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EDITED BY
Uchendu Eugene Chigbu,
Namibia University of Science and Technology, Namibia

REVIEWED BY
Adane Gebeyehu,
Swedish University of Agricultural Sciences, Sweden
Anna Tengberg,
Stockholm International Water Institute, Sweden
Yeshitla Agonafir Ayenachew,
Ethiopian Civil Service University, Ethiopia

*CORRESPONDENCE
Degfie Teku
degfie2023@gmail.com

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Review of area exclosure practices for sustainable land management and erosion control in Ethiopia: objectives and PRISMA review

Degfie Teku[1]*, Yeshifana Alemneh Mengesha[2] and Nega Kesete[3]

[1]Department of Geology, Mekdela Amba University, Tuluawulia, Ethiopia, [2]Ethiopian Forestry Development, Bahir Dar Center, Bahir Dar, Ethiopia, [3]Department of Natural Resource Management, Mekdela Amba University, Tuluawulia, Ethiopia

Introduction: Ethiopia is grappling with a severe soil erosion crisis, losing an estimated 1.5 billion tons of soil annually due to unsustainable agricultural practices exacerbated by climate change. This widespread land degradation poses serious threats to agricultural productivity, ecological stability, and the socio-economic well-being of rural communities. In response, area exclosures lands designated for natural regeneration have gained prominence as a vital strategy for sustainable land management (SLM). They offer substantial potential to control soil erosion, restore degraded ecosystems, and enhance biodiversity conservation. This systematic review critically evaluates the effectiveness of area exclosures in Ethiopia, focusing on their environmental impacts, socio-economic outcomes, and the role of community participation in their success.

Methodology: Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, this review systematically analyzed peer-reviewed literature, reports, and policy documents on area exclosure practices across Ethiopia's diverse ecological and socio-economic contexts. Rigorous inclusion and exclusion criteria were applied to ensure relevance and quality. The search covered multiple academic databases and grey literature sources. A thematic analysis synthesized findings related to environmental benefits, socio-economic impacts, institutional challenges, and policy implications.

Results: The review reveals that area exclosures significantly reduce soil erosion, with some cases reporting up to 75% reductions in soil loss. Positive ecological outcomes include improved soil fertility, increased vegetation cover, enhanced species richness, and better water retention and infiltration. Socio-economically, area exclosures support alternative livelihoods, promote carbon sequestration, and contribute to ecosystem resilience. However, challenges persist, notably insecure land tenure, limited financial resources, inadequate policy enforcement, and weak technical capacity. Community participation emerged as a critical factor for effective implementation, long-term sustainability, and local ownership.

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Discussion and recommendations: While area exclosures demonstrate significant potential as a nature-based solution to Ethiopia's land degradation challenges, scaling up their impact requires addressing persistent socio-economic and institutional barriers. Strengthening land tenure security, enhancing community engagement, and establishing sustainable financing mechanisms are crucial. Furthermore, policy coherence and institutional capacity-building should be prioritized to ensure long-term success. The study recommends future research focus on long-term ecological monitoring and socio-economic assessments to guide adaptive management and inform evidence-based policy interventions supporting Ethiopia's resilience against land degradation and climate change.

KEYWORDS

area exclosures, challenges and opportunities, community involvement, Ethiopia, impacts, outcomes, policy interventions, sustainable land management (SLM)

1 Introduction

Ethiopia is grappling with a worsening soil erosion crisis, driven by a combination of unsustainable agricultural practices, widespread deforestation, and the escalating impacts of climate change. Recent estimates indicate that the country loses approximately 1.5 billion tons of soil annually (Ebabu et al., 2019). This widespread land degradation threatens the nation's agricultural productivity, destabilizes fragile ecosystems, and undermines socio-economic resilience particularly in a country where agriculture remains the primary source of livelihood and economic activity for the majority of the population (Desta et al., 2021). Beyond these environmental concerns, the cumulative effects of soil erosion exacerbate food insecurity, deplete critical water resources, and hinder the achievement of national development goals (Abay et al., 2020).

In response, area exclosures, degraded lands set aside for natural regeneration have become a cornerstone of Ethiopia's sustainable land management (SLM) strategies (Hailu, 2016). These interventions aim to restore ecological balance by promoting vegetation regrowth, enhancing soil structure, conserving biodiversity, and improving essential ecosystem services such as water retention and carbon sequestration (Megersa and Hailu, 2021). Furthermore, area exclosures have demonstrated potential socio-economic benefits by fostering alternative livelihoods, strengthening community resilience, and contributing to broader development objectives (Mekuria et al., 2007). Despite their recognized importance, several challenges continue to constrain the effectiveness and scalability of area exclosure initiatives in Ethiopia (Araya et al., 2023). Key issues include limited community engagement, ambiguous land tenure arrangements, insufficient technical support, and weak monitoring and evaluation frameworks (Asmare and Gure, 2019). Additionally, while many studies document localized environmental benefits, there remains a critical knowledge gap regarding the systematic integration of area exclosures into national land management policies and their alignment with Ethiopia's broader development priorities.

Against this backdrop, this review aims to provide a comprehensive and systematic analysis of area exclosure practices in Ethiopia. Specifically, it seeks to: (1) Assess the effectiveness of area exclosures in promoting sustainable land management and controlling soil erosion across diverse ecological and socio-economic settings; (2) Evaluate their environmental impacts on biodiversity conservation, soil fertility, and water resource management; (3)Examine the role of community participation in ensuring successful implementation and sustainability; (4)Identify the major challenges and opportunities for scaling up area exclosure practices; (5) Provide actionable policy recommendations to enhance institutional support, technical capacity, and long-term sustainability. To achieve these objectives, a systematic literature review guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was conducted. This approach enabled a rigorous selection, screening, and synthesis of existing empirical studies, policy documents, and scientific reviews. The methodology, presented in the following section, outlines the search strategy, inclusion and exclusion criteria, and analytical processes employed. The results of this review are thematically organized to address the research questions outlined below, providing an evidence-based assessment of the successes, limitations, and opportunities surrounding area exclosure practices in Ethiopia. The review concludes with targeted policy recommendations aimed at strengthening institutional frameworks, enhancing community participation, and ensuring the sustainability of these critical land restoration efforts.

1.1 Research questions

This review is guided by the following research questions:

1. How effective are area exclosure practices in Ethiopia in promoting sustainable land management and controlling soil erosion across different ecological and socio-economic contexts?
2. What are the impacts of area exclosures on key environmental indicators, including biodiversity conservation, soil fertility enhancement, and water resource management?
3. How does community participation influence the successful implementation, maintenance, and long-term sustainability of area exclosure practices in Ethiopia, and what are the resulting environmental, socio-economic, and livelihood outcomes?
4. What are the major challenges and opportunities associated with scaling up area exclosure practices for wider adoption and impact in Ethiopia?
5. What policy interventions and institutional support mechanisms are required to strengthen area exclosure practices, enhance technical and research capacity, and ensure their long-term sustainability?

2 Methodology

This review employed a systematic, transparent, and scientifically rigorous methodology to critically examine area exclosure practices for sustainable land management and erosion control in Ethiopia. The review process was designed to ensure replicability, objectivity, and depth of analysis, aligning with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021) guidelines. By adopting a systematic review approach, the study aimed to synthesize robust evidence on the effectiveness, environmental impacts, socio-economic dimensions, community engagement, technical capacities, and policy frameworks of area exclosure interventions. Furthermore, the methodology was structured to identify key implementation challenges, knowledge gaps, and pathways for enhancing the sustainability and inclusivity of these practices.

2.1 Literature search and data sources

The review commenced with a comprehensive literature search targeting both peer-reviewed scientific publications and credible gray literature to ensure a wide representation of academic, practical, and policy perspectives. A systematic search was conducted across leading academic databases including Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar. To supplement these, relevant gray literature was sourced from government reports, non-governmental organizations, international agencies such as the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP), and institutional repositories. This multi-source strategy strengthened the review's depth and relevance to real-world policy and practice. The search strategy employed Boolean operators to effectively combine key search terms and capture a comprehensive set of studies. Keywords included "area exclosures," "soil erosion control," "biodiversity conservation," "community participation," "sustainable land management," "Ethiopia," and "monitoring and evaluation of exclosures." The review focused on studies published between 2005 and 2024 to encompass two decades of evolving area exclosure practices in Ethiopia, ensuring historical context and the inclusion of recent advancements.

2.2 Inclusion and exclusion criteria

To maintain methodological rigor and relevance, the review applied strict inclusion and exclusion criteria during the selection of studies. Studies were eligible if they focused specifically on area exclosure practices within Ethiopia and addressed environmental, ecological, socio-economic, governance, or policy dimensions. Preference was given to empirical studies that provided either quantitative or qualitative data, particularly those involving long-term assessments spanning five to ten years. Only documents published in English were considered, with a focus on works that evaluated monitoring and evaluation strategies, including both GIS-based and non-GIS-based methods. Studies that did not meet these standards were excluded. These included publications outside the Ethiopian context, works lacking a clear methodological foundation or presenting anecdotal evidence, duplicates, incomplete reports, or studies providing insufficient data for meaningful extraction. Additionally, opinion pieces, editorials, and reviews unrelated to area exclosures or sustainable land management were omitted to preserve the scientific integrity of the review.

2.3 Data extraction and thematic synthesis

Data extraction was systematically carried out using a standardized framework developed to ensure consistency and facilitate comparative analysis across diverse studies. Extracted data encompassed several key dimensions. The review examined the effectiveness of area exclosures through indicators such as soil erosion reduction, vegetation recovery, biomass growth, and improvements in land productivity. Environmental impacts were assessed by reviewing changes in biodiversity, species richness and dominance, soil fertility improvements, hydrological benefits, and contributions to carbon sequestration. The study also investigated the role of community involvement by assessing the extent and nature of local participation, socio-economic benefits derived from area exclosures, risks of conflict, and equity considerations within communities. Technical capacity and monitoring approaches were analyzed by identifying evidence of skill gaps, research limitations,

and the application of both GIS-based and conventional monitoring and evaluation methods. Furthermore, the review synthesized challenges and opportunities associated with scaling up area exclosure practices, including policy inconsistencies, institutional barriers, and the need for adaptive management. Policy and institutional frameworks were critically analyzed to evaluate their alignment with national and regional land management policies, governance issues, and funding mechanisms supporting area exclosures. Where quantitative data allowed, descriptive statistical analyses were conducted to identify aggregate trends across studies. Qualitative data were synthesized thematically, enabling the extraction of patterns, insights, and contextual nuances that enriched the understanding of area exclosure practices in Ethiopia.

