Green Anchor Zones (GAZ)

Local Microclimate Engineering for Climate Migrant Communities

Innovative Landscape-based Adaptation Framework to Support Climate Displaced Communities

July 2025

Abstract

The intensifying effects of climate change have emerged as a leading cause of population displacement, often outpacing conflicts and violence in their scope and severity. Forecasts indicate that by the year 2050, climate-related migration could impact anywhere from 25 million to 1 billion people globally. Ethiopia, with a population exceeding 120 million, is among the most vulnerable countries in the Horn of Africa. The Somali National Regional State alone accounts for 33.3% of the country's total migrant population. Within this region, the Shabelle Zone has experienced the worst drought in over 50 years since November 2016, driven by the compounded effects of failed seasonal rains and the El Niño phenomenon. In response to this crisis, the Green Anchor Zone (GAZ) initiative offers an innovative and sustainable solution aimed at reversing ecosystem degradation and reducing climate-induced migration. This multi-phase, 4–7-year project focuses on three core components: (1) Climate Migrant Community Mobilization and Co-Design, (2) Rapid Eco-Restoration and Water Harvesting Interventions, and (3) Skills Training and Local Eco-Innovation. The initiative aims to empower communities particularly youth to lead climate resilience efforts and take ownership of long-term environmental restoration. We believe the GAZ project holds transformative potential, not only to mitigate climate migration in affected regions but also to serve as a scalable model for other climate crisis zones, putting the power of change directly into the hands of those most affected.

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1. Introduction

1.1. Background Information

The consequences of climate change on migration present humanity with an unprecedented challenge. The number of storms, droughts, and floods has increased threefold over the last 30 years, with devastating effects on vulnerable communities, particularly in the developing world (Dasgupta et al. 2009). During 2008, weather-related disasters displaced around 20 million people, which significantly exceeded the 4.6 million displaced due to conflicts in that timeframe. It is estimated that 25 million to 1 billion people will be affected by climate change by 2050 (IOM 2009). For the most part, these figures represent the number of people exposed to the risk of climate change in certain parts of the world and do not take account of the measures that could be taken to adapt to these changes. The Horn of Africa region (Ethiopia, Eritrea, Somalia, Djibouti, Sudan, Kenya, and Uganda) supports one of the largest pastoralist areas anywhere in the world (Fre and Tsegay 2013). Aside from the long-running conflicts and political violence, it is one of the region's most vulnerable to climate-related risks. The Horn of Africa frequently encounters climate variations, reflected in falling water levels across lakes, rivers, and wetlands (lakes, rivers, wetlands, among others), unexpected rainfall patterns, prolonged drought, frequent floods, soil erosion, and erosion of temperatures. Increasing rainfall deficit has negatively affected the local populations whose livelihoods rely mainly on agriculture, livestock, forest resources, water, wetlands, etc (Somorin 2010).

Ethiopia, with a population of over 120 million, is among the most affected countries in the Horn of Africa. In the last several years, it has been facing unprecedented levels of displacement due to conflict and drought (Tufa 2024). The country has registered 4.4 million IDPs, who are hosted in numerous camps and camp-like environments. Additionally, the country also hosts 970,299 refugees and asylum seekers from neighboring South Sudan, Somalia, Eritrea, and Sudan

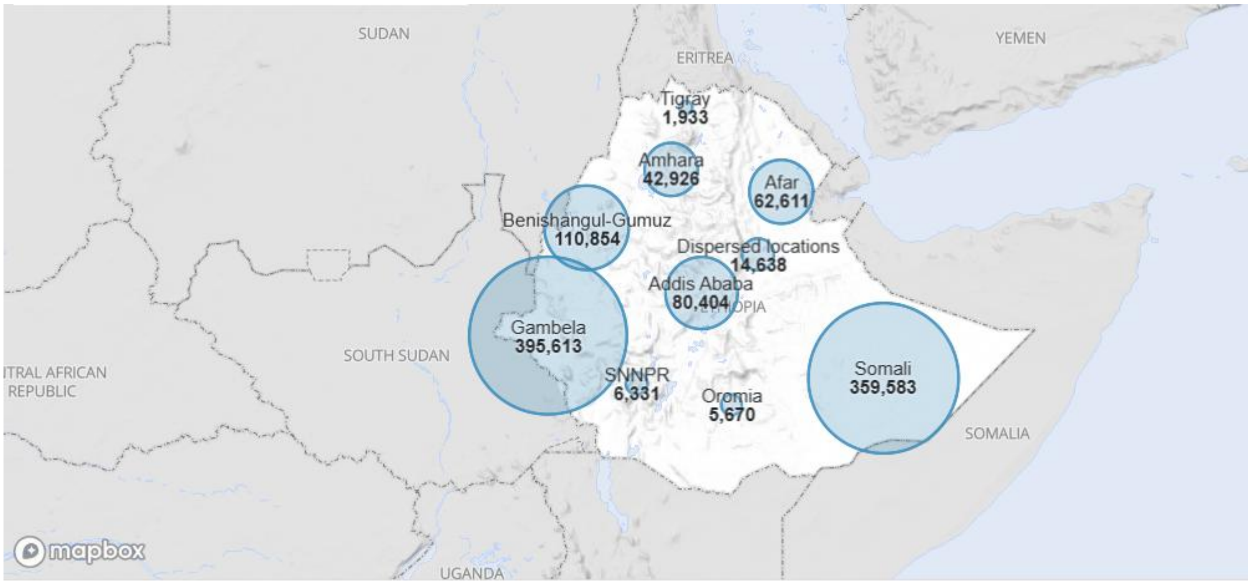

Figure 1. Total Refugees and Asylum Seekers in 2025 in Ethiopia (source; https://data.unhcr.org/en/country/eth)

The Somali National Regional State of Ethiopia hosts 33.3% of the total migrants. According to a recent assessment (limited to only accessible areas), the regional state hosts 542,807 climate-affected IDPs (the regional state claims the number is more than double), caused by the recent drought (Tufa 2024). In less than 10 years, Ethiopia has experienced multiple droughts, namely a drought between 2015 and 2017, and a drought since 2020, which, due to five consecutive failed rainy seasons, is among the most severe droughts recorded in the last forty years (Ferris 2020). The regions of Oromia and Somali currently host the highest drought displacement figures, specifically Dawa, Liban, Afder, and parts of the Shabelle zones in the Somali region and the Borena zone in the Oromia region and majorities of them are females (Figure 2) (Ferris 2020).

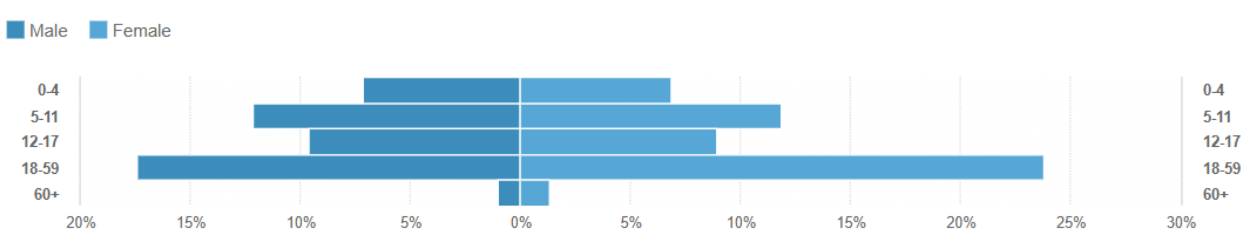

Figure 2. Total Refugees and Asylum Seekers in 2025 in Ethiopia breaking down by gender (source; https://data.unhcr.org/en/country/eth)

1.2. Problem statement

The eastern Horn of Africa is currently experiencing increasingly intense and recurrent cycles of flooding and drought. Across Ethiopia, Kenya and Somalia, From 2020 to 2022, the Horn of Africa experienced one of the most intense and prolonged La Niña events in seven decades, leading to at least four consecutive failed rainfall seasons (UNDRR 2024). The region experienced extreme rains in 2019-20, followed by widespread and devastating floods, then a drought from 2020 to 2023, and severe flooding in 2023-2024 (UNDRR 2024).

