



# Review of Water Conservation Techniques in The Dryland Environment: Focus on Somali Region, Ethiopia

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## ABSTRACT

Drylands cover more than 40% of the Earth's land surface and support approximately 2.5 billion people, yet they remain among the most environmentally fragile regions due to low and erratic rainfall, high evaporation rates, and recurrent droughts. Water scarcity in these environments presents significant challenges for food systems, rangeland productivity, and pastoral livelihoods. This narrative literature review examines the current state of knowledge on water conservation techniques in drylands, with a particular focus on the Somali Region of eastern Ethiopia, an arid to semi-arid area where pastoral and agro-pastoral communities face persistent water insecurity. The review synthesizes evidence from peer-reviewed journal articles, policy documents, technical reports, and literature published. A qualitative thematic analysis was employed to identify key patterns, challenges, and opportunities related to dryland water management. The results indicate that the Somali Region's water crisis results from interacting climatic, biophysical, socioeconomic, and institutional factors. Climatically, the region experiences highly variable annual rainfall ranging 410 mm-510 mm, accompanied by increasing temperatures. Bio-physically, approximately 61% of the land is classified as dry and 39% as very dry, with significant erosion risks in relatively wetter areas. Socioeconomic challenges, including widespread poverty, weak institutional capacity, fragmented governance structures, and reliance on trans-boundary water resources, further intensify water insecurity. The review highlights several water conservation strategies suitable for the Somali Region, including in situ rainwater harvesting techniques (e.g., contour bunds, terraces, and conservation tillage) that significantly improve soil moisture retention, and ex-situ systems such as sand dams, ponds, and rooftop harvesting that enhance drought resilience. Evidence from comparable dryland regions in East Africa shows that integrated watershed management and community-based interventions can improve groundwater recharge, restore degraded landscapes, and strengthen climate resilience. Achieving sustainable water security in the Somali Region, therefore, requires integrated, participatory, and context-specific approaches that combine climate-smart technologies with indigenous knowledge and coordinated institutional governance.

**Key Words:** Water conservation, Rainwater harvesting, Drylands, Somali Region, Climate resilience

## 1. Introduction

Drylands cover more than 40% of land and home to approximately 2.5 billion people. They play an important role in the global food and livestock system mainly through rain-fed agriculture (Diop et al., 2022). These areas are ecologically fragile due to low and erratic rainfall, high evaporation and frequent drought impeding biomass pro-

duction and ecological functioning (Xing & Wang, 2024). Water scarcity which is a fundamental feature of drylands shapes food systems, rangeland management, and livelihoods. The report of the United Nations Environment Programme (UNEP) informs that the stimulative impacts of climate change on crops are restricted to mainly high-latitude regions.

An area having aridity index of less than 0.65, drylands comprise of dry sub-humid, semi-arid, arid and hyper-arid (Xing & Wang, 2024). Rainfall is limited, runoff high, evaporation losses significant, soil organic matter poor, and biomass water availability restricted. The combination of climate stresses and soil deterioration is causing declining productivity which makes rural people dependent on rain-fed agriculture and pastoralists more vulnerable. Forecasts show that dryland areas like the Horn of Africa will encounter more unpredictable rainfall and hotter weather that will exacerbate drought on crops, livestock and water supplies (Abrham & Mekuyie, 2022).

Using water wisely in arid and semi-arid regions means

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capturing, storing, and using limited rainfall while minimizing losses. Experiencing soil and water management have a common denominator of increasing infiltration and consequently water available for plants (Diop et al., 2022). Both are critical for water security and drought resilience and sustainable livelihoods (Akuma et al., 2025).

According to what Meena et al. (2020) reported, farmers mostly use conservation tillage, agro-forestry, mulching, contour bunds, farm ponds, and in situ rainwater harvesting. Rainwater harvesting is the collection and use of runoff and rainwater according to Sharma et al. (2025). According to Lelamo et al. (2022), the recurrence of droughts in Sub-Saharan Africa significantly contributes to soil degradation and declining water availability. The eastern and southern drylands of Ethiopia, especially the Somali region, suffer from erratic rainfall, high temperatures and recurrent droughts thereby making water shortage a major problem (Abdela, 2024). The aim of various national strategies is to assist farmers or local communities with soil and water conservation, watershed management, rainwater harvesting and small-scale irrigation for increased climate resilience (Akuma et al., 2025).

The Somali region is mainly an arid environment with variable rainfall and frequent droughts, where livelihoods are pastoral and agro-pastoral (Lelamo et al., 2022). Yet, because of the prematurity of runoff and infiltration and low storage, only a small percentage of rains are captured. Water development that focuses on short-term outlook is harmful to sustainability (Madaki et al., 2025). The awareness of rainwater harvesting has increased, but regional evidence is limited, preventing effective planning for water security and climate change adaptation.