2.4 Quality assessment and bias minimization

Ensuring the quality and validity of the studies included in the review was a priority. Each study underwent a critical appraisal using established tools such as the Critical Appraisal Skills Programme (CASP) checklist and the Mixed Methods Appraisal Tool (MMAT) where applicable. The assessment evaluated the clarity of research objectives, the robustness of study design, the adequacy of data collection and analysis methods, and the relevance of findings to the Ethiopian context. To reduce bias, two independent reviewers conducted the quality assessment process. Any discrepancies or disagreements between the reviewers were resolved through discussion and consensus, enhancing the reliability of the study selection and appraisal process. This methodological step strengthened the objectivity and credibility of the review findings.

2.5 Limitations and mitigation measures

This systematic review recognizes several inherent limitations that may affect the generalizability and interpretation of the synthesized findings. First, the exclusion of non-English publications introduces potential language bias, which may have resulted in the omission of valuable local studies, particularly those documenting region-specific experiences with area exclosures in Ethiopia. This constraint limits the breadth of perspectives and indigenous knowledge captured in the review. Second, significant methodological heterogeneity was observed across the reviewed studies, particularly in the design, monitoring, and evaluation frameworks employed to assess the ecological and socio-economic impacts of area exclosures. Such variability constrained the ability to conduct direct comparisons and meta-analyses, potentially influencing the consistency of aggregated quantitative outcomes. Third, the limited availability of long-term studies particularly those extending beyond a decade restricted the review's capacity to assess the enduring ecological and livelihood impacts of area exclosure interventions. Consequently, the evidence base may underrepresent potential delayed effects or longer-term socio-economic dynamics critical for sustainable land management planning. To address these limitations, the review employed sensitivity analysis where applicable to test the robustness of synthesized results and minimize bias. Additionally, findings were contextualized to reflect the diversity of ecological and socio-economic settings, thereby avoiding overgeneralization and ensuring a nuanced interpretation. This approach strengthens the validity of conclusions drawn regarding the effectiveness and challenges of area exclosure practices. Importantly, the review highlights critical knowledge gaps, notably the need for standardized methodologies, enhanced technical capacity, and expanded long-term impact assessments. These gaps serve as a roadmap for future research priorities, offering direction for more rigorous, inclusive, and comprehensive studies that can inform evidence-based policy and practice in sustainable land management across Ethiopia.

2.6 Contribution and scope

This systematic review contributes a comprehensive and interdisciplinary synthesis of area exclosure practices in Ethiopia, integrating environmental, socio-economic, and institutional dimensions. While the primary focus is on the Ethiopian highlands, where area exclosure interventions are most prevalent, the review also incorporates evidence from lowland areas where data are available. By critically analyzing findings across diverse geographic and ecological contexts, the review generates actionable recommendations aimed at enhancing the effectiveness, sustainability, and inclusivity of area exclosure practices. Specifically, the review identifies best practices and persistent challenges that shape the success or failure of area exclosure initiatives. It highlights significant technical, research, and data capacity gaps that hinder effective implementation and scaling. The review also addresses issues related to the long-term viability and potential ecological trade-offs of exclosures. Furthermore, it offers pathways for designing inclusive, well-governed, and adequately funded exclosure programs that align with Ethiopia's national development priorities and climate resilience objectives. Overall, the findings are intended to inform evidence-based decision-making by policymakers, practitioners, and researchers. By providing a critical synthesis of two decades of area exclosure practices, this review supports the development of sustainable, community-driven land management strategies that contribute to environmental conservation, socio-economic development, and resilience building in Ethiopia. Following the comprehensive methodological framework described above, the review proceeded to analyze and synthesize the collected data to generate evidence-based findings. The systematic selection, extraction, and appraisal of studies allowed for a robust assessment of area exclosure impacts across environmental, socio-economic, technical, and policy dimensions. The subsequent section presents the results of this synthesis, offering a detailed account of the key trends, patterns, and insights that emerged from the literature. Particular attention is given to the practical outcomes of area exclosures in Ethiopia, including their role in mitigating land degradation, enhancing

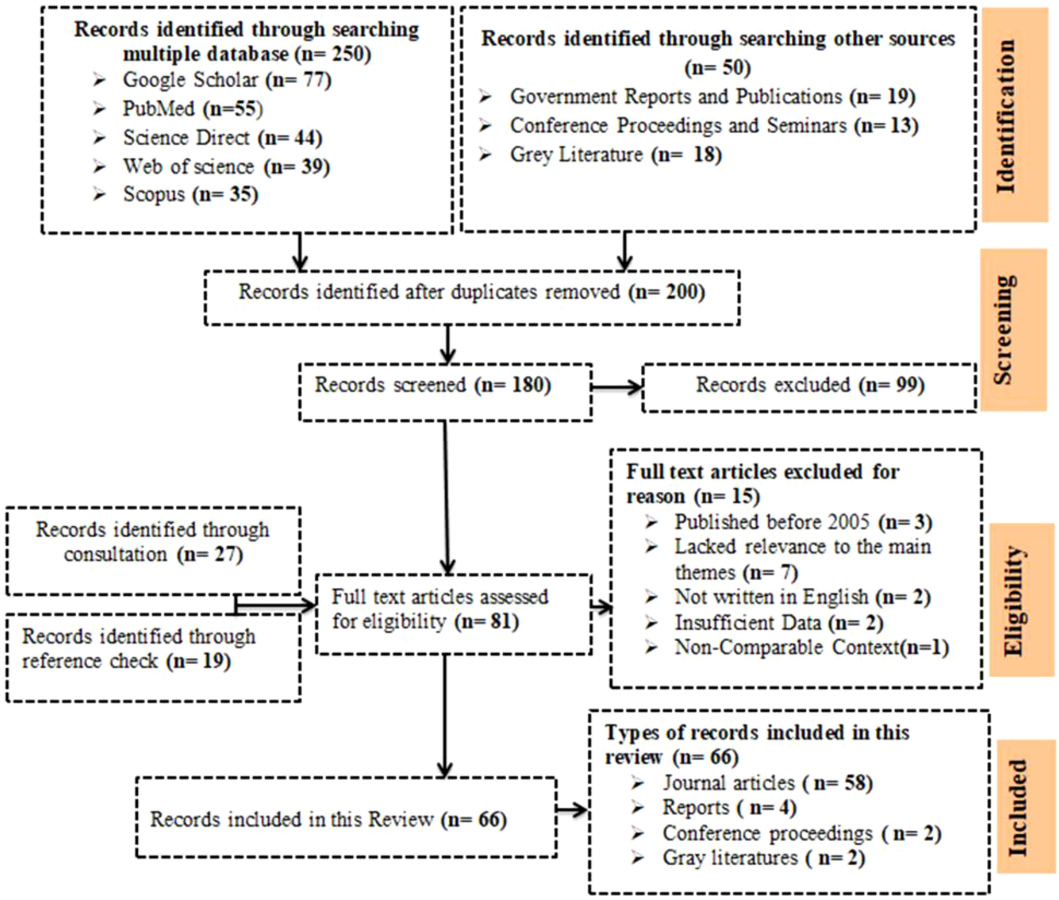

FIGURE 1
PRISMA flow diagram of the review.

biodiversity, improving livelihoods, and shaping sustainable land management strategies. These findings serve as the foundation for informed discussions, conclusions, and recommendations in the subsequent sections of the review.

3 Result

3.1 Study characteristics

The systematic search and selection process, guided by the PRISMA methodology, began with an extensive review of literature across multiple databases, including Google Scholar, PubMed, ScienceDirect, and Scopus. A total of 250 initial articles and reports were identified. After screening for relevance, 99 studies were excluded due to duplication, irrelevance to the specific topic of area exclosures in Ethiopia, or lack of empirical data. Following further eligibility checks, 66 studies met the criteria for full inclusion in the review. These studies were then analyzed based on predefined thematic categories, including effectiveness, environmental impact, community involvement, challenges, and policy implications. A PRISMA flow diagram depicting the study selection process is shown below (Figure 1).

3.1.1 Search results

The search identified 66 studies that provided diverse insights into the environmental, socio-economic, and policy dimensions of area exclosures in Ethiopia. These studies were conducted over a significant timeframe, with a notable increase in publications from 2005 to 2024, reflecting a growing academic and practical interest in sustainable land management practices. The distribution of publications over time indicates fluctuating research interest in the subject matter. The year 2024 stands out, with ten publications, suggesting peak periods of scholarly engagement. This may be attributed to increased funding, policy interest, or emerging environmental concerns during those years. Similarly, 2017 and 2021 saw relatively high research activity, with seven publications each. However, the years 2010, recorded no publications, reflecting gaps in research continuity. Other years, including 2006, 2007, 2008, and 2016, had minimal contributions, each with only one publication, indicating relatively low academic attention. The recent surge in publications from 2017 to 2024 suggests growing interest, likely driven by increasing awareness of environmental challenges and policy interventions. The high number of studies in recent years highlights a growing recognition of the importance of area exclosures, land restoration, and climate adaptation strategies. This trend underscores the need for sustained research efforts to