In Ethiopia, as of the end of July 2019, 425,000 people were living in displacement associated with drought, 64,000 triggered by sudden-onset disasters, such as floods and landslides, and 1.1 million by conflict (Cortés Ferrández 2019). In the Somali region, internal displacement, driven by alternating periods of drought and flooding and recurrent intercommunal conflict, has placed thousands of people in a situation of humanitarian crisis. About 1.05 million individuals remain displaced in 419 displacement sites in the region (UNICEF 2018).

Over recent years, the Somali Region has undergone shifts toward drier and hotter conditions, with increasingly erratic weather patterns and is expected to worsen in the future (Destrijcker et al. 2023). It is already feeling the adverse effects of climate-induced droughts, displacement, and water stress at an alarming level (Destrijcker et al. 2023). Consecutive and multi-year climate variability and extremes have left the region with drought and displacement, in addition to receiving refugees from other areas. The duration and severity of the current drought in Ethiopia have already exceeded the droughts of 2010–2011 and 2016–2017. Some 3.9 million people are estimated to require emergency food assistance in the region, which is 62 per cent of the population (Parliament 2024). As of March 2023, nearly 2.9 million people in the region were reportedly in urgent need of emergency water support and expecting to escalate the migrant in the region (OCHA 2023).

In early 2023, the Somali Region's Disaster and Risk Management Bureau shared that over 3 million people had been impacted by the current drought (especially in the Afder, Liben, and Dawa zones) and more than 4.5 million livestock had died since late 2021, leaving 30 million at risk (Destrijcker et al. 2023). Hence, Green Anchor Zone ideal solution by resorting the ecosystem to reduce the climate migrants in the region.

1.3. Problem Analysis

Previous droughts across the Horn of Africa brought already devastating effects on the population in Somali region. Additionally, since November 2016 Shabelle zone of Eastern Ethiopia has experienced the worst drought in more than 50 years. As a result of the failure of the weak Gu (spring) and Dyer (fall) rains, attributable to and exacerbated by the El Nino event, more than 10% (10.2 million) of the population are in need of emergency support (Austrian Development Agency 2017). In the Shabelle zone the livelihoods of 85% of the population are linked to livestock production and management. Harvests of food and livestock fodder in the agro-pastoralist areas will be far below the expected. Food prices are on the steep increase and many families are gathering around the few available water sources and food distribution points (FAO 2021). The lack of water in combination with the escalating impoverishment of large part of the population has triggered a serious acute water diarrhea epidemic and admission of severely malnourished children and women is constantly rising (Austrian Development Agency 2017).

An estimated 172,736 households comprising 1,025,535 IDPs were identified in 538 accessible sites in Somali region. These figures represent a decrease of 296,149 IDPs (-22.4%) since the consolidated round 33 (November 2022 – June 2023) (Tufa 2024). The decrease can be explained by the closure of 105 sites in Liban, Afder, Dawa, Doolo, Erer, Fafaan, Korahey, Nogob, Siti and Shabelle zones as IDPs either returned to their areas of origin or locally integrated (IOM 2023). IDPs in these sites were initially displaced by conflict, drought and flooding and high internal migration was registered in recent years (IOM 2023).

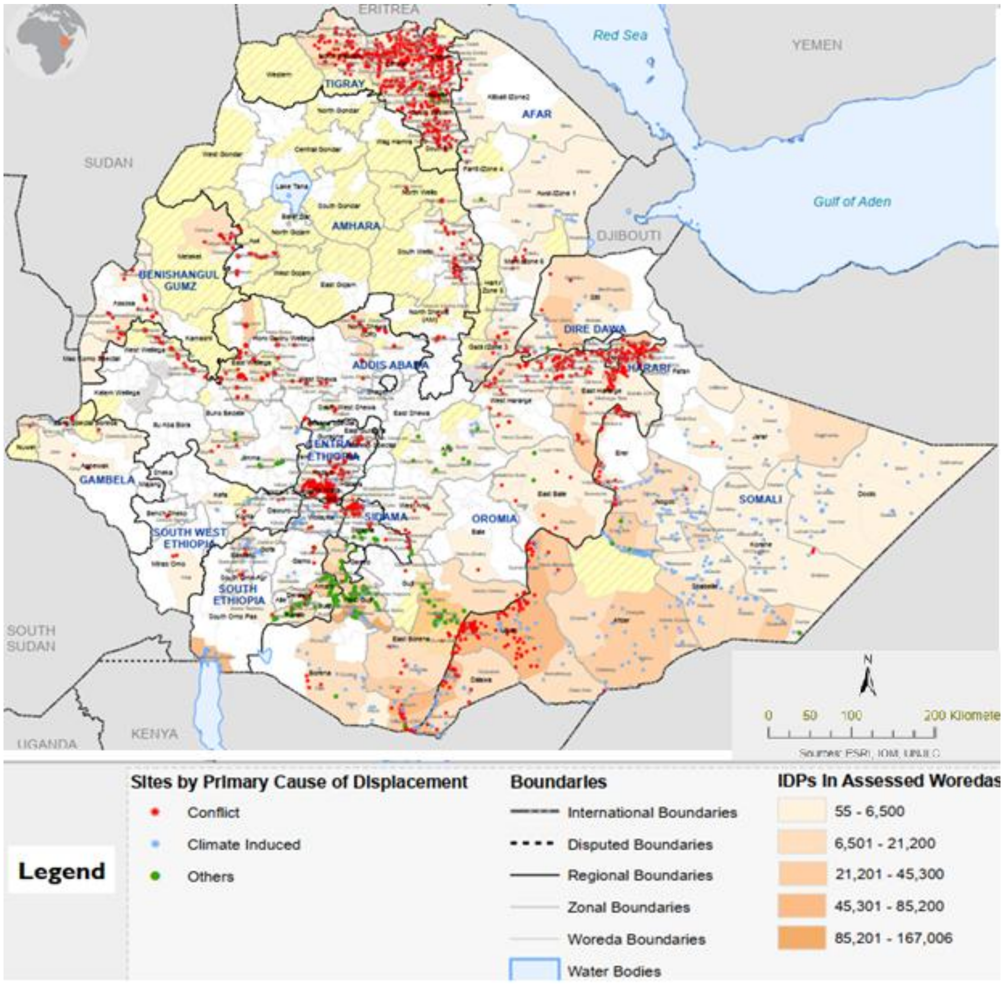

Figure 3: The estimated IDP caseload in Ethiopia based on data collected from August - September 2023 from the Site Assessment (IOM 2023).