## 2. Materials and Methods

### 2.1. Review design

This study uses a narrative literature review design to investigate and review the state of knowledge on water conservation techniques in drylands with a focus on the Somali region of Ethiopia. The review method facilitates a nuanced and contextual analysis of various literature sources, enabling the integration of a range of biophysical and socio-economic, institutional and policy perspectives pertaining to dryland water management. The complexity and contextuality of drylands water conservation are reflected in the design, where the evidence spans across a range of disciplines and approaches.

### 2.2. Information sources

The review utilizes a broad range of secondary data sources that include peer-reviewed journal articles, academic books and book chapters, policy documents, technical reports, and also literature from international organizations, governmental, and non-governmental organizations. Relevant empirical evidence from Master's and PhD theses was included, particularly studies focusing on under-researched dryland areas such as the Somali Region. The focus was mainly on climate change, drought, and sustainable management of water resources in drylands. Some earlier works were included to support the concepts.

### 2.3. Literature Search Strategy

A structured and flexible search strategy were employed to identify relevant studies. Searches were conducted in major databases, repositories of higher education institutions, and through manual examination of reference lists from key papers. Numerous combinations of terms and phrases including drylands, water scarcity, water conservation, rainwater harvesting, soil and water conservation, drought adaptation, Somali Region/Ethiopia, were searched. The search process involved iteration where keywords were refined, and additional sources were added as themes and relevant studies emerged.

### 2.4. Inclusion and Exclusion Criteria

Studies were admitted on the condition that they pertain to water conservation practices, rainwater harvesting, soil and water management, or drought adaptation in dryland, arid or semi-arid regions. The Somali region of Ethiopia the Horn of Africa or similar ecologically dryland areas. These areas were studied. Studies focusing exclusively on wet environments or high-input water management systems were not included. Scope restrictions also limited the inclusion of studies published in other languages.

### 2.5. Selection of Literature

The literature selection went through several stages. At first, those with obvious irrelevance were filtered from titles and keywords. The relevance of abstracts to meet the assessment study objectives. The full texts were consulted in order to understand the water conservation techniques, context and methodology of the programme. The final selection process of the literature was based on the extent to which each reference was relevant to at least one of the three core themes of the review, namely dryland water scarcity challenges, water conservation techniques, and sustainability and resilience outcomes.

### 2.6. Data Extraction and Organization

The investigator devised a structure to extract data. Data gathered included the location of the study and its ecological setting, the type of water conservation technique used, the scale of implementation, and reported benefits or limitations as well as the key contextual factors that would have affected one's performance. The gathered information was organized in accordance with the different themes of the review, which helped compare various studies and allowed for synthesis beyond individual cases.

### 2.7. Synthesis and Analysis

The review used a qualitative thematic synthesis approach. The information extracted was analyzed to determine any repeated patterns or themes regarding climatic variability, hydrological constraints, traditional and modern water conservation practices, governance and institutional factors and rainwater harvesting system. Using comparative analysis, Findings unique to the Somali Region, as well as those observed in other dryland areas, were identified. Water con-

ervation techniques were highlighted based on their practical relevance, sustainability, and contextual suitability.

## 2.8. Conceptual and Theoretical Framework

### 2.8.1. Concept of Water Scarcity and Water Security in Drylands

In the Horn of Africa, low renewable water resources are often highly variable due to high evapotranspiration, drought, and aridity (Hafeez et al., 2025). High evapotranspiration can also cause physical scarcity. Water is economic scarce when it exists, but people or ecosystems cannot use it and gain reliable access to it. This is often because of the lack of adequate infrastructure, investments and the right governance. This is a common occurrence in the Somali Region and eastern Ethiopia (Ali et al., 2025). Different sources express water security differently, but commonly through four domains which are availability, access, use and stability over time (Veness et al., 2025).

Water availability refers to the existence of water in rivers, aquifers and stored rainwater. Access refers to households' and livestock's ability to obtain water resources at a reasonable cost. Use includes quality, suitability, and stability reflects reliability across seasons and years (Veness et al., 2025). In the Somali Region and the broader Horn, repeated droughts as well as weak infrastructure and governance lead to deficits in all four areas. According to Leal Filho et al. (2022), the droughts have caused excess mortality and humanitarian crisis.

### 2.8.2. Socioecological Systems and Indigenous Knowledge Framework

The socioecological systems perspective is a key conceptual framework for the analysis of dryland water management. More precisely, it considers communities, institutions and ecosystems to be interacting components whose combination generates water availability and water resilience. In the Somali Region, pastoral communities have had a long-established arrangement for mobility, customary water rights, and a community-based governance system to allocate and access scarce water resources (Islam et al., 2023). Studies that focus on the Somali Region and the Horn underscore the significance of indigenous knowledge and traditional coping strategies. Among these strategies are the establishment of customary wells, seasonal rules of use, herd mobility, and local water sharing. On this note, it is best to integrate these practices in Implement Integrated Water Resources Management (IWRM) and regional cooperation. Community-based planning and participatory IWRM demonstrate systematic incorporation of local perceptions, knowledge and priorities in the implementation of a decision-support system for drought risk areas (Islam et al., 2023).

