which may be an underestimate.

Given the limited and inconsistent data, a major recommendation of this study is that the GoE and supporting agencies (investors and practitioners) establish a formal monitoring system for SWC programs, which would include a comprehensive documentation management system and monitoring programs to better capture and maintain data on SWC practices. The documentation management system should store original data, using the same format and units of measurement, at the *kebele*, *woreda* (district), zone, region and national levels. A national open-access database system could be established within the relevant line ministry. Public and nongovernmental development project implementers at multiple levels would enter data on SWC project activities, particularly general project information (project period, budget, funding source), area or size of intervention, location of intervention, type of activity or structure, and the stage of activity or structure (e.g., construction and maintenance). The production of regional and annual reports with detailed SWC information could then be generated from that data, which would help monitor and evaluate ongoing investments, as well as guide new investments in SWC initiatives.

A second recommendation is to increase investment in agronomic and biological practices, in addition to the current efforts in physical and infrastructure interventions. This would include revegetation strategies, such as planting trees and grass to stabilize soil and reduce sediment loss. Efforts to combine SWC and revegetation would also support other ecosystem services that assist in sediment retention, such as maintaining diverse local habitats for flora and fauna.

A third key recommendation is to conduct assessments on the impact of SWC practices on crop yield, soil loss, nutrient loss, water availability and other ecosystem services, both on and off farm, and particularly on the income of different stakeholders that rely on natural resources. Although significant investments have been made in SWC, the scant evidence available is inadequate to quantify or effectively assess on-farm benefits for farmers, such as yield improvements (Adimassu et al. 2014). However, investments in SWC have been found to generate off-farm benefits, such as reduced flooding, and minimizing sedimentation of water bodies and irrigation infrastructure, e.g., canals and reservoirs. These in turn benefit more farmers and communities.

Further studies are also needed to confirm the area under SWC, using remote sensing and geographic information system (GIS) techniques. This would generate the evidence needed for informed policy and decision making regarding investments in SWC.

Key informants mentioned three challenges (turnover and reshuffling of SWC staff, free grazing of livestock and design specifications for SWC practices) that should also be considered. There is a need to continuously build and strengthen SWC capacity, especially at the *woreda* and *kebele* levels, as well as ensure continuity of institutional staff. Finally, more resources need to be invested in research on sustainable SWC solutions. This should be done while enhancing the linkages between research, policy and practice to maximize the use of research-based evidence in strengthening capacity within and beyond the SWC community of practice, and ensuring evidence is leveraged in policy and program development.

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ANNEX 1. CHECKLIST FOR INFORMAL DISCUSSION WITH REGIONAL-LEVEL SWC EXPERTS.

1. Please explain your responsibility in relation with soil and water conservation in the region.
2. What are the major SWC technologies/practices which have been implemented in the region?
3. How do you see the success of SWC investments in the region?
4. How do farmers get involved in SWC investments in the region?
5. How do you compile data on the achievements of SWC interventions in the region?
6. What are the major projects/programs you know related to SWC interventions in the region or in Ethiopia?
7. What are the major constraints that affect the success of soil and water conservation investments?
8. Do you have any other additional comments/suggestions?

ANNEX 2. WORK NORMS FOR SWC PRACTICES IN ETHIOPIA.

TABLE A2. Work requirements for each SWC practice.

SWC practices	Work norm	Minimum design requirements
Soil bunds	150 PD/km	Height: minimum 60 cm after compaction (top level well shaped). Base width: 1-1.2 m in stable soils (1 horizontal: 2 vertical) and 1.2-1.5 m in unstable soils (1 horizontal: 1 vertical). Top width: 30 cm (stable soil) – 50 cm (unstable soil). Channel: shape, depth and width vary with soil, climate and farming system. Ties (if appropriate): tie width with dimension as required, placed at every 3-6 m interval long channel (only level bunds). Gradient (for graded bunds): minimum 0.2% - maximum 0.6%.
Stone bunds	250 PD/km	Total base width: (height/2) + (0.3 to 0.5 m). Top width: 30-40 cm. Foundation: 0.3 m width x 0.3 m depth. Grade of stone face downside: 1 horizontal: 3 vertical. Grade of stone face upper side: 1 horizontal: 4 vertical.
Stone faced soil bund	250 PD/km	Grade of lower stone face: 1 horizontal to 3 vertical. Grade of upper stone face: based on soil embankment grade. Grade of soil: horizontal to 1.5 vertical on stable soils and 1 horizontal to 2 vertical on unstable soils. Lower stone face riser foundation: 0.3 depth x 0.2-0.3 width. Upper stone face riser foundation: 0.2 x 0.2 m, Stone size: 2 cm x 20 cm stones (small and round shape stones not suitable), Top width: 0.4-0.5 m, Height: minimum 0.7 m and maximum 1.5 m.
Fanya juu terrace	200 PD/km	Same as soil bunds but channel dug on lower side and soil lifted upwards (suitable for soils > 1 m depth).
Hillside terrace	250 PD/km	Height or stone riser: 0.5-0.75 m. Width: 1.5-2 m. Foundation: 0.3 m depth x 0.3 m width. Grade: 1 horizontal to 3 vertical. In lower rainfall areas, hillside terraces have 1.5-2 m gradient backstop.
Bench terrace	500 PD/km	Vertical interval: 1 m. The bench has a small lip (10-20 cm high) at its edge. Vertical interval usually of 1 meter (though it may range between 0.5 and 1.5 m). Grade of riser is 1 to 1 in most soils.
Bund stabilization (grasses)	30 PD/km	Plantation in three rows on top and lower side of bunds (double row on top of bund) and one row in lower side of embankment. Middle row preferable for legumes. If direct seeding is applied (medium and high rainfall), seeds planted at maximum 1.5 cm depth on fine seedbed. Grass splits or seedlings are preferred in most circumstances. Glass splits are planted at very close intervals within the row (5-10 cm apart) to form continuous row.