2. Potential for Implementing the Local Microclimate Engineering project

Along the Shabelle river have been described as the breadbasket of Somalia. For several decades irrigated agriculture has been practiced along the plains, producing food not only for local consumption but also for export (Klas Sandström 2021). Available records indicate that before the collapse of the former Somali government in 1990, over 220,000 hectares of land along the flood plains were under either controlled irrigation or recession farming. Maize, sesame, fruits and vegetables were some of the crops grown for local market, while sugarcane and rice were grown for both local and foreign markets (Klas Sandström 2021).

The story is different now. A recent study by SWALIM and Mott McDonald (2015) in Middle Shabelle identified that the irrigation infrastructure is in poor operational condition, a status which also applies to other regions along the rivers where irrigated agriculture was practiced (FAO and SWALIM 2015). This has significantly affected the agricultural production in the region. The potential of the flood plains remains, however, and all that is required for their full exploitation is to restore the dilapidated infrastructure**.**

The Shabelle area in Ethiopia holds considerable potential, particularly in agriculture and water resource development, despite facing challenges with flood management and water scarcity. The region's flat topography and fertile land along the Shabelle River, which flows from the highlands, make it suitable for both rain-fed and irrigated agriculture (Klas Sandström 2021). Furthermore, the area's potential for livestock production, particularly cattle, could be enhanced with improved management practices and infrastructure.

Ecosystem restoration efforts, however, have shown measurable success in reversing this trend. Pilot projects in comparable arid and semi-arid regions of Ethiopia (such as Managing Environmental Resources to Enable Transitions (MERET) and SLMP (Sustainable Land Management Program demonstrated that restoring degraded land through soil and water conservation, reseeding native grasses, and building water harvesting structures can increase agricultural yields by up to 45%, improve water availability, and regenerate biomass (Abera et al. 2020). In community-managed enclosures where restoration took place, household income rose by 30–40%, and migration pressure decreased by up to 40% (UNDP 2022). Predictive models from Ethiopia’s Climate Resilient Green Economy (CRGE) Strategy and IFPRI simulations suggest that restoring just 30% of degraded land in Shabelle by 2030 could reduce climate migration by 35% and double water retention capacity (CRGE 2020;UNEP 2024). Therefore, ecosystem restoration is not only ecologically imperative but also a practical, evidence-based intervention to reduce displacement and enhance climate resilience in pastoral communities.

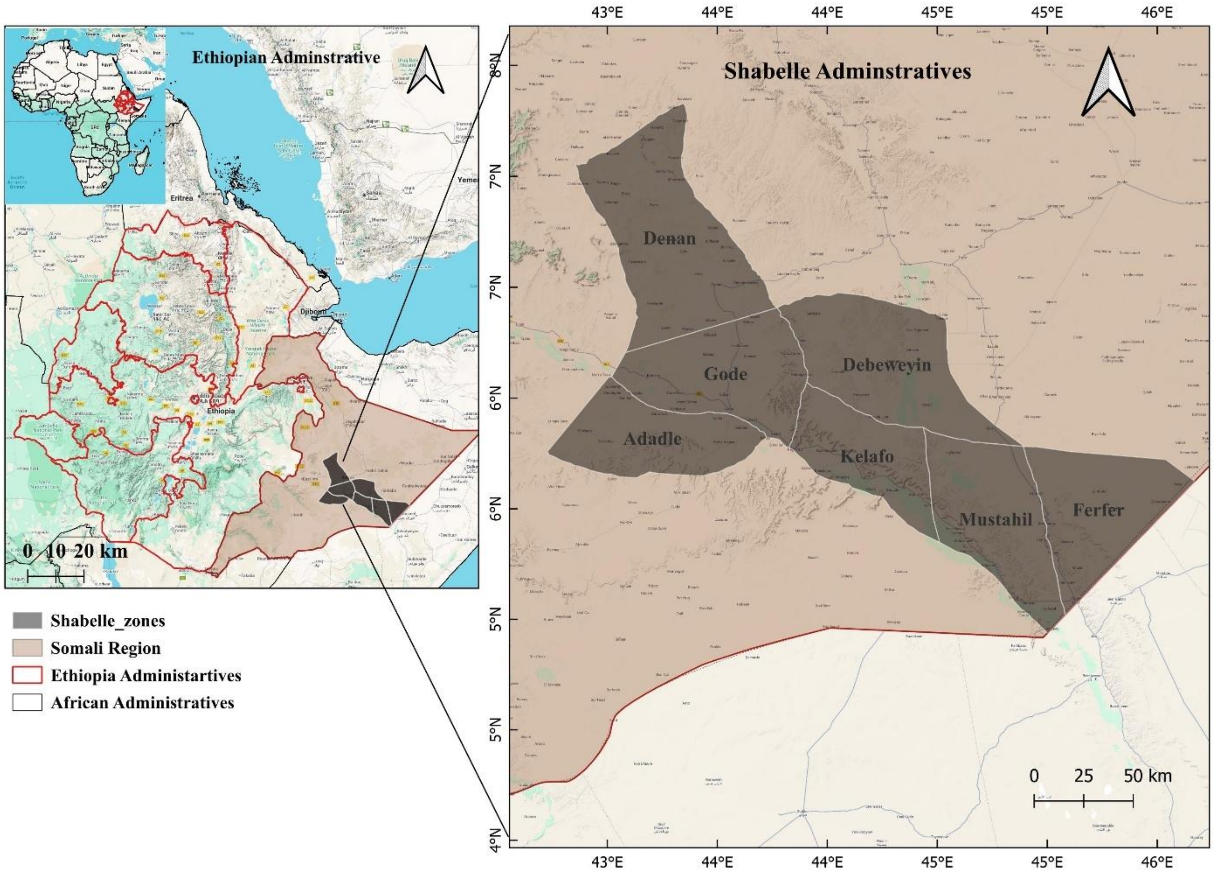

Figure 4: Location map of Shebelle district (Project Pilot area)

3. Strategic plan and solutions

Phase 1: Climate Migrant Community Mobilization & Co-Design

The main aim of this phase is to engage climate migrant populations as designers and owners of local microclimate engineering solutions. Hence, it follows several steps to achieve it. This phase includes the following activities:

a. Mapping push factors

To begin, detailed mapping exercises will be carried out to identify and document the main factors driving climate-induced migration in the target communities. These factors may include severe water shortages, widespread land degradation, ongoing food insecurity, loss of livelihoods from droughts or floods, and related social and economic challenges. The mapping process will combine participatory GIS methods with in-depth community interviews to ensure the information gathered is both accurate and relevant.

Location-specific adaptation strategies must be informed by charting and assessing push factors, as climate-related mobility theory prioritizes that adverse environmental conditions in sending communities (push factors) directly influence mobility choices (de Sherbinin et al. 2022).

b. Conducting community consultations

Structured community consultations are considered crucial for gaining insights on local adaptation experiences with climate impacts, vulnerabilities, adaptation measures, and traditional knowledge. This approach allows developing more effective, community-led adaptation plans (Schreckenberg et al. 2016).

