# Chapter 18
# Conceptual and Practical Approaches to Integrated Watershed Management and Agroforestry to Address Food Security and Environmental Degradation in Lake Tana and the Blue Nile River Basin, Ethiopia


**Badege Bishaw**

**Abstract** Forests and trees provide food, fuelwood, and construction materials and many environmental benefits, such as erosion control, clean water and air, biodiversity conservation, and carbon sequestration. The forest covers in Ethiopia and that of the Blue Nile River Basin in particular have been deteriorating at a progressive rate. The situation is even worse in the Angereb watershed. The major causes of deforestation and environmental degradation in Ethiopia are increasing population, increasing demand for farmlands, and increasing demand for fuelwood for cooking and construction materials. The effects of poor farming practices and lack of conservation are the main causes for the siltation of the Angereb dam and the pollution of drinking water from the dam. To address these environmental and livelihood problems, concepts of sustainability and ecosystem-based approaches were applied. We involved different stakeholders, such as the Gondar City Administration, Department of Forestry and Agriculture, Department of Water Affairs, Farmers in the Angereb watershed, University of Gondar, and the Corvallis-Gondar Sister Cities Association in the project. Through this participatory approach, the stakeholders identified the natural resource problems in the Angereb watershed, proposed integrated watershed management involving soil and water conservation, agroforestry, tree planting, and reduced siltation of the dam. Through this project, we improved the tree nursery at Weleka and raised multipurpose indigenous and exotic tree species for planting. Farmers were involved in tree planting and agroforestry practices, such as establishing riparian buffers along the streams, alley cropping for soil and water conservation by planting trees on terraces and agroforests/home gardens to address food security. Through this project, 2.5 million tree seedlings were planted on 560 hectares in the Angereb watershed in ten years. Since 2010, 19 water sources were constructed, including drilled wells,

B. Bishaw (✉)
Oregon State University, Corvallis, OR, USA
e-mail: badege.bishaw@oregonstate.edu



A. M. Melesse et al. (eds.), *Nile and Grand Ethiopian Renaissance Dam*,
Springer Geography, https://doi.org/10.1007/978-3-030-76437-1_18

hand-dug wells, and developed springs to provide clean drinking water for 1700 households in Gondar city and the surrounding villages. We recommend scaling up the ecosystem-based approaches, using lessons learned on agroforestry, tree planting, and soil and water conservation in the Angereb watershed to the larger Blue Nile River Basin. This will address environmental degradation, soil erosion, and food security, which will have great impacts on survival of Lake Tana and extend the longevity of the Grand Ethiopian Renaissance Dam (GERD) by reducing siltation.

**Keywords** Sustainability · Ecosystem-based · Agroforestry · Participatory approach · Integrated watershed · Angereb dam · Wells and springs · Drinking water · Blue Nile River Basin · Lake Tana · Siltation · Grand Ethiopian Renaissance Dam

## Introduction

Forests and trees provide food, fuelwood, and construction materials and many environmental benefits, such as erosion control, clean water and air, biodiversity conservation, and carbon sequestration. Deforestation, soil erosion, and land degradation are serious problems in Ethiopia (Bishaw 2001). The forest covers in Ethiopia and that of the Blue Nile River Basin in particular have been deteriorating at a progressive rate. The major causes of deforestation and environmental degradation in Ethiopia are increasing population, increasing demand for farmlands, and increasing demand for fuelwood to cook food and construction materials (Bishaw 2001; Haileslassie et al. 2008a, b; Gashaw et al. 2014, Kidane and Alemu 2015). The effects of poor farming practices and lack of conservation are responsible for the siltation of many rivers and dams in Ethiopia. The deforestation and soil erosion situations in the Angereb Watershed are worse and affect pollution of drinking water from the dam (Amare 2005; CSCA-Gondar 2020). The social and environmental problems in this watershed are complex and need long-term investment to improve sanitation, education, and livelihoods (Guillozet 2010). To address these environmental and livelihood problems, integrated watershed management and agroforestry were applied as strategy to overcome these problems. This chapter presents the challenges and opportunities faced by the Corvallis-Gondar Sister Cities Association on tree planting and agroforestry practices to address food security, soil erosion, and environmental degradation. It also explores the concepts of ecosystem-based approaches and integrated watershed management to achieve sustainability and proposes scaling up best practices for sustainable land use in Lake Tana and the greater Blue Nile Basin.

