

Dryland restoration and dry forest management in Ethiopia

Sharing knowledge to meet local
needs and national commitments

A review



Pastoral & Environmental Network
in the Horn of Africa





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About Tropenbos International

Tropenbos International (TBI) envisions a future in which forests and trees are used sustainably for the benefit of local people and the global community. By using evidence to make conscious choices and finding the right balance between the needs of all stakeholders involved, TBI contributes to sustainable solutions for forested landscapes. TBI works to improve the livelihoods of local communities, as well as bring significant benefits to global society through climate change mitigation and biodiversity conservation. TBI was established in 1986 and is registered in the Netherlands. Since 2017, it became a network of independent member organizations, and with other partners, works in more than ten tropical countries worldwide.

About the Pastoral and Environmental Network in the Horn of Africa

The Pastoral and Environmental Network in the Horn of Africa (PENHA) is a regional NGO, combining grassroots project implementation with research and policy analysis, focusing on rangelands and dry forests, governance and gender. The team working with TBI is led by Mitiku Haile, Professor at Mekelle University and PENHA senior advisor, alongside PENHA regional programmes coordinator Amsale Shibeshi, and regional policy officer John Livingstone. PENHA was established in 1981 by concerned professionals from Horn countries and is registered in the UK, with offices in Addis Ababa, Hargeisa (Somaliland) and London.

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Foreword

In early 2020, TBI began to work with PENHA to assess key gaps related to dryland restoration and dry forest management in Ethiopia, identifying the ‘Top 20’ challenges hampering the scaling up of successes. PENHA was contracted as interim partner in October 2020 to coordinate the initiation of a three-year programme (2021-23) as the basis for further work.

These activities are part of the Working Landscapes programme, financed by the Ministry of Foreign Affairs of the Netherlands, focusing on the roles and contributions of forests and trees to building climate-smart landscapes, improved livelihoods and environmental integrity. Activities are viewed under a lens of climate change mitigation and adaptation, to support the achievement of the Paris Agreement and Sustainable Development Goals (SDGs).

In Ethiopia, the initial focus will be on dryland restoration and the sustainable management of dry forests. At the outset, we look to build relationships with individuals and organizations that share a common vision, mission, focus and approach, with a view to knowledge-sharing and potential future partnerships.

The potential future role of dryland regions for economic development and as crucibles for climate change adaption and mitigation, as well as the associated potential for peace building, is vast, but hardly recognized, and almost entirely untapped. These landscapes are a fundamental source of livelihoods and cultural identity, especially through pastoralism. But they are also becoming increasingly degraded, and many are in such a severe state that immediate remedial action is required.

An initial national workshop was convened in Addis Ababa in April 2021 to review knowledge on dryland restoration and management of dry forests, and this national review is an output of that meeting. Resource persons and experts drawn from governmental and non-governmental organizations, research and higher learning institutions and the private sector deliberated on a compre-



hensive range of topics, covering global perspectives on dryland restoration as well as regional, national and local initiatives. The focus was on national policy, with a view to outlining the essential elements and principles that this should consist of, while considering the specific and differing needs and priorities of six dryland regions. There was also an awareness of the need to reverse the relative neglect of drylands by policy makers, and to address common misperceptions of dryland as being unproductive and resource poor.

The mere fact of convening this workshop was itself a step forward in this regard, and we are grateful to Prof Fekadu Beyene, Commissioner of the Ethiopian Forest and Climate Change Commission (EFCCC) for giving us his backing, in meetings ahead of the workshop, and to the Deputy Commissioner H.E. Kebede Yimam, for his active participation in crafting the workshop. Ato Tilaye Nigussie, Director of the Forest Sector Transformation Unit, gave a keynote address in which he reviewed the major aspects of policy development in the Ethiopian forestry sector and drew attention to the critical issue of the lack of coordination across different institutions with relevant and often overlapping responsibilities.

Notable policy makers from key institutions presented their views on particular aspects of policy, with all emphasizing the importance of the restoration and management of drylands and dry forests, which account for some 70%, of Ethiopia's carbon sequestration potential. Eighteen papers were presented and critically discussed, beginning with an overview that placed restoration efforts in the context of the particular challenges and opportunities in drylands, with a further nine papers encompassing national-level analyses and eight on regional experiences.

The workshop allowed a sharing of knowledge that has helped to build greater understanding and confirmed the importance of Ethiopian drylands in meeting national commitments to continental and global goals. Many issues were identified that must be addressed, including but not limited to increased positive impacts on livelihoods through rural enterprise that can develop new value chains such as gums and resins and other forest products, with job creation especially for youth and women. Also seen as crucial is to have a deeper understanding of how to enhance both participation in governance and incentives for conservation. Local ownership is the foundation for responsible forest governance, alongside the need to take a landscape view that integrates trees, fodder and livestock production as well as efficient water management and the critical issue of charcoal production and the dependence on wood for fuel.

Inspirational good practices that demonstrate the potential of the drylands, while illustrating the specific challenges, were shared from the dryland regions of Afar, Amhara, Benishangul-Gumuz, Oromia, Somali and Tigray. It was made abundantly clear that each region has its own distinct context that will need to be considered separately in a national

plan. Such a plan must accommodate tailored measures for specific regional issues, while at the same time recognizing the interdependencies that arise, for example in the trade-offs regarding economic development in one region and impacts in another including flows of water, sometimes destructive, and change in change of forest resources from one region to another.

Participants were clear that local and national efforts must be seen in global perspective, highlighting the fact that the UN Decade of Ecosystem Restoration is just beginning, and expressing the hope that these efforts will flourish and contribute significantly to Ethiopia's part in Africa's commitments to achieving the Bonn Challenge, the UN's Sustainable Development Goals, and the goals of UNFCCC's Paris Agreement.

Importantly, workshop participants agreed to establish the first Ethiopia Dryland Restoration Platform (EDRP), with thematic Task Teams that will work towards a National Dryland Restoration Strategy. This will involve local consultations across the regions and will be finalized over the course of a series of further workshops and submitted to government, with a view to its adoption by parliament. Participants also produced a Declaration, setting out agreed principles and shared commitments. And they identified the following important goals to be achieved through further deliberations:

- Improved knowledge management.
- Coherent planning with a longer-term perspectives.
- Greatly enhanced participation of communities in identifying options for building livelihoods and climate-smart landscapes.
- Increased and expanded inclusive value chains and markets for dryland forest products.
- Greater coordination of activities across sectors and actors, governmental agencies and NGOs, federal and regional administrations, communities and CBOs.
- A national drylands restoration strategy and action plan with clear lines of responsibility and accountability in relation to implementation and coordination.

After incorporating comments and feedback, authors submitted revised articles for publication in book form. We believe this book will contribute to the knowledge economy on dryland restoration and management of dry forests of Ethiopia, and will constitute both a solid output from these deliberations and a valuable resource for policy makers and practitioners alike.

Professor Mitiku Haile



Background and outcomes of this review process

Workshop summary

On Saturday 10 April, the 46 participants of a national workshop on dryland restoration and dry forest management ended an intensive three days of discussions with a huge result. The final declaration – or “a major breakthrough” as one senior participant described it – maps out a shared vision between the federal government, in the shape of the Environment, Forest and Climate Change Commission (EFCCC), and representatives of six regional governments (Afar, Amhara, Benishangul-Gumuz, Oromia, Somali and Tigray), international research institutions, and NGOs. It emphasizes the central importance of the drylands to Ethiopia’s national wellbeing, and in achieving its ambitious climate mitigation commitments. The drylands make up the bulk of Ethiopia’s land mass and account for some 70% of Ethiopia’s emissions reduction potential. Specifically, the declaration confirms a resolve to work together, towards greatly enhanced community participation to identify options for livelihoods and sustainable landscape management, develop inclusive value chains for dryland forest products, increase coordination across sectors and actors, and improve knowledge management and long term planning, as components of a national drylands restoration strategy and action plan with clear lines of responsibility and accountability.

A powerful opening speech was delivered by Ato Tilaye Nigussie, Director of the Forest Sector Transformation Unit, speaking on behalf of the Deputy Commissioner of the EFCCC, H.E. Kebede Yimam. This laid out the policy framework established by the government, and related commitments on climate mitigation, forests and trees. Ato Tilaye also recognized the challenges, emphasizing the need for clarity in strengthening coordination, as it is not clear at present which agencies are responsible for which results, adding that “this workshop is an important stepping stone for maintaining the momentum established so far.” In addition, Tesfaye Shiferaw of the Agency for Civil Society Organisations (ACSO) spoke for its director, Jima Dilbo, welcoming this initiative in a new era of government-CSO collaboration in which NGOs are encouraged to contribute towards policy formulation.

