INDONESIAN JOURNAL OF SOCIAL AND ENVIRONMENTAL ISSUES (IJSEI)
Journal Homepage: https://ojs.literacyinstitute.org/index.php/ijsei
ISSN: 2722-1369 (Online)
Review Article

Volume 4	Issue 3	December (2023)	DOI: 10.47540/ijsei.v4i3.1148	Page: 327 – 338

Effect of Forest Landscape Restoration on Ecosystem Services in Ethiopia: Review for Future Insight

Giche Yadesa Hirpa[1], Sammy C. Letema[2], Felix L.M. Ming'ate[3]
[1]Department of Environmental Planning and Management, Kenyatta University, Kenya
[2]Department of Spatial and Environmental Planning, Kenyatta University, Kenya
[3]Department of Environmental Studies and Community Development Kenyatta University, Kenya
Corresponding Author: Giche Yadesa Hirpa; Email: gicheyadesa4@gmail.com

A R T I C L E I N F O

Keywords: Deforestation; Ecosystem Service; Forest Landscape; Restoration Time.

Received : 24 September 2023
Revised : 19 December 2023
Accepted : 21 December 2023

A B S T R A C T

Forests are crucial covering 31% of the Earth's land surface. Deforestation has caused damage to these forest landscapes limiting their ability to provide ecosystem services like provisioning, supporting, regulating, and cultural services. In response to this degradation issue, the concept of forest landscape restoration was introduced in 2000. This review aims to provide comprehensive studies of existing literature on the effect of forest landscape restoration and restoration time on reversing ecosystem service in Ethiopia. The goal is to inform evidence-based decision-making and guide research in this field. The review analyzed 16 studies conducted from 2011 to 2023 that covered aspects of forest landscape restoration. The findings indicated that these restorations had an impact on ecosystem services such as improving soil properties, storing carbon stack, enhancing species diversity, richness, evenness, and regeneration status, and benefiting community livelihood. However, the review found that most of the studies were limited to specific regions, little information on the cultural service, and there were inconsistencies in some research findings. In general, this study provides significant evidence supporting the importance of restoration as a viable strategy to rehabilitate degraded forest landscapes. It also highlights the importance of long-term monitoring and considering ecological conditions for sustainable restoration efforts in regaining ecosystem services.

INTRODUCTION

Forest landscapes are vital worldwide resources providing ecosystem services (Díaz et. al., 2018; IPBES, 2018), accounting for 31% of the earth's land surface, but their area is shrinking owing to degradation and deforestation with 420 mha between 1990 and 2020 of main forests (FAO, 2020). This effect may hinder a forest's potential to provide ecosystem services such as climate change mitigation, soil erosion and soil formation, biodiversity management, source of water and food, and agricultural productivity (IPBES, 2019). As a result, people banded together to choose and carry out the best restoration intervention in a landscape. The idea of forest landscape restoration (FLR) emerged in 2000 with the aim of "halting and reversing the loss and degradation of forests and woodlands" (WWF & IUCN, 2000; Sabogal et al., 2015).

Around the world, FLR has been promoted through numerous initiatives. In this respect, The Bonn Challenge, launched in 2011, aims to restore 350 million hectares of degraded and deforested land worldwide by 2030 (The Bonne Challenge, n.d), the United Nations Convention on Biological Diversity's Aichi Targets 14 and 15 aim to recover 15% of degraded forest landscape (Convention on Biological Diversity, n.d), the 20x20 Initiative restoring 20 mha by 2020 (Initiative 20x20, n.d) of degraded forest landscape areas in Latin America.

In Africa, forest landscape restoration initiatives have been implemented in several countries, to restore degraded lands, increase biodiversity, and provide various ecosystem services. The African Forest Landscape Restoration Initiative (AFR100) was introduced in 2015 to restore 100 mha by 2030 (AFR100, n.d). Also, the Pan-African Agenda for Ecosystem Restoration for Resilience pledged to restore 200 mha (CBD, 2018). In addition, the introduction of the Great Green Wall for the Sahara and Sahel in 2007 resulted in a promise to rehabilitate 100 mha of degraded lands across the Sahel (UNCCD, 2020). According to Pasiecznik and Reij (2020), participating in African dryland restoration initiatives like AFR100, the Great Green Wall, and the Pan-African Agenda for Ecosystem Restoration can boost ecosystem service (provisioning, regulation, and supporting service) agricultural production, soil fertility, biodiversity, and climate resilience.