## Biophysical and Sociocultural Attributes of the Angereb Watershed

The Angereb watershed lies between UTM coordinate of N 1,394,096, N 1,407,336, E 328,073, and E 337,991 in North Gondar Zone, in the Amhara Regional State, Ethiopia (Fig. 18.1). Elevation ranges from 2100 to 2870 m above sea level and mean rainfall 1200 mm peaking in July and August (Guillozet 2010). The watershed covers approximately 7600 hectares and is part of the Blue Nile drainage (Fig. 18.1). The Blue Nile Basin (Abay in Ethiopia) covers wide range of landscapes and climatic zones in Ethiopia and Sudan. In response to those diverse landscapes and climatic zones, different agricultural production systems and socio-economic dynamics have evolved in the basin that responds to changing livelihoods opportunities (Haileslassie et al. 2008a, b, Kidane and Alemu 2015).

The watershed is the primary source of drinking water for the residents of Gondar. The Angereb River feeds the Angereb reservoir, and it is an earthen dam completed in 1986 to create the reservoir (Fig. 18.2). The reservoir was designed with a storage capacity of 5 million cubic meters (Amare 2005; Guillozet 2010; CSCA-Gondar 2020). The reservoir was expected to supply the majority of the city's drinking water until 2021; however, sediment from the surrounding hillsides

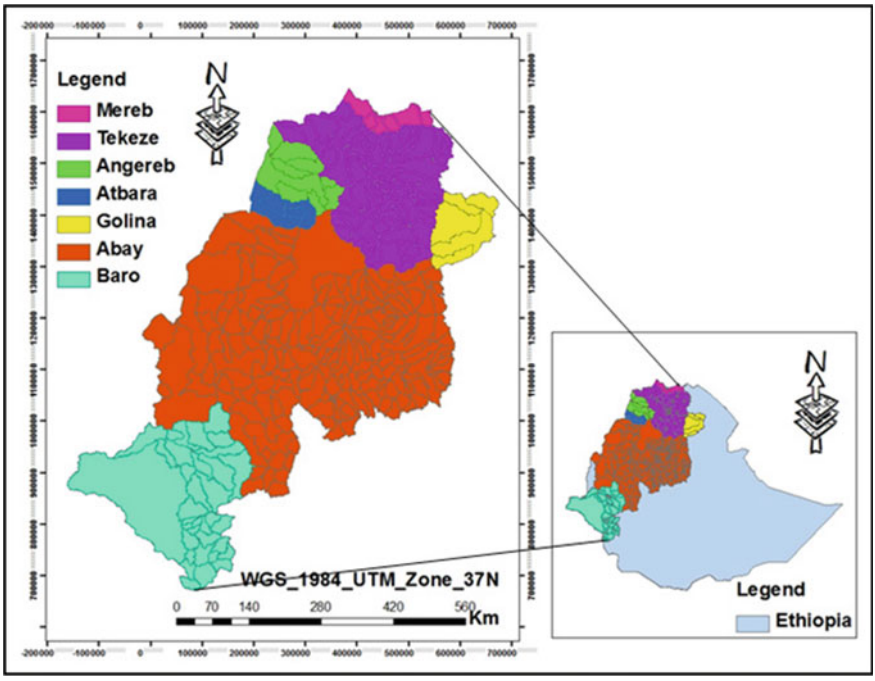


**Fig. 18.1** Map of the upper Blue Nile Basin, Ethiopia (Kidane and Alemu 2015)

and the Angereb River began accumulating soon after the completion of the dam. It is well documented that sedimentation problems will significantly reduce the life of the reservoir (Amare 2005; Guillozet 2010; CSCA-Gondar 2020).

Mixed farming practices of crops and livestock production using animal traction and wooden plows over centuries have created highly eroded soils leaving rocks scattered on fields and a reservoir half-filled with sediment (Hailesellasie et al. 2008a, b; Amare 2005; Guillozet 2010). Guillozet (2010) reported that the population of the Angereb watershed was 29,148 (5279 households) of which 57% urban and 43% percent rural. The average family size is about 5.52 persons. Population density within the watershed is about 382 per $km^2$. Approximately 13,685 persons or 2407 households engaged in farming, covering 70% of the watershed, with average farm size 2.2 ha. Main crop production includes wheat (38%), barley (28%), teff (21%), and horse beans (13%). Livestock is principal source of income and capital with estimates of 7000 cattle, 6300 sheep, 6500 donkeys, 3500 chicken, and 1100 goats. The hillside surrounding the reservoir has been stripped of trees primarily for fuelwood having the area adjacent to the reservoir exposed to soil erosion and entering the water as sediment.