### 2.8.3. Conceptual Framework for Water Conservation in the Somali Region

As shown the figure 1, the framework illustrates the systematic process used to review water conservation techniques in dryland environments, with a focus on the Somali Region of eastern Ethiopia, as shown in figure 1. The process

begins with defining the study focus, followed by a literature search using academic databases, institutional repositories, and key reports. Relevant studies are then screened based on predefined inclusion criteria related to water conservation in drylands, particularly within the Somali Region and the Horn of Africa. The selected studies undergo data extraction, focusing on study location, conservation techniques, implementation scale, and key findings. Finally, the information is synthesized and analyzed through qualitative thematic analysis to identify key insights for sustainable water management in the region.

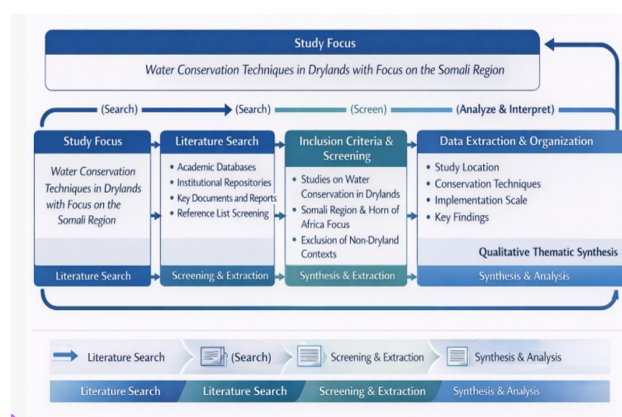


Figure 1: Conceptual framework for reviewing water conservation techniques in dryland environments.

## 3. Results and Discussions

### 3.1. Dryland characteristics shaping water availability in the Somali Region

#### 3.1.1. Climatic characteristics

The typical precipitation level in the Somali Region is going down with time and the generally high temperatures are also showing upward trends. Rainfall is unpredictable in the region and, indeed, more generally in the drylands of the Horn of Africa, which causes droughts are large areas. Numerous studies (Gebremeskel et al., 2025) have documented significant drought variability. Somalia has two rain seasons: Gu which normally occurs during the months of April and May and Deyr which takes place during the months of October and November.

#### 3.1.2. Biophysical and hydrological characteristics

Based on aridity indices, almost two third of the Somali region of Ethiopia are dry to very dry; with about 61% of the land dry and about 39% very dry (Nur et al., 2024). The range of cropping which and severity of biophysical stress and constraints on biophysical health e.g. crop diseases, waterlogging etc. The Somali Region receives little rainfall and it is very uneven. The humid zones in northwest (410 - 510 mm/year) and southwest are next to the lowland areas of Oromia as per Nur et al. (2024) and Muse et al. (2023). Northeast part of Canada gets very little rain, <90 mm (Muse et al., 2023; Nur et al., 2024). According of CORINE-based mapping, erosionity is low in the drier northwest (i.e., rain-fed drylands and river valley lands) but

higher in the wetter more humid and mountainous south (Nur et al., 2024).

### 3.1.3. Socioeconomic and institutional characteristics

Pastoralism and agropastoralism are the predominant livelihoods; however, they are highly sensitive to rainfall and pasture dynamics (Gebremeskel et al., 2025). Poverty is pervasive and conflict and displacement common during drought years (Omar et al., 2025). Using unimproved water sources is clearly associated with low economic status of households and vulnerability of communities (Hussein et al., 2025). In particular, the odds of using unimproved source are much higher among the poorest households and nomadic communities. Strong spatial clustering of use of unimproved water sources reflect regional hydrogeology, infrastructure, and insecurity (Hussein et al., 2025). According to Ali et al. (2025), weak institutional capacity, unclear mandate, and competition among agencies and projects undermine coordinated water management and investment planning.

### 3.1.4. Implications for water management in the Somali Region

Due to the high variability and recurrent droughts, planning water management should be given special attention. For example, using SPI/SPEI-based indices for monitoring and early warning is suggested (Muse et al., 2023). The limited rainfall and large potential evaporation of austral-zonal climate (considered as climate with summer wet and winter dry) do not permit possibility of large scale surface storage. Thus, there is an emphasis on local storage and infiltration (groundwater recharge, soil-water conservation, rainwater harvesting). This is further confirmed by the South-Malabar district of Kerala which recorded rising piezometric levels (Nur et al., 2024). Interventions that are targeted according to location are common in Somali drylands; the area has considerable spatial variation in aridity, erosivity, Rainwater Harvesting (RWH) suitability (Nur et al., 2024).