In Ethiopia, FLR accepted as a nature-based solution for restoring damaged landscapes (Lowell et al., 2014). Ethiopian country pledged under the Bonn challenge with the help of African Forest Landscape Restoration (AFR 100) regional initiatives to restore 15 mha of degraded landscapes (AFR 100, n.d; Shiferaw & Abebe, 2020). In the country several forest landscape restoration initiatives such as the National Forest Sector Development Program, the Land Degradation Neutrality Fund, and the Ethiopian Climate Resilient Green Economy Initiative (Lowell et al., 2014; Shiferaw & Abebe, 2020; Kassa et al., 2022).

Under these initiative frameworks, the most significant state-led FLR efforts in Ethiopia that aim to reduce forest and land degradation include exclosure (AE), participatory forest management (PFM), integrated watershed management IWM, and community mobilization and involvement to plant trees through Green Legacy program were conducted (Shiferaw & Abebe, 2020). These programs aim to restore degraded and deforested lands, enhance ecosystem services, and benefit the rural population.

Various studies proved that FLR practiced in Ethiopia had a valuable impact in regaining ecosystem service that had degraded before (Damene et al., 2013; Ameha et al., 2014; Hishe et al., 2017; Birhane et al., 2018; Mekuria et al., 2018; Sinore et al., 2018; Ebabu et al., 2019; Kassa et al., 2022; Solomon et al., 2022 Mengistu et al., 2023). As a result, despite the fact that FLR initiatives have been in place for more than 20 years and have a significant effect, the following gaps are identified. Firstly, lack of comprehensive studies that specifically focus on the impact of forest landscape restoration on different ecosystem services in Ethiopia. Most of the existing research tends to be limited in scope, focusing either on a specific ecosystem service or on a specific region within Ethiopia. This lack of comprehensive research hinders our understanding of the overall impact of forest landscape restoration on multiple ecosystem services across different regions of Ethiopia. Secondly, there is a limited understanding of the restoration time effects of forest landscape restoration on ecosystem services. Based on these gaps, the present review aims to address the following research questions: (1) What is the overall impact of forest landscape restoration on different ecosystem services in Ethiopia? (2) How do ecosystem services provided by restored forests change over restoration time?

Therefore, this review aims to provide a comprehensive and up-to-date synthesis of the existing literature review on FLR interventions in Ethiopia, which will inform evidence-based decision-making and future research studies on how the restoration of the forest landscape has affected ecosystem services such as provision, regulation, support, and cultural services.

MATERIALS AND METHODS

Search Strategy

A review was used as the research method for this study. Web of Science and Google Scholar were used to search for articles. The following keywords were used in the search: “forest landscape restoration” OR Ethiopia, “forest rehabilitation”, “reforestation”, “afforestation”, “ecological restoration”, “biodiversity conservation”, “forest ecosystem services”, “carbon sequestration”, “soil erosion control”, “climate change mitigation”, “habitat restoration”, “forest ecology”, “deforestation conservation”, “area enclosure”, “land restoration”, “agroforestry”, “livelihoods”, “soil and watershed management” OR Ethiopia, “restoration initiative”, “restoration status”, participatory forest management” OR Ethiopia.

Study Selection Criteria

The selection criteria were based on the PRISMA (Preferred reporting items for systematic reviews and meta-analyses) technique (Dea et al., 2021). The search mainly focused on studies conducted on forest landscape restoration in Ethiopia from 2011 to 2023. Articles published in peer-reviewed scientific journals were included and articles that failed to report forest landscape restoration in Ethiopia was excluded (Table 1).

Table 1. Criteria of Inclusion and Exclusion

Criteria of Inclusion	Criteria of Exclusion
Articles must be in English	Articles published other than in English
Restricted to peer-reviewed research articles	Not peer-reviewed journals
Area-restricted forest landscape restoration	Other than forest landscape restoration
Study conducted in Ethiopia	The study was conducted outside of Ethiopia
The time frame of the articles from 2011 to 2023	Study conducted before 2011

Data Extraction and Quality Assessment

The search results were combined using reference management software (Mendeley). Data were extracted from the study design, location of the study, and restoration outcomes (e.g. ecosystem services i.e. provisioning, regulating, and supporting service). To maintain the quality of the review, all duplications were checked thoroughly. The abstracts of the articles were checked deeply for the analysis and purification of the articles to ensure the quality and relevance of the literature included in the review process.