The Corvallis Sister Cities Association-Gondar (CSCA-Gondar) was established in 2005, and the primary goal of this partnership are (1) To promote awareness and understanding between the people of Corvallis, Oregon, and the people of Gondar,

**Fig. 18.2** Angereb reservoir (CSCA-Gondar 2020)

Ethiopia, and (2) To undertake activities that are beneficial to the people of both Corvallis and Gondar (CSCA-Gondar 2020). To achieve these goals, the CSCA-Gondar established three working groups: (1) water and watershed, (2) education and (3) health. This chapter will focus on the contributions of the water and watershed-working group.

In 2007, CGCA-Gondar hydrologist and forester made preliminary visit to the Angereb watershed. The hydrologist noted that the water plant intake had been raised approximately 4.5 m (14.8 ft) since the start of the operation of the reservoir and was raised an additional 3.0 m (9.8 ft) in 2014. The intake should be at a depth of 5.0 m (16.4 ft) below surface water. The intake is now only 0.5 m (1.6 ft) below surface water (CSCA-Gondar 2020).

CGSA-Gondar forestry expert visited the watershed with counterparts in Gondar to explore the current land use and farming practices in the watershed. There are mixed cereal-livestock farming practices with eroded farms, big gullies, and striped hillsides denuded of trees. Consultation with counterparts and stakeholders discussed options on restoration of the Angereb watershed to improve the environmental degradation and increase agricultural productivity through an integrated watershed management and agroforestry. They also discussed to improve the Woleka nursery and explored potential seed source for the tree planting and agroforestry practices.

## Restoring the Angereb Reservoir and Watershed

The goal of the Corvallis Sister Cities Association-Gondar integrated watershed management project is to improve existing environmental degradation, such as soil erosion and improve farming practices to produce food, fuelwood, and income, while integrating practices and interventions on ecosystem services and develop human capacity to deal with complex systems (Negasa 2020). The objectives of the project were (1) Promote integrated watershed management, soil conservation, and longevity of the Angereb reservoir; (2) Collaborate with farmers, government representatives, and NGOs to develop sustainable practices and enterprises; (3) Promote tree planting through agroforestry to improve environmental function; and (4) Increase the awareness and participation of people who live in the watershed.

### *Methodology*

The methodology applied for this project has two parts: (1) Implementing integrated watershed management and agroforestry practices in the Angereb watershed. (2) Explaining how the concepts of ecosystem-based approaches and sustainability applied in the Angereb watershed. We used participatory approaches and field visits

to identify the natural resources problems that affected the livelihoods in the Angereb watershed. We proposed and implemented integrated watershed management and agroforestry as solutions to address these problems.

## Participatory Approaches

We involved different stakeholders, such as the Gondar City Administration, Department of Forestry and Agriculture, Department of Water Affairs, Farmers in the Angereb watershed, University of Gondar, and the Corvallis-Gondar Sister Cities Association in the project (Fig. 18.3). Field visits were carried out by experts from the Department of Agriculture and Forestry, Department Water Affairs, Gondar City Administration, and Corvallis Water and Watershed work group to observe the watershed functions and current land use and farming practices in the watershed (Fig. 18.4). We conducted meetings with the urban residents and rural farming communities to identify and prioritize the problems in the Angereb watershed. Through the participatory approaches (Fig. 18.3), the stakeholders identified the following natural resource problems in the Angereb watershed: (1) deforestation, (2) soil erosion, (3) loss of soil fertility, (4) severe water shortage (urban and rural), (5) chronic health problem, and (6) high levels of poverty. These natural resources constraints and lack of coordinated planning were listed by people of the Amhara region as critical to sustainable livelihoods and ecosystem functions. These are wicked problems and have cascading effects on the farming and land use practices in the Angereb watershed. Figure 18.5 reflects the environmental degradation associated with food insecurity and poverty of the region.

## Application of Ecosystem Approaches and Sustainability

The ecosystem approach is a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. It is based on the application of scientific methodologies focused on levels of biological organization. The ecosystem approach encompasses the essential processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems. Additional information on ecosystem-based approaches can be found at: https://www.cbd.int/ecosystem/.