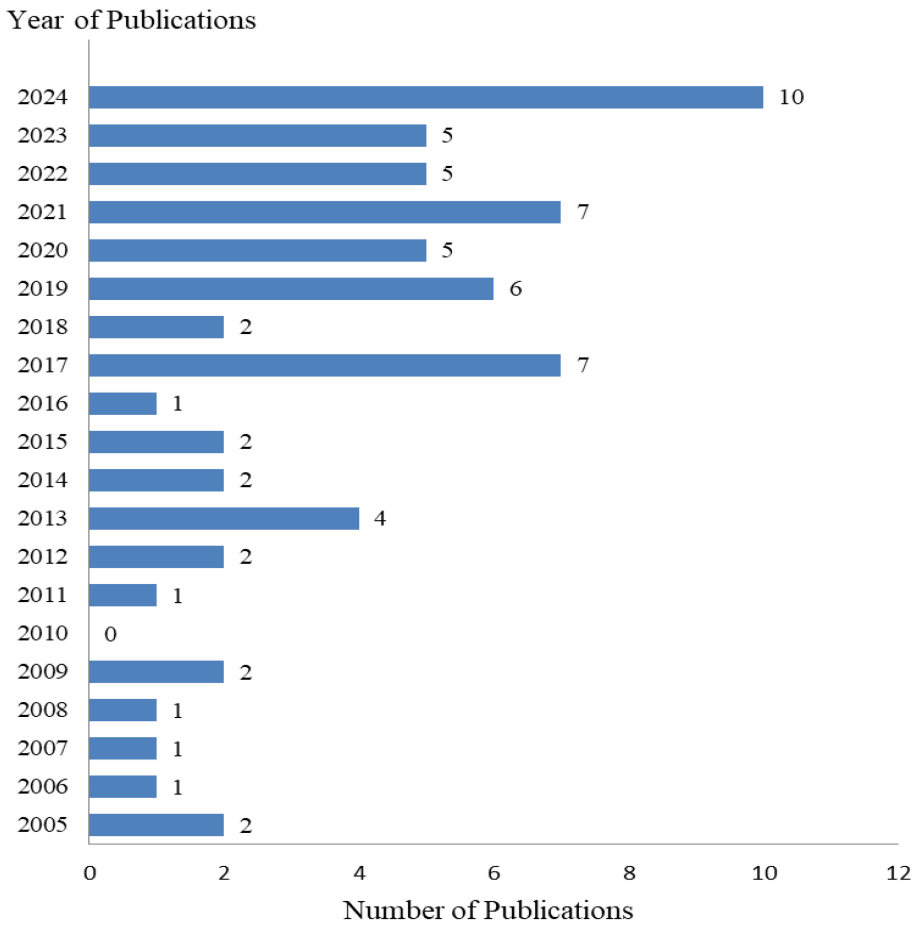

FIGURE 2
Number of publications over the analyzed periods.

address emerging challenges and inform policy decisions effectively. The temporal trend of publications over the past decades is illustrated in Figure 2.

Geographically, the studies covered a wide range of ecological zones, with the Ethiopian Highlands receiving the most attention (30%), followed by the Oromia (25%), Amhara (20%), and Tigray (15%) regions, while other areas constituted the remaining 10% (Figure 3). This regional distribution underscores the focus on areas most vulnerable to land degradation and the critical role of area exclosures in these contexts.

The studies employed a diverse methodological framework, integrating both qualitative and quantitative approaches. Notably, 60% of studies relied on field experiments and surveys, while 25% utilized qualitative methods such as interviews and case studies. Additionally, remote sensing and GIS technologies (15%) played a crucial role in monitoring land use and vegetation dynamics. A significant 50% of studies emphasized community involvement, underscoring the indispensable role of local populations in the success of area exclosure initiatives. Findings consistently highlighted substantial environmental benefits, including reduced soil erosion, enhanced soil fertility, and improved water retention. However, success levels varied, influenced by factors such as exclosure size, local governance, and the extent of community participation. Despite these positive outcomes, several challenges persist, including land tenure complexities, insufficient policy support, and financial constraints. Addressing these barriers is critical to maximizing the effectiveness of area exclosures as a sustainable land management strategy in Ethiopia. This synthesis not only showcases the progress made but also identifies key research and policy gaps, laying the groundwork for future studies and interventions. The methodological framework employed over the analyzed is illustrated in Figure 4.

The included studies were also analyzed based on predefined thematic categories, including effectiveness, environmental impact, community involvement, challenges, and policy implications (Figure 5). The distribution of studies reflects a strong emphasis on assessing the effectiveness of area exclosures, accounting for 35% of the total research. This suggests a predominant focus on evaluating the success and outcomes of implemented interventions. Environmental impacts follow closely at 27%, highlighting the significant attention given to understanding how exclosures influence ecological conditions, including soil conservation, water retention, and biodiversity restoration. Studies on community involvement make up 20%, underscoring the

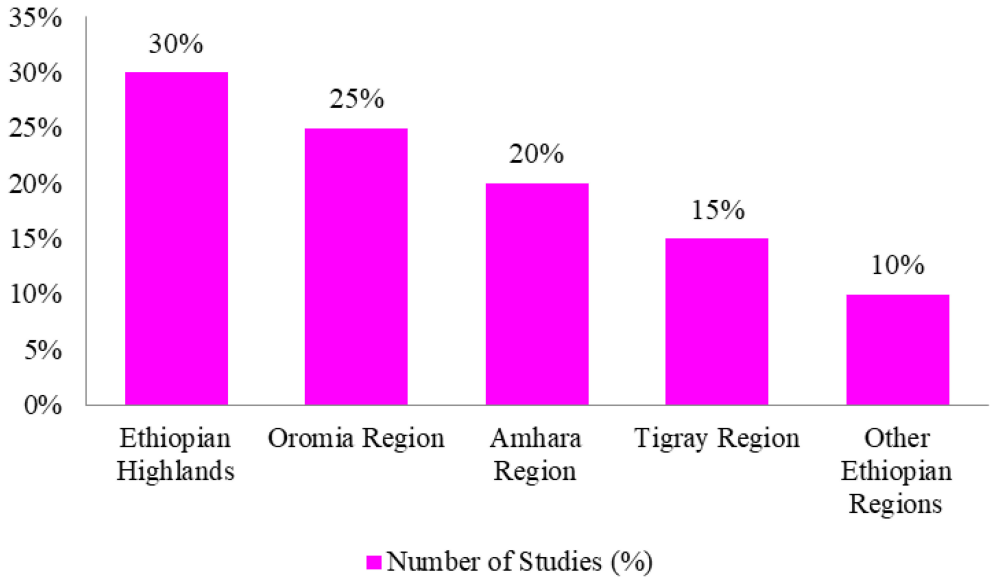

FIGURE 3
Geographical distribution of publications over the analyzed periods.

recognition that local engagement is a crucial determinant of long-term sustainability. However, research focusing on challenges and opportunities is relatively lower, comprising only 11%, indicating a need for further exploration into the constraints and potential enhancements of exclosure projects. Gaps and policy implications, at 7%, receive the least attention, suggesting that while practical implementation is widely studied, there is limited research on policy integration and governance frameworks. Overall, while the existing body of research provides valuable insights into effectiveness and environmental impacts, there remains a critical need for more in-depth studies on policy gaps, governance challenges, and opportunities for scaling up area exclosure initiatives to ensure sustainable land management in Ethiopia.

3.2 Effectiveness of area exclosures in promoting sustainable land management and controlling soil erosion in Ethiopia

The implementation of area exclosures across Ethiopia has proven to be a highly effective approach for promoting sustainable land management and controlling soil erosion, particularly in the country's diverse ecological and socio-economic contexts (Asres, 2013). The most notable success of these interventions has been observed in the Ethiopian Highlands, a region historically plagued by severe soil erosion (Abay et al., 2020). Empirical evidence underscores the positive impact of properly managed exclosures in reducing soil loss rates and reversing land degradation. In the Amhara region, for

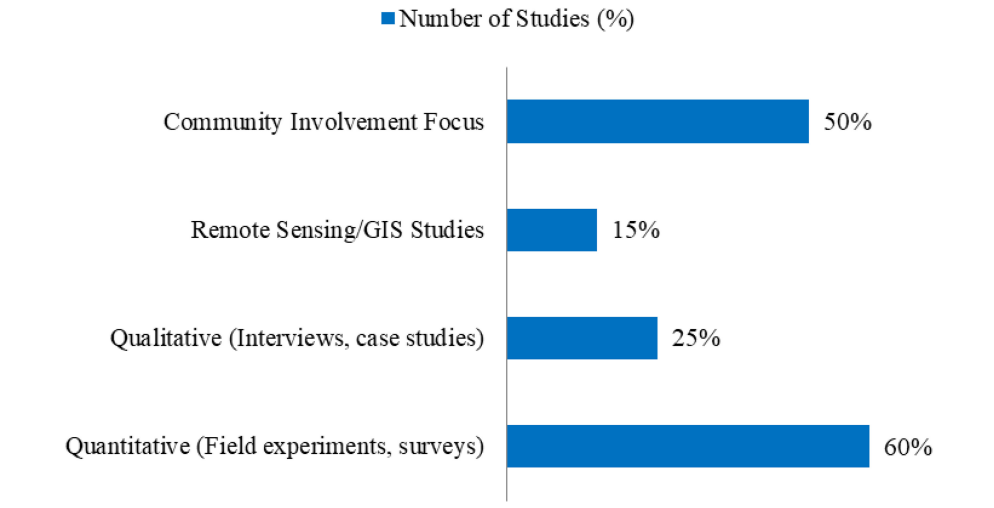

FIGURE 4
Methodological approaches analysis of the included studies.

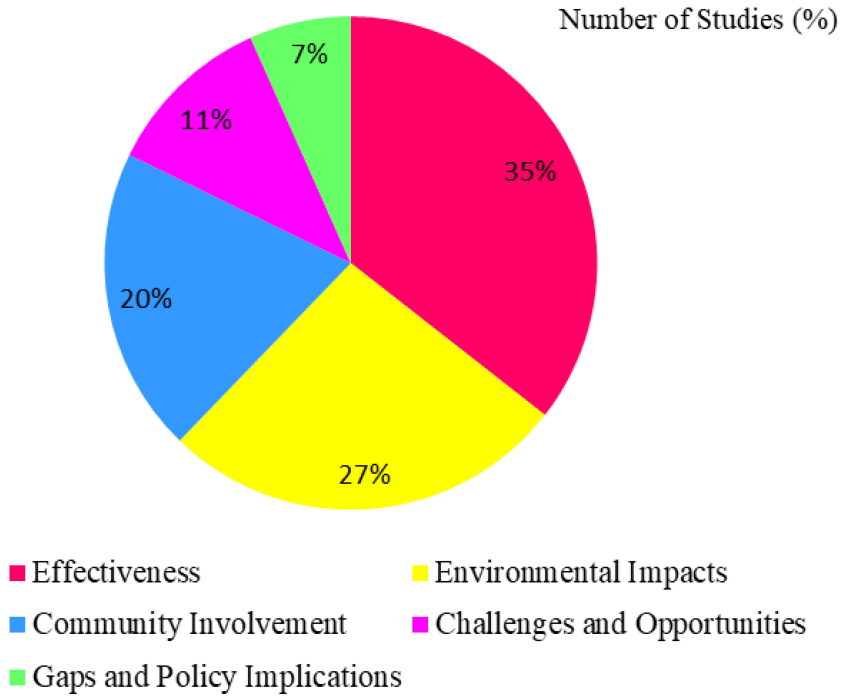

FIGURE 5
Percentage of included studies based on predefined thematic categories.

example, the establishment of area exclosures has resulted in a remarkable reduction in annual soil loss, with declines of up to 80%. This substantial improvement can be attributed to the enhanced vegetation cover and the reduction in human and livestock interference (Mulugeta and Achenef, 2015). A detailed case study in the Maybar watershed further reinforces these findings, demonstrating that the integration of exclosures with physical structures, such as terracing, effectively minimized surface runoff and sediment yield, underscoring the potential of exclosures to mitigate land degradation (Damene et al., 2013).