The Joanna Briggs Institute Critical Appraisal Checklist for Cohort Studies (Moola et al., 2020) was utilized to assess the quality of the study and identify any biases. Three authors were conducting quality assessments on the 18 studies that met the criteria for inclusion. Each study underwent two separate assessments. This tool consists of 11 questions that pertain to the study, with response options of 'yes' indicating higher quality, 'no' indicating poor quality, or 'unclear'. By employing this tool, the authors were able to determine whether to include or exclude studies based on their overall quality. If a study received three or more 'no' or 'unclear' ratings in the quality categories, it was excluded from the analysis. Any discrepancies in judgment regarding inclusion were resolved through discussion. Finally, 16 studies were included in the analysis and two studies were excluded. The results of the appraisal process conducted can be found in a supplementary table (Table 2).

Table 2. Joanna Briggs Institute Critical Appraisal Checklist for Cohort Studies

JBI Checklist Number of Study	1. Two Groups Similar and Recruited from the Same Population?	2. Were the Exposures Measured Similarly to Assign People to Both Exposed and Unexposed Groups?	3. Was the Exposure Measured in a Valid and Reliable Way?	4. Were Confounding Factors Identified?	5. Were Strategies to Deal with Confounding Factors Stated?	6. Were the Groups/ Participants Free of the Outcome at the Start of the Study (or at the Moment of Exposure)?	7. Were the Outcomes Measured in a Valid and Reliable Way?	8. Was the Follow-Up Time Reported and Sufficient to Be Long Enough for Outcomes to Occur?	9. Was Follow-Up Complete, and If Not, Were the Reasons to Loss of Follow-Up Described and Explored?	10. Were Strategies to Address Incomplete Follow-Up Utilized?	11. Was Appropriate Statistical Analysis Used?	Overall *
Mengistu et al., 2023	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Gebrehiwot et al., 2022	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Solomon et al., 2022	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Teka et al., 2020	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Abay et al., 2020	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Gebregergs et al., 2019	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Asmare & Gure, 2019	Yes	Yes	Yes	Unclear	No	NA	Yes	Yes	NA	NA	No	Excluded
Mekuria et al., 2018	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Sinore et al., 2018	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Mekuria et al., 2018	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Kedir et al., 2017	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included

Tadesse et al., 2017	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Hishe et al., 2017	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Mekuria et al., 2016	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Ameha et al., 2016	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Mekuria, 2013	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Damene et al., 2012	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA	NA	Yes	Included
Mekuria & Aynekulu, 2011	Yes	Yes	Yes	No	No	NA	Yes	Yes	NA	NA	No	Excluded

RESULTS AND DISCUSSION

Search Results

Our search criteria yielded about 748 articles (Figure 1). We excluded 579 articles by applying our inclusion/exclusion criteria to the titles and abstracts of the papers and removing duplicated papers. Yet another 137 papers were removed after thorough examinations of the entire text of the rest papers. The 18 papers that satisfied our criteria were included in the final batch and after conducting the final quality assessment 16 studies were included in the analysis. The included studies were conducted between 2011 and 2023.

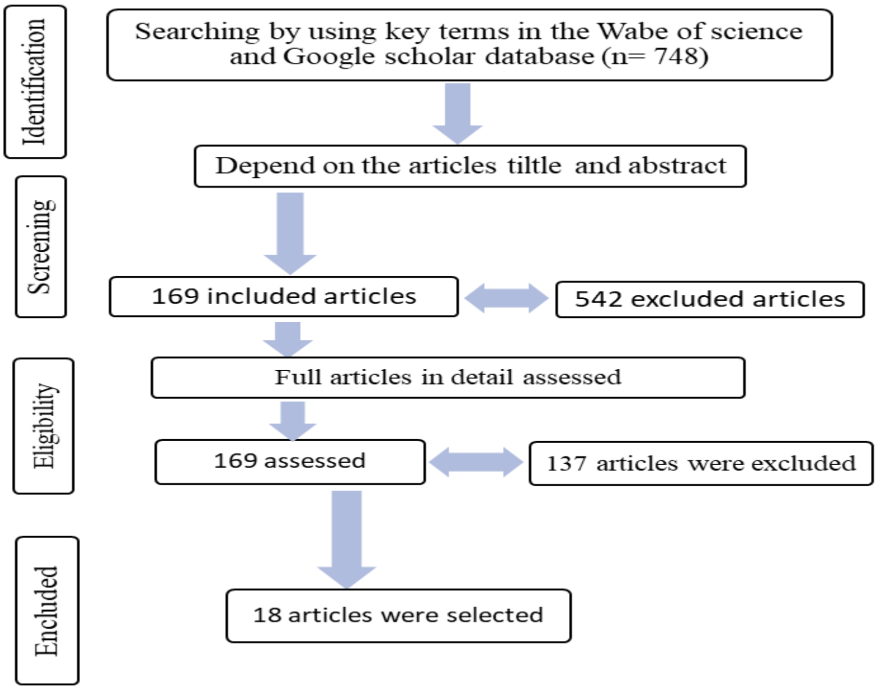

Figure 1. PRISMA flowchart of the articles selection process adopted from Dea et al., (2021).