The United Nations General Assembly first introduced the concepts of sustainability in early 1980s. The assembly was concerned about world population growth, deforestation, and environmental change. In 1987, the commission published "The Brundtland Report" or known as "Our common Future." In this report, they defined sustainable development: "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (Brundtland 1987; Kuhlman and Farrington 2010). The concept of sustainability is complex and important to find the balance between the ecological


**Fig. 18.3** Participatory approaches to identify natural resource problems

and human systems. The complexity lies in determining the nature of present and future needs, and who or what has those needs. Keeping with the traditional three-pronged approach to sustainability, "needs" can be generally broken up into those pertaining to the economy, to the environment, and to society. If sustainable development is to provide for the needs of the present as well as the future, economic priorities must shift from production to sufficiency; environmental concerns must focus on resilience; and society (farmers) must benefit equitably from resources.

In order to practice sustainability, one has to address the three pillars of sustainability that include environmental: addresses productivity and ecosystem services, society includes social, culture, ethical and political aspects, and economic market and non-market goods. The three pillars are interconnected and interdependent benefits. Giddings (2002) discuss about weak and strong sustainability and defines strong sustainability, as "a healthy environment is the foundation for heathy society and healthy economy."

To apply the concepts of ecosystem approaches and natural resource sustainability, we applied the following practices: integrated watershed management, (management of land, water and living resources), integrated socio-agro-ecological approach (long-term approach) (Fig. 18.6), integrate farming practices, resource conservation, reservoir maintenance (sustain long-term function), and adaptive management (learning-by-doing). Project implementation was carried out through


**Fig. 18.4** Field visit to the Angereb watershed to understand land use and farming practices

agroforestry and tree planting (nursery improvement, tree planting, and building terraces), community participation (participatory approaches, training, workshop, and extension), and strong integration (watershed restoration, water supply, and education).

## Result and Discussion

The stakeholders implemented integrated watershed management involving soil and water conservation, agroforestry, and tree planting to reduce siltation of the reservoir and alleviate food security and poverty. Through this project, the tree nursery at Weleka was improved and raised multipurpose indigenous and exotic tree species for planting. The following indigenous species raised at the nursery for planting: Weira (*Olea europaea*), Gesho (*Rhamnus prinoides*), Kentetifa (*Entada abyssinica*), Wanza *(Cordia Africana*), Misana (*Croton macrostachyus*), and Birbira (*Milletia ferruginea*). The following exotic species raised at the nursery for planting: Nim (*Azandirachta indica*), Key bhairzaf (*Eucalyptus camaldulensis*), Yeferenj tid (*Cupressus lustanica*), Nech bahirzaf (*Eucalyptus globulus*), Arzelibanos (*Casuarina equestifolia*), Yeferenj Grar (*Acacia decurrens*), Spatodea (*Spathodea nilotica*), Kundo berbere *(Schinus molle*), Gravilia (*Gravilia robusta*),