This exercise in mapping will be followed by community consultations through facilitated workshops for the project. The workshops will utilize methods such as climate stories, seasonal calendars, migration timelines, and participatory resource mapping to enable unstructured interaction and discussion among community members. The aim is to find out how the effects of climate are being experienced, why individuals migrate, coping mechanisms, and adaptive capacities of communities. Specific focus will be directed toward indigenous knowledge and local adaptation strategies documentation because these will be the pivot on which the following project interventions will be built.

c. Establishing a community Eco-action committee

This committee will be the central governance framework, and its responsibility will be to co-design project interventions, legitimize activities, and to act as a bridge between the project team and the wider community. The Community Eco-Action Committee will have several key roles, such as

- Reviewing and approving plans for microclimate engineering initiated by the community
- Monitoring progress
- Providing ongoing feedback

In addition, committee members will undergo training exercises to develop local leadership to strengthen the capacity of all community members to undertake project leadership, an important factor to foster long-term project sustainability. In community governance practices, committees have to ensure engagement of female, youth, and pastoralist representatives, in addition to the traditional authority leaders, to ensure participatory and equitable decision-making and avoid marginalization of some groups (Rodgers 2021)

d. Validation sessions

All the results from the previous consultations, including the action plan, the report on the push factors and the community stories will be shared with all stakeholders through workshops, to maintain transparency and ensure community support. The aim is to build trust, strengthen accountability, and foster collective motivation for effective implementation in future phases.

Outcome

An important outcome of this phase will be the creation of a detailed local action plan developed and agreed upon by the committee and the wider community. This plan will set out priority activities for restoring the local microclimate, along with clear roles, responsibilities and timelines. It will provide a solid foundation for the next phases focused on rapid restoration and long-term resilience.

Phase 2: Rapid Eco-Restoration & Water Harvesting Interventions

Arid lands are a critically important yet often overlooked resource, comprising about 41 % of the Earth's terrestrial surface (Gaur and Squires 2018). Approximately two billion people reside in these regions, relying on croplands, forests, and grasslands to sustain their livelihoods (Sunderland and Rowland 2019). These lands, despite being frequently underappreciated, host some of the most biologically and biogeochemically active and diverse ecosystems and cover a substantial portion of the Earth's terrestrial surface. They support an array of ecosystem services, including carbon storage and sequestration, climate regulation, food provision, and eco-tourism, with an annual economic value exceeding trillions of dollars (Ayesu et al. 2024). However, arid lands are particularly susceptible to water scarcity, drought, and climate change, posing significant threats to human survival, food security, and ecological safety (Jain et al. 2024). With the current escalation of global climate change and human activities, the probability of anomalies in temperature, precipitation, and evapotranspiration is increasing (Dai et al. 2018). The ongoing trend towards warmer and drier conditions, coupled with the emergence of extreme weather events, has led to ecological thresholds being exceeded in some areas, resulting in vegetation and soil degradation particularly in Somali region (Ummenhofer and Meehl 2017;Gebremeskel et al.

2025). In this context, the swift and effective restoration of the ecological environment and fostering the development of ecosystems to fully leverage their service functions have become pressing scientific imperatives that demand urgent resolution and refinement. Hence, the goal this phase 2 is to create immediate ecological anchor points to stabilize communities and attract return migration as pilot project.

2.1. **Water-Focused local microclimate Engineering**

The Shebelle Zone in southeastern Ethiopia faces increasing water scarcity due to erratic rainfall, land degradation, and the impacts of climate change (Sahal and Tilahun 2023). As a partial arid and semi-arid region dependent on seasonal water sources, local solutions are essential to enhance water availability and resilience. This phase explores the effective water-focused local microclimate engineering techniques tailored to the Shebelle context, including rainwater harvesting, sand dams, greywater reuse, and potential floodplain restoration. These methods aim to sustainably capture, store, and reuse water to support communities, recharge groundwater, and strengthen the local ecosystem.

Rain water harvesting (RWH) is main potential source for the project area to secure water scarcity. According to Bojer et al. (2024), identifying potential RWH locations in drought-prone areas, specifically the regional states of Somali using geospatial techniques and a multi-criteria decision analysis (MCDA). In Shebelle zone the result shows, there is a potential for RWH ranges from low up to medium. Since such action is not enough to full fill for ecosystem restoration. Installing Sandy dams are essential to the project area since the area are susceptible to flash flood (Merga et al. 2023;Ibrahim et al. 2024). During the restoring process such kind of preservation much be considered as potential as well as a threat for the project.

Check dams and stone bunds in Northern Ethiopia reduce runoff peaks by 12% and total runoff by 18%, enhancing infiltration and baseflow (Muhidin et al. 2024), such preserving type can be installed in the project area and integrated with sandy dam to conserve water and reduce evapotranspiration. The technology filters and protects water from contamination and evaporation with low to no maintenance cost. Sand dams improve the socio-economy of the community and help to cope with drought and climate change (Yifru et al. 2021). According to Ryan and Elsner (2016), utilizing multi-year satellite imagery to monitor the effect of droughts at sand dam location in Arid area. A time series of satellite images was analyzed to compare vegetation at sand dam sites and control sites over selected periods of drought. The results show that vegetation biomass was consistently and significantly higher at sand dam sites during periods of extended droughts. It is also shown that vegetation at sand dam sites recovers more quickly from drought.

Additional water use system is nature based grey water reuse in community centers is one way to address the scarcity of water. Such practice also applied in Burkina Faso (Maiga et al. 2024), This study implemented and assessed, over a period of four weeks, a full-scale constructed wetland designed to collect and treat the greywater for a rural household located in an arid environment typical of Africa's Sahel region. The system was constructed from local materials and consisted of a shower room; a receiving basin, a pre-treatment filter, and a subsurface horizontal flow wetland planted with *Chrysopogon zizanioides*. Results showed the overall removal of organic matter was greater than 90%, and orthophosphate and ammonium were reduced by 73% and 60%, respectively, allowing for the treated water to retain some embedded nutrients. In Ethiopia, constructed wetlands have also been used effectively for example, to treat coffee-processing wastewater using vetiver grass, achieving comparable pollutant removals (Yohannes et al. 2024). Taken together, these studies support the idea that nature-based greywater reuse systems are both feasible and effective in dryland contexts, including the Shebelle region. They offer water recycling, irrigation potential, low-cost implementation, and ecosystem benefits.

Restoring the wetlands and floodplains along the Shebelle zone is also another approach to recharge groundwater and support biodiversity. The Somali region has always been a dry place, but the soils are rich and the wetlands here have good potential to contribute to water security (Sharmarke 2018). The people who live here are highly dependent on their environment and its sparse wetlands for food and water. In the Upper Fafan catchment of the Shebelle Basin (Somali region), Wetlands International implemented ecosystem-based interventions starting in 2019 (Mukhtar Ali 2022). These included reforestations, check dams, and management planning that simultaneously addressed flood buffering, groundwater recharge, and wetland rehabilitation. This approaches in some area of Shebelle District restored degraded seasonal wetlands and helped regulate water flows.

2.2. **Land and Soil-Focused Local microclimate Engineering**

Restoring the degraded land, declining soil fertility, and moisture in Shebelle Zone in southeastern Ethiopia essential since it faces loss of biodiversity frequent, livestock deaths, low crop yields and poverty, due to arid climatic conditions and unsustainable land use management mostly among agro-pastoral communities (Zerga et al. 2018). To address these challenges, land and soil-focused local microclimate engineering offers practical, nature-based solutions that restore ecological balance while improving water retention and agricultural productivity. Techniques such as zai pits, contour trenches, compost and biochar amendments, and the use of drought-tolerant vegetation can regenerate degraded soils, enhance infiltration, and create favorable microclimates (Kerubo 2022;Kabiri 2024). This approach aims to revitalize landscapes and support sustainable livelihoods in one of Ethiopia's most climate-vulnerable regions.