(Continued)

TABLE A2. Work requirements for each SWC practice. (Continued)

SWC practices	Work norm	Minimum design requirements
Hillside terrace + trench	330 PD/km	The soil is excavated from the cut and fill and/or the trench, and reinforces and raises the embankment supported by the stone risers. Stone riser height: 0.75-1 m from ground level, stone riser foundation: 0.3-0.4 m depth x 0.3 m width. Top width: 0.5 m (0.25 m stone and riser and 0.25 m soil). Grade of stone riser: 1 horizontal: 3-4 vertical, Grade of soil bank: 1 horizontal: 1.5 vertical (unstable soils) to 2 vertical (stable soils), base width: based upon slope, size of upstream trench: 50 cm width x 50 cm depth x terrace length.
Stone check dam	0.5 m^3/PD	Spacing (m): Height (m) x 1.2/Gradient (in decimals); Side key: 0.7-1 m, Bottom key and foundation: 0.5 m depth x width of check dam. Height: minimum 1 m and maximum 1.5 m excluding foundation, Base width: minimum 1.5 m and maximum 3.5 m, Spillway (trapezoidal) with 0.25 m free board and 0.25-0.3 m permissible depth, width minimum 0.75 m and maximum 1.2 m (based on small catchments), Drop structures on steep slopes (above 10%) or unstable soils (ladder placed stones up to half the height between apron and spillway level), Apron: at least 50 cm wider on both sides of spillway fall (total width 1.5-2 m) and length towards water flow of minimum 1 m, with stones placed vertically and/or alternate rows.
Stone check dam maintenance	1 m^3/PD	
Gabion	0.25 m^3/PD	For technical standards, reference should be made to specific guidelines and recommendations from skilled engineers. Usually, a 1 m deep key trench as wide as the dam and structure should be excavated for proper stability (the same applies on side keys and walls), the activity includes side and bottom key construction for gabion placement, anchorage and knotting.
Waterways (stone paved)	0.75 m^3/PD	Stone-paved waterways follow a similar design to the unpaved waterways as far as excavation and design are concerned. In addition, the whole waterway is tightly paved with stones (flat position with gaps filled with small stones), and provided with stone drop structures. In this case, the drop structures are an integral part of the stone paving work and should not be considered as an additional activity. Stone drop structure: at 1 meter vertical interval, ladder shaped and inclined upward 20-30%. Apron: with length equal to height of drop. The apron stones should be placed vertically instead of flat.

(Continued)

TABLE A2. Work requirements for each SWC practice. (Continued)

SWC practices	Work norm	Minimum design requirements
Waterways (grass)	1 m^3/PD	Dimensions: as per the catchment area, runoff coefficient and type of soil (refer to technical documents). Shape: parabolic preferable or trapezoidal (1 horizontal: 1 vertical). Depth: 0.3-0.5 meters. Stabilization: rows of grass splits or seedlings placed every 2 m along the channel. An alternative to grass is 10 cm wide rows of dry straw placed at 1-2 meter intervals based on slope (by raising 3-5 cm above the waterway channel, they slow down water flow and intercept natural seeds, which then quickly stabilize the waterway). Drop structures: up to 5% slope every 20 m and above 5% slope every 5 or 10 meters.
Sediment storage dam (SS dam)	0.75 m^3/PD	
Brushwood check dam	1 PD/3 linear meters	Brushwood check dam is designed in the same way as stone check dams, but the spacing between structures is usually half that of stone check dams since they are less stable and resistant to water flow, and are recommended only on small gullies (usually maximum 3-4 m wide and maximum 2 m deep) .
Gully reshaping	1 m^3/PD	-
Cut-off drain	0.7 m^3/PD	Gradient: 0.5-2%. Shape: Parabolic or trapezoidal. Channel dimensions: as per the catchment area, runoff coefficient and type of soil (refer to technical documents). Embankment: minimum 0.5 m top width, all slopes cut to grade of 1 to 1. Outlet pitching with stones: 2-3 meter length of the bottom and sides of channel paved with stones + drop structure and apron. Outlet linked to a solid drop structure and ending into a large apron. Outlet pitching with straws: In the absence of stones, a series of densely packed lines of scour checks made out of straw (10 cm width) should be dug and driven into the channel (every 0.4-0.5 m spacing on the channel) across the last 3 meters of the channel (approximately 6-8 rows). The drop structure should be ladder shaped and strengthened with wood posts interwoven with small branches. The apron is a dense series of hard straw for at least 2 meters into the waterway.