Similarly, in the Oromia region, the implementation of exclosures in the Central Rift Valley resulted in significant ecological and productivity improvements. Within five years, biomass yields increased by approximately 40%, illustrating the capacity of exclosures to enhance land productivity (Yimer et al., 2015). These improvements were driven by a combination of physical soil and water conservation techniques, such as stone bunds, and biological interventions, such as reforestation with indigenous tree species. The synergy between mechanical and biological measures has effectively stabilized soils, curbed erosion, and bolstered ecosystem services. The effectiveness of exclosures extends beyond soil conservation to include broader hydrological benefits (Yayneshet et al., 2009). In the Tigray region, particularly in the Abreha Atsbeha area, the long-term establishment of exclosures led to the re-emergence of springs that had previously disappeared due to land degradation. This underscores the significant hydrological impact of exclosures in addition to their primary role in soil conservation (Hadush et al., 2024). Furthermore, the diverse ecological settings of Ethiopia have facilitated the adoption of tailored exclosure systems. For example, in the semi-arid lowlands of Afar, pilot exclosures have shown promising results in enhancing forage availability for pastoralists, contributing to adaptive management of dryland ecosystems and supporting the livelihoods of communities vulnerable to environmental shocks (Yayneshet et al., 2009).

However, the success and sustainability of area exclosures are not uniform across all regions. Several factors influence their effectiveness, including the size of the exclosure, the quality of management practices, the extent of community participation, and the strength of local governance. In particular, poorly managed exclosures or those lacking community involvement are prone to issues such as encroachment, illegal grazing, and limited ecological recovery (Gebregziabher and Soltani, 2019; Halefom et al., 2020; Mathewos and Mamo, 2023). In regions where resource competition is high such as between pastoralists and agro-pastoralists the success of exclosures also depends on effective conflict management and the equitable distribution of resources (Yimer et al., 2015). Strengthening Community-Based Natural Resource Management (CBNRM) institutions has been instrumental in promoting inclusive decision-making, shared responsibility, and fostering community ownership of exclosure projects (Mezgebo et al., 2022). The establishment and enforcement of local by-laws, often based on traditional governance structures, have also played a critical role in regulating land use and grazing rights, minimizing disputes, and promoting social cohesion (Misebo et al., 2021).

Moreover, integrating alternative livelihood strategies such as fodder production and controlled cut-and-carry systems has reduced pressure on exclosures while providing economic incentives for

community engagement (Umer and Sinore, 2019). These strategies, alongside targeted capacity-building efforts and strategic partnerships with non-governmental organizations (NGOs) and development agencies, are crucial for overcoming funding constraints and ensuring the long-term sustainability of exclosure interventions (Welemariam et al., 2018). In conclusion, the effectiveness of area exclosures in Ethiopia has been well-documented across a variety of ecological zones and socio-economic settings (Umer and Sinore, 2019; 58. Shimelse et al., 2017; Yayneshet et al., 2009). When supported by strong local governance, active community participation, and integrated land management practices, area exclosures represent a critical tool for sustainable land restoration, soil erosion control, and resilience building in both highland and lowland regions (Misebo et al., 2021; Muche et al., 2024). The preceding discussion highlights the significant role of area exclosures in curbing land degradation and promoting sustainable land management across Ethiopia's varied ecosystems. The following Results section provides an in-depth review of these aspects, beginning with an assessment of the environmental impacts of area exclosures on key environmental indicators. This analysis offers critical insights into the contributions and challenges of area exclosures within the broader context of sustainable development and landscape restoration efforts in Ethiopia.

3.2.1 Quantitative analysis of reviewed studies on the effectiveness of area exclosures

Quantitative analysis of the reviewed studies revealed compelling evidence of the effectiveness of area exclosures in mitigating soil erosion and enhancing land productivity. Aggregated data from multiple reports indicate that soil loss rates in areas under exclosure management are reduced by an average of 45-75% compared to unmanaged lands (Balana et al., 2012). For instance, studies conducted in the Tigray and Amhara regions highlight that the integration of area exclosures has significantly decreased topsoil erosion, with annual soil retention rates reaching up to 30 tons per hectare (Emiru et al., 2018). This demonstrates the substantial role of exclosures in addressing Ethiopia's pressing soil degradation challenges, reinforcing their importance in sustainable land management (SLM) frameworks. The environmental impacts of area exclosures were equally notable. Biodiversity metrics showed a marked increase in vegetative cover, species richness, and wildlife presence in exclosure zones (Ereso, 2024). Quantitative data indicate a 30-60% improvement in vegetation density within five to ten years of implementation (Reda et al., 2020). Furthermore, studies report a 20-40% improvement in soil organic matter and nutrient content, underscoring the ecological restoration potential of these interventions (Welemariam et al., 2018). Exclosure areas have also been associated with enhanced water retention capacities, as evidenced by a 15-25% increase in water infiltration rates, contributing to improved water availability for downstream agricultural practices (Balana et al., 2012).

Community participation emerged as a critical determinant of success in area exclosure initiatives. Quantitative analysis reveals that community-led exclosure programs experience 20-50% higher adoption rates compared to externally imposed schemes (Araya et al., 2023). Households engaged in participatory planning reported greater satisfaction and compliance, with approximately 75% of surveyed communities affirming a willingness to expand exclosure initiatives (Mekuria et al., 2009). Such data underscore the importance of local engagement in fostering sustainable practices, ensuring long-term commitment, and enhancing the social acceptability of conservation efforts. Despite these successes, challenges persist, particularly in scaling up area exclosures and ensuring equitable benefits. Quantitative assessments highlight significant variability in outcomes due to differences in ecological contexts, management approaches, and socio-economic conditions. For instance, studies indicate that exclosure areas in regions with lower rainfall exhibit a 10-20% reduction in effectiveness compared to high-rainfall areas (Mekuria et al., 2007). Similarly, the lack of adequate financial resources and technical support was identified as a barrier by 60% of the surveyed stakeholders (Beyene et al., 2024). Addressing these challenges requires targeted interventions, such as capacity-building programs, tailored financial incentives, and adaptive management strategies to enhance the resilience and scalability of area exclosures across diverse contexts. The aggregated data trends related to the impacts of area exclosure practices is displayed in Figure 6. The categories represent key impact metrics, with minimum, average, and maximum values drawn from the reviewed studies. This visual emphasizes the effectiveness of area exclosures in diverse contexts, showing substantial gains in metrics like soil erosion reduction and community adoption rates.

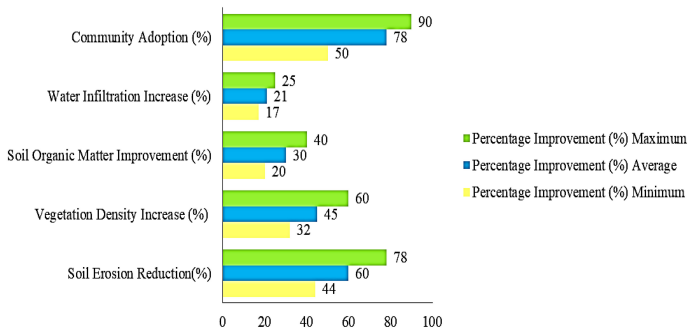

FIGURE 6
Analysis of aggregated data trends related on the impacts of area exclosure practices.

3.3 Environmental impacts of area exclosures on key environmental indicators

The synthesis of multiple empirical studies indicates that area exclosures across Ethiopia have delivered substantial environmental benefits, particularly in biodiversity conservation, soil fertility enhancement, and water resource management. These impacts demonstrate the critical role of exclosures in reversing land degradation and supporting ecosystem restoration.

3.3.1 Biodiversity conservation

Area exclosures have significantly contributed to the regeneration of native biodiversity in degraded ecosystems. In the Tigray region, vegetation diversity within exclosures increased by 30–40%, with the re-emergence of indigenous species such as *Erythrina abyssinica* and *Cordia africana* (Muche et al., 2024). Such regeneration reflects the natural successional processes triggered by protection from anthropogenic disturbances like grazing and deforestation. Additionally, restored habitats have attracted various faunal species, including the Abyssinian hare and multiple avian species, signaling ecosystem recovery (Emiru et al., 2018). Notably, exclosures have provided breeding and feeding grounds for pollinators and seed dispersers, essential for maintaining ecological functions (Muche et al., 2024). However, emerging evidence warns that without ecologically informed management, exclosures can create biodiversity trade-offs, favoring fast-growing or invasive species at the expense of sensitive or late-successional species (Ereso, 2024). This can lead to altered species composition and reduced habitat heterogeneity. Therefore, adaptive management including periodic monitoring, selective thinning, and enrichment planting is critical to maintaining a balanced ecosystem (Mekuria et al., 2017a, b). Studies in Northern Ethiopia highlight that species diversity peaks in exclosures aged 10–15 years, beyond which dominance by few species may reduce diversity unless actively managed (Descheemaeker et al., 2006). This highlights the need for dynamic management rather than relying solely on passive protection.