Dr Mohammad Musa, PENHA’s Ethiopia Country Representative offered “best wishes for good deliberations and I hope you will come with specific recommendation, achievable and practical, and ways forward.” And PENHA

Regional Programmes Coordinator and the energy behind much of the workshop organization, Amsale Shibeshi, reminded participants that “our aim is to strengthen coordination, collaboration and information sharing, and to start working towards a national strategy on dryland restoration.”

In the first session, the overarching themes and context of the workshop were set out in presentations by leading national figures in Ethiopian dryland restoration and climate mitigation efforts, Prof Mitiku Haile (Mekelle University/PENHA) and Dr Habtemariam Kassa (CIFOR). Dr Yetebitu Moges (REDD+ Secretariat) highlighted the international perspective of Ethiopian dry forests in relation to its Nationally Determined Contributions (NDCs). Dr Wubalem Tadesse (EEFRI) offered reasons for the failure to coordinate across agencies, and a lively exchange with Ato Tilaye in the presence of Demeke Tsehay of the National Planning Commission, the body charged with ensuring coherence across government, enabled a rich discussion on the scope to rationalize institutional set-ups that can incentivize coordination.

Dr Yigardu Mengesha (EEFRI) described the range of suitable indigenous seeds available from her national governmental organization and the challenges of managing seedlings in dryland environments. EEFRI’s Director Dr Agena Anjulo presented findings from recent research on the expanding problem of bush encroachment in Borena. The need for solution-oriented research was emphasized, rather than purely academic work not directly linked to the needs of ongoing restoration and forest management programmes. Dr Aklilu Mekuria described the work of the NGO WeForest and the need to direct carbon payments to communities for strengthening and diversifying livelihoods, and to build governmental institution capacity at regional and federal levels. These were followed by views from representatives of six regions, on their experience, challenges and opportunities, stimulating lively discussions. Employing youth in restoration efforts was a recurring theme.

In group sessions, experiences from across the country showed different approaches to landscape restoration, including area exclosures in Tigray, participatory forest management in Benishangul-Gumuz, and rangeland rehabilitation in Somali Region. But all agreed on the centrality of economic benefits to local communities, without which restoration efforts cannot be sustained. Participants from Somali stated the effectiveness of traditional institutions and customary law, pointing to successes in maintaining biodiversity and commercially valuable tree resources, especially frankincense. Those from Afar drew attention to some downsides of traditional, clan-based natural resource management associated with local conflict. But given ongoing violence between Afar and Somali clans, it was significant that representatives of these two regions sat together to discuss solutions to their environmental and development challenges.

Presentations and discussions also focused on charcoal and the need to develop alternative energy sources. Dr Dawit Gebrezgabiher (Mekelle University) presented a recent

assessment with Prof Mitiku Haile, informing Dr Belayneh Ayele of the Regional Environmental Authority (Amhara Region) that much of the charcoal currently being used in Tigray is sourced from Amhara, with conflict-related power cuts having induced an environmentally devastating increase in demand for wood fuel. The problem of invasive prosopis trees was highlighted in Afar and Somali, with a set of identified solutions proposed. Dubale Admasu (USAID) described the development of a national prosopis control and use strategy, building on work by Farm Africa, PENHA, GIZ and others, endorsed by the government. Dubale also acknowledged the foundational work of TBI's Nick Pasiecznik which informed his own research on the issue. A regional conference organized by GIZ, in which PENHA presented lessons from Somaliland, led to a multi-stakeholder process that translated the strategy into set of actions that is now being implemented.

Mohammed Idris, Economic Advisor to the President of Afar Region noted that “We are now on the second day but I have gained the experience that I could not get in two years.” The next steps were outlined on the third and final day of the workshop. Regional action plans were developed, setting out priorities and key actors, with agreement on the membership of task teams in four thematic areas. Dr Yigardu argued that PENHA should not only lead the development of a national dryland restoration strategy, that is ultimately owned by the EFCCC, but that it should also play a role in its implementation. So over the next nine months, PENHA will organize quarterly meetings with inputs from the regions and community consultations integrated into a multi-stakeholder ‘Ethiopian Drylands Restoration Platform’. A draft strategy with an outline of implementation modalities will be presented to the EFCCC before the end of 2021.

Ethiopia is contending with multiple, almost Biblical, crises – locusts, floods, drought, conflict and Covid – so the fact that so many chose to participate is a testament to the commitment to tackling issues related to dryland forest management and climate change mitigation. The warm spirit in the room extended to London and Wageningen, where PENHA and TBI directors and senior staff were able to address participants via Zoom, expressing solidarity and philosophical outlooks on inclusive participation, peace building and sustainable development.

The workshop was organized by PENHA (the Pastoral and Environmental Network in the Horn of Africa) and TBI (Tropenbos International), with the financial support of the Ministry of Foreign Affairs of the Netherlands and the backing of the Government of Ethiopia. It is also the first formal event in this new partnership, as part of TBI's Working Landscape programme, building on reviews, interviews and field surveys conducted in 2020. Special thanks also to EFCCC Commissioner, Professor Fekadu Beyene, and Deputy Commissioner Kebede Yimam. The workshop was held in the Capital Hotel, Addis Ababa, 8-10 April 2021, with appropriate Covid-safe measures in place.

Opening remarks

H.E. Ato Kebede Ynam, Deputy Commissioner, Environment, Forest and Climate Change Commission (EFCCC) - *delivered by Tilaye Nigussie, Director, Forest Sector Transformation Unit (FSTU)*

Ladies and gentlemen, representatives of government agencies, research institutes, regional administrations, representatives of the Embassy of the Netherlands and the Royal Norwegian Embassy, representatives of development partners, distinguished participants and colleagues, I am very pleased to be here and to make the opening address on behalf of the Environment, Forest, and Climate Change Commission (EFCCC).

Ethiopia plans to transform its economy by wisely using natural resources, restoring degraded landscapes, and reducing greenhouse gas emission by 50% in 2030. So far, progress has been made in: (i) reversing the loss of forest cover through protection, restoration, afforestation, and reforestation, (ii) enhancing forest-based economic, social, and environmental benefits by improving livelihoods of forest dependent communities – for example, participatory forest management initiatives, (iii) developing and implementing policies, legislations, strategies, and programs, and (iv) building the institutional capacity of the sector at various levels and enhancing collaboration with diverse actors and stakeholders.

Despite the progress made so far, there are considerable challenges that need to be addressed, particularly in the drylands of Ethiopia. Please allow me to briefly describe the state of drylands in Ethiopia in the context of climate change. I am aware that there are several experts who are committed to transform Ethiopia's Drylands. On this occasion, it would be appropriate to appreciate the pioneering work of Dr Kidane Giorgis who tirelessly directed the attention of experts, policy, and decision-makers to Ethiopia's drylands. Thank you, Dr Kidane, for your technical and advocacy work! It is also an opportune occasion to thank all those who have contributed to the efforts the EFCCC made in formulating policies, strategies and programs aimed at transforming the sector; including Dr Habtemariam Kassa who is present here.

In view of the theme of this workshop, it would be appropriate to highlight the salient climate change-related issues affecting drylands. The few issues, among others, include the following:

- Ethiopia's vulnerability to climate variability and change continues to increase especially in the drought prone drylands, which cover about 75% of the country's landmass.
- Increase in mean annual temperature and rainfall variability between years, seasons, and regions.

- Changes in rainfall and temperature exert pressure on livelihood systems and practices in drylands.
- Expansion of invasive weeds and woody species put productive rangelands out of use and exacerbate livelihood insecurity.
- It is estimated that Ethiopia's dry forests cover 12.3 million ha and emit 9.2 million tCO₂e, about 55% emissions of the overall forest sector.

Although the above-mentioned challenges are daunting, Ethiopia in collaboration with the World Resource Institute (WRI) has identified 54 million hectares of degraded land that could be rehabilitated using tree-based restoration options to be applied in three priority areas - priority 1 (11 million ha), priority 2 (18 million ha), and priority 3 (25 million ha). Through the African Forest Landscape Restoration Initiative, the Bonn Challenge, and the New York Declaration on Forests, Ethiopia has committed to restore 22 million ha of deforested and degraded land. It is recognized that dry forest biomes, in particular *Combretum-Terminalia* and *Acacia-Commiphora*, constitute an estimated 70 million tCO₂eq, about 54% of the total abatement potential of the forest sector. Furthermore, the EFCCC is committed to sustainably manage dry forests and reduce the vulnerability of communities in the dry lands of Ethiopia.