Characteristics of the Selected Articles

A total of 18 studies related to FLR in Ethiopia were included in this review and 16 studies were included in the analysis after conducting quality assessment. Of the total selected articles, thirteen studies were focused on supporting services of ecosystem (Asmare & Gure, 2019; Sinore et al., 2018; Mekuria et al., 2018; Mekuria & Aynekulu, 2011; Damene et al., 2013; Mekuria, 2013; Ameha et al., 2016; Mekuria et al., 2016; Hishe et al., 2017; Kedir et al., 2017; Abay et al., 2020; Solomon et al., 2022; Mengistu et al., 2023) one study focused on provision service (Mekuria et al., 2018), two studies focused on both regulation and supporting service (Gebregergs et al., 2019; Gebrehiwot et al., 2022) one studies found provision and regulation service of ecosystem (Teka et al., 2020), and one study focused on supporting and provision service (Tadesse et al., 2017). From this study Author identified that most of studies were failed to report the impact of restoration on the cultural service of the ecosystem.

Regarding to study sub-location, nine were conducted in the northern part of the country (Damene et al., 2013; Mekuria, 2013; Mekuria & Aynekulu, 2013; Hishe et al., 2017; Mekuria et al., 2018; Gebregergs et al., 2019; Abay et al., 2020; Teka et al., 2020; Gebrehiwot et al., 2022;) four studies in the northwest (Mekuria et al., 2016; Mekuria et al., 2018; Asmare & Gure, 2019; Mengistu et al., 2023) three studies in the south (Ameha et al., 2016; Sinore et al., 2018; Solomon et al., 2022). Also, one study in the southeast (Kedir et al., 2017) and one study in the southwest (Tadesse et al., 2017) was considered. This review article found that most of the studies were only in a few regions of the country. All selected studies were found that restoration had a significant impact on the improvement of ecosystem service i.e. supporting, regulating, and provisioning.

Effect of Forest Landscape Restoration on Ecosystem Services

Humans receive ecosystem services from the natural world and healthy ecosystems like agroecosystems, forest ecosystems, grassland ecosystems, and aquatic ecosystems (Millennium Ecosystem Assessment, 2005; Tallis et al., 2013). The four categories of ecosystem services: provisioning, regulating, cultural, and supporting are ecosystems' direct and indirect contributions to humans and affect our survival and standard of living (Millennium Ecosystem Assessment, 2005; Maithya et al., 2020; Maithya *et al*., 2022). This review has found that FLR interventions, such as area AE, IWM, and PFM had significant positive effects on the ecosystem services such as provisioning, regulating, and supporting services in Ethiopia (Table 3). However, the impact of restoration on cultural services will need further study.

Table 3. Ecosystem Service Revealed by the Studies

Authors	Location	Ecosystem services	Reported outcomes
Mengistu et al., 2023	Northwest	Supporting	Species richness, diversity, and evenness, composition, and regeneration improved
Gebrehiwot et al., 2022	North	Regulating and supporting	vegetation cover and total SOC stock increased
Solomon et al., 2022	South	Supporting	Species density, diversity, and regeneration status improved
Teka et al., 2020	North	Provisioning and regulating	Soil erosion reduced and livelihood improved
Abay et al., 2020	North	Supporting	Soil fertility improved
Gebregergs et al., 2019	North	Regulating and supporting	Soil fertility improved, increase carbon stock
Asmare & Gure, 2019	Northwest	Supporting	diversity, abundance, evenness, and richness increased
Mekuria et al., 2018	North	Provisioning	Biomass increased
Sinore et al., 2018	South	Supporting	Soil physical and chemical properties improved
Mekuria et al., 2018	Northwest	Supporting	Species diversity, richness, abundance, density, and biomass, soil fertility improved
Kedir et al., 2017	Southeast	Supporting	Forest coverage and regeneration increased
Tadesse et al., 2017	Southwest	Supporting and provisioning	Forest cover and Livelihood increased
Hishe et al., 2017	North	Supporting	Soil properties improved
Mekuria et al., 2016	Northwest	Supporting	Soil fertility increased
Ameha et al., 2016	South	Supporting	Species density and composition improved
Mekuria, 2013	North	Supporting	Soil fertility increased
Damene et al., 2012	North	Supporting	Soil fertility increased
Mekuria & Aynekulu, 2011	North	Supporting	Soil fertility improved

1. Supporting service

FLR interventions play an important role in enhancing the soil properties of damaged forest landscapes. Different authors (Damene et al., 2013; Mekuria & Aynekulu, 2013; Mekuria, 2013; Mekuria et al., 2016; Mekuria et al., 2018; Gebregergs et al., 2019; Abay et al., 2020) found that FLR interventions such as AE has led to improvements in soil physicochemical properties. All the results show that enclosure improves the physicochemical characteristics of soil when compared to open grazing land. This finding is in line with the study of Kassaye et al. (2021).