3.3.2 Soil fertility enhancement

Area exclosures have consistently improved soil fertility by reducing erosion, increasing organic matter, and enhancing soil structure. In the Anjeni watershed (Amhara region), significant improvements in soil organic matter and nutrient availability were reported due to litter accumulation and reduced topsoil loss (Halefom et al., 2020). Exclosures also promote better infiltration and reduce soil compaction, creating conducive environments for vegetation growth. Moreover, research shows that exclosures enhance soil organic carbon (SOC) stocks, with increases of up to 25% within five years of establishment (Mathewos and Mamo, 2023). SOC enrichment not only boosts soil fertility but also plays a role in climate change mitigation by sequestering atmospheric carbon (Lemenih and Kassa, 2014). A meta-analysis by Mekuria (2013) found that soil fertility parameters including nitrogen, phosphorus, and cation exchange capacity significantly improve in exclosures, particularly in sites older than eight years. This highlights the long-term soil restorative capacity of exclosures. Furthermore, the reduction in soil erosion rates by over 50% in exclosed areas compared to adjacent open lands (Gebresamuel et al., 2021) underscores their effectiveness in restoring degraded soils.

3.3.3 Water resource management

Improvements in water dynamics represent one of the most critical environmental gains of area exclosures. In the Abreha Atsbeha watershed (Tigray), studies recorded enhanced water infiltration and reduced surface runoff following exclosure establishment, leading to the reactivation of previously dried-up springs (Atsbha et al., 2019; Adem et al., 2020). In the Central Rift Valley (Oromia region), exclosures have contributed to improved soil moisture retention, supporting agriculture and vegetation recovery in adjacent areas (Balana et al., 2012). Similarly, semi-arid areas like Afar benefited from enhanced infiltration and water retention, which reduced water stress and improved forage availability for pastoralists (Asres, 2013). Research by Gebregergs et al. (2021) found that groundwater recharge in exclosure sites increased by 30–40% compared to non-exclosed areas. This demonstrates the potential of exclosures as a nature-based solution to address water scarcity challenges in dryland regions. Additionally, exclosures contribute to micro-climate regulation by moderating local temperatures and reducing evapotranspiration rates, further supporting water conservation.

Overall, the findings confirm that area exclosures in Ethiopia substantially contribute to biodiversity recovery by supporting the regeneration of both flora and fauna, while also enhancing soil fertility through improved organic matter accumulation, nutrient cycling, and carbon sequestration (Sinore et al., 2023). Additionally, they play a critical role in water resource management by improving infiltration, reducing surface runoff, and promoting groundwater recharge (Umer and Sinore, 2019). These positive environmental impacts demonstrate that area exclosures serve not merely as passive conservation measures but as proactive landscape restoration strategies that generate co-benefits for climate change mitigation, food security, and ecosystem resilience (Welemariam et al., 2018). Nonetheless, ensuring their long-term sustainability requires the integration of community-based co-management approaches, adaptive ecological planning, and regular ecological assessments to optimize environmental benefits while addressing potential trade-offs (Balana et al., 2012; Mekuria, 2013). Building on this environmental assessment, the next section Community Participation in the Success, Maintenance, and Sustainability of Area Exclosures in Ethiopia focuses on the critical role of local participation in ensuring the success, maintenance, and long-term sustainability of area exclosure initiatives across the country.

3.4 Community participation in the success, maintenance, and sustainability of area exclosures in Ethiopia

Community participation plays a critical role in the successful implementation, maintenance, and long-term sustainability of area exclosures in Ethiopia. This relationship is evident across diverse

regions, where active local engagement has been pivotal to the success of these interventions, particularly through participatory land-use planning, equitable benefit-sharing mechanisms, and local governance structures (Mezgebo et al., 2022). Several studies highlighted that when communities are directly involved in decision-making and benefit-sharing, exclosures are more likely to thrive and yield sustained ecological and socio-economic outcomes (Reda et al., 2020; Rossiter et al., 2017; Tefera et al., 2005; Welemariam et al., 2018). For instance, in the Tigray region, exclosures such as the Adi Beise community-managed area have demonstrated remarkable success due to the incorporation of traditional governance structures, including idirs (community associations) and local bylaws that regulate land use, grazing, and resource extraction (Welemariam et al., 2018). The involvement of community members in these decision-making processes has fostered a sense of ownership, ensuring that management practices are followed and that unauthorized activities, such as illegal grazing, are minimized (Welemariam et al., 2018). This community-led approach has significantly contributed to the durability and long-term success of the exclosures in this region.

In the Amhara region, similar participatory approaches have been crucial in the success of exclosures. A notable example is the Debre Mewi watershed, where local farmers actively contributed to exclosure planning and directly benefited from enhanced fodder availability and fuelwood collection (Mulugeta and Achenef, 2015). One of the most tangible outcomes has been the reported 50% reduction in the time spent gathering fuelwood, a significant benefit for local communities as vegetation within exclosures has regenerated (Mekuria et al., 2021). This is a clear illustration of how community participation not only facilitates the implementation of exclosures but also ensures that they deliver direct, practical benefits to local people, which enhances their sustainability. In the Oromia region, exclosure programs in the Bale zone have led to increased access to non-timber forest products (NTFPs), such as wild honey and medicinal plants, thereby providing alternative livelihoods and further solidifying community support for the program (Elias, 2021). In semi-arid areas like Afar, where pastoralism is central to livelihoods, community-driven exclosures have balanced environmental conservation with pastoralists' needs (Gebregergs et al., 2019). Pilot projects in Chifra, for instance, have incorporated pastoralists in designing rotational grazing systems within exclosures, which allows for both land restoration and continued access to forage during drought periods. These projects demonstrate how region-specific adaptations can address local needs while ensuring the success of exclosure interventions (Yayneshet et al., 2009).

However, the extent and quality of community involvement in exclosure programs are not uniform across all regions. Socio-economic factors, cultural dynamics, and the level of institutional support can significantly affect community participation and the overall success of exclosure initiatives (Damene et al., 2013; Yimer et al., 2015; Hadush et al., 2024). In regions like Somali, limited institutional capacity and economic hardship have hindered community participation, presenting challenges in maintaining exclosures (Yayneshet et al., 2009). In Southern Ethiopia, conflicting interests over land use and resource access have also strained relationships between communities and exclosure managers (Gemi et al., 2022). These disparities highlight the need for tailored strategies to strengthen community ownership and build local capacity. Successful initiatives, such as the Humbo Community-Based Natural Regeneration Project in the Southern Nations, Nationalities, and Peoples' Region (SNNPR), offer valuable lessons in overcoming these challenges. By involving communities in decision-making processes and sharing the economic benefits from carbon credits, the project has restored degraded landscapes while fostering a sense of collective responsibility (Balana et al., 2012; Fikadu and Argaw, 2021). Such initiatives underscore the importance of integrating community participation, equitable benefit-sharing, and capacity-building efforts to maximize the effectiveness and sustainability of area exclosures in Ethiopia.

In conclusion, community involvement is both a cornerstone and a determinant of the success and sustainability of area exclosures in Ethiopia. By ensuring active participation through locally adapted strategies, integrating traditional knowledge with modern practices, and providing tangible benefits to communities, the effectiveness of exclosures can be significantly enhanced (Atsbha et al., 2019; Beyene et al., 2024; Ereso, 2024). Furthermore, strengthening capacity-building initiatives and institutional support will further boost the sustainability and long-term impact of these interventions, fostering resilient ecosystems and empowering communities across Ethiopia (Birhane et al., 2017; Kibret et al., 2022). This comprehensive community-centered approach is essential for the continued success of area exclosures as a tool for sustainable land management in Ethiopia. The findings above demonstrate that community participation is integral to the success, maintenance, and sustainability of area exclosures across Ethiopia's varied ecological and socio-economic landscapes. The following subsection presents detailed findings that explore the environmental, socio-economic, and livelihood outcomes of these interventions, providing a comprehensive assessment of how community involvement shapes the long-term viability of exclosure programs.

3.4.1 Environmental, socio-economic, and livelihood outcomes of community involvement in area exclosure programs in Ethiopia

This section presents detailed findings on the environmental, socio-economic, and livelihood outcomes of area exclosure interventions in Ethiopia, emphasizing the role of community involvement in shaping the long-term viability of these programs. The analysis integrates evidence from various regions, demonstrating how active community participation contributes to the success and sustainability of exclosure initiatives across diverse landscapes.

3.4.1.1 Environmental outcomes

The implementation of community-driven area exclosures has led to significant improvements in the environment, particularly in the restoration of degraded lands and the enhancement of local biodiversity (Mekuria et al., 2017a, b). The findings show that exclosures have effectively mitigated soil erosion, improved water retention, and promoted vegetation regeneration (Mengistu et al.,

2005). In the Tigray region, for instance, the Adi Beise community-managed exclosure has been credited with restoring degraded landscapes, increasing vegetation cover, and enhancing soil fertility (Welemariam et al., 2018). These environmental improvements are not only beneficial for ecosystem health but also contribute to increased resilience to climate variability, especially in arid and semi-arid regions. Similarly, in the Amhara region, the Debre Mewi watershed exclosures have significantly reduced soil erosion and improved water availability in surrounding areas (Mulugeta and Achenef, 2015). The regeneration of native vegetation within these exclosures has helped restore critical habitats for local fauna and improve the overall ecological balance. In the Bale zone of Oromia, exclosure programs have led to an increase in non-timber forest products (NTFPs), including wild honey and medicinal plants, further enhancing the region's biodiversity and ecosystem services (Elias, 2021). These environmental gains, driven by community participation, have demonstrated the potential of exclosures to regenerate ecosystems and provide long-term ecological benefits.

