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Forest landscape restoration in Ethiopia: Progress and challenges

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The government of Ethiopia has made an ambitious plan of building a carbon-neutral and middle-income economy by 2030. In 2016, the country pledged to restore 15 million hectares of degraded landscapes as part of the African Forest Landscape Restoration Initiative (AFR 100). A total of three major forest landscape restoration (FLR) initiatives have been used to achieve this target: participatory forest management (PFM) to engage communities in sustainably managing natural forests; area enclosures/exclosures (AEs) to socially fence hillsides and degraded communal lands and allow these areas regain their productive potential; and sustainable land management program and the Green Legacy Initiative (SLM-GLI) that aim at conserving soil and water resources and planting seedlings to increase forest cover. After describing these FLR initiatives, this study evaluated their impacts on land use land cover change over time and assessed them against the six FLR principles by selecting nationally relevant criteria under each principle. The results showed that the FLR initiatives were rated rather low in terms of focusing on and managing landscapes for multiple benefits, in participation and benefits of stakeholders, in ownership and use rights, in employing approaches tailored to the local context, and in managing adaptively for long-term resilience. Concerning impacts, varying trends were observed for different areas, time periods, and restoration types. Recognizing and mitigating the limitations of these initiatives together with addressing site-specific drivers will improve the conservation and livelihood outcomes of FLR initiatives in Ethiopia. It is hoped that the findings of the study will inform FLR practitioners in other countries on the practical use of FLR principles in assessing the impacts of FLR initiatives.

KEYWORDS

participatory forest management, area exclosures, governance, sustainable land management, tree planting, FLR

Background

A decline in ecosystem services due to deforestation and degradation (D&D) is costing the world over USD 6.3 trillion, equivalent to 8.3% of global GDP in 2016 (Sutton et al., 2016). Large areas of agricultural lands and forests in developing countries are facing high rates of degradation. The urgency of the need for addressing D&D to

better adapt to and mitigate the impacts of climate variability and change is gaining global attention. An example is the designation by the United Nations of the 2021–2030 UN Decade on Ecosystem Restoration, which highlights increased recognition of the critical role of ecosystem restoration for sustainable development (UN New, 2019). The Global Partnership on Forest and Landscape Restoration (GPFLR), with more than 30 governments, non-governmental organizations (NGOs), and networks as its members, has played important roles in raising awareness on the need for forest and landscape restoration (FLR) and in identifying key principles to characterize FLR and improve outcomes.

Although national governments are making concerted efforts to restore landscapes, protecting forests and rehabilitating degraded landscapes constitute not only opportunities but also challenges (Shukla et al., 2019). This is partly because managing forests and rehabilitating degraded lands are a complex process as they involve working at different scales and engaging multiple actors often with contradicting interests (Chazdon et al., 2021). Thus, identifying and using innovations that can be adapted to the specificities of the landscapes and applying approaches that facilitate active engagement and negotiation with key stakeholders to optimize conservation and economic objectives are needed if FLR initiatives are to result in sustainable restoration outcomes. Furthermore, despite global initiatives and national commitments, challenges persist in taking FLR forward and achieving transformative changes. The main challenges are associated with selecting appropriate FLR options that fit local contexts and meet the interests of multiple stakeholders, and the lack of clarity on how to measure FLR success (Kassa et al., 2017). In addition, institutional and governance limitations as well as financial challenges continue to undermine FLR initiatives (Chazdon et al., 2020).

Major FLR initiatives in Ethiopia

Ethiopia made the largest FLR commitment in Africa when it pledged to restore 15 million hectares of degraded lands in 2016. This is in addition to the plan to manage 7 million ha of forests and woodlands as part of its Climate Resilient Green Economy (CRGE) Strategy enacted in 2011. The strategy aims to make Ethiopia a middle-income country by 2025 and to build a carbon-neutral economy by 2030. It also aims to guide and support initiatives that would enable the country to better adapt to the impacts of climate variability and change [Climate Resilient Green Economy Strategy (CRGE), 2011]. The sum, that is, 22 million hectares, reflects what we see as official announcement made by Ethiopia during the 2014 New York Declaration on Forests. Sustainably managing existing forests and woodlands and establishing new forests through afforestation and reforestation were identified as priorities of the government in its recently updated nationally determined contribution (NDC) (Federal Democratic Republic of Ethiopia, 2019). Forestry is expected to help create around half of the abatement potential needed to achieve the targets set in the CRGE and the NDC (Federal Democratic Republic of Ethiopia, 2015).

In Ethiopia, the concept of FLR is understood to include activities that restore ecological and productive functions of degraded forests and agricultural landscapes along the forest farm continuum to better support human wellbeing now and in future (Kassa et al., 2017). Generally, the most important state-led FLR initiatives aimed at reducing forest and land degradation in Ethiopia include engaging communities in the management of state-owned natural forests through participatory forest management (PFM), assisting natural regeneration in degraded lands by excluding human and animal interference through the establishment of area enclosures/exclosures (AEs), and mobilization of communities and engaging them in soil and water conservation works and tree planting campaigns through sustainable land management programs and the recent Green Legacy Initiative (SLM-GLI) to promote tree planting and increase national forest cover.