So, the potential of drylands and dry forests is recognized. There is also a realization that restoring drylands and managing dry forests could have positive outcomes in reducing unemployment and or underemployment, the potential for conflict, internal displacement, and migration.

The question is: where do we go from here? It is important to build on the efforts made over the past several years. This workshop is an important steppingstone for maintaining the momentum established so far. In this regard, I would like to thank PENHA for promoting and supporting pastoral development, with an emphasis on empowering people and communities to improve their livelihoods. I would also like to recognize the value Tropenbos International adds in sharing its experience and expertise in knowledge management. I also appreciate the support the Dutch Ministry of Foreign Affairs provided to this timely initiative coordinated by TBI and PENHA.

With continued support from the government of Ethiopia, our development partners and your concerted efforts, I believe it would be possible to:

- Identify changes to made to improve the state and productivity of drylands.
- Describe what has worked, what has not, and what the key gaps are.
- Provide recommendations on what should be done to improve coordination and collaboration among actors and stakeholders.
- Provide evidence-based advice on appropriate policy interventions that could be instrumental in reducing the threats drylands are exposed to because of the expansion of large-scale commercial farmers, unsustainable use of wood and non-wood products, overgrazing, and forest fires.

During your deliberations, which I observe will focus on appraising the current state of knowledge on drylands, and identifying the challenges and opportunities for program implementation; and c) mapping pathways for improving coordination, you will reach a consensus on key policy, institutional, technical, and social barriers that if addressed will transform the drylands of Ethiopia. I wish you all the best during the workshop. The EFCCC will continue to work with you and support the drylands platform to be established. With these remarks, I now declare the workshop open! Thank you.

H.E. Jima Dilbo, Director General, Agency for Civil Society Organisations

I am grateful for the opportunity to say a few words to this gathering of environmental and forest management experts. It is very encouraging to see civil society organisations, research institutions and governmental agencies, representing six regions of Ethiopia, coming together to address national development challenges. This is a new era of collaboration between government and civil society. In 2019 the government established a new legal framework for NGO engagement in Ethiopia. ACSO is the body that is primarily responsible for implementing relevant laws governing the operation of CSOs. The agency aims to create a conducive environment for the full exercise of freedom of association, maximizing public benefit, and enhancing the culture of philanthropy and voluntarism in society.

The Government wishes to see NGOs playing a full role in development, and complementing national efforts. This new PENHA-TBI program aims to work with others in order to contribute to the development of the policies and laws that support forest management. This kind of collaboration is welcome. Collaboration between NGOs, research institutions, international development agencies and government can greatly enrich policies and programs.

My agency recently approved PENHA's registration to operate in Ethiopia. PENHA has set out a strategy that focuses on environmental management in the drylands, while emphasizing livelihoods, and capacity building at the regional level. I am also happy to welcome Tropenbos International to Ethiopia. From its base in the Netherlands, Tropenbos supports forest protection and climate mitigation activities in 11 countries. Ethiopia is now the 12th TBI country.

I hope that this international collaboration will strengthen programs here in Ethiopia, as well as Ethiopian participation in international efforts to promote climate-resilient development. I am told that this workshop aims to produce some specific outputs, including action plans for the regions and guidelines for national policy. My very best wishes for the next three days of discussions. Thank you.

Opening remarks were also presented by Mohammed Musa, PENHA Ethiopia country representative, and Amsale Shibeshi, PENHA regional programmes coordinator.



Declaration of a commitment towards a national dryland restoration strategy

From a national workshop

**Dryland restoration and dry forest management:
Sharing knowledge to meet local needs and national commitments**

Addis Ababa, 10 April 2021

The potential future role of dryland regions for economic development and as crucibles for climate change adaption and mitigation, as well as the associated potential for peace-building, is vast, but hardly recognized, and almost entirely untapped.

We, the participants of this national workshop on dryland restoration, acknowledge the overwhelmingly crucial role of Ethiopia's drylands to its national wellbeing. These landscapes are a fundamental source of livelihoods and cultural identity, especially through pastoralism. But they are also becoming increasingly degraded, and many are in such a severe state that immediate remedial action is required.

This workshop has allowed a sharing of experiences that has helped to build a greater understanding and confirmed the importance of Ethiopian drylands towards meeting national commitments to continental and global goals. We have identified many issues that must be addressed, including but not exclusively: rural enterprises, employment, youth, gender, local ownership, decentralization of resource governance, fodder and live-stock, fuel and charcoal, and developing new value chains and those for gums and resins and other forest products.

Inspirational good practices that demonstrate the potential of drylands and specific challenges have been shared from dryland regions of Afar, Amhara, Benishangul-Gumuz, Oromia, Somali and Tigray. And we acknowledge that each region has its own distinct context that will be considered separately in a national plan.

But these few days have also shown that there is still much to share, and much to do – and we declare that we will continue to do so through individual and institutional commitments to collaboration, sharing knowledge and raising awareness.

We, representatives of the federal government, of regional governments, of international organizations and of NGOs, agree on the need for consensus on a clear and coherent draft national strategy on dryland restoration, and commit ourselves to working together to achieve this goal by the end of 2021.

The UN Decade of Ecosystem Restoration is just beginning, and we wish that these efforts will flourish and contribute significantly to Ethiopia's part in Africa's commitments to achieving the Bonn Challenge, the UN's Sustainable Development Goals, and the goals of UNFCCC's Paris Agreement.

We resolve to work towards:

- improved knowledge management;
- planning with a longer-term perspective;
- greatly enhanced participation of communities in identifying options for building livelihoods and sustainably managing landscapes;
- inclusive value chains and markets for dryland forest products;
- greater coordination of activities across sectors and actors, governmental agencies and NGOs, Federal and regional administrations, communities and CBOs; and,
- a national drylands restoration strategy and action plan with clear lines of responsibility and accountability in relation to implementation and coordination.

And we sincerely acknowledge, with thanks, the full support of the Government of Ethiopia, the work of all workshop participants and their partners, the workshop organizers PENHA and Tropenbos International as neutral knowledge brokers, and financial support from the Netherlands Ministry of Foreign Affairs.

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Drylands and dry forests: the global and East African context

Yitebitu Moges

Introduction

Drylands cover 6.1 billion hectares, or 41% of the Earth's land. Some two billion people live in the drylands, 90% of whom are in developing countries. Most depend on trees and grasslands to meet their basic needs for food, fodder cooking, heating, medicines, shelter, and for income. Life is precarious, and the socioeconomic status of people in drylands is significantly lower than that of people in most other climates. Water scarcity and high levels of spatial and temporal variability in water and fodder availability are key factors that shape and constrain human livelihoods. Drylands are vulnerable to drought, desertification and degradation, with dangerous ramifications for food security, livelihoods and wellbeing. Trees and forests help mitigate these challenges through the provision of economic products and environmental services.

This review analyzes drylands and dry forests at global and regional levels, their ecology, economy and vegetation, as well as the threats they face, and the policies and measures needed to address the problems faced. It also looks at future directions for the sustainable management of drylands and dry forests.

Yitebitu Moges, National REDD+ Programme Coordinator, National REDD+ Secretariat, Environment Forest and Climate Change Commission, Addis Ababa, Ethiopia

The most common parameter used to distinguish aridity is the aridity index (AI), being the ratio between average annual precipitation and total annual potential evapotranspiration, but which also corresponds closely to mean annual rainfall (mm). Drylands occur at all elevations, but 80% of all dry-

lands are found below 500 m. UNEP-WCMC define drylands as having an aridity index <0.65 , defined into four zones.