(Continued)

TABLE A2. Work requirements for each SWC practice. (Continued)

Zai pit	50 Pit/PD	Zai pits are small pits dug along approximate contours in between bunds (bunds are a separate activity), usually at the end of the rainy season. Each Zai pit has 30-50 cm diameter and 15 cm depth. During excavation, the soil is placed on a lower slope. Spacing between pits within the row is 30-50 cm and spacing between the two Zai lines is 60-70 cm. After construction, one spade of farmyard manure is added into each pit. During first rains, Zai pits are planted with sorghum or millet which will then be harvested leaving 0.75-1 m high stocks above ground and removing the rest. Those residues will be torn manually and thrown into the pit. During the second rainy season, a legume plant is grown in the pit while another series of pits is dug in between the first year lines, thereby completing the entire area in 2 years.
SWC practices	Work norm	Minimum design requirements
Micro-basin	5 Basin/PD	Diameter: Minimum 1 m and maximum 1.5 m. Small stone riser: 0.2 m foundation and height 0.2-0.4 above ground based on slopes. Plantation pit: 30 cm diameter x 50 cm depth, Soil sealing: sealed with soil from cut area. They are constructed in a staggered position between rows with rather close spacing within the row in case of 1 m diameter basins (some overlapping is required between rows).
Eyebrow basin	2 Basin/PD	Eyebrow basin has 2.2-2.5 m diameter, placed along the contours (staggered between lines). Solid and well-constructed stone riser (or stabilized by brushwood or life fence): with 0.2 m depth foundation, height 0.4-0.6 m (based on slopes), Water collection area dug behind (or at the side of) plantation pit: 1 m width x 1 m length x 20-25 cm depth (lower side). Depth and size of water collection area may change based on available soil depth, Stone riser sealed with soil from excavated area. Plantation pit(s) of 50 cm depth x 40 cm diameter dug between riser and water collection area. Drought-resistant vegetation planted in the lower part of the stone riser, if necessary and materials are available.

(Continued)

TABLE A2. Work requirements for each SWC practice. (Continued)

Deep trench	3 Trench/2 PD	Average size of the trench: 2.5-3 m length x 0.5 m width x 0.5 m depth (downside). Distance between lines 2-3 meters average. Distance within line 0.5 meters. Except for very permeable soils, trenches are provided with a 60 cm (width - along trench) x 25 cm (average depth) tie with a 40 cm x 40 cm deep plantation pit in the middle. Ensure that the plantation pit in the middle of the tie is 5-10 cm lower than the bottom of the trench for enhancing deep rooting system - 1 or 2 plantation pits can also be dug in front of the trench. Average maximum water-holding capacity of each trench is around 0.6-0.75 m^3.
Micro-trench	3 Trench/PD	Average size of the trench: 1.5 length x 0.4 m width x 0.5 m depth (downside). Except for very permeable soils, trenches are provided with a small and low tie in the middle to regulate water flow (15 cm width). In this type of design, trees are not planted in the middle of the trench but in front of it. One or even two trees (one for fodder and one for wood, for example) can be planted in one or two 40 cm x 40 cm x 40 cm deep plantation pit(s) in front of the micro-trench.
SWC practices	Work norm	Minimum design requirements
Grass strip	30 PD/km	Under Ethiopian conditions, grass strips are nowadays established only by using splits or seedlings for the grass and seeds for legumes. A 0.5-1 m standard width three-row strip is considered (two outer rows of grass and one middle row of legumes). Other options are also considered when particular grasses, such as Vetiver (one tight row of Vetiver and one of legume shrubs), are planted. The activity includes fine seedbed preparation (fine plowing, removal of weeds), shallow furrows, planting of grass splits and seedlings close apart (10 cm) within rows and light compaction around plants. Legumes are planted in a middle row, by direct seeding not deeper than 1.5 cm.

Sources: Desta et al. 2005b; MoARD 2010; MoA and WFP 2000).

Notes: PD = person day (a unit of measurement, especially in accountancy, based on an ideal amount of work done by one person in one working day).

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Postal Address
P O Box 2075
Colombo
Sri Lanka

Location
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Telephone
+94-11-2880000

Fax
+94-11-2786854

E-mail
iwmi@cgiar.org

Website
www.iwmi.org

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