Zai pits are dug into degraded soil in arid and semi-arid regions to harvest and conserve water that crops like maize, onions, potatoes, bananas and vegetables need to grow. These basin-shaped pits are filled with organic manure, compost and mulch which help to rehabilitate the soil and conserve soil moisture before seeds are added. The pits, which are 20-30 cm in width, 10-20 cm deep, and 60-80 cm apart, help to ensure water availability at the plants' roots. In Burkina Faso, Niger and Kenya, farmers dig zai pits on their farms and some have (Africa 2024). *Zai* pits have been used as a soil and water conservation strategy in the drylands of Africa in combination with integrated soil fertility management (ISFM) options to improve soil fertility, increase the overall crop yields and the economic returns (Getare and Mucheru-Mucheru-Muna 2024).

Integration of land restoration with several native legume trees ideal for soil shading, moisture retention, and fodder is critical step. Common and native species in lowlands and semi-arid zones such as: Acacia tortilis, A. seyal, A. mellifera, Dichrostachys cinerea, and Tamarindus indica providing leaf shade, nitrogen fixation, livestock forage, and soil conserved through root systems (Abraham et al. 2022). Additionally, Desho grass (Pennisetum pedicellatum) is a native, drought-resistant grass reaching 1 m height, used in soil bunds for erosion control; grows on degraded sandy soils and improves water infiltration (Desta 2024). Napier grass (Cenchrus purpureus) also a deep-rooted and drought-tolerant, suitable for cut-and-carry fodder systems and stabilizing contour terraces; yields 20–30 t DM/ha annually (Aleme et al. 2024). Since the 1970s, vetiver grass has been implemented in erosion control strategies, especially along terraces and drains to stabilize soil and conserve moisture, increase soil moisture retention, and improve soil fertility (Ghosh and Bhattacharya 2017).

Ethiopians mainly use vetiver to protect the edges of contour drains, but the plant is becoming increasingly popular as an ornamental around houses (Terefe 2011). In addition, local farmers have found that the foliage makes excellent mulch, and they say that (compared to napier grass, for example) it is easier to manage because it does not seed or take root when they spread it on their gardens or fields (West 2020). Pine needles, which were traditionally laid on the floor during coffee ceremonies, are now commonly replaced by vetiver leaves. Vetiver straw is also gaining popularity as a thatch and as a stuffing for mattresses because it resists rot and lasts longer than other straws (Terefe 2011). Those approaches improve restore the drought area, soil moisture and organic content while offering shade that reduces evaporation.

Phase 3: Skills Training and Local Eco-Innovation

This phase focuses on providing climate migrant communities with practical skills, encouraging local innovation, and supporting eco-entrepreneurship. The main aim is to empower community members so they can take the lead in building climate resilience and manage microclimate engineering efforts independently over the long term.

Activities

a. Participatory documentation of indigenous knowledge

A key activity in this phase is the careful documentation and integration of indigenous knowledge and traditional ecological practices into current resilience strategies. This will be achieved through interactive workshops and participatory sessions where elders, pastoralists, and local experts share their experience in sustainable land and water management suited to the area. Documenting these practices not only preserves cultural heritage but also helps ensure that local approaches are accepted and combined effectively with scientific methods.

Interactive workshops through participatory sessions to document traditional ecological knowledge are regarded as essential for incorporating indigenous practices into climate resilience planning. This approach helps ensure that adaptation strategies are both contextually relevant and culturally appropriate (Ciocco et al. 2024).

b. Training sessions for youth

The training programs for skills will be primarily developed for young people, particularly those impacted by climate change. Trainees will be made ready to work as Eco-Technicians after being trained practically in terms of building, maintaining, and monitoring of systems such as sand dams, greywater systems, zai pits, swales, and contour trenches. Training will be given in the classroom followed by field experience to acquire practical knowledge.

c. Deploying mobile training units

To extend coverage, mobile training units will be deployed in climate migrant settlements and Green Camps. The units are meant to bring training activities to remote or inaccessible communities, allowing even the remotest and most marginalized groups to participate. Each unit will consist of technical trainers who will provide training sessions, local eco-entrepreneurs who will provide practical experience, and social mobilizers to extend peer learning and knowledge sharing.

d. Empowering women

Women empowerment will be the central theme for this phase, with special focus on women-led green enterprise. Women will be encouraged to start and run plant nurseries, composting units, herbal plots, and small green enterprises. Women training will include business management, sustainable production techniques, and marketing so that they make economically viable ventures. Empowering women to carry out these activities will enhance community resilience by providing stable incomes and strengthening social connections.

e. Distributing starter kits

In order to initiate eco-entrepreneurship, workshop trainees will be given starter kits with basic tools and materials to carry out activities such as micro-irrigation, water conservation technology, composting, and small-scale agro-processing. Starter kits will enable direct entry into productive activity, enabling individuals to implement the skills acquired on the job, increase agricultural production, and establish new livelihood opportunities.

Outcome

By the end of this phase, the project appears to have a team of skilled Eco-Technicians and entrepreneurs capable of duplicating and applying local microclimate interventions. They will play an important role in building community resilience, promoting sustainable livelihoods, and for sustaining the GAZ project in the long term.

4. Monitoring and Evaluation plan

Component	Activity	Duration	Indicators	Expected Outcome
Phase 1: Climate Migrant Community Mobilization & Co-Design (6 month)				
Mapping Push Factors	Stakeholder inception and planning meeting	1 week	- Number of meetings- Stakeholder attendance- Work plan developed	Project partners aligned on objectives and timeline
	Develop participatory GIS tools and interview guides	2 weeks	- Number of tools created- Technical validation complete	Custom tools ready for data collection
	Train field teams in participatory GIS and interview methods	1 week	- Training sessions completed- Number of trainees- Evaluation scores	Field teams capable of conducting accurate data collection
	Conduct participatory GIS mapping and community interviews	3 weeks	- Number of mapping sessions- Interview transcripts- Number of participants (disaggregated)	Verified data on climate stressors and mobility factors
	Conduct key informant interviews and focus group discussions	3 weeks (concurrent with GIS)	- Number of interviews/FGDs conducted- Transcripts and notes collected	Qualitative data on social, economic, and environmental push factors collected
	Validation workshop with community and stakeholders	1 week	- Workshop report- Number of attendees- Feedback collected	Findings verified and refined with community/stakeholder inputs
	Final report preparation and dissemination	1 week	- Final report completed- Copies distributed/shared- Summary briefs developed	Final documented baseline of climate-related migration drivers supports next phase planning
	Analyze and synthesize data on push factors	2 weeks	- Draft analysis report- Number of key push factors identified	Evidence base for climate-induced migration drivers
Community Consultations	**Activity**	**Duration**	**Indicators**	**Expected Outcome**
	Design and schedule structured community consultation workshops	1 week	- Workshop plan finalized- Number of locations selected- Number of facilitators identified	Workshops are well-organized, inclusive, and adapted to local context
	Conduct community workshops using participatory methods (climate stories, seasonal calendars, migration timelines, resource mapping)	2 weeks	- Number of workshops held- Number of participants (disaggregated by gender, age, pastoralist status)- Quality of data collected (e.g., stories, calendars, maps)	Community members express lived experiences, climate impacts, migration causes, and resource challenges
	Facilitate open discussions on climate impacts, migration decisions, coping strategies, and adaptive capacities	Concurrent with workshops	- Number of group discussions held- Number of different perspectives recorded (youth, women, elders)- Summary reports of sessions	Rich qualitative insights into migration drivers and local resilience strategies