- Hyper-arid: $AI < 0.05$ (16% of drylands), often <100 -150 mm mar
- Arid: $AI > 0.05$ but < 0.2 (25% of drylands), often 150-400 mm mar
- Semi-arid: $AI > 0.2$ but < 0.5 (37% of drylands), often 400-700 mm mar
- Dry sub-humid: $AI > 0.5$ but < 0.65 (22% of drylands), often, 700-1000 mm mar

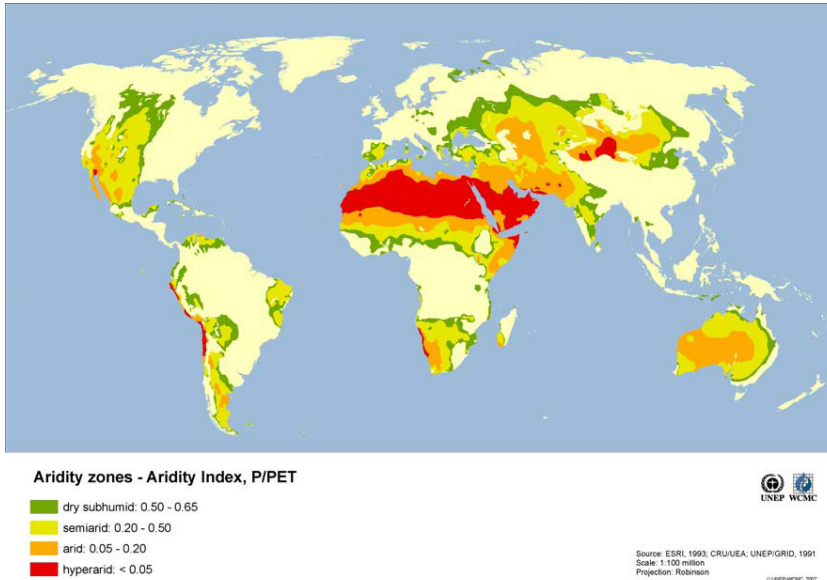


Figure 1: Drylands of the world (UNEP-WCMC, 2007)

Ecological and economic significance of drylands

FAO (2019) estimated that drylands globally contain 1.1 billion hectares of forest, corresponding to 27% of the world's total forested area (4 billion ha), and that forest accounts for 18% of drylands, mostly in subhumid and semi-arid zones, while barren land makes up 28%, grassland 25%, and cropland 14%. More than half of dryland forest (52%) is in the dry sub-humid zone, mostly in southern Africa and South America; 41% lies in the semi-arid zone, 7% in the arid zone, and less than 1% in the hyper-arid zone. The assessment also showed that 51% of dryland forest has a dense canopy cover of 70-100%, while two-thirds has cover of $>40\%$. Two-thirds of dryland forests are broadleaved, 15% are coniferous, and 10% are mixed, with only 2% being planted forest.

Dry forests are an important resource base for livelihoods and economic development (Paumgarten and Shackleton, 2009; Shackleton et al., 2008), with 320 million Africans dependent on dry forest resources to meet their basic needs (Petheram et al., 2006).

The dominant land use in drylands is pastoralism, with land tenure systems based on common property rights. Besides livestock production, drylands also provide ecosystem goods and services, including fuelwood, charcoal, gums and resins, fruit and other tree products, wildlife habitats. Trees in the drylands reduce wind erosion and moderate local climates. But drylands are undergoing rapid population growth and are highly sensitive to climate change, leading to extended droughts, regional warming. A growing human population has been associated with land degradation and desertification.

People in the drylands face challenges posed by a combination of environmental and socio-economic factors, not limited to low and variable quantities of rainfall, which leads to fluctuations in forage availability for livestock. Land degradation and population increase tend to result in resource conflicts and pasture scarcity. These challenges call for changes in production and land use management. The major transitions experienced across most rangelands include changes from (a) nomadic to sedentary lifestyles and production systems, (b) subsistence to intensified commercial production, and (c) collective to private land tenure. Most pastoralists and agro-pastoralists now have permanent habitations. Seasonal livestock migration (transhumance) is more limited in scope and no longer involves the whole household. A family member, often a young man, will move with the livestock and return to their permanent home after the migration season. Hence, the term sedentarization in this article describes a change in the grazing pattern from a purely transhumant pastoralism (seasonal migration over a wide area involving the whole household) to a more agropastoral, enclosure-dominated lifestyle that still has its economic base in livestock and its cultural identity in pastoralism.

Climate and vegetation in Eastern Africa

Eastern Africa, also called the Greater Horn of Africa, includes 11 countries (Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania and Uganda), and is a relatively dry area despite its equatorial location, notwithstanding its lush farming areas and wet mountain regions. All these countries are also amongst the poorest 25% of all nations in the world, which added to dependence on the agricultural sector, makes climatic conditions and particularly rainfall a crucial issue for social and economic development. Only 28% of Eastern Africa receives more than 1000 mm of annual rainfall, in three zones: (a) the Ethiopian highlands; (b) the area that spreads from the eastern Congo Basin to the western Kenya highlands across Uganda and Lake Victoria, and (c) an area stretching from southern Tanzania to the Kenyan coast.

The Ethiopian Highlands display a marked asymmetry. Facing the southwesterly monsoon winds, the southwestern highlands, although not the highest, reaching 2363 mm at Masha, are the wettest, with 1500-2000 mm.. The relatively wet Nile Plains also contrast with the leeward and thus arid Afar Depression and the Gulf of Aden to the northeast.

The eastern part of Eastern Africa is the driest part of Africa, and this relates to the large seasonal amplitude of the Indian Ocean monsoons, enhanced by the north-south barrier formed by the east African highlands (Slingo et al., 2005), which also block moist air arriving from the Congo Basin. In the west of the region, dry conditions are also found in northern Sudan, but with a southward gradient of increasing rainfall that replicates that found in West Africa.

Drylands cover 47% of Eastern Africa with a total area of 328 million hectares, and represent 5.3% of the world's drylands. These are distributed across the semi-arid (37%), dry sub-humid (33%) and arid (26%) zones (Figure 2). Only a small fraction of drylands is hyper-arid (4%). As much as 69% of Eastern Africa is arid, semi-arid or hyper-arid (UNDP/UNSO, 1997), with mean annual rainfall less than 50% of mean annual potential evapotranspiration. Annual rainfall is lower than 400 mm in much of Sudan, the Red Sea coast, the Afar Depression, and northern Somalia (Figure 2). Hyper-arid conditions are also found towards the Egyptian border and near the tip of the Horn. An area of annual rainfall less than 400 mm also stretches from eastern Ethiopia to Lake Turkana through northeastern Kenya, prolonged by a relatively dry corridor (annual rainfall <700 mm) from eastern Kenya to central Tanzania. Two main types of seasonal rainfall regimes occur. In the northwest, they are single-peak with a summer maximum (July-August). The rainy season lengthens, moving southwards along the Nile Valley, but still with a distinct summer peak, and a dry winter. In northeastern Ethiopia, there is a sharp summer maximum, but this is complemented by spring rains (February-May) called *belg*, or *sugum* in the Afar depression (Camberlin and Philippon, 2002; Habtemichael and Pedgley, 1974).

Camberlin (2018) provides a comprehensive analysis of the East African climate, which is helpful in developing our understanding of the relationships between geography and climate, socio-economic development and ecological potential, while underlining the significance of the drylands. Eastern Africa is classically presented as a dry climate anomaly in the otherwise wet equatorial belt, and a transition zone between the monsoonal domains of West Africa and the Indian Ocean. Eastern Africa includes the highest and lowest points in Africa, i.e. Mt Kilimanjaro in Tanzania (5895 masl) to Lake Asal in Djibouti (153 m below sea level). This complex relief adds to the huge diversity of climatic conditions that lead to a wide range of vegetation, biodiversity and human occupations. The highlands form an almost continuous north-south barrier from the Red Sea to southern Tanzania, including the Ethiopian Massif, containing almost 50% of Africa that is above 1500 m (McCann, 1995). Large tablelands are dissected by deep valleys, dominated by summits above 4000 m. Further south lie the East African Highlands in two mountain arcs following the eastern and the western Rift valleys, with the Kenyan highlands in the east at 1500–2500 m, prolonged southwards by the Eastern Arc Mountains of lower elevation. In the west, the western Rift Mountains run from western Uganda to southern

Tanzania including several peaks above 3000 m. Between these two arcs is a large tableland, at around 1000–1200 m, in which lies Lake Victoria. The East African highlands have a major impact on regional and extra-regional climates (Slingo et al., 2005).

Temperatures vary seasonally by no more than 5°C in Eastern Africa, except in the southern highlands of Tanzania, and northern parts (Sudan, Red Sea, Afar Depression, northern Somalia). The mean diurnal temperature range (10–15°C) well exceeds the annual temperature range, being smaller during the rainy seasons due to cloud cover restricting daytime warming and night cooling, and in coastal areas. Eastern Africa also includes the hottest known place on earth, at Dallol in the Afar Depression (130 m below sea level), with mean annual temperature (1960–1966) of 34.6°C (Pedgley, 1967). The lowest mean annual temperature is –7.1 °C on the summit of Mt Kilimanjaro (Thompson et al., 2002). Over most of Eastern Africa, frost occurs sporadically at 2200–2400 m, and is common above 3500 m.