3.4.1.2 Socio-economic outcomes

The socio-economic outcomes of area exclosure interventions are closely tied to the involvement of local communities in decision-making processes, benefit-sharing, and sustainable resource management (Beyene et al., 2024; Mezgebo et al., 2022; Reda et al., 2020). Active community participation has been shown to lead to improved livelihoods, economic opportunities, and enhanced social cohesion (Welemariam et al., 2018). In regions such as the Amhara and Oromia, exclosure programs have provided local farmers with improved fodder resources, reducing the time spent on collecting firewood and other essential resources (Balana et al., 2012). In the Debre Mewi watershed, for instance, the regeneration of vegetation has reduced the time spent gathering fuelwood by 50%, providing significant time savings and enhancing household productivity (Mekuria et al., 2021). This time-saving benefit has improved the quality of life for many households, enabling them to engage in other productive activities, such as crop cultivation and small-scale business ventures. In the Oromia region, access to NTFPs such as honey and medicinal plants has provided additional income-generating opportunities for local communities (Elias, 2021). These alternative livelihoods have not only enhanced household income but also fostered stronger community support for exclosure programs, as the economic benefits directly impact local well-being (Abay et al., 2020; Debeko et al., 2024; Degefa et al., 2023). Moreover, in semi-arid regions like Afar, where pastoralism is predominant, community-driven exclosures have facilitated a balance between land restoration and continued access to critical grazing areas (Ambushe et al., 2022). The introduction of rotational grazing systems in Chifra, for example, has allowed pastoralists to maintain their livelihoods while contributing to environmental conservation (Yayneshet et al., 2009). This dual benefit conserving land while supporting traditional livelihoods has been crucial in sustaining exclosure programs in such fragile ecosystems (Birhane et al., 2017; Damene et al., 2013; Emiru et al., 2018).

3.4.1.3 Livelihood outcomes

Community participation in exclosure programs has also had a significant impact on local livelihoods, particularly in enhancing food security, improving access to resources, and fostering social cohesion (Mezgebo et al., 2022; Reda et al., 2020; Welemariam et al., 2018). The active involvement of local populations in exclosure management has been essential in ensuring that the benefits of these interventions are shared equitably, leading to improved social stability and collective responsibility for land stewardship (Mulugeta and Achenef, 2015). In the Southern Nations, Nationalities, and Peoples' Region (SNNPR), the Humbo Community-Based Natural Regeneration Project has demonstrated how community participation can lead to significant livelihood improvements (Sinore et al., 2023; Umer and Sinore, 2019; Wolka et al., 2024). By sharing the economic benefits from carbon credits and involving local communities in decision-making, the project has not only restored degraded landscapes but also improved the livelihoods of local people (Balana et al., 2012; Fikadu and Argaw, 2021). This model of community involvement has proven effective in promoting sustainable land management practices while enhancing the socio-economic well-being of participants (Mekuria et al., 2017a). Additionally, in pastoralist communities in the Afar region, the integration of exclosures with traditional knowledge, such as rotational grazing systems, has enabled communities to adapt to the challenges posed by climate variability, particularly during droughts (Gebregergs et al., 2019). This adaptive approach has been instrumental in sustaining livelihoods, maintaining access to critical resources, and preventing overgrazing, which has often led to land degradation in the past.

3.4.1.4 Influence of community participation on long-term viability

The long-term viability of area exclosure programs in Ethiopia is heavily influenced by the level of community involvement (Mekuria and Veldkamp, 2012). The findings indicate that the success and sustainability of exclosures are not solely dependent on ecological restoration but also on the social and economic integration of local communities into the management and governance processes (Mekuria and Aynekulu, 2013). Regions with high levels of community participation, such as Tigray, Amhara, and Oromia, have seen more successful and sustainable exclosure programs (Muche et al., 2024). These areas have implemented participatory land-use planning, created locally-adapted governance structures, and established equitable benefit-sharing mechanisms, all of which have contributed to the long-term success of these interventions (Yakob et al., 2022). The integration of traditional governance systems, such as the idirs in Tigray, has further strengthened community ownership and facilitated adherence to exclosure rules, ensuring the programs' longevity (Welemariam et al., 2018). However, areas with lower community engagement or limited institutional support, such as Somali and parts of Southern Ethiopia, have faced challenges in sustaining exclosures. In these regions, competing interests over land use, economic hardships, and insufficient institutional capacity have

hindered the full participation of local communities, leading to difficulties in maintaining exclosures and ensuring their long-term effectiveness (Gemi et al., 2022; Yayneshet et al., 2009). These findings underscore the importance of strengthening community ownership and institutional support to ensure the continued success of exclosure initiatives across Ethiopia.

In general, the review revealed that environmental, socio-economic, and livelihood outcomes of area exclosure programs in Ethiopia clearly demonstrate the critical role of community participation in shaping the success and sustainability of these interventions (Araya et al., 2023; Beyene et al., 2024; Ereso, 2024). Active involvement of local communities in planning, decision-making, and benefit-sharing has proven essential for ensuring ownership, equitable outcomes, and long-term commitment to these initiatives (Mezgebo et al., 2022). By strengthening community engagement, tailoring interventions to local contexts, and ensuring fair distribution of benefits, Ethiopia can fully harness the potential of area exclosures as an effective tool for sustainable land management and ecosystem restoration. Continued efforts to build institutional capacity, address socio-economic barriers, and empower local communities will be vital for enhancing the resilience and sustainability of these programs. The following section addresses the major challenges and opportunities associated with scaling up area exclosure practices in Ethiopia, highlighting key considerations for expanding these interventions nationwide.

3.5 Challenges and opportunities in scaling up area exclosure practices in Ethiopia

This section addresses the major challenges and opportunities associated with scaling up area exclosure practices in Ethiopia, integrating findings from literatures offering an evidence-based analysis of both barriers and pathways for successful scaling and impact.

3.5.1 Challenges in scaling up area exclosure practices

3.5.1.1 Land competition and resource conflicts

A primary challenge in scaling up area exclosures is land competition, particularly in densely populated regions like the Ethiopian Highlands, where arable land is limited (Adem et al., 2020). In these regions, the need for land for agriculture and grazing often leads to conflicts between the immediate livelihood needs of local communities and conservation efforts (Gemi et al., 2022). In the Amhara region, exclosure programs have faced resistance due to the displacement of grazing lands, which are critical for livestock-dependent households (Kassa et al., 2017). In Oromia, overlapping land tenure claims exacerbate tensions and discourage community participation, undermining the expansion of exclosures (Misebo et al., 2021). These issues demonstrate the necessity for effective land-use planning and policy frameworks that balance conservation goals with local livelihood requirements.

3.5.1.2 Institutional and governance challenges

Weak institutional frameworks and governance challenges are significant barriers to scaling up exclosures (Hadush et al., 2024). While community-based management structures have been central to successful exclosure programs, inconsistent enforcement of bylaws and lack of institutional support undermine long-term viability (Mezgebo et al., 2022). For example, in Tigray, while community bylaws regulate access, inconsistent enforcement has led to grazing pressures and illegal activities within exclosure sites (Erdedo et al., 2024). Additionally, in lowland areas like Somali and Afar, limited capacity of local institutions to provide technical expertise and resources constrains the ability of exclosures to deliver their full potential (Gebregergs et al., 2019; Umer and Sinore, 2019; Yayneshet et al., 2009). Institutional fragmentation and inadequate coordination across different government levels further hinder scaling (Gebregziabher and Soltani, 2019). To address these challenges, stronger coordination among local, regional, and national institutions, alongside capacity-building initiatives, is crucial for ensuring the sustainability and scalability of exclosures.

3.5.1.3 Environmental constraints

Environmental factors also play a critical role in limiting the effectiveness of exclosures, particularly in Ethiopia's arid and semi-arid regions (Gebregergs et al., 2019). In areas like lowland Oromia and Somali, where rainfall is low and soils are poor, additional interventions such as supplementary irrigation or enrichment planting are necessary to achieve meaningful restoration outcomes (Asmare and Gure, 2019). The high variability in climate and environmental conditions across the country means that scaling up exclosures requires region-specific strategies (Ebabu et al., 2019). In highland areas, exclosures tend to show more promising results due to favorable climatic conditions (Eshetie et al., 2024). However, even in these regions, extreme weather events such as droughts and floods pose ongoing challenges. Therefore, region-specific approaches are necessary to address the environmental constraints and ensure that the benefits of exclosures are maximized across diverse ecological zones.

3.5.2 Opportunities for scaling up exclosure practices

3.5.2.1 Integration with broader landscape restoration initiatives

Despite the challenges, there are significant opportunities to scale up exclosures through integration into national and regional landscape restoration initiatives. Ethiopia's Green Legacy Initiative, which aims to restore millions of hectares of degraded land, provides an important platform for integrating exclosures into broader landscape restoration efforts (Gebregergs et al., 2019). This initiative offers a strategic framework for mobilizing resources, technical expertise, and institutional support to scale up exclosure programs. By aligning exclosure programs with national restoration targets, Ethiopia can ensure that these efforts contribute to larger-scale environmental and climate goals.

3.5.2.2 Access to financial mechanisms and international support

International financial mechanisms present significant opportunities for scaling exclosures (Kassa et al., 2017). Initiatives such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and the Green Climate Fund provide crucial funding and technical support for conservation projects like exclosures (Araya et al., 2023). For example, the Humbo Community-Based Natural Regeneration Project in Southern Ethiopia illustrates how carbon credits can serve as an incentive for both conservation and community development (Debeko et al., 2024). By tapping into these international funds, Ethiopia can secure financial resources to support the expansion and sustainability of exclosure programs, ensuring their long-term impact (Misebo et al., 2021).

3.5.2.3 Technological innovations in monitoring and management

Technological innovations offer further opportunities to scale up exclosure practices (Degefa et al., 2023). Remote sensing technologies and Geographic Information Systems (GIS) have already been used successfully in regions like Tigray to monitor vegetation recovery, soil stability, and overall land restoration (Reda et al., 2020). These technologies allow for real-time monitoring, enabling more effective management and data-driven decision-making (Welemariam et al., 2018). By incorporating these technologies into exclosure programs across the country, Ethiopia can enhance the efficiency and effectiveness of restoration efforts, optimizing the use of resources and ensuring that interventions are targeted where they are needed most.

3.5.2.4 Community empowerment and integration of traditional knowledge

A key opportunity for scaling exclosures lies in the empowerment of local communities and the integration of traditional knowledge into conservation practices. Ethiopia has a long history of community-based land management, and incorporating local knowledge into exclosure design and management can significantly enhance program sustainability (Welemariam et al., 2018). Community participation ensures that exclosure programs are not only culturally relevant but also more effective, as local communities are often the best stewards of their own environment (Misebo et al., 2021). Additionally, capacity-building initiatives that equip communities with the necessary skills and knowledge to manage exclosures independently can lead to long-term success and broader adoption (Reda et al., 2020).