	Document indigenous knowledge and traditional adaptation practices	Concurrent	- Number of traditional strategies documented- Types of indigenous practices recorded- Verified knowledge inventory	Local adaptation practices and traditional ecological knowledge are documented and preserved for integration into project design
	Synthesize consultation findings for inclusion in the local action plan	1 week	- Summary report drafted- Key themes identified- Number of consultation inputs integrated into planning	Community insights directly shape action plan priorities and interventions
Establish Eco-Action Committee	**Activity**	**Duration**	**Indicators**	**Expected Outcome**
	Facilitate inclusive community nomination and selection of committee members	1 week	- Number and profile of committee members (disaggregated by gender, youth, pastoralists)- Selection criteria applied- Community endorsement records	A representative, community-trusted Eco-Action Committee is formed
	Provide capacity-building training on governance, leadership, and co-design	1 week	- Number of training sessions held- Number of members trained- Pre/post-training assessments	Committee members gain knowledge and skills to lead project activities
	Define and document committee structure, roles, and responsibilities	1 week	- Roles and responsibilities outlined- Committee terms of reference approved- Meeting schedule developed	Committee is fully operational with a clear mandate and accountability structure
	Involve the committee in reviewing and co-designing microclimate interventions	1 week	- Number of project proposals reviewed- Recommendations and changes incorporated- Minutes of co-design sessions	Committee takes leadership in project planning, ensuring ownership and relevance
	Ensure gender/youth/traditional leadership representation and decision-making equity	Ongoing	- Representation checklist- Meeting participation logs- Community feedback on inclusiveness	Equitable governance structure promotes broad-based community participation
Validation Sessions	**Activity**	**Duration**	**Indicators**	**Expected Outcome**
	Organize stakeholder and community validation workshops	1 week	- Number of validation workshops conducted- Number of participants (disaggregated)- Workshop reports	Stakeholders and community members validate project findings and outcomes
	Present and discuss reports on push factors, consultation outcomes, and draft action plan	Concurrent	- Documents shared prior to meeting- Number of feedback inputs received- Level of consensus achieved	Transparent sharing of project insights builds trust and credibility
	Collect and incorporate feedback into final action plan and documentation	1 week	- Number of revisions made- Updated action plan approved- Summary of changes tracked	Community-approved and refined action plan finalized for implementation
	Document lessons from validation sessions to inform future phases	Concurrent	- Lessons learned document- Stakeholder reflections recorded	Strengthened community engagement and improved processes for upcoming project phases

Phase 2: Rapid Eco-Restoration & Water Harvesting Interventions (6 year)				
2.1: Water-Focused LMC	**Activity**	**Duration**	**Indicators**	**Expected Outcome**
	Conduct geospatial analysis to identify rainwater harvesting (RWH) potential zones	4 weeks	- RWH suitability map- GIS layers developed- Number of potential sites identified	High-potential RWH zones are mapped to guide infrastructure planning
	Design and construct sand dams in flash-flood areas	3 months	- Number of sand dams constructed- Volume of water stored- Area of impact	Increased water storage capacity and reduced flood impact
	Install check dams and stone bunds to manage runoff and improve infiltration	3 months	- Number and length of structures built- Water infiltration rate- Reduced soil erosion data	Runoff is controlled, infiltration is improved, and soil degradation reduced
	Implement community-based greywater reuse systems (wetland model)	6 months	- Number of systems installed- Volume of greywater reused- Water quality test results	Improved access to recycled water and reduced pressure on freshwater sources
	Restore seasonal wetlands and floodplains in target zones	1.5 -2 year	- Area of wetland restored- Biodiversity index- Groundwater recharge rate	Enhanced ecosystem functions, water retention, and community resilience
	Train communities in O&M of water infrastructure	1 week	- Number trained- Maintenance plan in place- post-training evaluation	Community ensures long-term sustainability of water systems
2.2: Land and Soil-Focused LMC	**Activity**	**Duration**	**Indicators**	**Expected Outcome**
	Establish zai pits for moisture conservation and soil fertility, Apply compost, mulch, and biochar for soil regeneration	6 months	Number of zai pits established- Soil moisture content- Crop survival rates and - Quantity of inputs applied- Organic matter levels- Soil fertility tests	Improved crop yield and soil water retention on degraded lands Enhanced soil health and restored productivity of degraded areas
	Introduce drought-tolerant native grasses and legume trees	2 months	Area planted with native species- Species survival rate- Increase in biomass	Microclimate improved, fodder availability increased, and soil stabilized
	Construct and stabilize contour bunds/terraces using vetiver and desho grass	2 months	Length of bunds constructed- Vegetative cover density- Runoff reduction rate	Erosion controlled, evaporation reduced, and water retention improved
	Train farmers and pastoralists on land restoration techniques	1 week	Number of people trained- Adoption rate of techniques- Knowledge retention survey	Local capacity built for sustainable land management and restoration
Phase 3: Skills Training and Local Eco-Innovation (2.7 month)				
3: Skills Training and Local Eco-Innovation	**Activity**	**Duration**	**Indicators**	**Expected Outcome**

	Participatory documentation of indigenous knowledge	2 weeks	Number of participatory workshops held- Number and type of indigenous practices documented- Number of elders/pastoralists involved (disaggregated)	Traditional ecological knowledge preserved and integrated into resilience planning
	Training sessions for youth as Eco-Technicians	3 weeks (1 week classroom, 2 weeks field)	Number of youths trained- Skills assessment results- Number certified as Eco-Technicians	Youth are equipped with hands-on skills for implementing and maintaining local microclimate solutions
	Deploying mobile training units to remote communities	4 weeks (rolling deployment)	- Number of mobile units deployed- Number of remote locations reached- Number of trainees (disaggregated by gender and location)	Increased access to training for marginalized and remote communities' Widespread community participation and localized knowledge transfer
	Empowering women through green enterprise training	2 weeks	- Number of women trained- Number of women-led enterprises launched- Business plans developed	Women-led green enterprises established, improving household income and social empowerment Women play active role in sustainability and economic resilience
	Distributing starter kits to trainees	1 week (post-training)	- Number of starter kits distributed- Types of tools/materials included- Number of enterprises initiated using kits	Immediate transition from training to livelihood application Enhanced productivity and entrepreneurial uptake and Direct application of acquired skills boosts local innovation and income generation

5. Advanced development goal

To embed successful community-led Local Microclimate Engineering (LME) models into broader adaptation and migration strategies, Shabelle District can serve as a prototype for regional scale-up across climate-vulnerable areas in Ethiopia. First, sharing outcomes and empirical evidence from pilot LME interventions with key regional stakeholders including Regional Climate Task Forces, Disaster Risk Reduction (DRR) Units, and Humanitarian Resilience Clusters—can create political and institutional momentum.

Secondly, the "Migration Buffer Villages" concept designating ecologically restored zones in high-outmigration corridors offers a replicable solution to prevent displacement. These buffer zones could integrate rainwater harvesting, reforestation, and diversified climate-resilient livelihoods (e.g., agroforestry, eco-enterprises), making them anchors of both ecosystem stability and social resilience. In the Somali Region, zones like Gode, Afder, and Liben face similar outmigration drivers and could benefit from this scalable model.