Due to its dryness, natural vegetation in Eastern Africa is dominated by often wooded grassland and shrubland. In eastern Ethiopia, northern Somalia and northern Kenya, drier conditions result in open grassland and shrubland, while woodlands and wooded grasslands dominate the relatively wetter western lowlands. The only continuous zones of closed evergreen forests are in southwestern Ethiopia and on the edges of the Congo Basin. Other isolated patches of evergreen forests are found across parts of Kenya, Tanzania and Uganda, often on steep slopes, but have been heavily encroached with the resulting land cover including many perennial species. Broadleaved vegetation dominates western parts of Eastern Africa, while acacias dominate in the east. Bare soil or bare rock dominate the shores of the Red Sea and Gulf of Aden, the Afar Depression, parts of northern Somalia, the Turkana gap, and northern Sudan, where sandy areas are also found.

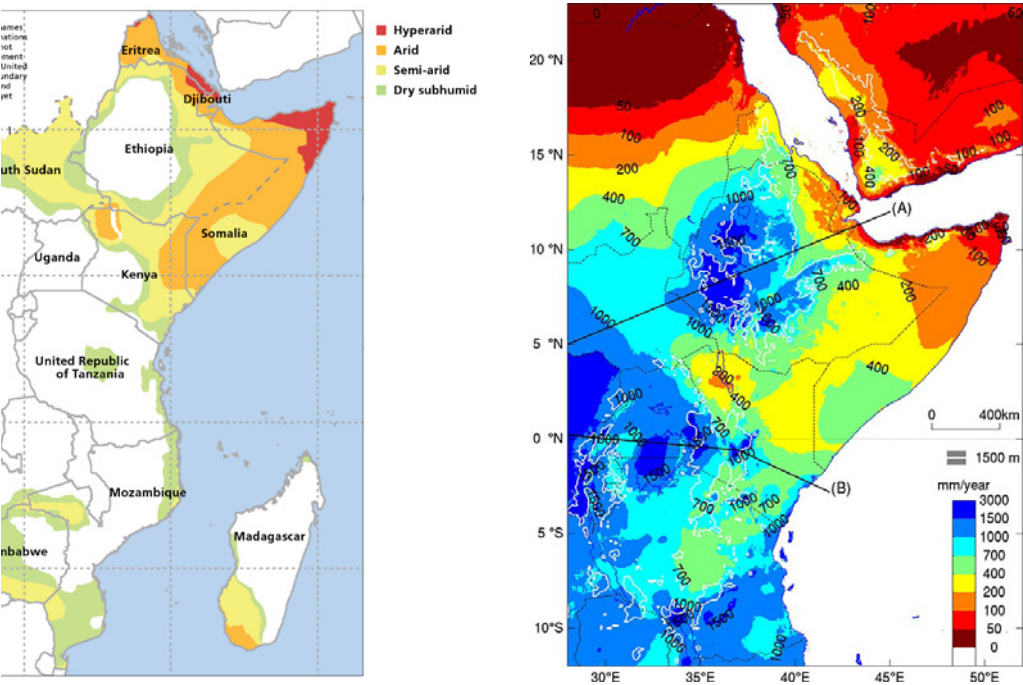


Figure 2: Left: Eastern Africa by dryland zones (FAO, 2019); Right: by mean annual rainfall (Camberlin, 2018).

The maps presented above also illustrate a central fact of Ethiopian geography – the wet highlands being surrounded by semi-arid lowlands, which become more arid as we move towards the Somali and Eritrean coasts. It is important, here, to note the interdependencies and cross-border dimensions that are evident when we take a regional view. Water flows from the Ethiopian highlands, across the dry lowlands and on to neighboring countries. And these interdependencies and cross-border dimensions are economic and social, with pastoral livelihoods depending on a high degree of cross-border economic activity, trade and interaction, underpinned by the basic facts of the region’s geography.

Dryland forests in Eastern Africa

In Eastern Africa, forests cover 116 million hectares, and more than one third of the drylands (FAO, 2019). Other wooded areas span 54 million hectares, or one sixth of the drylands. Almost half of the dry forest in Eastern Africa occurs in the dry sub-humid zone (47%), with 36% in the semi-arid zone (FAO, 2019). Other wooded land is mainly distributed across the semi-arid (37%) and arid zones (35%), while only 3% is in the hyper-arid zone. However, most (47%) of the drylands in Eastern Africa are classified

as ‘other land’, whereas in northern parts of the region, which are drier, other land and other wooded land dominate, with scattered forest patches.

More than 80% of forests in the Eastern Africa drylands is predominantly broadleaved (FAO, 2019), with forest type not specified for 14%, and 3% classified as mixed. Riparian forests account for 2% (almost 3 million hectares), being particularly important for grazing especially in the dry season, as well as for conservation and ecotourism. Only a few planted forests and mangroves were identified. However, as these are scattered, such estimates, derived from sampling, are of limited accuracy. Most of the other wooded land (94%) is dominated by grassland with trees and shrubs, or with shrubs alone, known as bushland and thicket.

Some 131 million hectares or 40% of the drylands in the region have no trees (FAO, 2019). Tree canopy cover is denser in the south, where canopy cover averages 45%, with a clear gradient corresponding to aridity. Forests are densest in the dry sub-humid zone with an average of 50% tree canopy cover, and sparsest in the hyper-arid zone with an average of 21% tree canopy cover. Open forest comprises 54% of the total, with a tree canopy cover <40%, 20% of the land has tree cover of 40-70%, and 25% has a dense canopy >70% (FAO, 2019). Shrubs are present in 60% of the drylands (with densities of <40%, 20%, or <10%), while dense shrubs are found in only 3% of the drylands.

Conclusions

This review draws attention to the often underestimated and overlooked significance of the drylands, globally and regionally. Almost one third of the world’s forest lies in the drylands. While semi-arid conditions make pastoralism (partly mobile livestock keeping) the basis of livelihoods in the drylands, it is important to recognize that millions of people in these regions depend on dry forests for their livelihoods. It is also important to recognize the importance of woodlands as well as the ecological and economic roles played by trees in the grasslands and in the ecosystems of the arid and semi-arid pastoral areas.

Clearly, when policy makers and program designers look at restoration, regeneration and carbon sequestration, they should not think only of the dense, wet forests of the highlands. Policies and programs need to address the dry forests, woodlands and trees across East Africa’s vast drylands.

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Improving natural resource management in Ethiopian drylands: drivers of change, livelihood dynamics and challenges

Habtemariam Kassa

Introduction

Drylands in Africa cover 43% of the continent, 75% of the agriculture land, and host 50% of the total population and most of its poorest people (Gray et al., 2016). In Ethiopia, drylands cover about two thirds of the country. People in lowland dry areas have more limited access to markets and social services than those in wetter, richer and more densely populated mid and highland areas. And the capacity of government institutions is also generally weaker in the drylands. Thus, communities depend largely on traditional institutions to govern access to and use of natural resources, notably land and forests, and to manage conflicts. But over time, the value systems of the youth are changing, government institutions are becoming established, and the role of traditional institutions is being contested, and also declining. As such, the legal framework is unclear as to the roles and responsibilities of traditional institutions in managing natural resources, with at times, parallel power in governing resources.

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Population expansion and the rise in dependence on natural resources due to increased vulnerability has led to high levels of resource degradation, linked to increased incidences of droughts and floods due to climate variability and change. Consequently, food insecurity is a chronic challenge, and communities have been receiving food aid for decades, with most vulnerable and food insecure people living in dryland

areas (Figure 1). And despite decades of relief work, the effects of food aid on their age-old coping mechanisms has not been systematically examined, though evidence from drought prone localities suggests that recipient communities and local authorities alike have developed a dependency on food aid (Weldeselasie et al., 2017).

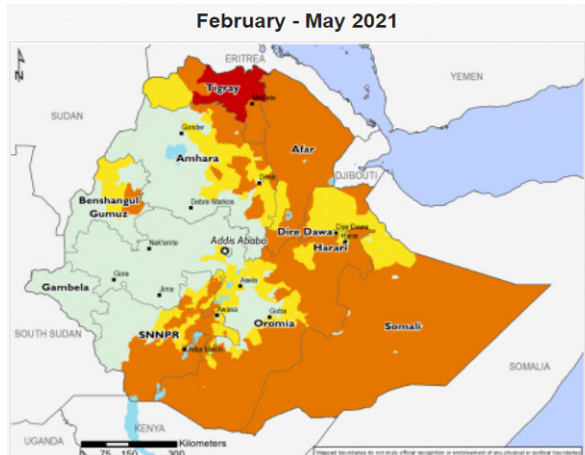


Figure 1. Food security outlook, February-May 2021.