However, there were some inconsistencies in the changes in some soil physicochemical characteristics between area exclosure and open grazing fields. Mekuria (2013), for instance, discovered no significant difference in cation exchange capacity between enclosure and open grazing land, whereas Mekuria and Aynekulu

(2011) and Gebregergs et al. (2019) discovered that enclosure resulted in significant increases in cation exchange capacity when compared to open grazing land. Similarly, differences in soil pH and electrical conductivity between the two land use types were inconsistent across studies, with Gebregergs et al. (2019) reporting no significant differences and Mekuria et al. (2018) finding that soil pH was significantly higher in grazing land than a nearby enclosure. Whereas Abay et al., (2020) did not observe significant changes in certain soil properties such as soil pH, available phosphorus, and electrical conductivity in AE. In this inconsistency, the Authors pointed out that this might be due to different seasons of data collection affecting it.

IWM interventions had significant effects on the improvement of soil physicochemical parameters (Hishe et al., 2017; Sinore et al. 2018). Hishe et al. (2017) discovered statistically significant variations in various soil parameters, including cation exchange capacity, organic carbon content, nitrogen, phosphorus, and soil pH, between exclosure and grazing land. Other physicochemical parameters, such as bulk density, soil moisture content, sand, silt, and clay content exchangeable bases, were not significant. Sinore et al. (2018), on the other hand, discovered that IWM significantly improved multiple soil physiochemical parameters, including higher clay fraction, lower bulk density, higher pH, higher soil organic carbon, total nitrogen, available phosphorus, cation exchange capacity, and exchangeable bases, when compared to degraded grazing land.

Kedir et al., (2017) pointed out that PFM had a positive impact on forest cover increment and regeneration of forest landscape with increasing community perception. Asmare & Gure (2019) showed that exclosure sites had higher species diversity, species composition, and density of woody species than the adjacent open grazing lands. The study observed that exclosure sites showed active regeneration. However, the study did not took, consideration of the factors of enrichment planting, and compare distribution patterns of the soil seed bank. Ameha et al (2016) stated that PFM had a positive impact on species distribution and density than forests managed by the government. However, the study did not evaluate other factors, such as socio-economic or policy factors that may also influence forest management outcomes.

Damene et al. (2013) found that AE had a substantial effect on vegetation cover increment, structure, and composition protection, as compared to adjacent lands. After four years, the exclosure had significantly higher plant species richness, diversity, evenness, woody species density, basal area, and aboveground woody biomass than the adjacent land (Mekuria et al., 2018). According to Solomon et al., (2022), exclosure is an efficient strategy for repairing degraded lands and boosting biodiversity, with strong vegetation regeneration and diversity in the exclosure region, while competition among established saplings may limit the emergence of new seedlings. Area exclosure has a substantial impact on woody species diversity, composition, and regeneration status, with having better species richness than nearby degraded areas (Mengistu et al., 2023).

The Authors highlighted in their study that this inconsistency might be attributed to variations in the seasons during which data was collected.

2. Provisioning services

Teka et al. (2020) found that IWM activities had positive changes in crop productivity, water availability, and feed availability, with increases of 22%, 33%, and 10% respectively and household income also increased by 56%. Tadesse et al. (2017) revealed that PFM had a significant impact on the improvement of natural and social assets of livelihoods in forest-dependent communities. Also, Mekuria, et al., (2018) found that significant impact on provision service i.e. biomass production increased as compared to grazing land. However, Tadesse et al. (2017) proved that PFM had no significant effect on physical and human assets of livelihood improvement in forest-dependent communities.

The Authors stated that contrasting results call for a more in-depth comparative analysis to understand the factors contributing to the varied effects of PFM in different contexts. Also, discrepancy suggests a need to explore the factors influencing the diverse effects of Participatory Forest Management on different aspects of livelihoods.