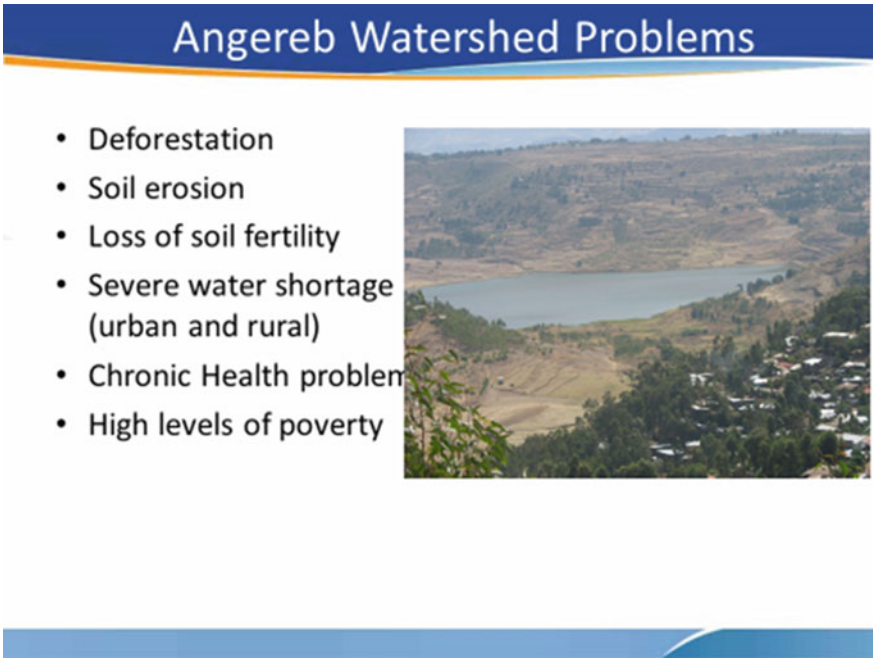


**Fig. 18.5** Environmental degradation, food insecurity, and poverty

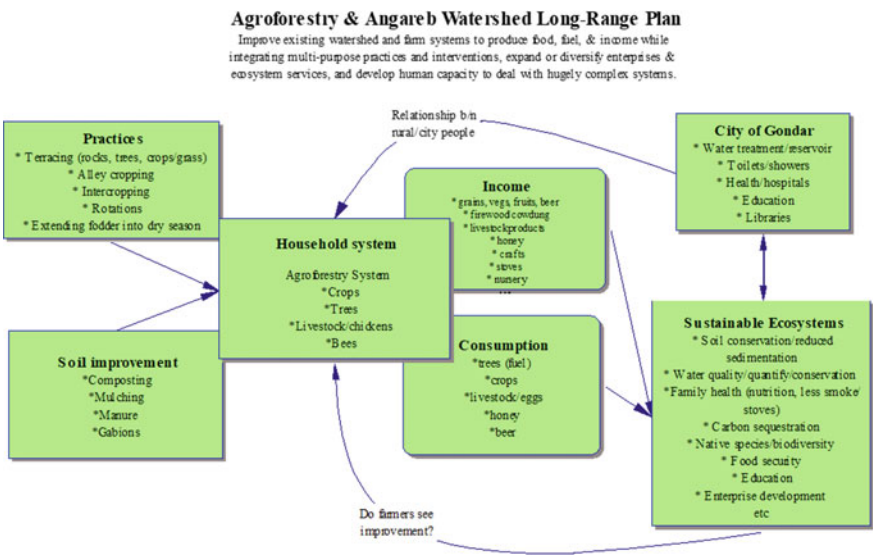


**Fig. 18.6** Angereb watershed long-range plan

and Sesbania (*Sesbania sesban*). Women were hired to plant seeds and take care of the seedlings at the nursery and created jobs for women in the neighborhoods. Figures 18.7, 18.8, 18.9, and 18.10 show the seedling preparation and reforestation process.

Farmers were involved in tree planting and agroforestry practices, such as, establishing riparian buffers along the streams, alley cropping for soil and water conservation by planting trees on terraces and agroforests/home gardens to address food security. Men prepared the site for field planting and take care of the seedlings by weeding, cultivation, and protecting from grazing animals. The first tree planting started in 2008 and 67,000 seedlings were planted on 20 ha in the immediate vicinity of the reservoir. During the 2009 planting season, an additional 250,000 seedlings planted around the reservoir. In 2010, tree-planting efforts shifted from the immediate area of the reservoir to various sub-watersheds within the Angereb watershed. In 2013, Gondar citizens committee recommended a more comprehensive approach, and the Bukaya sheleko sub-watershed (Fig. 18.9) selected as a demonstration area for more integrated and comprehensive approach to watershed restoration.

In addition to planting trees, income generation projects were included to provide residents with alternatives to gathering and selling firewood and grazing the hillsides. The tree planting continued from 2015 to 2019 and the CSCA-Gondar