Participatory forest management

This is a generic term for different initiatives like community-based forest management, collaborative forest management, and joint forest management. It has been a dominant feature of forest governance in the tropics since the 1980s (Arts and Buizer, 2009). The introduction of PFM in Africa in the 1990s was associated with the movement to decentralize and devolve forest management (Amanor, 2004). In many African countries, participatory forest management (PFM) took different forms as it needed to consider the diversity of social and biophysical contexts in promoting sustainable management of forests (Wily, 2003). The literature asserts that PFM can potentially contribute toward achieving improved forest conditions and enhanced rural livelihoods, if local communities are recognized as important stakeholders in forest management and encouraged to participate actively (Kassa et al., 2017; Siraj et al., 2018). Attempts to promote effective and meaningful involvement of local communities in managing forests were made in the Asia-Pacific region, for instance, in the devolution of management responsibilities for some forestry activities to local government units and to communities in the Philippines, China, India, Nepal, Laos, and Vietnam (Guiang et al., 2012). Studies, however, showed that unequal power relationships led to poor governance (Guiang et al., 2012), indicating the need for making forest user groups as equitable, inclusive, and pro-poor as possible.

The government of Ethiopia adopted PFM as a mechanism to help improve the management of natural forests and woodlands that have been under state ownership since the

mid-1970s. In Ethiopia, PFM was introduced by NGOs in the mid-1990s, aiming to reduce D&D while also improving community access to and use of natural forests according to site-specific management plans that would be developed by the state forest agency in collaboration with the communities engaged in PFM (Tesfaye et al., 2012a; Ameha et al., 2014). Approaches of PFM recognize and manage conflicts between livelihood needs and economic interests of communities, and conservation and protection objectives of the state (Tesfaye et al., 2012b). Although the government has recognized PFM as a mechanism to reduce D&D in state-owned natural forest and woodland resources, PFM remains an initiative of NGOs and has not thus far been adequately mainstreamed in government forest management structures. Where PFM has been implemented, D&D declined and tree regeneration improved (Tesfaye et al., 2012b). Members of PFM use forest resources as per the management plans that generally allow benefiting from non-timber forest products (NTFPs) (Tesfaye et al., 2011, 2012b). Various studies show that without PFM, rates of D&D would have been much higher (Kassa et al., 2009). Moreover, local communities have developed a strong sense of ownership, although this has not yet been supported by secure tenure regimes. The expectation by community members of long-term use rights over forests is likely to be the rationale behind a more positive attitude of PFM members toward conserving forests than actual economic returns gained from engaging themselves in PFM as volumes and values of NTFPs remain low for most forests under PFM (Kassa et al., 2017). An estimated 1.5 million ha of forest in Ethiopia is now managed through PFM initiatives (Lemenih and Kassa, 2014). A recent report of the Ethiopian Forestry Development and the then Environment, Forest and Climate Change Commission (EFCCC) covering the 2016-2020 planning period indicated that the total areas of natural forests under PFM had reached 2 million ha [Environment Forest and Climate Change Commission (EFCCC), 2020], indicating that PFM is one of the main strategies to achieve the commitment of Ethiopia to reducing D&D.

Enclosures/exclosures (AEs)

The term AEs refers to the practice of excluding a designated degraded land from grazing, cutting trees, and shrubs as well as from cultivation to allow vegetation to regenerate, to reduce soil erosion, to increase rainwater infiltration, and increase biomass production (Aerts et al., 2009; Abiyu et al., 2011). Assisting rehabilitation of the productive potential of the land is attained either through resting alone or coupled with soil and water conservation (SWC) work and tree planting interventions (Asfaw et al., 2015). Studies show that scaling out AEs to neighboring areas (horizontally) and then to regional and national levels requires making the necessary legal, institutional, and logistical arrangements (i.e., vertically) with a view of enhancing ecological and socioeconomic benefits of landscapes (Mekuria and Aynekulu, 2013). Widespread state-led efforts to establish large-scale AEs began in the 1980s in the Tigray region, northern Ethiopia. Later on, it became the major means of rehabilitating degraded lands in other regional states of the country. The benefits of AEs for restoring soil properties and improving availability of wood have also been documented (Birhane et al., 2018; Mekuria et al., 2018). Over time, AEs became an integral part of FLR initiatives to allow degraded lands to rest, recover, and be more productive (Birhane et al., 2018). The exact figure of areas put under AEs in Ethiopia is lacking, but areas under AEs in the Tigray region alone grew from 1.2 million ha in 2012 to 1.5 million ha in 2015 (Birhane et al., 2018).

Sustainable land management and the green legacy initiative

Sustainable land management refers to a set of technologies and tools that integrate ecological with socioeconomic and political principles in land husbandry (Hurni, 1997, 1999). It attempts to rehabilitate productivity of degraded lands in ways that are ecologically sound, socioculturally acceptable, and technically and economically feasible. In Ethiopia, efforts to support farmers to build terraces to conserve soil and moisture was initiated in the Tigray region as early as the 1960s (Nyssen, 1997). Nation-wide state-led SWC work gained momentum in the late 1970s following the drought that affected many in the country. Later on, a watershed-based approach took hold in the 1980s (Hurni, 1988). Experiences so gained helped the Ministry of Agriculture (MoA) to develop a national SWC program, called sustainable land management (SLM), in 2008, which has been supported by various donors. The SLM program aims at promoting SWC measures such as soil or stone bunds, bench terraces, trenches, cutoff drains, drainage canals, and check dams (Schmidt and Tadesse, 2014). Over time, SLM scopes expanded and included planting of different trees, shrubs, and herbaceous species, and establishing AEs and discouraging free grazing of livestock, hence ensuring a sustainable flow of ecosystem services (Ebabu et al., 2019).

The national tree planting activity gained momentum in 2008 to mark the Ethiopian Millennium. Since then, successive 5-year development plans have set targets to plant large numbers of seedlings. The second growth and transformation plan (GTP II, from 2016 to 2020) of Ethiopia targeted to identify 5 million ha of land and rehabilitate the area using afforestation or reforestation to increase the national forest cover by 4.5% by 2020. The GTP II plan also envisaged to plant 21 billion tree seedlings but managed to produce and plant 15 billion seedlings on an area of 2.6 million ha [Environment Forest and Climate Change Commission (EFCCC), 2020]. In 2019, H.E.