6. Reference

Abera, Wuletawu, Lulseged Tamene, Degefie Tibebe, Zenebe Adimassu, Habtemariam Kassa, Habtamu Hailu, Kindu Mekonnen, et al. 2020. “Characterizing and Evaluating the Impacts of National Land Restoration Initiatives on Ecosystem Services in Ethiopia.” *Land Degradation and Development* 31(1): 37–52. doi:10.1002/ldr.3424.

Abraham, Getachew, Yisehak Kechero, Dereje Andualem, and Temesgen Dingamo. 2022. “Indigenous Legume Fodder Trees and Shrubs with Emphasis on Land Use and Agroecological Zones: Identification, Diversity, and Distribution in Semi-humid Condition of Southern Ethiopia.” *Veterinary Medicine and Science* 8(5): 2126–37.

Africa, Farem Bis. 2024. “Zai Pits Raise Semi-Arid Farmer Yields 300%.” https://farmbizafrica.com/zai-pits-raise-semi-arid-farmer-yields-300/ (June 26, 2025).

Agency, Austrian Development. 2017. “Enhancing the Social and Economic Stability of Drought-Affected Households in Gode, Ethiopia.” https://www.entwicklung.at/en/projects/detail-en/enhancing-the-social-and-economic-stability-of-drought-affected-households-in-gode-ethiopia#:~:text=Previous droughts across the Horn,and women is constantly rising.

Aleme, Melkam, Dereje Tulu, and Mesfin Dejene. 2024. “Biomass Production, Growth Performance and Character Relationship of Six Varieties of Napier (Pennisetum Purpureum L Schumach.) Grass at Teppi South West Ethiopia.” *Heliyon* 10(23).

Ayesu, Samuel, Olivia Agbyenyaga, Victor Rex Barnes, Adwoa Gyamfi, and Richard Krobea Asante. 2024. “Advancing Multiple Ecosystem Service Assessment in the Tropics: Evidence from Barekese and Owabi Watersheds in Ghana.” *Heliyon* 10(18).

Bojer, Amanuel Kumsa, Desta Jula Bekalo, Taye Girma Debelee, Saralees Nadarajah, and Ayad M Fadhil Al-Quraishi. 2024. “Rainwater Harvesting Site Selection for Drought-Prone Areas in Somali and Borena Zones, Oromia Regional State, Ethiopia: A Geospatial and Multi-Criteria Decision Analysis.” *Water* 16(13): 1789.

Ciocco, Tony W, Brian W Miller, Stefan Tangen, Shelley D Crausbay, Meagan F Oldfather, and Aparna Bamzai-Dodson. 2024. “Indigenous Knowledge in Climate Adaptation Planning: Reflections from Initial Efforts.” *Frontiers in Climate* 6: 1393354.

Cortés Ferrández, Pablo. 2019. "'Nothing to Put in Your Mouth'. Seeking Durable Solutions to Drought Displacement in Ethiopia." (December). https://api.internal-displacement.org/sites/default/files/publications/documents/201912-ethiopia-slow-onset.pdf.

CRGE. 2020. "Overview Report." *Ethiopia's Climate Resilient Green Economy (CRGE) Strategy (2011-2019) – Implementation Progress Assessment Report* (May): 180–208. doi:10.1057/9781137471475.

Dai, Aiguo, Tianbao Zhao, and Jiao Chen. 2018. "Climate Change and Drought: A Precipitation and Evaporation Perspective." *Current Climate Change Reports* 4: 301–12.

Dasgupta, Susmita, Benoit Laplante, Siobhan Murray, and David Wheeler. 2009. "Climate Change and the Future Impacts of Storm-Surge Disasters in Developing Countries." *Center for Global Development Working Paper* (182).

Desta, Alemu Gashe. 2024. "Dry Matter Yield of Desho Grass (Pennisetum Pedicellatum) Varieties." *Sustainable Environment* 10(1): 2345435.

Destrijcker, Lucas, Michael Thomson, and Yishuang Antonio Xu. 2023. "Climate , Peace and Security Study : Somali." (July). https://weatheringrisk.org/sites/default/files/document/Climate_Peace_Security_Study_Somali_Region_Ethiopia.pdf.

FAO. 2021. Somalia | Shocks, agricultural livelihoods and food security *Somalia | Shocks, Agricultural Livelihoods and Food Security*. doi:10.4060/cb7641en.

FAO and SWALIM. 2015. "The Juba and Shabelle Rivers and Their Importance to Somalia." https://faoswalim.org/article/juba-and-shabelle-rivers-and-their-importance-somalia#:~:text=The story is different now,to restore the dilapidated infrastructure. (July 14, 2025).

Ferris, Elizabeth. 2020. "Durable Solutions for IDPs." (August): 1–9. https://dtm.iom.int/sites/g/files/tmzbdl1461/files/reports/Durable Solutions for Drought Affected IDPs in Somali Region - DTM HLIS.pdf.

Fre, Zeremariam, and B Tsegay. 2013. "Economic Contribution of Pastoral and Agro Pastoral

Production to Food Security and Livelihoods Systems in Africa: The Case of Eastern Sudan, Eritrea and Western Ethiopia in the Horn of Africa." *Ethiopian e-journal for research and innovation foresight* 5(2): 14–31.

Gaur, Mahesh K, and Victor R Squires. 2018. "Geographic Extent and Characteristics of the World's Arid Zones and Their Peoples." *Climate variability impacts on land use and livelihoods in drylands*: 3–20.

Gebremeskel, Esayas Nigatu, Degefa Tolossa, and Getachew Gebru. 2025. "Analysis of Climate Variability and Its Linkage with Large-Scale Climate Oscillations: Implications to Pastoral and Agropastoral Livelihood Resilience in Siti Zone, Somali Region, Ethiopia." *International Journal of Climate Change Strategies and Management*.

Getare, Ednah Kerubo, and Monicah Mucheru-Mucheru-Muna. 2024. "The Role of Zai Pits and Integrated Soil Fertility Management Options in Improving Crop Productivity for Smallholder Farmers in the Drylands of Sub-Saharan Africa." *Journal of Aridland Agriculture* 10: 94–101.

Ghosh, Chandan, and Shantanoo Bhattacharya. 2017. "By Vetiver System." *Disaster Risk Governance in India and Cross Cutting Issues*: 387.

Ibrahim, Omer Ahmed, Demelash Wondimagegnehu Goshime, Sirak Tekleab, and Rafik Absi. 2024. "Flood Inundation Mapping and Mitigation Options in Data-Scarce Region of Beledwayne Town in the Wabi Shebele River Basin of Somalia." *Natural Hazards Research* 4(2): 336–46.

IOM. 2009. "International Organisation for Migration. Migration, Cimate Change and the Environment." *International Organisation for Migration*: 1–320. https://www.iom.int/sites/g/files/tmzbdl486/files/2018-07/compendium_climate_change_0.pdf.

IOM. 2023. "Site Assessment Round 34 and Village Assessment Survey Round 17 Ethiopia National Displacement Report 17 National Displacement Report Ethiopia National Displacement Report 17." (September). www.ethiopia.iom.int.

Jain, Shubham, Aman Srivastava, Leena Khadke, Uday Chatterjee, and Ahmed Elbeltagi. 2024.

"Global-Scale Water Security and Desertification Management amidst Climate Change." *Environmental Science and Pollution Research* 31(49): 58720–44.

Kabiri, Stella. 2024. "A Basket of Regenerative Agriculture Technologies for the Improvement of Soil Health in Africa."