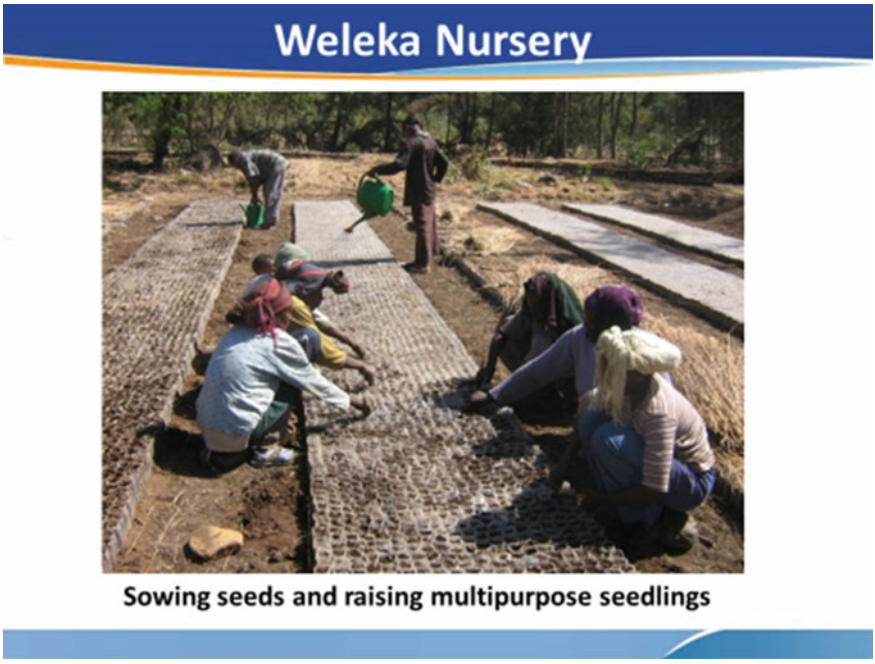


**Fig. 18.7** Sowing multipurpose seedlings Weleka Nursery


**Fig. 18.8** Seedlings of multipurpose trees ready for planting

provided funding to purchase seeds and raise the necessary seedlings in partnership with the Gondar Department of Agriculture and Gondar-based nonprofit Bridge of Hope. Through this project, 2.5 million tree seedlings planted on 560 hectares in the Angereb watershed in ten years (Table 18.1). These trees planted on terraces for soil and water conservation as alley cropping provided riparian buffers to reduce siltation of the reservoir. The planted multipurpose trees in home gardens address food security and alleviate poverty. In Table 18.1, it is assumed, 1.5 × 1.5 m spacing (2.25 $m^2$/seedling), 4450 seedlings/ha, and dividing 2,497,220 million seedlings by 4450 gives 561 ha.

## *Agroforestry for Food Security*

Mixed farming, which integrates trees, crops, and livestock, is common practice in the Ethiopian highlands. This farming practice planting patterns include sequential and intercropped designs that optimize land use and labor, conserve resources, and provide multiple benefits. Alley cropping which involves planting trees closely within rows, but rows are widely spaced on the contour to form natural terraces when coppiced at 25 cm to collect soil, while tree residues are used as fuel,


**Fig. 18.9** Site preparation for field planting

fertilizer, or fodder. On steep hillsides, this is a common practice to produce wheat, barley, and teff and conserve soil and water. One framer in Sabia sub-watershed planted gesho shrubs on the contour in a limited form of alley cropping giving promise that careful selection of tree species may make this practice feasible on steep sites. Gesho is a cash crop used for local brewing. Farmers in the Angereb watershed should also be encouraged to plant nitrogen fixing trees and shrubs to improve soil fertility and increase crop yields and income.

## *Agroforestry for Soil and Water Conservation*

Farmers expressed interest to improve or practice conservation that include terraces using rocks and planting trees and interplant grasses in upland fields. Trees and shrubs planted on terraces reduce soil erosion, create physical barrier, and enhance water infiltration. Eucalyptus trees planted in woodlots, on terraces or rock piles, and along riparian streams to reduce bank collapse. Farmers also expressed interest in planting multipurpose trees along 5 m of the stream, inter planting trees and grasses to upland cropland, and adding fruit (low-chill apple, mango, citrus, etc.) and gesho shrubs to their farming system. The fruit trees and gesho can offer


**Fig. 18.10** Agroforestry tree panting project

**Table 18.1** Seedling produced and planted in the Angereb watershed 2008–2019

| Year | # Seedlings |
|---|---|
| 2008 | 67,000 |
| 2009 | 250,000 |
| 2010 | 350,000 |
| 2011 | 291,165 |
| 2012 | 228,347 |
| 2013 | 253,160 |
| 2014 | 262,548 |
| 2015 | 200,000 |
| 2016 | 125,000 |
| 2017 | 125,000 |
| 2018 | 125,000 |
| 2019 | 100,000 |
| Total | 2,497,220 |

additional income sources but need additional study perhaps by the University of Gondar. Farmers might consider grass mixes to optimize fodder choices for livestock while contributing to ecosystem services and conservation practices.

### *Agroforestry for Biodiversity*

Home gardens agroforestry is a more complex multi-stratum than other agroforestry systems (Asfaw et al. 2015). In home garden agroforestry, cultivation of planned and intensively managed trees, crops, and livestock exists. In the Angereb watershed, farmers by growing food crops, shrubs, herbs, and medicinal plants practice home garden. Traditional medicinal shrubs and herbs grow in the understory. Home gardens are diverse, provide ecosystem balance and sustainability, household food security, and rural development in Ethiopia. The multipurpose trees and shrubs planted in agroforestry systems increase vegetation diversity. The diverse nature of agroforestry helps increase biodiversity, reduce crop failure, and economic risks.