Dr Abiy Ahmed, prime minister of Ethiopia, launched the GLI with a target of planting 20 billion seedlings in 4 years. The forest sector plan for 2021–2025 is designed to help realize this goal [Environment Forest and Climate Change Commission (EFCCC), 2020]. There are still challenges in obtaining reliable information as to what species should be planted, where, for what objectives, and who will be responsible for post-planting care. However, efforts are being made to address these gaps and to report with better accuracy the survival and performance of seedlings planted under the GLI. The high-level political commitment and the ability to voluntarily mobilize millions of man-days annually to engage in tree planting are among the strengths of the sustainable land management and the green legacy initiative (SLM-GLI).

To support and guide FLR initiatives, the EFCCC in collaboration with the WRI developed a National Tree-Based Landscape Restoration Potential and Priority Map in 2018 (Wondimu Zeleke et al., 2018). The map shows a total of 82 million hectares of land as having potential for tree-based restoration, of which 11 million hectares is classified as priority requiring rehabilitation. These maps identify areas where (i) existing forests can be restocked for biodiversity conservation, carbon sequestration, and flow of ecosystem services; (ii) planted forests can be established to generate economic benefits and prevent landslides and flooding; (iii) agroforestry can be scaled up to produce food, wood, and fodder; (iv) planting trees could be planned to stabilize riverbanks and reduce sedimentation; and (v) commercial plantations can be promoted to meet the growing wood demand for industrial and domestic uses. Although biophysical parameters were used help identify these potential areas for tree-based restoration, mapping of FLR actors, their networks, and priorities in restoring landscapes was not undertaken. There is little evidence to show that this map is being used in informing SLM-GLI activities in the country.

Methods

The hierarchical analytical process is often used to frame complex decision problems (Saaty, 1987). The hierarchy process is used to decompose the overall objective into its distinct and measurable components. Although this technique is developed to compare alternatives for complex decision process, the design can be modified to assess principles and criteria and indicates in sustainable forest management (Mendoza and Prabhu, 2000). Similarly, clustering was developed to frame basic principles and criteria of FLR. The impacts of the three major state-led FLR initiatives were assessed using land use land cover changes (LULCC) over time. The six principles proposed by Chazdon et al. (2020, 2021) were used in assessing these FLR initiatives. The principles are (i) focusing on landscapes, (ii) engaging diverse stakeholders and supporting participatory governance, (iii) restoring multiple landscape functions, (iv) maintaining and enhancing natural ecosystems, (v) tailoring to the local context using a variety of approaches, and (vi) adaptively managing for long-term resilience. Connecting principles of FLR with the criteria and indicators for monitoring FLR is challenging (Buckingham, 2018; Buckingham et al., 2021). In view of this challenge, for each of the six principles, the authors identified criteria that are nationally relevant to assess FLR initiatives in Ethiopia (Figure 1). Each initiative was rated against a set of criteria for achieving the overall objective of FLR. The assessment was based on a scale from highest (three pluses) to lowest (three minuses). Expert knowledge of researchers who are active in forest development activities was utilized for ranking the initiatives. This is based on the assumption that the participants will have exposure to the challenges and opportunities of both research and development of FLR in Ethiopia.

The study sites were drawn from three regional states, namely, Amhara, Oromia, and Tigray (Figure 2). In each region, one of the most commonly used FLR initiatives was examined to assess if options and strategies used in that FLR initiative conform with the key principles of FLR. In Oromia, PFM was examined. In Amhara, SLM intervention was assessed. In Tigray, AEs were evaluated. In all cases, multi-temporal and multispectral satellite imageries were used to estimate LULCC in selected intervention areas.

PFM

The assessment of PFM focused on the forest cover change over time. The years 1986, 1996, 2006, 2010, 2015, and 2017 were used as they coincide with important political-economic and sociocultural changes in the country with expected subsequent impacts on LULCC. In total, two major forested areas were considered, namely, Bale and Yayu forests. Radiometrically and geometrically corrected Landsat images were downloaded from the USGS GLOVIS website (http://glovis.usgs.gov) for cloud-free months of the year. Each image was georeferenced to WGS1984 UTM zone 37 North. Important land cover classes were defined through visual assessment of the satellite images. These land cover classes were forest, woodland, shrub/bushland, grassland, cropland, water body, and settlements. The full scene of the satellite image was divided into a number of sub-scenes that consist of similar biophysical and sociocultural settings. After sub-setting the images into homogenous units, unsupervised classification was applied on each sub-image, using ISODAT algorithms. The unsupervised classification was performed after sub-setting each footprint of the Landsat scenes by the identified landscape zones. The final class labeling was carried out by displaying each piece of unsupervised images over original forest cover change Landsat images. Each adjoining classified Landsat subset was checked for consistency, and inconsistences were corrected.