Source: <https://fews.net/east-africa/ethiopia>.

Causes and drivers of dryland degradation

There are six commonly cited causes of natural resource degradation in dryland areas.

1. Erratic rainfall resulting in droughts and floods.
2. Expansion of invasive plants on rangelands.
3. Overgrazing of poorly governed, communally owned rangelands.
4. Excessive tree cutting for subsistence and sale.
5. Farming of dry season grazing land, hillsides, and marginal land.
6. Overgrazing of rangelands and around water points.

These accompany three underlying drivers:

1. Population pressure, with growth rates higher than the national average due to in-migration to pastoral and agropastoral lowlands from more densely populated highland areas, and improvements in access to health services leading to decreasing death rates.
2. Institutional failures, with a lack or inadequacy of legal and institutional instruments to regulate or enforce existing laws, that result in more overgrazing, wood extraction and agricultural expansion. Ethiopia still does not have a national land use policy and plan to govern land use changes, and lacks a clearly articulated tenure system for defining the role of traditional institutions in managing communal resources in drylands.

3. Climate variability and change, more acute in the dryland areas, leading to declining plant productivity (Figure 2), and shorter rangeland growing periods (Figure 3).

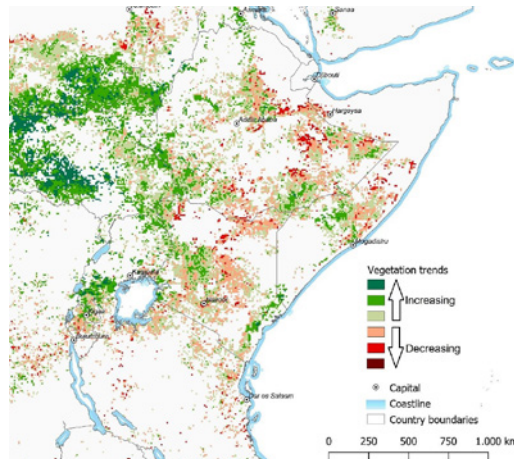


Figure 2. Trends in annual plant productivity in East Africa, 1981-2010.

Source: Berkhout et al., 2021.

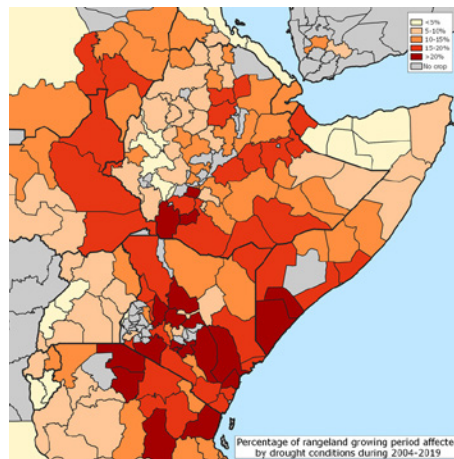


Figure 3. Impacts of droughts on rangeland growing period, 2004-2019.

Source: Berkhout et al., 2021.

Drivers of change

Five major drivers of change in dryland areas are identified, though for many years interventions have focused mainly on relief to improve access to food aid, water and health services, and integrated natural resource management has not yet been a focus in the agenda of development partners (Weldeselasie et al., 2017).

1. **Land fragmentation.** Traditionally, forests, woodlands and rangelands in dryland areas are communally used and traditionally managed. But increasingly, land is being fragmented in various ways and coming under different ownership regimes – often individual, or privatized for investment, for enclosures, and for commodification of rangeland resources (Lind et al., 2016), reducing mobility of people and their livestock.
2. **Sedentarization.** Population growth and improvements in road, transport and communication services facilitate the emergence and expansion of small towns, with increased demand for fuelwood and charcoal.
3. **Resource related conflicts.** Frequent droughts, dependence on natural resources, and land fragmentation, all fuel intra-ethnic and inter-ethnic conflicts, increasing vulnerability and undermining livelihood options.
4. **Market failures.** Livestock and livestock products are the major sources of income for pastoralists and agropastoralists. Much trade is international (Figure 4), so the facilitation of legal cross border trade and addressing the root causes of regular livestock trade bans and border closures is required, such as increased incidence of livestock diseases, and security related concerns.
5. **Climate variability and change.** Long term trends show an increased incidence and severity of droughts and floods, aggravating resource related conflicts, as well as an increased incidence of human and livestock diseases, all compounded by locust invasions and Covid.

These must be dealt with in an integrated manner, building the resilience of dryland socio-ecological systems, and building the capacity of communities to manage their resources and their conflicts.



Figure 4. Livestock flows and marketing routes in eastern Africa.

Sources: Lind et al., 2016.

Dynamics of livestock-dependent livelihood systems

The systems

Most people living in dryland areas are largely dependent on livestock production, which consists of three major livestock based livelihood systems (Lind et al., 2017) (see also Figure 5).

1. Customary pastoralism, highly dependent on livestock production, based on herd splitting and long distance movement to use periodically available feed and water resources, and based on a network of clan and family relationships for the exchange of livestock and labour.
2. Agropastoralism, combining livestock production with crop farming, and to a lesser extent other forms of income generating activities. Most income is from livestock, though there is a trend towards alternative sources as the poverty level increases.
3. Commercial farms or ranches, oriented towards meeting the demands of domestic and international markets, which are becoming increasingly important in East Africa but are less well developed in Ethiopia.

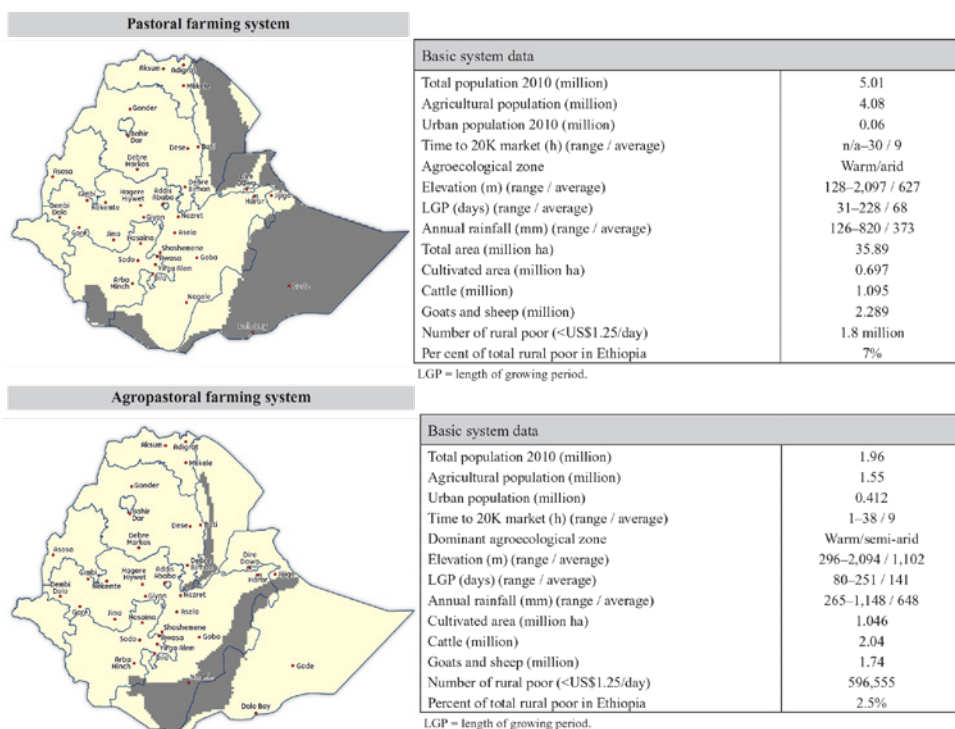


Figure 5. Pastoral and agropastoral production systems in Ethiopia. Source: Amede et al., 2017.

Though pastoralism and agropastoralism are the major livelihood systems, a closer look at the livelihoods of dryland communities shows that they are diversified, with access to markets and good natural resources the two major driving forces (Lind et al., 2017). Accordingly, community members who have both of these will keep their livestock and move towards increased commercialization. But a greater and growing number of people find themselves on the opposite end of the scale, and are forced to exit livestock production and engage in low-return alternatives (Figure 6).