## 3.2. Water availability and management challenges in the Somali Region

### 3.2.1. Surface and groundwater limitations

According to Ibrahim Ali et al. (2022), per capital renewable freshwater dropped from 2,087 m<sup>3</sup> in 1962 to 411 m<sup>3</sup> in 2017. Around 80% of the supply is sourced from groundwater but this resource is getting increasingly over abstracted and contaminated (salinity, fluoride, pathogens) (Ahmed et al., 2024). Many rivers and seasonal streams run dry: The flow of the Juba-Shabelle Rivertakes is very variable and has strong influence by rainfall in Ethiopia and upstream abstractions (Ibrahim Ali et al., 2022).

### 3.2.2. Mobility, conflict, and access to water

The mobility of pastoral and nomadic populations is dependent on movements, their likely projection to be mobile due to drought and fiasco spread of waterpoints often displace or crowd (Omar et al., 2025). According to Hussein et al. (2025), the countries of north and nomadic water use

hotspots have been marked by spatial analyses and socio-economic and regional inequalities by strong wealth and region interactions. Water points have sometimes been contested and regulated and conflict over boreholes and grazing land has at times triggered local feud.

## 3.3. Traditional water conservation in the Somali Region

### 3.3.1. Traditional water harvesting and storage systems

In the Somali region, dryland communities depend on rainwater harvesting systems such as roof and ground catchments that feed ponds, tanks, and small reservoirs for drought buffering (Ali et al., 2025). Geo-spatial analysis in the Somali and Borena zones reveals that between 1% and 13% of the land is moderately to highly suitable for RWH indicating considerable potential to scale up local practices. In situ water harvesting across SSA, a lever at the micro catchment level, hugely enhances soil moisture (+59%) and reduces runoff (-53%) (Bojer et al., 2024).

### 3.3.2. Modern water conservation in the Somali Region

The drylands of Ethiopia are seeing the application of widespread physical measures such as stone/soil bunds, terraces, use of contour ridges, check dams and grassed water ways (Belachew et al., 2020). Through such strategies, the rate of runoff and erosion and buffer against the drought impact on yields can be reduced (Belste & Wolka, 2025). The education level; access to technical extension and credit; availability of family labour; and the perceived benefits from the Catchment-Based Watershed Conservation Measures; influences the choice and adoption of the soil and water conservation measures (Brhane, 2025).

### 3.3.3. Rooftop rainwater harvesting systems

In Ethiopia, a national program promotes low-cost domestic supply by rainwater harvesting to supply human consumption or other domestic usages from rooftops in places where other sources are unavailable (Teresa & Mosisa, 2021). In a semi-arid zone, a study found that 55% of the households used a rooftop system but many having metal roofs still did not harvest due to no tanks and their low awareness. According to the reviews, roof type and surface systems can be installed economically and technically at any household or a small one (Teresa & Mosisa, 2021).

## 3.4. Water conservation techniques

### 3.4.1. Water availability and storage performance

In semi-arid systems, both rainwater harvesting as well as soil-water conservation increase water table. According to Garg et al. (2020), check dams, ponds and field structures constructed in India reduced the surface runoff (250 → 150 mm/year) by 40%. In addition, groundwater was raised by 2-5 m. Thus, there was an expansion in the irrigable area as well as access to dry season water. The depth of well water level improved positively with the construction of cement bunds and recharge structures from 4.07 to 2.81 m, which benefited crops through protective irrigation and improved the yield by 20–39% (Patode et al., 2025). Ex situ harvesting is common in south Asia which usually harvests extra

runoffs of 50–150 mm and enhances groundwater recharge. In arid areas, managed aquifer recharge related to harvesting increased aquifer storage (Anantha et al., 2021).

#### 3.4.2. Agricultural and livelihood impacts

Across drylands, conservation and RWH substantially increase yields and incomes. Integrated soil–water measures raised crop yields by 10–70%, converted 20% of fallow land to crops, and nearly tripled household income (US\$ 960→2700/yr) in Bundelkhand, India (Garg et al., 2020). In Ethiopia, adopters of SWC had higher wheat yields (654 vs 496 kg/ha) and farm income than non-adopters (Masha et al., 2021). Meta syntheses show in situ measures typically raise cereal yields by 200–1000 kg/ha and save 50–300 mm/yr of water (Anantha et al., 2021). Conservation systems (no till, cover crops, rotations) improve soil organic carbon, infiltration, water use efficiency, and profitability in water-limited US systems (Nilahyane et al., 2023).