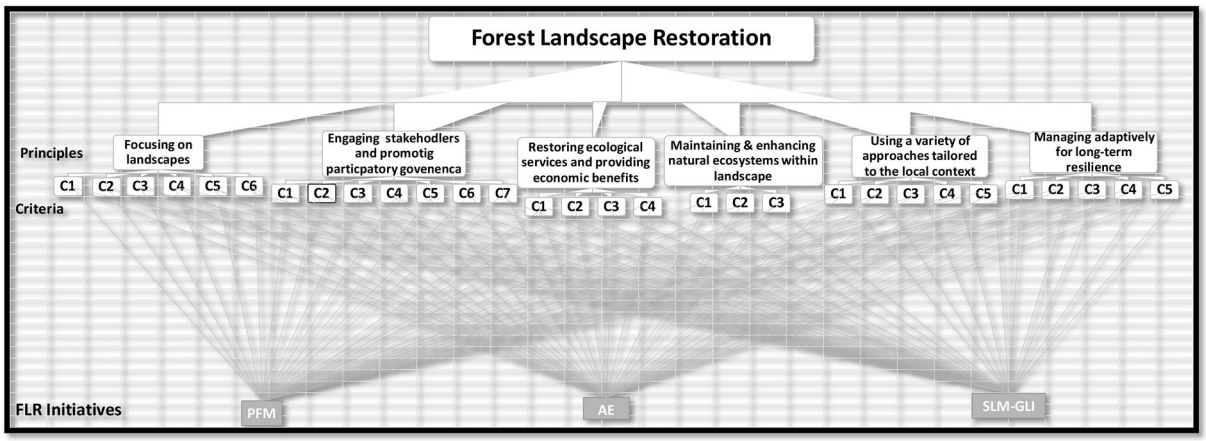

FIGURE 1
Hierarchical construct of the methodology for the evaluation of the three state-led FLR initiatives by using the proposed principles and selected criteria under each principle. C1, C2, C3,..., Cn refers to the criteria under each principle.

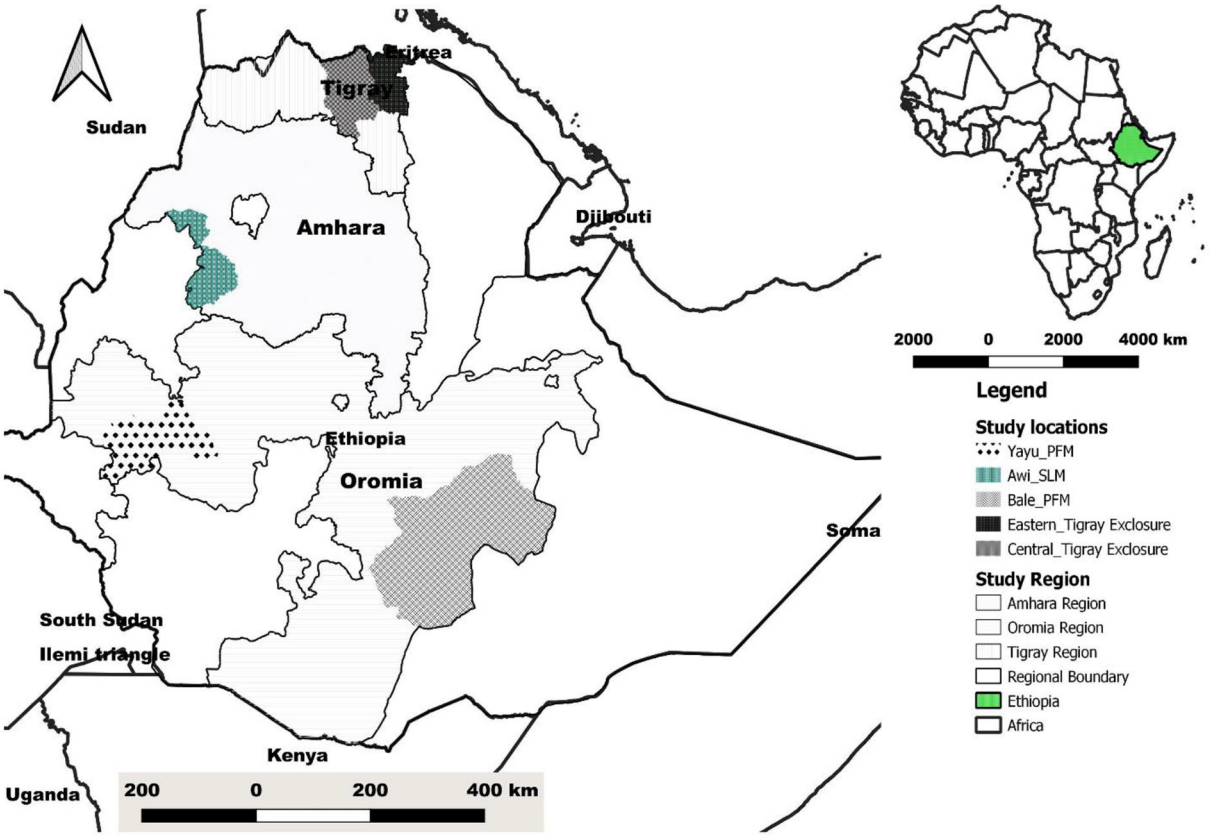

FIGURE 2
Map showing the regional states and study sites.

After properly labeling each subset of Landsat scenes with better accuracy, all the subsets were merged and used for change analysis. Field visits were carried out before and after satellite image classification to confirm result-based ground-truthing. The field visit helped obtain good local knowledge on factors that influence spatial and temporal spectral differences between

FIGURE 3
Forest cover change between 1980 and 2020 in selected areas where the different FLR initiatives have been implemented.

forest types. Furthermore, observation was made on farming systems, natural physiological characteristics of forests, and human activities (land-use practices). By doing so, forest types were properly differentiated, further improving the accuracy of each period of the LULC maps as well as the change estimates. Likewise, the image segment approach was applied to identify and map LULC classes of the Yayu forest area. To produce improved multi-temporal LULC maps of the study area, hybridized but systematized classification techniques were implemented for feature identification, image classification, and feature extraction.