3. Regulating services

FLR practices had a significant impact on regaining regulating service i.e. climate relation via carbon storing (Abay et al., 2020; Gebrehiwot et al., 2022) and soil erosion control (Teka et al., 2020).

Both Abay et al. (2020) and Gebrehiwot et al. (2022) discovered that exclosures had much more soil organic carbon (SOC) than grazing land. Gebrehiwot et al. (2022) discovered that forest soils had the largest mean SOC stock, while bare land soils had the lowest value, followed by cropland soils. Abay et al. (2020) discovered that converting grazing land to exclosure caused a substantial variance in SOC stock, increasing from 45.64 2.57 Mg/ha in grazing land to 73.61 4.94 Mg/ha in exclosure. Both researchers found that management practices such as minimizing grazing pressure and increasing vegetative cover had a vital role in improving SOC stock.

Effect of Restoration Duration on Ecosystem Service

The studies, by Damene et al. (2013), Mekuria & Aynekulu (2013), Mekuria (2013), Mekuria et al. (2018), and Gebregergs et al. (2019) have found that exclosures can significantly improve soil fertility, and restore degraded grazing pastures, increase biomass output, and sequester carbon. However, there are inconsistent data concerning the effect of exclosure age on specific soil attributes. Mekuria et al. (2018) discovered that the age of exclosure has a beneficial effect on biomass output, but Mekuria (2013) discovered that younger restoration ages had a stronger impact on soil qualities. According to Gebregergs et al. (2019), the 10-year exclosure had the highest carbon stock, but the lesser ages did not differ significantly from grazing land. According to Mekuria and Aynekulu (2011) and Mekuria et al. (2018), even the youngest exclosures have a favorable impact on supporting service i.e. soil fertility, species diversity, richness, and density which is significant for farmers hoping for quick results. On the other hand, Mekuria et al., (2018) provision service i.e. wood biomass is higher at longer age than at lower age. Also, Damene et al. (2013) emphasize the significance of long-term monitoring and agroecological conditions for the sustainable restoration of restoring supporting services. Overall, the research suggests that exclosures can be a useful tool for healing damaged soil characteristics and rehabilitating degraded grazing pastures.

Challenges and Way Forward on the Effect of Forest Landscape Restoration on Ecosystem Services

Based on the conducted review, the following research gaps were identified:

1. Lack of long-term effect: Some studies are conducted on short restoration time, making it impossible to determine the long-term impact of restoration measures. As a result, longitudinal studies are required to evaluate the long-term impact of restoration efforts on ecological services.
2. Inadequate information on cultural service: While some studies have looked at the other ecosystem services of forest landscape restoration in Ethiopia, there is still a lack of information on cultural service. More research was focused on supporting services than other services. Therefore, it is better to diversify the research on all aspects of ecosystem services.
3. Inconsistencies in research findings: The findings of studies on the impact of forest landscape restoration approaches on soil characteristics are inconsistent. Some research, for example, revealed considerable improvements in soil physicochemical qualities with area exclosure, while others found no significant differences between exclosure and grazing land. More study is needed to reconcile these discrepancies and provide a more complete knowledge of the impact of restorative therapies.
4. Studies' relevance to other locations is limited: Many studies on forest landscape restoration in Ethiopia are limited to specific regions, limiting their applicability to other areas. As a result, more research covering a broader range of environmental variables and management practices are required to provide more generalized suggestions for restoration measures.

Furthermore, most studies concentrated on three FLR options (AE, IWM, and PFM) while ignoring other potential restoration approaches such as enrichment planting and tree-planting initiatives. It would be good to investigate the efficacy of this research in various circumstances to establish the best restoration method for certain places.

Conclusion

The review found that forest landscape restoration approaches such as area exclosure, integrated watershed management, and participatory forest management had a significant effect in restoring ecosystem services such as provisioning, supporting, and regulating services of degraded forest landscapes as compared to adjacent landscapes where restoration was not carried out. Particularly improvements in soil physicochemical properties, vegetation coverage and species diversity, livelihood enhancement, and wood biomass were observed. However, differences in some soil physicochemical parameters between area exclosure and open grazing areas as well as physicochemical parameters of some studies between authors were inconsistent. The review emphasizes the importance of long-term monitoring and taking into account agroecological circumstances for ecosystem services restoration.

References

Abay, K., Tewolde-Berhan, S., & Teka, K. (2020). The effect of exclosures on restoration of soil properties in Ethiopian lowland conditions. *SN Applied Sciences*, *2*(11), 1–12.

AFR100 (n.d). The African Forest Landscape Restoration Initiative. https://afr100.org/content/countries.