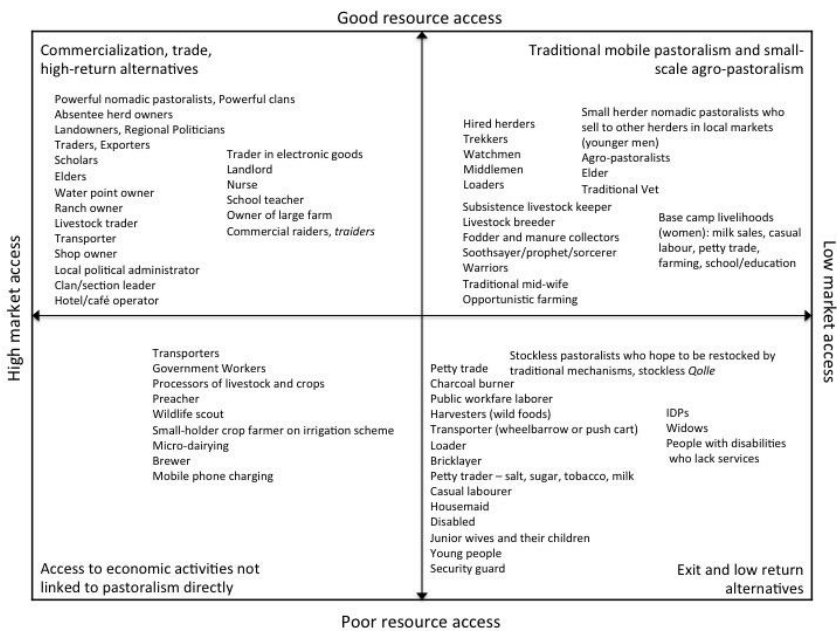


Figure 6. Mapping household and individual livelihood and economic activities.
Source: Lind et al., 2017 (p32).

Income sources

These are diverse, and, noting the importance of food aid to households (Figure 7a), include cash from the sale of gums and resins (7b), firewood and charcoal (7c), and from petty trade and self-employment (7d), with non-livestock sources of income particularly high among poorer people.

Natural resource management challenges

Poor governance of natural resources and weak implementation capacity of key actors at grassroots level have been identified as chronic challenges that aggravate the impacts of climate variability and change in the dryland areas. Over decades, attempts to combat

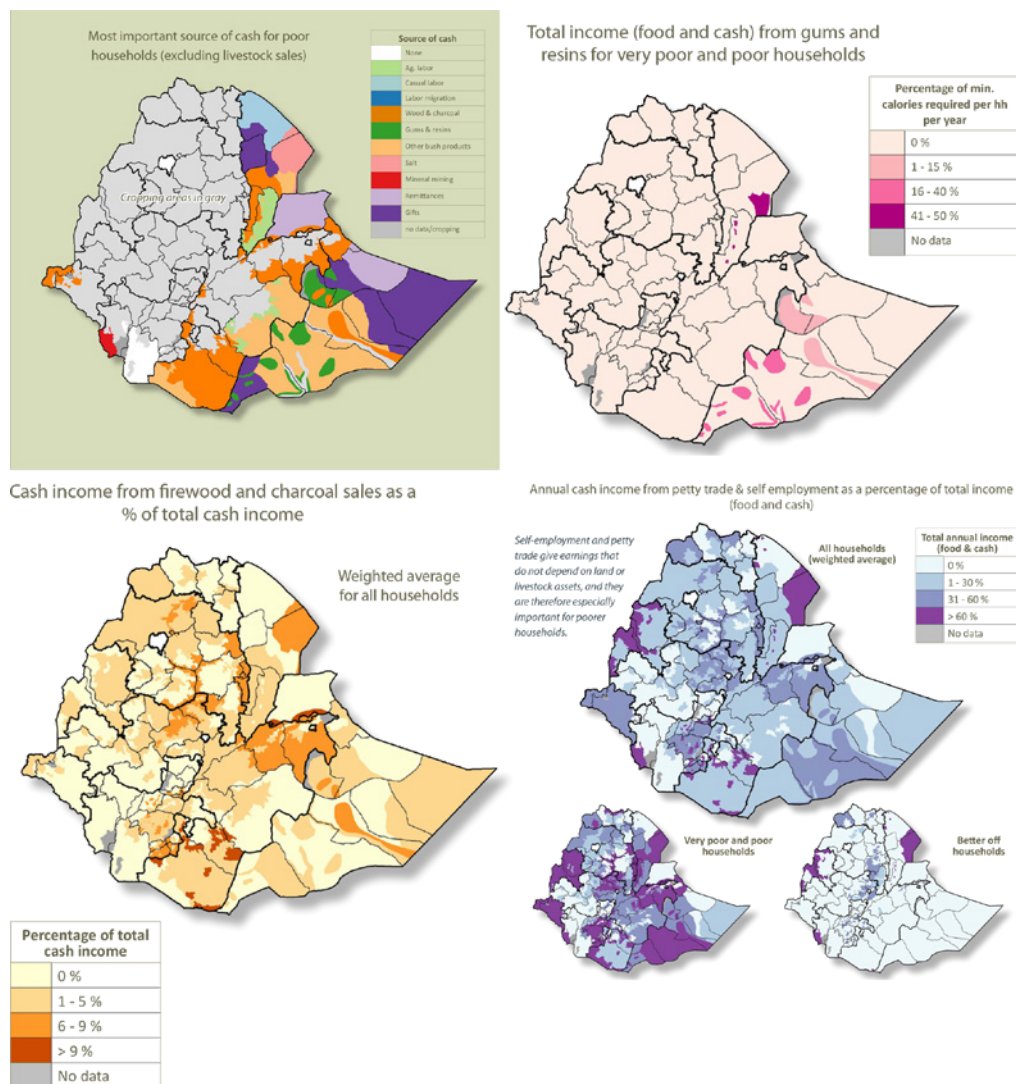


Figure 7. (a) Main cash sources for poor pastoralists (top left), (b) annual cash incomes from sale of gums and resins (top right), (c) firewood and charcoal (bottom left), and (d) petty trade and self-employment (bottom right). Source: http://foodeconomy.com/wp-content/uploads/2016/02/Atlas-Final-Web-Version-6_14.pdf

famine and poverty focused on relief and, when they did address livelihoods, on increasing food production. Little or no emphasis was given to rehabilitating degraded drylands and managing natural resources at landscape level in ways that would better support agriculture and other sectors (e.g. water and energy). The fundamental connection between the resource base and livelihoods, described above, was missed. Moreover, disconnects

within and between sectoral policies and strategies persist, notably with respect to food production, energy generation and forest conservation. As a result, in spite of all the efforts to address it, food insecurity continues, and vulnerability remains high in dryland areas.

The following four key challenges need to be addressed in order to increase the effectiveness and efficiency of efforts towards improved, integrated natural resource management, and produce better livelihood outcomes in the drylands.

1. Lack of reliable data to inform planning, requires improved collection, analysis and sharing of biophysical and socioeconomic data on dryland resources and communities.
2. Knowledge gaps must be addressed, for example on appropriate tenure regimes that would work in pastoral and agropastoral areas, on the optimal role that traditional institutions can play, on how best to manage interactions between livestock and natural resources, and on competing demands for land and changes in land use.
3. The short term and top down planning practices of government and NGOs needs to be revisited, as they fail to involve key actors, notably communities, in identifying options for building livelihoods and sustainably managing natural resources in dryland areas.
4. Poor coordination of activities across and between different sectors and actors, particularly those of land, water, agriculture, forests and wildlife, and investors from the private sector. Even research, education, and development institutions within the same sector fail to work together effectively, and have sub-optimal engagement with communities and CBOs. Sectoral activities at landscape level must be coordinated to minimise trade-offs, costs, and duplication of efforts, and to maximize complementarity.

In light of the key issues raised above, with respect to a broad set of interlinked resource management and livelihoods challenges, agencies working towards restoring landscapes while at the same time improving the livelihoods of communities in drylands, are advised to take note of and internalize the following.

- Reducing socioecological vulnerability requires a realization that the task is not simple, but complex and requires a landscape approach, putting in place accountable and effective governance that also facilitates the marketing of livestock and other products from dryland resources, and ensuring genuine participation of communities and their traditional institutions.
- Improved natural resources management will reduce trade-offs and maximize synergies between economic development and conservation goals, and also minimize the duplication of efforts across different sectors and actors, thus reducing the costs of uncoordinated and sector-specific interventions.

- Restoring landscapes and natural resource management, including the management of dryland forests, must be based on good science and also be informed by local knowledge. Efforts must also simultaneously support and promote livelihoods, and be nested from local to national levels, so that they are mutually consistent.