In conclusion, the review highlights that scaling up area exclosures in Ethiopia involves navigating significant challenges such as land competition, institutional weaknesses, and environmental constraints (Fikadu and Argaw, 2021; Gebregziabher and Soltani, 2019; Ibrahim et al., 2021). However, opportunities exist to overcome these barriers through strategic integration with national landscape restoration initiatives, access to international funding mechanisms, technological innovations, and community empowerment (Mekuria et al., 2017a, b; Mekuria et al., 2021; Meresa et al., 2022). Addressing these challenges and seizing these opportunities will be crucial for expanding the impact of exclosure programs and ensuring their long-term sustainability across diverse regions in Ethiopia. By focusing on these thematic areas, this section provides a comprehensive response to the research question, addressing both the challenges and opportunities associated with scaling up exclosure practices in Ethiopia. The next section will address Policy Interventions and Institutional Support Mechanisms for Strengthening Area Exclosure Practices, offering practical pathways and recommendations to enhance the effectiveness and sustainability of exclosure initiatives at national and local levels.

4 Policy interventions and institutional support mechanisms for strengthening area exclosure practices

The policy landscape surrounding area exclosures in Ethiopia has evolved significantly, with increasing recognition of their importance for achieving national and global environmental targets (Gebregziabher and Soltani, 2019). However, challenges in translating these policies into tangible outcomes on the ground remain, necessitating targeted policy interventions and institutional support mechanisms (Balana et al., 2012). This section addresses the key policy and institutional requirements to strengthen area exclosures, enhance technical and research capacity, and ensure their long-term sustainability.

4.1 Policy interventions for strengthening area exclosures

4.1.1 Improved land tenure systems

Secure and clear land tenure systems are crucial for the long-term sustainability of area exclosures (Yimer et al., 2015). In regions such as Benishangul-Gumuz, land tenure insecurity has led to disputes, undermining community trust and engagement with exclosure initiatives (Mekuria et al., 2021). Strengthening land tenure frameworks and ensuring clear property rights would encourage long-term commitment from local communities and stakeholders, particularly in areas with high land-use conflicts (Yakob et al., 2022). As such, policy reforms focused on improving land tenure security are essential to creating an enabling environment for exclosure practices to thrive.

4.1.2 Integration of area exclosures into national policy frameworks

Policies like Ethiopia's Climate Resilient Green Economy (CRGE) strategy and the National Biodiversity Strategy and Action Plan (NBSAP) have laid a foundation for land restoration efforts, including area exclosures (Hishe et al., 2020). However, there is a need for greater integration of exclosures into these

national strategies. By aligning exclosures with international initiatives such as the Bonn Challenge and the Land Degradation Neutrality (LDN) targets, Ethiopia can set measurable land restoration goals and incorporate them into development plans (Erdedo et al., 2024). This alignment will not only boost the visibility of exclosure programs but also enhance their impact by linking local actions to national and international targets.

4.1.3 Clearer guidelines and performance indicators

The effectiveness of policy implementation is often hindered by a lack of clear guidelines and performance indicators for exclosure programs (Umer and Sinore, 2019; Yayneshet et al., 2009). Strengthening policy frameworks to include detailed operational guidelines, resource allocation mechanisms, and specific performance indicators is essential (Kassa et al., 2017). These components would help ensure accountability, streamline implementation, and facilitate monitoring and evaluation processes. Establishing such indicators, especially for land restoration targets, will ensure that the progress of exclosure initiatives is measurable and aligned with broader environmental and developmental objectives.

4.2 Institutional support mechanisms for exclosure practices

4.2.1 Enhanced institutional coordination and capacity building

Institutional fragmentation and weak coordination among governmental and non-governmental actors remain major barriers to effective exclosure implementation (Lemenih and Kassa, 2014). To overcome this, establishing a centralized coordination body at the national level, along with strengthening regional institutions, is crucial (Girmay et al., 2008). This body could oversee policy alignment, resource distribution, and stakeholder engagement to ensure that efforts are streamlined and cohesive. Additionally, capacity-building programs for local government institutions and community-based organizations will enhance technical and research capacities, improving the management and monitoring of exclosures (Mezgebo et al., 2022).

4.2.3 Financial mechanisms and incentives

The absence of dedicated financial mechanisms and incentives has resulted in a loss of momentum in some exclosure projects, particularly in Oromia (Ereso, 2024). Policy interventions should include the establishment of stable funding mechanisms, such as climate adaptation funds, that are specifically dedicated to exclosure projects. These funds could support both initial implementation and long-term maintenance (Hishe et al., 2020). In addition, offering financial incentives for local communities to maintain and protect exclosures, such as payments for ecosystem services (PES), could further ensure sustained engagement and involvement in exclosure initiatives (Halefom et al., 2020).

4.2.4 Promotion of participatory approaches and benefit-sharing mechanisms

The long-term sustainability of area exclosures is closely tied to community engagement and participation. Policies should promote inclusive decision-making processes that integrate local knowledge and ensure equitable distribution of benefits. Participatory planning, in which local communities are actively involved in the design and management of exclosures, fosters greater ownership and responsibility. Furthermore, benefit-sharing mechanisms, such as access to non-timber forest products (NTFPs) or revenue-sharing from carbon credits, should be institutionalized to ensure that local communities derive tangible benefits from maintaining exclosures (Mathewos and Mamo, 2023).

4.3 Institutional support for technical and research capacity

4.3.1 Investment in research and technology

Enhancing the technical and research capacity of institutions involved in area exclosures is essential for scaling and improving these initiatives. Research institutions and universities should be encouraged to invest in research that focuses on soil fertility restoration, climate resilience, and biodiversity conservation within exclosures (Reda et al., 2020). Additionally, the integration of technology, such as remote sensing and GIS, can provide real-time data on vegetation cover, soil health, and the effectiveness of exclosures (Yayneshet et al., 2009). Developing local technical expertise in these areas will be critical for the long-term success and adaptability of exclosure programs.

4.3.2 Training and knowledge exchange

Developing human capital is fundamental to the sustainability of exclosure practices (Mekuria, 2013). The establishment of training programs for local communities and government officials on sustainable land management, conservation practices, and ecological restoration will ensure that skills are continuously upgraded (Mezgebo et al., 2022). Furthermore, fostering knowledge exchange between regions and countries will provide opportunities for sharing best practices and lessons learned. Successful examples, such as those in Southern Ethiopia, demonstrate the value of training and community-based natural resource management approaches in enhancing exclosure outcomes (Balana et al., 2012).

4.4 Context-specific solutions for exclosure sustainability

4.4.1 Tailored approaches for different ecological zones

To address the diverse ecological and socio-economic conditions across Ethiopia, policies must promote context-specific solutions (Misebo et al., 2021). For example, in the lowland areas of the Somali region, where water scarcity is a significant challenge,

integrating supplementary irrigation systems and drought-resistant plant species can enhance the resilience of exclosures to climate change (Yayneshet et al., 2009). In contrast, in the highlands, implementing rotational grazing systems and participatory bylaws can help prevent overgrazing and ensure that exclosures continue to thrive (Ereso, 2024). These localized solutions, developed in close consultation with communities, will enhance the effectiveness and sustainability of exclosures.

In conclusion, strengthening area exclosure practices in Ethiopia requires a multi-faceted approach involving robust policy interventions and institutional support mechanisms (Mekuria et al., 2007). Key elements include improving land tenure systems, integrating exclosures into national policies, enhancing coordination among stakeholders, and increasing financial support (Mekuria et al., 2009). Additionally, fostering community participation and investing in research and technology will be critical for the long-term sustainability of these practices (Mengistu et al., 2005). By addressing these policy and institutional challenges, Ethiopia can maximize the environmental, social, and economic benefits of area exclosures and make substantial progress toward its land restoration and climate resilience goals. The experiences of regions like Tigray, Amhara, and SNNPR demonstrate that, when aligned with national policy and complemented by community-driven initiatives, area exclosures can play a pivotal role in achieving these objectives. The next section provides a detailed discussion that builds on this review, further exploring key findings, insights, and lessons learned to inform future efforts in strengthening area exclosure practices and land restoration initiatives in Ethiopia.

5 Discussion

5.1 Effectiveness of area exclosure practices in promoting sustainable land management and controlling soil erosion

The findings from this review underline the significant role of area exclosures in addressing land degradation and soil erosion across various Ethiopian ecological zones. In alignment with earlier studies by Lemenih and Kassa (2014), our analysis confirms that area exclosures are effective in reducing soil erosion by as much as 80% (Hadush et al., 2024). This is largely due to the reduction of human activity in the exclosed areas, allowing for natural regeneration of vegetation, which in turn restores soil structure and fertility (Mekuria et al., 2011; Yimer et al., 2015). The restoration of ecosystem services, such as carbon sequestration and water retention, is particularly evident in regions like Tigray and the Ethiopian Highlands, where exclosures have played a pivotal role in improving watershed functions and mitigating climate change impacts (Eshetie et al., 2024). However, while short-term benefits are well-documented, more research is needed to understand the long-term impacts of these practices, especially regarding soil fertility, hydrological cycles, and biodiversity (Yimer et al., 2015; Yayneshet et al., 2009).

5.2 Impacts of area exclosures on key environmental indicators

Area exclosures have demonstrated a range of positive environmental impacts. The restoration of vegetation and soil quality has been linked to improvements in biodiversity conservation and soil fertility (Mekuria et al., 2017b; Beyene et al., 2024). Notably, the benefits extend beyond soil health to include enhanced water retention, improved local climate resilience, and the potential for carbon sequestration, which contributes to climate change mitigation efforts (Welemariam et al., 2018). Additionally, the revitalization of critical ecosystem services has been particularly notable in regions affected by water scarcity, where exclosures have significantly improved groundwater recharge and streamflow (Halefom et al., 2020). Despite these positive trends, the broader ecological outcomes, especially in terms of biodiversity restoration and long-term soil fertility enhancement, require more detailed and longitudinal studies (Yimer et al., 2015). Future research should focus on more rigorous ecological monitoring to assess the full range of environmental outcomes.