In addition to tree planting and agroforestry practices, the CSCA-Gondar constructed 19 water sources including drilled wells, hand-dug wells, and developed springs to provide clean drinking water for 1,700 households in Gondar city and the surrounding villages (CSCA-Gondar 2020).

### *Agroforestry for Mitigating Climate*

Managing sustainable development in the face of a drastically changing climate can be very difficult. Knowing and deciding, which actions taken in the present will be sustainable in the future, are even harder decision to make. Management for future conditions is even more difficult given that some tree species may not even be present in the future. Although the best and most current science and literature can be applied to ecosystem-based approaches, the uncertainties about future climates make management a difficult task (Bishaw et al. 2013). Although there are many pessimistic outlooks regarding future resource management and climate change, carbon offset sales programs may be a positive policy that could relate to more sustainable development. These carbon offset management actions would be looking at additional values beyond just the board foot value of agroforestry.

## Conclusions and Recommendations

Agroforestry is a dynamic, ecological-based natural resources management system that provides many environmental services and production systems and address the social and economic benefits that society needs. In addition to the environmental services and improving production systems, agroforestry plays great role in climate change adaptation and mitigation (Kuyah et al. 2019; Tamirat and Mekides 2020). Climate change is one of the challenges of subsistence farmers, and farmers in the Angereb watershed are no exception. Because of its diverse nature, agroforestry serves as tools for climate change adaptation and mitigation. Farmers by using

drought resilient crop varieties such as sorghum, millet, and yam, they can adapt to climate change. Farmers should also change their farming strategies by adapting shorter agricultural calendar. Regarding livestock, farmers should switch to animals, which can live more easily in dry conditions such as goats that do not need as much water as sheep and cows (Bishaw et al. 2013). Agroforestry also sequester more carbon from the atmosphere, trees, and shrubs on farms can sequester carbon and mitigate climate change. Agroforestry systems store significant amount of carbon belowground. Carbon stored in agroforestry systems could be sold in carbon credit markets and generate additional income to the farm household.

To promote sustainable integrated watershed management and agroforestry practices in the Angereb watershed, we recommend the following biophysical, social, cultural, and policy frameworks. (1) Control soil erosion by constructing check dams, terraces, and soil improvement activities. (2) Focus on multipurpose trees, shrubs, and fruit trees to improve agricultural production and increase incomes. (3) Use participatory approaches, build on existing culture, and address local development issues. (4) Build capacity and awareness of local people through training and workshops. (5) Promote education and training in environmental health and climate change at elementary, high schools, and universities. (6) Increase the scientific knowledge on ecosystem-based approach by engaging universities, national, and international research institutions. (7) Increase interagency collaborations among ministries, such as agriculture, forestry, environment, water, health, and education, etc. These are similar to the findings and recommendations given to improve watershed management practices in Ethiopia (Negasa 2020).

We recommend scaling up the ecosystem-based approaches and sustainability concepts using lessons learned from the integrated watershed management and agroforestry practices on tree planting, soil and water conservation, and food security in the Angereb watershed to the larger Blue Nile River Basin. Despite the many opportunities agroforestry provides, there are several challenges to scale up agroforestry practices. These are issues regarding social (demographic factors, land ownership, unavailability of markets, infrastructure), economic (financial incentives, economic benefits), and environmental (soil erosion, water quality, global climate change) (Tamirat and Mekides 2020).

Lake Tana, one of the biggest Lake in Ethiopia, is affected by an invasive weed, water hyacinth. This weed has affected the biological, physical, and social life in and around the lake. Integrated control strategy, such as manual, mechanical, and biological control can be used to remove this weed. It is also proposed to improve the riparian buffers along the lake to filter sediment, nutrients, and pesticides. We recommend integrated watershed management and agroforestry practices to reduce siltation of the Lake and address environment services and food security.

Concerning the Grand Ethiopian Renascence Dam (GERD), while completion of the first phase is a great success, there is great concern about siltation of the dam ( Deribe and Tirusew 2020) and the dam being affected by water hyacinth. We recommend treating the whole Blue Nile River Basin with integrated watershed management and agroforestry practices to address the ecological, social, and economic issues and promote sustainable development. We hope this will address the

environmental degradation, soil erosion, and food security, which will have great impacts on survival of Lake Tana and extend the longevity of the Grand Ethiopian Renaissance Dam (GERD) by reducing siltation.