Kerubo, Getare Ednah. 2022. "Sorghum Production Using Zai Pits and Integrated Soil Fertilty Management in Kitui County, Kenya."

Klas Sandström. 2021. "Somalia: Surface Water and Riverine Assessment." https://documents1.worldbank.org/curated/en/099430012022130498/pdf/P17499403c63df07e086e90eab1140bf66d.pdf.

Maiga, Ynoussa, Cheik Omar Tidiane Compaoré, Seyram Kossi Sossou, Hermann YempalaSomé, Mamady Sawadogo, Issa Nagalo, James R Mihelcic, and Aboubakar Sidiki Ouattara. 2024. "Development of a Constructed Wetland for Greywater Treatment for Reuse in Arid Regions: Case Study in Rural Burkina Faso." *Water* 16(13): 1927.

Merga, Biratu Bobo, Feye Lama Mamo, Mitiku Badasa Moisa, Firdisa Sadeta Tiye, and Dessalen Obsi Gemeda. 2023. "Assessment of Flood Risk by Using Geospatial Techniques in Wabi Shebele River Sub-Basin, West Hararghe Zone, Southeastern Ethiopia." *Applied Water Science* 13(11): 214.

Muhidin, Mohammed Seid, Mekonen Ayana, Zelalem Birru Gonfa, Tena Alamerew, and Gizaw Desta Gessesse. 2024. "The Impact of Soil and Water Conservation Measures on Base Flow Modification in the Northeastern Highland of Ethiopia."

Mukhtar Ali, Alebachew Adem. 2022. "Reducing Ecosystem-Based Disaster Risk in Eastern Ethiopia." https://www.preventionweb.net/news/reducing-ecosystem-based-disaster-risk-eastern-ethiopia#:~:text=As part of a global,Zone%2C namely Shebelle and Gursum. (June 25, 2025).

OCHA. 2023. "Ethiopia: Drought Situation Update." *United Nations Office for the Coordination of Humanitarian Affairs* (March): 1–8. https://fscluster.org/sites/default/files/documents/ethiopia_-_drought_situation_update_1_-_as_of_10_march_2023.pdf.

Parliament, UK. 2024. “Ethiopia: Conflict and Food Insecurity 40 Years on from the 1984 Famine.” https://lordslibrary.parliament.uk/ethiopia-conflict-and-food-insecurity-40-years-on-from-the-1984-famine/#:~:text=According to the WFP’s assessment of Ethiopia,people needed food assistance across the country. (July 14, 2025).

Rodgers, Cory. 2021. “Community Engagement in Pastoralist Areas: Lessons from the Public Dialogue Process for a New Refugee Settlement in Turkana, Kenya.” *Pastoralism* 11(1): 26.

Ryan, Catherine, and Paul Elsner. 2016. “The Potential for Sand Dams to Increase the Adaptive Capacity of East African Drylands to Climate Change.” *Regional Environmental Change* 16: 2087–96.

Sahal, Kurbad Mahamed, and Zewde Alemayehu Tilahun. 2023. “Factors Affecting Farmer’s Adoption of Soil and Water Conservation Practice in Case of Gode District, Shebelle Zone, Somali Region, Ethiopia.”

Schreckenberg, K, C Torres-Vitolas, S Willcock, C Shackleton, C Harvey, and D Kafumbata. 2016. “Participatory Data Collection for Ecosystem Services Research: A Practitioner’s Manual.” *Ecosystem Services for Poverty Alleviation Working Paper no* 3.

Sharmarke, Abdi Musse. 2018. “Assessing the Impact of Water Scarcity on Agriculture Productivity: A Case Study of Gabiley District, Somalia.”

de Sherbinin, Alex, Kathryn Grace, Sonali McDermid, Kees Van der Geest, Michael J Puma, and Andrew Bell. 2022. “Migration Theory in Climate Mobility Research.” *Frontiers in Climate* 4: 882343.

Somorin, Olufunso A. 2010. “Climate Impacts, Forest-Dependent Rural Livelihoods and Adaptation Strategies in Africa: A Review.” *African journal of environmental science and technology* 4(13): 903–12.

Sunderland, Terry C H, and Dominic Rowland. 2019. “Forests, Land Use, and Challenges to Climate Stability and Food Security.” In *Sustainable Food and Agriculture*, Elsevier, 95–116.

Terefe, Tekalign Negash. 2011. “Farmers’ Perception on the Role of Vetiver Grass in Soil and Water Conservation in South Western Ethiopia: The Case of Tulube Peasant Association, Metu District.” *Metu District*.

Tufa, Fekadu Adugna. 2024. "Conflict, Climate Change and Displacement in the Somali Region of Ethiopia." https://odihpn.org/en/publication/conflict-climate-change-and-displacement-in-the-somali-region-of-ethiopia/ (July 14, 2025).

Ummenhofer, Caroline C, and Gerald A Meehl. 2017. "Extreme Weather and Climate Events with Ecological Relevance: A Review." *Philosophical Transactions of the Royal Society B: Biological Sciences* 372(1723): 20160135.

UNDRR. 2024. "Horn of Africa Floods and Drought, 2020-2023 - Forensic Analysis." https://www.undrr.org/resource/horn-africa-floods-and-drought-2020-2023-forensic-analysis#:~:text=The eastern Horn of Africa,%2C water resources%2C and health. (July 14, 2025).

UNEP. 2024. "The Restoration Initiative: Uniting for Nature to Build Climate Resilience and Combat Land Degradation." https://www.decadeonrestoration.org/restoration-initiative-uniting-nature-build-climate-resilience-and-combat-land-degradation#:~:text=Combat Land Degradation-,The Restoration Initiative: Uniting for Nature to Build,Resilience and Combat Land Degradation&text=In response to pressing climate,management on a global scale.

UNICEF. 2018. "European Civil Protection and Humanitarian Aid Operations." https://civil-protection-humanitarian-aid.ec.europa.eu/where/africa/somalia_en#:~:text=47%25 of the population in Somalia is,of urgent%2C lifesaving humanitarian assistance and protection. (July 7, 2025).

United Nations Development Programme (UNDP). 2022. "Independent Country Programme Evaluation: Ethiopia." *UNDP Independent Evaluation Office*: 70. http://web.undp.org/evaluation/evaluations/adr/burundi.shtml.

West, Jenna. 2020. "Vetiver Grass Hedgerow on Terraced Agricultural Land in Yemen to Prevent Soil Erosion and Runoff: A Critical Analysis."

Yifru, Bisrat Ayalew, Min-Gyu Kim, Jeong-Woo Lee, Il-Hwan Kim, Sun-Woo Chang, and Il-Moon Chung. 2021. "Water Storage in Dry Riverbeds of Arid and Semi-Arid Regions: Overview, Challenges, and Prospects of Sand Dam Technology." *Sustainability* 13(11): 5905.

Yohannes, S B, D U Mihret, and A G Asamire. 2024. "Use of Vetevera Grass (Chrysopogon

Zizanioides) in a Constructed Wetland to Remove Heavy Metals from Kege Wet Coffee Processing Plant, Dale Woreda, Sidama Regional State, Ethiopia." *Journal of Applied Sciences and Environmental Management* 28(4): 1083–95.

Zerga, Belay, Bikila Workineh, Demel Teketay, and Muluneh Woldetsadik. 2018. "Rangeland Degradation and Rehabilitation Efforts in the Somali National Regional State, Eastern Ethiopia: A Review." *International Journal of Innovative Research and Development* 7(5): 84–100.