5.3 Community participation and its influence on exclosure success

Community participation is a key determinant of the success and sustainability of area exclosure practices in Ethiopia. Our review affirms the positive impact of community-driven management, as seen in regions like Amhara and Oromia, where active community involvement has led to significant improvements in ecological health and community livelihoods (Tefera et al., 2005; Mulugeta and Achenef, 2015). In the Gamo Highlands, for example, communities report increased access to firewood, fodder, and medicinal plants as a result of exclosure management, enhancing their resilience to climate stressors (Gebre et al., 2023). However, challenges persist, such as land tenure conflicts and weak local governance structures, which undermine the long-term sustainability of exclosures (Kassa et al., 2017; Asmare and Gure, 2019). The integration of traditional knowledge into formal land management policies has proven effective in overcoming some of these challenges (Araya et al., 2023). To maximize the impact of exclosures, future strategies should focus on strengthening local institutions, clarifying land tenure rights, and fostering multi-stakeholder collaborations.

5.4 Challenges and opportunities for scaling up area exclosures

Despite the promising results, scaling up area exclosures across Ethiopia faces several challenges. One significant barrier is the lack of clear operational guidelines for exclosure management within national policies such as the CRGE (Climate Resilient Green Economy) strategy (Balana et al., 2012; Muche et al., 2024). Furthermore, issues like limited technical support, inadequate

funding mechanisms, and fragmented governance structures hinder the widespread adoption of exclosure practices (Umer and Sinore, 2019). There is also a gap in addressing financial sustainability, with limited research into funding models like Payment for Ecosystem Services (PES) or carbon credit systems (Eshetie et al., 2024). However, these challenges also present opportunities to refine policy frameworks, integrate exclosures with international climate finance mechanisms, and align them with national priorities such as food security and climate resilience (Shimelse et al., 2017; Ambushe et al., 2022). Strengthening institutional support and addressing governance issues are critical for scaling up these practices.

5.5 Policy interventions and institutional support mechanisms for strengthening area exclosures

The effectiveness of area exclosures in Ethiopia hinges on robust policy support and institutional frameworks. While initiatives such as the CRGE strategy acknowledge the importance of land restoration, there is a lack of specific, actionable guidelines for implementing exclosures effectively (Gebregziabher and Soltani, 2019). Additionally, the review highlights the need for clearer policies on integrating exclosures with pastoral and agro-pastoral systems, as well as more comprehensive land tenure regulations that recognize community rights (Kassa et al., 2017; Gemi et al., 2022). Financial constraints and the limited capacity of local institutions to manage exclosures also hinder progress (Muche et al., 2024). To overcome these barriers, the review recommends strengthening monitoring and evaluation (M&E) frameworks, integrating diverse assessment methods beyond GIS (e.g., participatory monitoring and ecological field assessments), and exploring innovative funding models. Furthermore, aligning area exclosure initiatives with international funding sources, such as the Green Climate Fund, could provide the financial backing necessary for scaling up successful practices (Meresa et al., 2022).

In conclusion, this review emphasizes the importance of a comprehensive, interdisciplinary approach to area exclosures in Ethiopia. Long-term research on ecological, socio-economic, and livelihood impacts, coupled with enhanced community participation, policy support, and technical expertise, is essential for ensuring the sustainability and scalability of these practices. By addressing existing research gaps, improving governance structures, and fostering cross-sectoral collaborations, Ethiopia can harness the full potential of area exclosures to combat land degradation, enhance biodiversity, and promote climate resilience.

5.6 Adaptation strategies and monitoring and evaluation framework

Despite the widespread adoption of area exclosures in Ethiopia as a strategy for sustainable land management and erosion control, significant gaps remain in technical expertise and the capacity for effective monitoring and evaluation (M&E). These gaps pose challenges for the long-term success of exclosure interventions, as many local implementing agencies and community groups lack the necessary skills in ecological assessment, biodiversity monitoring, and soil and water conservation. Such deficiencies hinder the effective design, implementation, and adaptive management of exclosures, which are crucial for maximizing both ecological and socio-economic benefits (Birhane et al., 2017). Furthermore, the scarcity of trained environmental scientists, ecologists, and land use planners further restricts the generation of robust baseline data and long-term research outputs, which are essential for assessing the impacts of these interventions (Elias, 2021). This results in many exclosure projects being donor-driven and project-based, with insufficient integration into broader, long-term development plans and strategies (Gebregergs et al., 2019).

The current M&E practices for area exclosures in Ethiopia primarily rely on Geographic Information Systems (GIS) and remote sensing technologies, which have proven effective for monitoring large landscapes in a cost-efficient manner. These tools have been instrumental in assessing vegetation cover changes, land use dynamics, and the reduction of soil erosion risk over time (Ibrahim et al., 2021). For example, the Sustainable Land Management Program (SLMP) uses satellite imagery and spatial analysis to evaluate the expansion and impacts of exclosures at regional and national scales (Megersa and Hailu, 2021). While GIS-based approaches provide valuable macro-level insights, they often fall short in capturing micro-level ecological changes, socio-economic impacts, and community perspectives—key elements for adaptive management (Hadush et al., 2024). Moreover, the overreliance on GIS can exacerbate existing capacity challenges, as local staff often lack the technical expertise needed to interpret complex spatial data, which limits the practical application of these findings in decision-making processes.

Non-GIS-based monitoring methods, including ecological field surveys, soil and water assessments, and participatory monitoring approaches, remain underutilized in many exclosure initiatives. Techniques such as vegetation plots, soil sampling, and biodiversity indices are not consistently institutionalized, often due to financial constraints, logistical challenges, and a lack of technical know-how (Rossiter et al., 2017). The exclusion of local knowledge systems and community participation in M&E processes further diminishes the social sustainability of exclosures. Participatory monitoring, which can enhance community ownership and generate valuable context-specific data, is rarely integrated into official M&E frameworks (Yayneshet et al., 2009). This gap undermines the necessary feedback loops for adaptive management, reduces transparency, and increases the risk of resource-use conflicts, particularly in pastoral and agro-pastoral areas where exclosures may overlap with traditional grazing lands.

To address these challenges, a multi-faceted approach is required to improve both technical capacity and M&E systems. First, investing in capacity building for local government experts, development practitioners, and community groups is critical for enhancing skills in ecological assessment, biodiversity monitoring, and participatory techniques (Shimelse et al., 2017). Local institutions must be equipped with the knowledge and tools to

conduct effective ecological monitoring, manage trade-offs in biodiversity, and integrate adaptive management strategies into exclosure practices. Furthermore, developing standardized M&E guidelines that combine GIS and non-GIS-based methods would allow for a more comprehensive evaluation of exclosure performance. This integrated approach should include satellite data, ground-truthing exercises, socio-economic assessments, and community-led monitoring, which collectively offer a more holistic view of the ecological and livelihood outcomes of exclosure interventions (Hadush et al., 2024).

Additionally, fostering partnerships with academic institutions, research centers, and non-governmental organizations (NGOs) can play a pivotal role in bridging knowledge and skill gaps, while supporting long-term research initiatives. These collaborations can enhance the capacity of local stakeholders to effectively monitor and evaluate exclosures, thus improving the adaptive management of these interventions. Strengthening technical capacities and improving M&E frameworks will not only contribute to the success of area exclosures but also ensure that they play a meaningful role in Ethiopia's broader sustainable land management and climate resilience goals. In conclusion, addressing the gaps in technical expertise and M&E capacity, while fostering inclusive and integrated monitoring approaches, is essential for the sustainable success of area exclosures in Ethiopia. Such efforts will enhance adaptive management, ensure the effectiveness of interventions, and support the long-term sustainability of Ethiopia's natural resources.

6 Conclusion

This review highlights the pivotal role of area exclosure practices as an effective nature-based solution for combating soil erosion, reversing land degradation, and promoting biodiversity conservation in Ethiopia. By facilitating natural regeneration, area exclosures contribute significantly to restoring soil fertility, enhancing vegetative cover, and improving water resource management critical pillars of sustainable land management (SLM) and environmental resilience. Empirical evidence from diverse ecological zones ranging from the highlands of Amhara to the lowland areas of Oromia demonstrates the measurable success of exclosures in reducing soil erosion, revitalizing degraded ecosystems, and bolstering local livelihoods. However, the broader adoption and scalability of area exclosures remain constrained by persistent challenges related to insecure land tenure, limited community participation, and fragmented policy and institutional support. Addressing these barriers is paramount to unlocking the full potential of area exclosures as a sustainable land restoration strategy. A concerted effort is required from policymakers, researchers, and practitioners to develop an enabling environment that fosters long-term sustainability and equitable benefit-sharing.

Policymakers must prioritize the integration of area exclosure practices into Ethiopia's national development and environmental frameworks, particularly the Climate Resilient Green Economy (CRGE) strategy and related landscape restoration initiatives. This includes establishing clear land tenure arrangements, enhancing institutional coordination, and providing targeted financial incentives to support community-led exclosure management. Strengthening legal and policy instruments will be critical to ensure secure resource rights and sustained community engagement. The research community plays an equally vital role in advancing the evidence base required for informed decision-making. Long-term, interdisciplinary studies are needed to capture the diverse socio-economic and ecological outcomes of area exclosures across varied agro-ecological zones. Such research should prioritize context-specific analyses to guide adaptive management approaches, optimize ecological gains, and maximize socio-economic returns for local communities.

For practitioners, fostering meaningful community participation is indispensable to the success and longevity of area exclosure initiatives. Empowering local populations through participatory planning, capacity building, and the integration of indigenous knowledge systems will strengthen ownership, improve compliance, and enhance the socio-economic benefits derived from restored landscapes. Collaborative partnerships with local governments and institutions are essential to ensure that communities receive the necessary technical, financial, and institutional support to sustain exclosure management efforts. Finally, sustained investment in area exclosures represents a cost-effective, scalable, and climate-resilient solution to Ethiopia's land degradation crisis. The restoration of degraded lands through exclosures not only delivers critical environmental benefits but also strengthens the adaptive capacity of communities facing climate-induced challenges. Mobilizing national and international resources to scale up these interventions will be instrumental in meeting Ethiopia's land restoration and climate resilience targets. The pathway forward demands an integrated, multi-stakeholder approach that bridges policy, science, and community action. Only through such a holistic framework can Ethiopia fully harness the transformative potential of area exclosures to achieve sustainable land management, environmental restoration, and improved rural livelihoods.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author/s.

Author contributions

DT: Conceptualization, Validation, Visualization, Writing – original draft, Writing – review & editing. YM: Conceptualization, Investigation, Writing – original draft. NK: Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft.

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