Ameha, A., Meilby, H., & Feyisa, G. L. (2016). Impacts of participatory forest management on species composition and forest structure in Ethiopia. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *12*(1–2), 139–153.

Ameha, A., Nielsen, O. J., & Larsen, H. O. (2014). Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. *Ecological Economics*, *97*, 162–171.

Asmare, M. T., & Gure, A. (2019). Effect of exclosure on woody species diversity and population structure in comparison with adjacent open grazing land: the case of Jabi Tehnan district north western Ethiopia. *Ecosystem Health and Sustainability*, *5*(1), 98–109.

Birhane, E., Mengistu, T., Seyoum, Y., Hagazi, N., Putzel, L., Rannestad, M. M., & Kassa, H. (2018). Exclosures as forest and landscape restoration tools: lessons from Tigray Region, Ethiopia. *International Forestry Review*, *19*(4), 37–50.

CBD. (2018). Pan-African Action Agenda on Ecosystem Restoration for Increased Resilience. *UN Biodiversity Conference - COP 14*, *8*, 38.

Convention on Biological Diversity (n.d). Aichi Target 15. https://www.cbd.int/nbsap/.

Damene, S., Tamene, L., & Vlek, P. L. G. (2013). Performance of exclosure in restoring soil fertility: A case of Gubalafto district in North Wello Zone, northern highlands of Ethiopia. *Catena*, *101*, 136–142.

Ebabu, K., Tsunekawa, A., Haregeweyn, N., Adgo, E., Meshesha, D. T., Aklog, D., Masunaga, T., Tsubo, M., Sultan, D., Fenta, A. A., & Yibeltal, M. (2019). Effects of land use and sustainable land management practices on runoff and soil loss in the Upper Blue Nile basin, Ethiopia. *Science of the Total Environment*, *648*(August 2018), 1462–1475.

FAO. (2020). *Global Forest Resources Assessment 2020: Main report*.

Gebregergs, T., Tessema, Z. K., Solomon, N., & Birhane, E. (2019). Carbon sequestration and soil restoration potential of grazing lands under exclosure management in a semi-arid environment of northern Ethiopia. *Ecology and Evolution*, *9*(11), 6468–6479.

Gebrehiwot, G., Teka, K., & Welday, Y. (2022). Can landscape restoration improve soil carbon stock? A study from Sero Watershed, Northern Ethiopia. *Global Ecology and Conservation*, *39*.

Hailu Shiferaw and Adugna Abebe. (2020). *Forest Landscape Restoration (FLR) Options for Southern Nations, Nationalities and Peoples (SNNP) Regional State. Ethiopian Environment, Forest and Climate Change Commission and World Resources Institute.* (Issue May).

Hishe, S., Lyimo, J., & Bewket, W. (2017). Soil and water conservation effects on soil properties in the Middle Silluh Valley, northern Ethiopia. *International Soil and Water Conservation Research*, *5*(3), 231–240.

Initiative 20x20 (n.d). Initiative 20x20 member countries in Latin America and the

Caribbean. https://initiative20x20.org/regions-countries

IPBES. (2018). *Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (M. S. and L. W. (eds.). R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince (ed.); IPBES secr, Issue July 2018).

IPBES. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* (and C. N. Z. (eds.). S. Díaz, J. Settele, E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A (ed.); IPBES secr).

Kassa, H., Abiyu, A., Hagazi, N., Mokria, M., Kassawmar, T., & Gitz, V. (2022). Forest landscape restoration in Ethiopia: Progress and challenges. *Frontiers in Forests and Global Change*, *5*.

Kedir, H., Negash, M., Yimer, F., & Limenih, M. (2017). Contribution of participatory forest management towards conservation and rehabilitation of dry Afromontane forests and its implications for carbon management in the tropical Southeastern Highlands of Ethiopia. *Journal of Sustainable Forestry*, *37*(4), 357–374.

Lowell, E. C., Maguire, D. A., Briggs, D. G., Turnblom, E. C., Jayawickrama, K. J. S., & Bryce, J. (2014). Effects of silviculture and genetics on branch/knot attributes of coastal Pacific northwest douglas-fir and implications for wood quality-a synthesis. *Forests*, *5*(7), 1717–1736.

Wetland Utilization and its Implications on Provisioning Ecosystem Services of Nyando Wetland, Lake Victoria Basin, Kenya. *Journal of Environmental Assessment Policy and Management,* 24(01).

Maithya, J. K., Ming'ate, F. L. M., & Letema, S. C. (2020). A Review on Ecosystem Services and their Threats in the Conservation of Nyando Wetland, Kisumu County, Kenya. *Tanzania Journal of Science*, *46*(3), 711–722.