#### 3.4.3. Environmental and socioeconomic impacts

SWC reduces runoff, erosion, and nutrient loss, improving water quality and groundwater recharge while providing ecosystem services (soil fertility, biodiversity, microclimate) (Adimassu et al., 2016). Technologies like sand dams protect water from evaporation and contamination and support drought coping (Yifru et al., 2021). Socioeconomically, interventions increase employment, diversify livelihoods, and can empower women via nursery and restoration activities (Meena et al., 2020).

#### 3.4.4. Sustainability and management Challenges

Maintenance, governance, and equity pose serious challenges. Sustained maintenance is required for many benefits; systems, especially those based on nature or farmer designs, may undermine due to unclear responsibility, poor financing, and uncertainty related to longer term performance (Knapik et al., 2024). The establishment of physical soil and water conservation can reduce the area that can be cultivated and may result in reduced yields initially except unless combined with other agronomic practices and productive use of bund land. The adoption of these practices is hampered by factors such as labor requirements and associated costs and risks, along with limited farmer participation in design. Up-scaling requires long-term monitoring, rewards, participatory governance, and a combination of in situ, ex situ and policy instruments (Adimassu et al., 2016).

### 3.5. Dryland experiences in Ethiopia and East Africa highlight

#### 3.5.1. Insights from East African arid regions

The studies conducted show that rainwater harvesting and conservation strategies are important adaptation strategies of Kenya's semi-arid and Tanzania's semi-arid and sub-humid regions to climate change (Gebru et al., 2020). Farmers from the regions have widely adopted this method which is known to enhance soil moisture and yield. Road water harvesting in the dryland of Ethiopia and road-based

macro catchment delivery systems (linked to roads) in Tanzania have improved yields and farm income considerably. The fact that transport infrastructure can be converted into potentially productive water harvesting assets proves the point. It has been found that in drylands of Sub Saharan region, households usually adopt crop, livestock, soil and water management as the key adaptation strategies (Gebru et al., 2020).

#### 3.5.2. Experiences from Ethiopian drylands

Semi-arid Tigray and northern Ethiopia provide illustration that long-term, watershed-based soil and water conservation and water harvesting interventions can get degraded landscapes into transformational pathways. Further, there was an increase in groundwater levels, spring discharge, irrigated area (from <3.5 to 166 ha), while physico-chemical water quality did not show any degradation (Woldearegay et al., 2024).

#### 3.5.3. Applicability to the Somali Region

The case studies Bojer et al. (2024) show that the Somali Region has a semi arid climate, rainfall variability, and pastoral/agropastoral livelihoods in common. Geospatial work has already earmarked large areas in the Somali and Borena zones for suitability for rainwater harvesting (Bojer et al., 2024). The Somali Region's most useful lessons are: Give priority to integrated management of watersheds and rangelands rather than dispersed structures (Woldearegay et al., 2024), design RWH for multiple uses (domestic, livestock, and small-scale irrigation) and drought buffering. Backing local authorities, pastoral organizations, and skill development to prevent top-down, wholesale failures of large-scale dryland interventions in Ethiopia (Fenta et al., 2024).

### 3.6. Effective policy for the Somali Region should prioritize adaptive

#### 3.6.1. Climate-smart and nature-based solutions

Give priority to watershed-scale rainwater harvesting, soil–water conservation, wetland and rangeland restoration as discharge into water bodies will be regulated and blocked. Embed NbS into regional plans and codes of practice. The use of hybrid systems should be incentive, particularly when combined with strategic grey-infrastructure for extremes (Chausson et al., 2020).

#### 3.6.2. Community-based and participatory water management

Facilitate the participatory planning, where pastoralists, women, youth and customary leaders participate from diagnosis to implementation and evaluation for the regional water strategies. Efforts should be made to promote the establishment of water user associations and integrated community structures, which include experts, scientists, extension workers and liaisons towards local institutions with good capacity to mobilize and with strong customary institutions. The guidelines conflict resolution methods and access to and benefit sharing of natural resources must be clearly defined and accepted (Lema, 2025).

## 4. Conclusion And Recommendation

### 4.1. Conclusion

The review highlights that the water shortage crisis in the Somali Region is not due to one factor, but rather, a number of factors. On one hand the climatic conditions of the region are very harsh and on the other hand its biophysical environment is quite fragile. Complicating matters are the social economic and institutional issues. The livelihood of the people is pastoral and agro-pastoral in nature. Moreover, the weak water institutional setup of the region posed a challenge.

In addition, the weak water systems and dependence on neighbouring countries increase its susceptibilities. The climate of the Somali Region is arid to semi-arid with low and irregular rainfall. Natural water availability in the region is affected by high temperature and high evaporation. Variability of rainfall is worsening the drought situation in the region. The rainfall is unimodal or bimodal, but occasionally the southern parts experience two wet seasons. As mentioned above, the (indigenous) water conservation system and techniques have the potential to However, the sustainable application and scaling up of these techniques in the Somali Region has been constrained by a number of factors.