AEs and SLM-GLI

Landsat TM, +ETM, and OLI-TIRS from USGS Earth Resources Observation Systems (https://earthexplorer.usgs.gov/) of the years 1985, 2000, 2009, and 2019 were used for selected geographical areas in Amhara and Tigray regions, where SLM-GLIs and AEs have been implemented, respectively. All the Landsat images have a spatial resolution of 30 m and were referenced and projected using UTM WGS 84 Zone 37N. Digital image preprocessing, that is, the improvement of digital images for human interpretation, was conducted for all downloaded and extracted Landsat images, for further analysis. The primary LULC map was produced from a preprocessed image using a support vector machine (SVM) algorithm.

Ground truth data were collected because data acquired from satellite sensors should be supported and checked with reality by using solid ground truth information. Hence, ground truth data were collected from the field using a handheld global positioning system (GPS). Moreover, the collection of training data was also supported by local experts' and elder people's knowledge who have lived for a sufficiently long period in the area. Google Earth high-resolution satellite imagery was used to collect supplementary information. Accuracy assessment was conducted to obtain better data from sample points using the GPS and comparing these data with the map classification to reduce uncertainty. The final LULC classification map was produced using the SVM. The final map was reclassified into forest and non-forest (i.e., agricultural land, bare land, and other land). Finally, these thematic maps were used to assess forest cover changes over the last 3 decades.

Results and discussion

Impacts of FLR initiatives on land cover changes

Figure 3 shows the rates and directions of changes in forest cover over time in selected areas where AEs, PFM, and SLM-GLI have been promoted.

PFM

Yayu and Bale are among the two main forested areas where PFM has been promoted. The results show that forest cover has been declining over time, with varying trends (Figure 3). For instance, in Bale, the deforestation rate between 1973 and 1986 was slightly less than that between 1986 and 2010. This may be due to insecurity created following the change of government in 1991, which resulted in the institutional gap to effectively protect forests. After 2010, the rate of forest loss declined as a large piece of forest area was put under PFM. In Yayu, forest cover declined between 1985 and 1995 but increased between 1995 and 2005. The positive gain coincides with the expansion of PFM. As of 2010, the implementation of PFM expanded and involved a growing number of forest-dependent communities. Nevertheless, a slight decline in forest cover is also observed. This calls for a closer look at the reasons behind the decline, including modalities of engaging communities in PFM and benefits communities obtain from being engaged in PFM.

The turning points in the decline and then the rise and increase in forest cover coincide with two important political-ecological events. The first one is the fall of the Derg regime in Ethiopia, which created temporary disorder, where forest destruction was common. The second important event is the emergence of donor-supported PFM in Bale and Yayu forest areas. The introduction of PFM in the Bale area did not help increase forest cover. In Yayu forest, we can observe that PFM has helped increase forest cover.

The comparative effectiveness of PFM in Yayu and Bale could be related to demographic and policy orientation of the government. Population growth, followed by expansion of farm or grazing land and settlement area, has been mentioned as major drivers of deforestation in Bale ecoregion (52). Politically motivated inward migration, facilitated by local government heads, for the purpose of increasing voters and resource share, is also a major phenomenon contributing to deforestation in Bale. Villagization, that is, converting semi-nomads to sedentary farmers as a common policy trend, has also created pressure on the natural forest of Bale (52).

AEs

Reports indicate that in Tigray, AEs have contributed to increasing forest cover and area of shrublands (Alemayehu et al., 2009; Seyoum et al., 2015). Our study also showed that in eastern and central Tigray, forest cover has increased between 1985 and 2000 (Figure 3). However, starting from 2000, the forest cover change showed a clear difference between eastern and central Tigray. In central Tigray, forest cover has declined after 2000, but in eastern Tigray, the increment of forest cover was steady (Figure 3). The success of AEs in increasing forest cover varied with intervention areas. Further studies are suggested to identify the reasons behind these differences.

The reason why the forest cover, in the eastern zone, has increased as compared to the central zone is mainly attributed to the involvement of many development partners and NGOs through multiple projects and programs. Because of this, the scale and intensity of the restoration activities have been huge compared to the central zone. Also, the eastern zone is more accessible, and many of the district areas are close to the reginal city, Mekelle. Moreover, because of these all interventions, the capacity and awareness of the community in the eastern zone are relatively better than those in the central zone, where these communities are closer and more exposed to various capacity building trainings. Therefore, the forest cover in the eastern zone increased as the encroachment and interference are limited.

SLM-GLI

In the Awi zone of the Amhara region, a steady increment of forest cover has been observed since the year 2000. Many factors might have contributed to the observed change. Specifically, poor productivity of soils, tolerance of trees to acidic soils, and high economic returns of tree growing were the major drivers of *Acacia decurrens* plantation expansion in the area (Nigussie et al., 2016; Chanie et al., 2021). As acidity of soils has been undermining crop production (Amare et al., 2022), farmers opted to shift toward tree growing. Over the last 10 years, growing *Acacia decurrens* has become a widespread practice and an alternative livelihood option in the Awi zone. The area has now become a major supplier of charcoal to urban centers nearby and even to Addis Ababa, the capital city of Ethiopia.

Assessing state-led FLR initiatives against FLR principles

The assessment of the three FLR initiatives based on the six principles and a set of selected nationally relevant criteria for each principle was carried out using a scale, from highest (three pluses) to lowest (three minuses). Expert knowledge of researchers was utilized in the ranking of indicators. The results are presented in Table 1. The detailed accounts of assessments against each principle are presented in the following sections.