Mekuria, W. (2013). Conversion of Communal Grazing Lands into Exclosures Restored Soil Properties in the Semi-Arid Lowlands of Northern Ethiopia. *Arid Land Research and Management*, *27*(2), 153–166.

Mekuria, W., & Aynekulu, E. (2013). Exclosure land management for restoration of the soils in degraded communal grazing lands in northern Ethiopia. *Land Degradation and Development*, *24*(6), 528–538.

Mekuria, W., Langan, S., Noble, A., & Johnston, R. (2016). Soil Restoration after Seven Years of Exclosure Management in Northwestern Ethiopia. *Land Degradation and Development*, *28*(4), 1287–1297.

Mekuria, W., Wondie, M., Amare, T., Wubet, A., Feyisa, T., & Yitaferu, B. (2018). Restoration of degraded landscapes for ecosystem services in North-Western Ethiopia. *Heliyon*, *4*(8).

Mekuria, W., Yami, M., Haile, M., Gebrehiwot, K., & Birhane, E. (2018). Impact of exclosures on wood biomass production and fuelwood supply in northern Ethiopia. *Journal of Forestry Research*, *30*(2), 629–637.

Mengistu, D. A., Bekele, D. A., Gela, A. G., Meshesha, D. T., & Getahun, M. M. (2023). Woody species diversity and regeneration status of Sub-Alpine forest of Mount Adama exclosure site, Northwestern highlands of Ethiopia. *Heliyon*, *9*(6), e16473.

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: synthesis* (Issue January). Island Press.

Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu P-F. (2020). Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis. JBI.

N. Pasiecznik and C. Reij. (2020). *Restoring African Drylands* (N. Pasiecznik and C. Reij (ed.); Tropenbos, Issue 60). Tropenbos

International.

O'Dea, R. E., Lagisz, M., Jennions, M. D., Koricheva, J., Noble, D. W. A., Parker, T. H., Gurevitch, J., Page, M. J., Stewart, G., Moher, D., & Nakagawa, S. (2021). Preferred reporting items for systematic reviews and meta-analyses in ecology and evolutionary biology: a PRISMA extension. *Biological Reviews*, *96*(5), 1695–1722.

S. Díaz, U. Pascual, M. Stenseke, B. Martín-López, R. T. Watson, Z. Molnár, R. Hill, K. M. A. Chan, I. A. Baste, K. A. Brauman, S. Polasky, A. Church, M. Lonsdale, A. Larigauderie, P. W. Leadley, Alexander P. E, and Y. S. (2018). Assessing nature's contributions to people. *Science*, *359*(6373), 270–272.

Sabogal, C., Besacier, C., & McGuire, D. (2015). Forest and landscape restoration: Concepts, approaches and challenges for implementation. *Unasylva*, *66*(245), 3–10.

Sinore, T., Kissi, E., & Aticho, A. (2018). The effects of biological soil conservation practices and community perception toward these practices in the Lemo District of Southern Ethiopia. *International Soil and Water Conservation Research*, *6*(2), 123–130.

Solomon, T., Derero, A., & Lemenih, M. (2022). Woody species regeneration through exclosure and perception of local community on mountain Damota, Wolaita, Ethiopia. *Trees, Forests and People*, *8*(March), 100234.

Tadesse, S., Woldetsadik, M., & Senbeta, F. (2017). Effects of participatory forest management on livelihood assets in Gebradima forest, southwest Ethiopia. *Forests Trees and Livelihoods*, *26*(4), 229–244.

Tallis, H., Guerry, A., & Daily, G. C. (2013). Ecosystem Services. *Encyclopedia of Biodiversity: Second Edition*, *2*, 96–104.

Teka, K., Haftu, M., Ostwald, M., & Cederberg, C. (2020a). Can integrated watershed management reduce soil erosion and improve livelihoods? A study from northern Ethiopia. *International Soil and Water Conservation Research*, *8*(3), 266–276.

Teka, K., Haftu, M., Ostwald, M., & Cederberg, C. (2020b). Can integrated watershed management reduce soil erosion and improve livelihoods? A study from northern Ethiopia. *International Soil and Water Conservation Research*, *8*(3), 266–276.

The Bonn Challenge (n.d). Restore our future Bonn challenge. https://www.bonnchallenge.org/

United Nations Convention to Combat Desertification. (2020). *The Great Green Wall United Nations Convention*.

WWF and IUCN, 2000. Minutes of the Forests Reborn Workshop, Segovia (unpublished).