External interventions that are often dismissed include interventions that influence the local social-ecology of pastoral systems, poor technical design and maintenance of water harvesting structures, fragmented and top-down governance, and absence of long-term supportive policies. Integrated watershed management, strong local level ownership by communities and good adaptive governance, much like that experienced from other Ethiopian and East African Dryland, is a key to success. Thus, the water security in the Somali Region of Ethiopia requires a much broader transformation from single issue technical and engineering-centric project activities to integrated, systems-based interventions. It is vital that water management related measures for climate adaptation, restoration of rangelands and livelihood diversification are meaningfully integrated to facilitate context specific, socially inclusive and ecologically sustainable systems-based interventions.

### 4.2. Recommendation

To advance sustainable water conservation and climate resilience in the Somali Region, the following integrated recommendations are proposed: Moreover, consideration of community-level participatory water governance is essential. Similarly, an integrated watershed strategy is needed in the region to scale up climate-smart, nature-based solutions, particularly in the country's marginal and dry areas. The impact of climate change on water sector is very substantial. Many developing countries in the world are experiencing a serious shortage of water. Also, the water held up in dams and diverted through canals and pumping is vital to irrigated agriculture.

Create Management Frameworks That Are Adaptive and Flexible: Establish governance frameworks that are adaptive in nature and flexible enough to accommodate pastoral mobility and manage variability. This can involve efforts to

create flexible water allocation systems, developing conflict resolution mechanisms around water points, and a assessment of drought early warning systems with contingency planning for mobile populations.

At the regional and woreda levels, there needs to be institutional coordination among the water, agriculture, livestock, and the environment sector. Implement Integrated Water Resources Management (IWRM) principles on the ground, especially at major river basins critical to the region (like the Fafen) to harmonize upstream and downstream uses and avoid tensions. Offer applied research on the socio-economic impacts and long-term sustainability of a variety of techniques in water conservation and diversification in the Somali context. Create systems to track the performances, learn from the failures, and adapt to the learning. Enhance hydro-climatic data gathering for informed investment planning.

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### Conflict of interest

The authors declare that there is no conflict of interest associated with the publishing of this review article.

### References

- Abdela, U. (2024). Assessment of community-driven drought risk management strategies in pastoral and agro-pastoral district of bale zones south east ethiopia. *Frontiers in Environmental Science*, 12. <https://doi.org/10.3389/fenvs.2024.1411138>
- Abrham, T., & Mekuyie, M. (2022). Effects of climate change on pastoral households in the harshin district of the somali region, ethiopia. *Jàmbá: Journal of Disaster Risk Studies*, 14(1). <https://doi.org/10.4102/jamba.v14i1.1202>
- Adimassu, Z., Langan, S., Johnston, R., Mekuria, W., & Amede, T. (2016). Impacts of soil and water conservation practices on crop yield, run-off, soil loss and nutrient loss in ethiopia: Review and synthesis. *Environmental Management*, 59(1), 87–101. <https://doi.org/10.1007/s00267-016-0776-1>
- Ahmed, M. M., Asowe, H. A., Dirie, N. I., Mohamud, A. K., Lucero-Prisno III, D. E., Okesanya, O. J., Ogaya, J. B., Musa, S. S., Musa, M. K., Othman, Z. K., Shomuyiwa, D., & Abdulsalam, A. (2024). The nexus of climate change, food insecurity, and conflict in somalia: A comprehensive analysis of multifaceted challenges and resilience strategies. *F1000Research*, 13, 913. <https://doi.org/10.12688/f1000research.154400.1>
- Akuma, G. O., Köhlin, G., & Guta, F. (2025). Adapting to drought: How do public works affect conservation and labor engagement in rural ethiopia? *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-00942-2>