Principle 1: Focusing on landscapes

The first principle of FLR states that restoration needs to take place within and across landscapes, representing mosaics of interacting land uses and management practices under various tenures and governance systems. Ecological, social, and economic priorities of the restoration area need to be synchronized to maximize the collective benefits of FLR initiatives.

TABLE 1 Assessment of major state-led FLR initiatives against FLR principles.

Principles	Criteria	PFM	AEs	SLM-GLI
Focusing on landscapes	Takes place within and across entire landscapes	++	++	++
	Takes place in representative mosaics of interacting land uses and management practices	+	+	++
	Takes place under various tenure systems	- - -	- -	+ +
	Balances ecological priorities	+ + +	+ + +	- - -
	Considers social priorities	- - -	+	+
	Takes into account economic priorities	- -	+	+ +
Engaging stakeholders and promoting participatory governance	Actively engages stakeholders at different scales	- -	-	+
	Promotes participation of vulnerable groups (inclusiveness)	- - -	- - -	- -
	Key stakeholders are involved in decision-making regarding selection of sites for and participants in FLR and setting objectives of FLR and means to achieve objectives	+	++	- - -
	Engages key stakeholders in defining net benefit sharing mechanisms	+	++	- -
	Engage stakeholders in monitoring and evaluation	+	+	+
	Government provides institutional backing and legal support to FLR actors	- - -	+	+ + +
	Adapts to local capacities and existing or new governance structures	-	-	+
Restoring ecological services and providing economic benefits	Restores multiple ecological function	+ + +	+ +	+
	Maintains and enhances biodiversity	+ + +	+ +	+
	Provides multiple socio-economic benefits to FLR actors	+ +	+	+
	Benefits accrue to multiple stakeholder groups	+	+	-
Maintaining and enhancing natural ecosystems within landscape	Enhances the conservation of natural forests or other systems	+ + +	++	- -
	Facilitates recovery of forests	+ + +	++	+
	Supports sustainable management of forests or other systems	+ + +	+	-
Using a variety of approaches tailored to the local context	Uses a variety of approaches adapted to local socio-cultural contexts	- - -	- -	+
	Responds to local economic needs	-	- -	+ +
	Fits to the agroecological setting of the location	++	+	
	Considers landscape history	+ + +	++	+
	Draws on latest science and best practice	+	+	+
	Builds on traditional and indigenous knowledge	+	++	+
Managing adaptively for long-term resilience	Focuses on enhancing landscape resilience	+ + +	++	+
	Aims at building stakeholder's resilience to climate variability and change	+	+	+
	Aims to enhance species and genetic diversity	+	++	+
	Attempts to adjust over time to changes in climate and other environmental and socio-economic conditions, and to changes in values, knowledge, skills, capacities, and needs of stakeholders	-	-	-
	Promotes co-learning by integrating research and generating evidence in the process	-	-	-

PFM

When PFM is examined using the double filter criteria of ecological and socioeconomic outcomes, it becomes apparent that these two priorities are not balanced as the process has been focused mainly on conserving forests. Community members who were not members of PFM are generally excluded from forest use. The impact of PFM on improving the livelihoods of communities participating in PFM has reportedly been minimal (Tesfaye et al., 2011; Ameha et al., 2014). This is mainly because the use of forest products is largely limited to NTFPs, which still have limited economic contributions to ensure active and sustained participation of communities in PFM. We need to note that before forests were put under PFM, community members had *de facto* free access to almost all state forests and used to harvest wood products.

AEs

AEs have been implemented mainly on hillsides and degraded communal lands. The size of an AE varies from few hectares to several hundred hectares (Birhane et al., 2018). When a given landscape is put under AE, there are forgone benefits by the community who had free access to it previously either for grazing or to cut trees and shrubs following the traditionally recognized access and use rights. With establishment of AE, there is a change in access to and use rights over resources as it

is mainly those who actively engage in its protection who share the direct benefits. After intervention, AEs are managed either by all members of the community or by certain segments of the community, and use of products and services will be regulated by norms, sanctions, and reciprocity. Like PFM, AEs are largely undertaken on communal lands, and as such, tenure insecurity of rehabilitated landscapes persists. At times lands rehabilitated using AEs are redistributed to the landless youth. Management objectives of AEs often sideline economic gains and opt for ecological restoration, although benefit streams from organic matter accumulation have not been easy to quantify (Babulo et al., 2006; Kassa et al., 2017).

SLM-GLI

This FLR initiative has been implemented using the watershed approach and across mosaic of land uses. In most cases, SLM practices are expected to bring economic benefit in the form of improved crop productivity [Hurni, 1997, 2000; Ministry of Agriculture and Rural Development (MoARD), 2010]. Although tree planting is promoted as part of SLM, there is no guideline on options as to how to balance, and if possible, maximize ecological and economic objectives of the SLM-GLI. The focus thus far is increasing the number of seedlings planted assuming that this will increase the national forest cover. Thus, Ethiopia needs to have a well-thought strategy to improve the selection of sites for tree planting and the selection of species to be planted for desired objectives, and to promote post-planting care in view of increasing the survival rate of planted seedlings. As of 2020, the SLM-GLI has begun emphasizing the need for using landscape restoration, and tree planting campaigns also create jobs and improve food and wood availability to meet domestic and market needs. Thus, economic and conservation objectives need to be reconciled, and location- and context-specific plans must be prepared to better guide the SLM-GLI. Also, the SLM-GLI needs to be implemented by a dedicated and resourced institutional arrangement put in place at all levels of the government structure.

The second principle: Engaging diverse stakeholders and supporting participatory governance

This principle emphasizes the need for FLR to actively engage stakeholders, including vulnerable groups, in decision-making notably in making land-use changes, setting economic and ecological objectives of FLR, defining the means to achieve these objectives, and agreeing on implementation modalities, net benefit sharing mechanism, and the planning and evaluation of interventions.