## References

Amare A (2005) Study of sediment yield from the watershed of the angereb reservoir. M.Sc. Thesis, Alemaya University, December 2005, p 114

Asfaw Z, Linger E, Zewudie S (2015) Plant species richness and structure of homegarden agroforestry in Jabithenan District, Northwestern Ethiopia. Int J Environ Sci 4(2):52–58

Bishaw B (2001) Deforestation and land degradation in Ethiopian highlands: a strategy for physical recovery, vol 8, issue 1. Oregon State University, Corvallis. North East Africa Sturdies (ISSN 0740–9133), pp 7–26

Bishaw B, Neufeild H, Mowo J, Abdulkadir A, Muriuki J, Dalle G, Assefa T, Guillozet K, Kassa H, Dawson IK, Luedeling E, Mbow C (2013) In: Davis CM, Bernart B, Dmitriev A (eds) Farmers' strategies for adapting to and mitigating climate variabilty and change through agroforestry in Ethiopia and Kenya. Forestry Communications Group, Oregon State University, Corvallis, Oregon, pp 15–20

Brundtland, Gro Harlem (1987) Report of the World Commission on Environment and Development: Our Common Future. http://www.un-documents.net/our-common-future.pdf. Accessed 12 Jan 2021

Convention on Biological Diversity (CBD), Ecosystem Approach. https://www.cbd.int/ecosystem/. Accessed 31 Dec 2020

Corvallis Sister Cities Association-Gondar, Ethiopia (CSCA-Gondar) (2020) Restoring the angereb reservoir and watershed. Accessed 31 Dec 2020. https://sistercities.corvallis.or.us/angereb-watershed-restoration/

Gashaw T, Bantider A, G/Silassie G (2014) Land degradation in Ethiopia: causes, impacts and rehabilitation techniques. J Environ Earth Sci 4(9). ISSN 2224–3216 (paper) ISSN 2225–0948 (online)

Giddings B, Hopwood B, O'Brien G (2002) Environment, economy and society: fitting them together into sustainable development. Sustain Dev 10(4):187–196

Guillozet P (2010) Angereb watershed targeted revegetation strategy. Gondar, Ethiopia. Corvallis Sister Cities Association Gondar, Ethiopia, Report April 2010. p19

Haileslassie A, Hagos F, Mapedza E, Sadoff C, Awulachew SB, Gebreselassie S, Peden D (2008) Institutional settings and livelihood strategies in the Blue Nile Basin: implications for upstream/downstream linkages. Colombo, Sri Lanka: International Water Management Institute, p 81 (IWMI Working Paper 132)

Haileslassie A, Hagos F, Awulachew SB, Peden D, Gebreselassie S, Negash F (2008) Indicators of environmental degradation in the Blue Nile Basin: exploring prospects for payment for environmental services. Paper presented at the Second Nile Development Forum, Khartoum, Sudan, 17–19 November 2008, 37p. https://hdl.handle.net/10568/38113

Kidane D, Alemu B (2015) The effect of upstream land-use practices on soil erosion and sedimentation in the Upper Blue Nile Basin. Res J Agric Environ Manag 4(2):055–068. Available online at http://www.apexjournal.org

Kuhlman T, Farrington J (2010) What is sustainability? Sustainability 2(11):3436–3448

Kuyah S, Whitney C, Jonsson M, Sileshi G, Oborn I, Muthuri C, Luedeling E (2019) Can agroforestry enhance ecosystem services provision without reducing productivity. Agroforestry 2019, Regular Talk

Negasa DJ (2020) Major constraints of watershed management practices in ethiopia and ways forward (review article). Int J Environ Protect Policy 8(4):70–76. https://doi.org/10.11648/j.ijepp.20200804.11

Tamirat W, Mekides A (2020) Opportunities and challenges of scaling up agroforestry practices in Sub-Saharan Africa: a review. Agric Rev 41(3):216–226. Submitted: 09–06–2020 Accepted: 22–08–2020 Published: 11–09–2020

Deribe M, Tirusew A (2020) Beyond the normalization of climate change, Ethiopia's Green Legacy is a must have insurance for the GERD. Accessed May 18, 2021https://www.weaspire.info/.