- Ali, O. A., Siad, D. A., Alasow, A. S., Mohamed, A. D., Abdullahi, A. Y., & Ali, A. A. (2025). From scarcity to sustainability: A review of the causes, consequences, and management strategies of water scarcity in somalia. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-01695-8>
- Anantha, K., Garg, K. K., Barron, J., Dixit, S., Venkataradha, A., Singh, R., & Whitbread, A. M. (2021). Impact of best management practices on sustainable crop production and climate resilience in smallholder farming systems of south asia. *Agricultural Systems*, 194, 103276. <https://doi.org/10.1016/j.agsy.2021.103276>
- Belachew, A., Mekuria, W., & Nachimuthu, K. (2020). Factors influencing adoption of soil and water conservation practices in the northwest ethiopian highlands. *International Soil and Water Conservation Research*, 8(1), 80–89. <https://doi.org/10.1016/j.iswcr.2020.01.005>
- Belste, T. A., & Wolka, K. (2025). Evaluating the impacts of physical soil and water conservation measures implemented by community mobilization in shebel berenta district of northern ethiopia. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-99986-7>
- Bojer, A. K., Bekalo, D. J., Debelee, T. G., Nadarajah, S., & Al-Quraishi, A. M. F. (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. <https://doi.org/10.3390/w16131789>
- Brhane, N. (2025). Socioeconomic drivers influencing performance of soil and water conservation measures in tigray, northern ethiopia. *Asian Soil Research Journal*, 9(3), 50–64. <https://doi.org/10.9734/asrj/2025/v9i3190>
- Chausson, A., Turner, B., Seddon, D., Chabaneix, N., Girardin, C. A. J., Kapos, V., Key, I., Roe, D., Smith, A., Woroniecki, S., & Seddon, N. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. *Global Change Biology*, 26(11), 6134–6155. <https://doi.org/10.1111/gcb.15310>
- Diop, M., Chirinda, N., Beniaich, A., El Gharous, M., & El Mejahed, K. (2022). Soil and water conservation in africa: State of play and potential role in tackling soil degradation and building soil health in agricultural lands. *Sustainability*, 14(20), 13425. <https://doi.org/10.3390/su142013425>
- Fenta, H. M., Aynalem, D. W., Malmquist, L., Hailelassie, A., Tilahun, S. A., Barron, J., Adem, A. A., Adimassu, Z., Zimale, F. A., & Steenhuis, T. S. (2024). A critical analysis of soil (and water) conservation practices in the ethiopian highlands: Implications for future research and modeling. *CATENA*, 234, 107539. <https://doi.org/10.1016/j.catena.2023.107539>
- Garg, K. K., Singh, R., Anantha, K., Singh, A. K., Akuraju, V. R., Barron, J., Dev, I., Tewari, R., Wani, S. P., Dhyani, S., & Dixit, S. (2020). Building climate resilience in degraded agricultural landscapes through water management: A case study of bundelkhand region, central india. *Journal of Hydrology*, 591, 125592. <https://doi.org/10.1016/j.jhydrol.2020.125592>
- Gebremeskel, E. N., Tolossa, D., & Gebru, G. (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*, 17(1), 678–704. <https://doi.org/10.1108/ijccsm-11-2024-0200>
- Gebru, K. M., Woldearegay, K., van Steenberg, F., Beyene, A., Vera, L. F., Tesfay Gebreegziabher, K., & Alemayhu, T. (2020). Adoption of road water harvesting practices and their impacts: Evidence from a semi-arid region of ethiopia. *Sustainability*, 12(21), 8914. <https://doi.org/10.3390/su12218914>
- Hafeez, M. M., Cheema, M. J. M., Liaqat, U. W., Amin, M., & Usman, M. (2025). Mapping of potential storages and rainwater harvesting sites in arid region of indus basin using analytical hierarchy technique. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-20915-9>
- Hussein, M. A., Abdi, A. N., Yousuf, A. M., Nadarajah, S., Abdikarim, H., & Muse, A. H. (2025). Spatial distribution and determinants of unimproved sources of drinking water among somali households: Spatial and multilevel analysis using nationwide survey data. *Journal of Water and Health*, 23(6), 806–825. <https://doi.org/10.2166/wh.2025.140>
- Ibrahim Ali, A., Kassem, Y., & Gökçekus, H. (2022). Current and future challenges for better water supply sustainability in somalia. *International Journal of Engineering Applied Sciences and Technology*, 7(5), 252–257. <https://doi.org/10.33564/ijeast.2022.v07i05.041>
- Islam, M., Kashem, S., Momtaz, Z., & Hasan, M. M. (2023). An application of the participatory approach to develop an integrated water resources management (iwrms) system for the drought-affected region of bangladesh. *Heliyon*, 9(3), e14260. <https://doi.org/10.1016/j.heliyon.2023.e14260>
- Knapik, E., Brandimarte, L., & Usher, M. (2024). Maintenance in sustainable stormwater management: Issues, barriers and challenges. *Journal of Environmental Planning and Management*, 68(12), 2769–2795. <https://doi.org/10.1080/09640568.2024.2325041>
- Leal Filho, W., Totin, E., Franke, J. A., Andrew, S. M., Abubakar, I. R., Azadi, H., Nunn, P. D., Ouweeneel, B., Williams, P. A., & Simpson, N. P. (2022). Understanding responses to climate-related water scarcity in africa. *Science of The Total Environment*, 806, 150420. <https://doi.org/10.1016/j.scitotenv.2021.150420>