PFM

In some PFM sites, the PFM implementation process was not given sufficient time to convince and meaningfully engage all concerned segments of communities (Ameha et al., 2014). Although communities were consulted, the process was largely top-down. Little has been carried out to allow for proper consideration of local stakeholders' views and objectives and to encourage proper participation of all community members, women-headed households, and marginalized segments of the population. Even active participant members of communities felt that their voices were not properly listened to as key decisions such as objective setting, developing management plans, and defining net benefit sharing mechanisms were driven by forestry experts (Tadesse et al., 2017). Although a national working document to guide the process of establishing PFM was developed, this is hardly adhered to, and until recently, the government did not have a dedicated institutional arrangement to establish and support PFM groups. As a result, variations are observed among PFM sites regarding establishment and operational aspects of community engagement and participation. Approaches followed in site selection, in engaging communities, in setting PFM objectives, in developing management plans, in defining net benefit sharing arrangements, and in monitoring and evaluation of PFM varied with NGOs that established and supported PFM. Accurate information regarding the status of PFM established since the mid-1990s, and the locations and boundaries of all forests put under PFM is therefore difficult to obtain. Until now, monitoring and reporting tools to assess progress in PFM are also lacking. As state forestry agencies struggled to monitor and support communities organized under PFM, most PFM established and supported by projects failed to continue to operate fully as soon as externally funded projects working on establishing and assisting PFM groups terminated.

AEs

Unlike PFM, the initiative to establish AEs is taken primarily by governmental organizations, notably district offices of agriculture, although some NGOs played role in establishing AEs. The main limitations observed in PFM also prevail in AEs, notably failure to properly balance economic and ecological objectives of restoring landscapes. Also, the level of engagement of communities, and legal and institutional support to communities managing AEs remain limited. The incentives for communities to continue actively engaging in managing AEs remain low mainly due to limited tangible economic benefits and lack of a negotiated long-term plan for areas put under AEs. This is illustrated by the fact that in some cases, rehabilitated landscapes by communities were transferred to landless youth with little or no consultation with communities managing AEs sites. Such actions will erode community interest in establishing new AEs.

SLM-GLI

This FLR initiative promotes public engagement in SWC work and in tree planting. For instance, in July 2019, the Ethiopian government attracted substantial publicity when 350 million seedlings were reported by the national media to have been planted in a day (https://edition.cnn.com/2019/07/29/africa/ethiopia-plants-350-million-trees-intl-hnk/index.html). The national tree planting activities are coordinated by a national technical committee composed of senior experts from the Ethiopian Forestry Development of MoA; Ministry of Water, and Irrigation (MoWI); and Ministry of Urban Development (MOUD). A clearly defined road map helps know where to plant, what species to plant for a given objective, the post-planting care needed, and use rights over plantations. This needs to be supported with rigorous planning and monitoring mechanism.

Planning and implementing FLR initiatives cannot be seen within a scope of one project cycle as it is a long-term engagement involving multiple stakeholders having their own interests in the process. Thus, FLR initiatives should ensure that involvement of local stakeholders is genuine, gender-sensitive, equitable, and socially inclusive. This in turn requires FLR governance arrangement that is adaptable to local contexts and minimizes power imbalances as these are not uncommon in local contexts. Local ownership, leadership, and sustained involvement of stakeholders are fundamental for FLR to succeed at a landscape level (Chazdon et al., 2020).

The third principle: Restoring multiple landscape functions

This principle calls for managing landscapes and restoring their multiple functions for multiple benefits to meet expectations of diverse stakeholders. FLR interventions should be designed and implemented to simultaneously restore multiple ecological, social, and economic functions of degraded landscapes.

PFM

PFM focuses on how best to conserve natural forests. Attempts to increase economic contribution of forests to PFM participant community members have often been limited to the collection and marketing of NTFPs, resulting in low economic benefits to communities.

AEs

Studies have shown positive conservation gains from AEs in terms of re-emergence of natural flora composition, better above-ground biomass and livestock feed, improved soil physical and chemical properties, higher carbon stock and groundwater recharge, and reduced sediment load and run-off. As the focus has been on reducing further degradation and conserving remaining natural resources, little emphasis was given to options that would also maximize economic benefits to land managers. As a result, economic contributions of AEs to communities engaged in establishing and managing these landscapes remain much lower than their expectations (Babulo et al., 2006; Kassa et al., 2017).

SLM-GLI

The SLM-GLI initiatives are better placed to simultaneously generate both conservation and livelihood benefits than PFM and AEs, even though efforts are still skewed toward conserving soil and water and increasing forest cover. The explicit inclusion of fruit trees in the national tree planting campaign as of 2020 planting season shows the growing recognition of the need to also achieve economic objectives and food and nutrition security in implementing SLM-GLI.

The fourth principle: Maintaining and enhancing natural ecosystem

This principle emphasizes that FLR initiatives should focus on enhancing and sustaining ecosystems goods and services within restored landscapes and beyond. It implies that FLR should not lead to the conversion or degradation of natural forests or other ecosystems. Instead, it should help in the conservation, recovery, and sustainable management of these natural systems. Among the interventions, PFM is meant to improve conservation of natural forests. Given enough time and with the best design principles, AEs can also lead to the formation of secondary forests. With the SLM-GLI, however, it is too early to state whether this will help enhance natural ecosystems such as forests. This will happen if tree planting initiatives become part of the management strategy of restoring deforested areas and degraded forests.