- Lelamo, L. L., Shenkut, B. T., & Abdilahi, A. H. (2022). Drought characteristics and pastoralists' response strategies in korahey zone, somali regional state, eastern ethiopia. *Scientific African*, *16*, e01254. <https://doi.org/10.1016/j.sciaf.2022.e01254>
- Lema, M. W. (2025). Sustaining rural livelihoods through participatory water governance: A review of community-driven water resource management models in east and central africa. *Environmental Quality Management*, *34*(3). <https://doi.org/10.1002/tqem.70023>
- Madaki, M. Y., Ullah, A., Ahado, S., Agyemang, S. A., Kofi, T. O., Darr, D., & Bavorova, M. (2025). Small dams for climate adaptation: Evidence from ghana's one-village-one-dam program for water security and agro-pastoral resilience in semi-arid africa. *Journal of Environmental Management*, *393*, 127164. <https://doi.org/10.1016/j.jenvman.2025.127164>
- Masha, M., Yirgu, T., & Debele, M. (2021). Impacts of soil and water management measures on crop production and farm income of rural households in the damota area districts, southern ethiopia (V. Popovic, Ed.). *International Journal of Agronomy*, *2021*, 1–13. <https://doi.org/10.1155/2021/5526713>
- Meena, D. C., Rao, C. A. R., Dhyani, B. L., Dogra, P., Samuel, J., Dupdal, R., Dubey, S. K., & Mishra, P. K. (2020). Socio-economic and environment benefits of soil and water conservation technologies in india: A critical review. *International Journal of Current Microbiology and Applied Sciences*, *9*(4), 2867–2881. <https://doi.org/10.20546/ijemas.2020.904.336>
- Muse, N. M., Tayfur, G., & Safari, M. J. S. (2023). Meteorological drought assessment and trend analysis in puntland region of somalia. *Sustainability*, *15*(13), 10652. <https://doi.org/10.3390/su151310652>
- Nilahyane, A., Ghimire, R., Sharma Acharya, B., Schipan-ski, M. E., West, C. P., & Obour, A. K. (2023). Overcoming agricultural sustainability challenges in water-limited environments through soil health and water conservation: Insights from the ogallala aquifer region, usa. *International Journal of Agricultural Sustainability*, *21*(1). <https://doi.org/10.1080/14735903.2023.2211484>
- Nur, A. H., Mohamed, A. A., & Ahmed, A. H. (2024). Spatial assessment of soil erosion and aridity in somalia using the corine model. *Asian Soil Research Journal*, *8*(4), 111–123. <https://doi.org/10.9734/asrj/2024/v8i4167>
- Omar, O. O., Azizi, M. I., Prashad, R., Biko, T., & Joseph, N. (2025). Impacts of climate change on water resource availability in somalia: A comprehensive review. *European Journal of Theoretical and Applied Sciences*, *3*(1), 395–406. [https://doi.org/10.59324/ejtas.2025.3\(1\).35](https://doi.org/10.59324/ejtas.2025.3(1).35)
- Patode, R. S., Chorey, A., Wankhade, R., Ganvir, M. M., Pandagale, V. P., Mali, R. S., Morey, S., Fukat, P., & Sinha, M. (2025). Enhancing agricultural water efficiency through conservation and ground-water management in akola district, vidarbha region. *Archives of Current Research International*, *25*(1), 90–97. <https://doi.org/10.9734/acri/2025/v25i11040>
- Sharma, S., Yost, M. A., & Reeve, J. R. (2025). Roles of organic agriculture for water optimization in arid and semi-arid regions. *Sustainability*, *17*(12), 5452. <https://doi.org/10.3390/su17125452>
- Teressa, D., & Mosisa, H. (2021). The effectiveness of rain water harvesting for sustainable practices in west hararghe zone, oromia regional state, ethiopia. *Engineering Science*, *6*(1), 1. <https://doi.org/10.11648/j.es.20210601.11>
- Veness, W. A., Balfour, N., O'Keeffe, J., & Buytaert, W. (2025). Humanitarian management of drought needs better water security data. *Disasters*, *49*(3). <https://doi.org/10.1111/disa.12687>
- Woldearegay, K., Grum, B., Hessel, R., van Steenberg, F., Fleskens, L., Yazew, E., Tamene, L., Mekonnen, K., Reda, T., & Haftu, M. (2024). Watershed management, groundwater recharge and drought resilience: An integrated approach to adapt to rainfall variability in northern ethiopia. *International Soil and Water Conservation Research*, *12*(3), 663–683. <https://doi.org/10.1016/j.iswcr.2023.08.009>
- Xing, Y., & Wang, X. (2024). Precision agriculture and water conservation strategies for sustainable crop production in arid regions. *Plants*, *13*(22), 3184. <https://doi.org/10.3390/plants13223184>
- Yifru, B. A., Kim, M.-G., Lee, J.-W., Kim, I.-H., Chang, S.-W., & Chung, I.-M. (2021). Water storage in dry riverbeds of arid and semi-arid regions: Overview, challenges, and prospects of sand dam technology. *Sustainability*, *13*(11), 5905. <https://doi.org/10.3390/su13115905>