The fifth principle: Tailoring to local contexts using various approaches

FLR initiatives are expected to use a variety of approaches that are adapted to the local social, cultural, economic, and ecological aspects and duly consider local capacities and existing governance structures. FLR should also consider the values, needs, and objectives of land managers. FLR actors need to learn from the history of the landscape to be rehabilitated (Kassa et al., 2011), build on traditional knowledge in natural resource management, and draw on latest science and best practices in setting restoration objectives and in defining the steps and actions needed to maximize conservation goals

and economic gains. In this regard, both PFM and AEs use existing social norms, legal instruments, and government structures in managing areas put under PFM or AEs. Yet, the support they get from relevant local authorities, especially offices in charge of forests, and from law enforcement agencies is reportedly much lower than their expectations (Kassa et al., 2009).

The sixth principle: Managing adaptively for long-term resilience

FLR initiatives are expected to enhance the resilience of the landscape and its stakeholders over the medium and the long term. Restoration approaches should enhance species and genetic diversity and be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs, and societal values. In this regard, none of the three state-led FLR initiatives could be reported as having plans to adjust activities and plans to meet changing needs and expectations of stakeholders and to take measures necessary to build resilience of communities and landscapes in the long term. As restoration progresses, monitoring of activities and gains needs to generate evidence to inform FLR planners, researchers, and policymakers on the steps to be taken and aspects that need to be integrated into management plans to build long-term resilience.

Working mainly with a subset of community members (not being inclusive and failure to anticipate and account for implications to other members of the community both in the short and the long term) continues to be one of the sources of conflict between participant and non-participant members of the community in a given FLR initiative, which in turn undermines sustainability. In addition, starting from the process of site selection to determining restoration objectives and developing management plans, evidence is limited to suggest that planned activities by local experts and communities were adequately informed by the available scientific knowledge and decision support tools. Moreover, experiences gained and the challenges faced during the planning and implementation of FLR initiatives are poorly documented. As a result, opportunities to learn from success stories and failures and to build on strength by identifying and addressing weaknesses have largely been missed. Capacities at the local level to identify and use options that would maximize economic and ecological impacts and minimize trade-offs and risks of FLR initiatives at the landscape level are also limited. In general, mechanisms for coordination, learning, adaptive management, and, more importantly, institutionalizing PFM, AEs, and SLM-GLI are lacking.

Conclusion

This study assessed the three major state-led FLR initiatives based on multi-temporal and multispectral satellite imageries and expert knowledge to examine their impacts and sustainability. The assessment showed that the initiatives vary in many ways. In particular, they varied in their impact on forest cover. They also differ in their attempt to balance between ecological and economic priorities at the landscape level and in the technical and institutional support they receive from governmental agencies. They are rated fairly regarding conservation outcome but rather poorly concerning the level of participation of key stakeholders in decision-making, in the use of various approaches that fit to local contexts, and in being inclusive as they mainly worked with a subset of community members, which could become source of conflict within communities. They are rated low for lack of well-thought planning and implementation procedures, independent and objective monitoring, evaluation, and reporting mechanisms. They also lack mapping of FLR actors and their interests. This limits opportunities to identify and address weaknesses and to promote co-learning that is needed to improve subsequent planning, implementation, and monitoring of FLR initiatives. To address these limitations, FLR initiatives should be designed to promote joint planning and co-learning through adopting compliance-oriented collaborative monitoring (Guariguata and Evans, 2020).

If state-led FLR initiatives are to achieve both conservation and developmental goals in a sustainable way, the government needs to improve tenure security by providing clearly defined use rights over planted trees and rehabilitated lands. Economic gains should be obtained in the form of concrete benefits balanced with societal ecological priorities. Participation should be genuine, and key stakeholders should be actively engaged in decision-making at all stages of the FLR process. Employing a variety of approaches that adapt to changing socioeconomic and political realities on the ground and that are tailored to fit the existing ecological context, local capacities, and governance systems while also adequately responding to local economic and ecological needs is also recommended. Ownership and use rights of trees planted and landscapes rehabilitated need to be clarified, and institutional weaknesses of both government and community-based organizations must be addressed. Well-thought plans are needed to build and maintain capacities of local government structures and community-based organizations to sustain their involvement in FLR.

Most regional governments still do not have a dedicated forestry institution to help achieve national targets. There is also no community-centered collective governance put in place to support FLR. The major actors in FLR—the state,

NGOs, and communities—hardly come together to review and learn from experiences and facilitate scaling up of successful practices. Costs and benefits of FLR interventions are hardly adequately analyzed and short- and long-term benefits quantified and explained to FLR actors. These knowledge gaps need to be bridged. The FLR initiatives at the local level should be informed by the national restoration potential map that identified areas requiring tree-based restoration options. If Ethiopia is to make significant progress in achieving it's the AFR 100 commitment, it is suggested that the challenges associated with state-led FLR initiatives be addressed as quickly, jointly, and objectively as possible. Most importantly, we need to state the fact that no clearly defined monitoring, evaluation, and reporting mechanism is officially adopted and used to support the FLR initiatives in Ethiopia, although attempts are being made for REDD+ interventions. As a result, although FLR initiatives have been implemented for over 2 decades, systematic and comprehensive assessments are lacking. This study aims to contribute to such attempts. Addressing the limitations identified will help improve and sustain the conservation and livelihood outcomes of FLR initiatives in Ethiopia. The process followed in this study would inform and encourage FLR practitioners in the use of FLR principles in assessing FLR initiatives in their countries.

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.

Author contributions

HK wrote the first draft. AA developed the first draft and enriched with data. MM read the article and added inputs. NH enriched the manuscript with area exclosures data. VG collaborated in the conception of the idea with HK. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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