Conclusions

The goal of natural resources management is to increase the resilience of socioecological systems in ways that build livelihoods while also maintaining and, if possible, improving the health of the ecosystems. In support of efforts towards this goal, this review of the context for dryland restoration efforts has outlined the main characteristics, drivers of change and livelihood dynamics in drylands. In Ethiopia, significant disconnects exist between agricultural and forest policies and their supporting strategies, and these policies and strategies have been on a collision course (Franks et al., 2017). This is much more evident in dryland areas where the need to conserve existing forests is pressing, and must be part of a broader effort to combat desertification and conserve biodiversity. But the risks and trade-offs associated with these sectoral disconnects have been greatly underestimated.

A much better understanding of the major drivers of change is needed, along with the proper articulation of options that maximize synergies when planning interventions to achieve SDG 2, to ‘end hunger, achieve food security and improved nutrition, and promote sustainable agriculture’, and SDG 15, to ‘protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and biodiversity loss’. The following are essential prerequisites for the agencies and programs involved.

- Critically assess and learn from past and on-going conservation and development interventions.
- Adopt a landscape approach to better manage risks and trade-offs, and maximize synergies in pursuing conservation and food production goals simultaneously.
- Move towards cross-sectoral planning and collaboration by actively engaging with relevant actors across sectors to minimize gaps and overlaps.
- Facilitate genuine participation of communities, with an emphasis on women and youth.
- Build effective partnerships with relevant institutions working in dryland areas and negotiate and agree on plans and implementation modalities and responsibilities.
- Become active players in building knowledge, with joint planning and monitoring and evaluation, so that intervention plans support the natural resource base, and increase productivity and incomes.

- Facilitate and promote co-learning amongst actors and encourage use of future scenarios and models to select preferred pathways of change, to maximize and sustain positive changes in people's lives and in ecosystems.

Promoting sustainable forest management and building local livelihoods also requires an acknowledgement of the rapid changes in land use and land cover that have occurred. These changes are partly due to population pressure and climate variability, but also to institutional failures, such as not having the necessary national plans and policies in place, and a failure to enforce the relevant existing laws. In addition, knowledge on feasible restoration options in the drylands, including through tree planting, remains limited, making it doubly important to protect what still exists and use it responsibly, rather than planning the establishment of new forests.

Development and conservation efforts need to complement each other. Interventions should use scientific and technological advances and be informed by local experiences. This calls for cross-sectoral collaboration and landscape level planning, and working together through jointly agreed plans and targets, and implementation and monitoring mechanisms. The challenges that restrict this kind of collaboration must immediately be addressed. If given the right policy signals, institutional and market support, the people themselves become active agents of landscape restoration. Thus, plans should bring communities to the centre, and promote active community participation and involvement in decision-making. Finally, a greater effort is needed to ensure that communities have attractive economic incentives to engage in the sustainable management of dryland forests and woodlands.

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Towards the sustainable conservation, management and utilization of dry forests in Ethiopia

Wubalem Tadesse

Introduction

Drylands cover nearly 75% of Ethiopia, with 55% of this being arid and semi-arid lands, and are home to 12% of the population, most having pastoral and agropastoral based livelihoods. Ethiopian dry forests contain diverse and multipurpose timber and non-timber producing tree and shrub species. The most important non-timber forest products include natural gums and resins, honey and beeswax, bamboo, and other edible and medicinal plant products. However, dry forest resources are threatened by accelerated deforestation and degradation, driven by a set of interrelated factors.

Drylands contain diverse renewable and non-renewable natural resources that have enormous socioeconomic and ecological significance. The major dryland resources include dry forests, water, diversified livestock and crop species, most of the country's protected areas and mineral resources. But recent decades have seen the introduction of large scale development programme such as hydroelectric dams and expanding commercial agriculture, which will enable expanded use of the abundant resource potentials available. The drylands also support millions of pastoral and agropastoral people, with the provision of vital goods and services (Lemenih and Bongers, 2011).

Dry forest resources are threatened however, as a result of accelerated degradation and deforestation aggravated by sev-

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eral interrelated factors including the expansion of agricultural land, overgrazing, population growth, forest fires, pests and diseases, the ever-growing demand for wood for fuel and construction, and unsustainable resource utilization (Lemenih and Kassa, 2010; Eshete, 2011). The lack of forest ownership, for local communities, the growth of competing land uses, demographic pressure and climatic changes also seriously undermine the conservation and development of dry forest resources (Atmadja et al., 2019). The major overarching challenges are the lack of coordination among stakeholders, poor land use planning, ill-defined ownership rights, and weak legal frameworks and law enforcement. As such, mitigation measures include implementing land use planning, putting in place strong institutions, strengthening collaboration among main partner institutions, and enforcing and harmonizing forest-related policies, proclamations and legislation with those governing other sectors such as agriculture, energy, and industrial development, which impinge upon forests.

Ethiopian dry forests are legally owned by the state, but governed by institutions with a low capacity for proper forest management. Consequently, forests are mined rather than properly managed, which accelerates their degradation (Lemenih, 2011). Management of dry forests to enhance the economic and ecological benefits of gum and resin producing trees is limited. One of the major constraints on the promotion of sustainable dry forest management is a lack of awareness of their importance, combined with inadequate knowledge about the sustainable production and marketing of forest products (Lemenih and Kassa, 2011). In what follows, we will describe the main challenges, relating to poor coordination among the main stakeholders, land use planning, ownership, legal frameworks and law enforcement, and suggest possible mitigation measures.

Coordination between stakeholders

Main challenges

Weak coordination in and among sectors, e.g. between the forestry and agricultural sectors, leads to the mismanagement of dry forest resources. Moreover, the problems are compounded by the weak links between forestry institutions (those for research, education and extension) and with policy makers, NGOs and the private sector actors engaged in the development and management of natural gum and resin products. Effective implementation of policies and legislation relies upon effective coordination across different sectors and at different levels. Furthermore, development is hampered by poor institutional arrangements, and the lack of the kinds of flexible legal frameworks that are appropriate for the new challenges in forest management, as well as a lack of capacity in forest governance, with forestry institutions that are underfunded and understaffed. In addition, there has been a failure to harmonize policies across forestry and other sectors, so that policies on investment, water, energy and food security are not consistent with, or tend to work against, sustainable forest management (CIFOR, 2015). There is also a lack of clear

and equitable benefit sharing mechanisms. According to Proclamation No. 1065/2018, local communities have the right to equal benefit sharing from forest management programmes. However, the non-existence of institutional mechanisms, such as standards, directives or guidelines for implementation, has fostered dissatisfaction, for example, surrounding the management and conservation of *Boswellia-Acacia-Commiphora* dominated woodlands by local communities.

Mitigation measures

It is important to realize the importance of and improve collaboration between stakeholders with a mutual interest in the sustainable management of dry forests (Atmadja et al., 2019). Issues around sustainable forest management touch upon the livelihoods of a broad spectrum of people, from people working in government agencies to households living next to forests, and urban households, industries, tour operators, refugee camp managers and residents, and exporters of forest products. Some aspects of policy, notably the national REDD+ strategy and participatory forest management programs, are being integrated systematically within government systems and the actions of local communities. This needs to be further strengthened by empowering local communities, forestry experts and law enforcement agencies to work together, in ways that foster mutual trust and in pursuit of mutual benefits. And this requires a system of accountability based on a clear delineation of roles, rights, and responsibilities (Atmadja et al., 2019). The success of policies and regulations depends on the coordination of actions in different sectors at different levels and on institutional arrangements that provide for coherent functional linkages among the various institutions relevant in the forest, agriculture and energy sectors. This kind of coordination is essential for the successful production, marketing and utilization of dry forest resources. A central principle here is the integration of economic and environmental sustainability, and enhanced coordination is crucial in this.

Recommendations here are to (i) improve inter-sectoral integration and harmonization of government policies, strategies proclamations and regulations, (ii) promote local value addition, processing and post-harvest handling of forest products, encouraging organized production and collective marketing for enhanced productivity, quality and strong financial returns, and (iii) strengthen existing cooperatives and collective actions to boost the bargaining power of local actors and the traceability of products.

Land use planning and clear ownership

Main challenges

The lack of land use planning has presented serious challenges, affecting national forest development in general and dry forest resources management and utilization in particular. Communities and households have been managing forests for centuries, despite not

having clear ownership over these resources. The traditional institutions, which once regulated the use of forests and trees quite effectively, have been eroded. In the absence of clear ownership rights, decisions are skewed towards short-term gains, since there are no guarantees that community members would be able to benefit from any investments in the long term (Atmadja et al., 2019). Further, weak rural land administration capabilities and complex administrative arrangements in the different regions hamper the coordination and implementation of dry forest management and utilization practices (CIFOR, 2015).

Mitigation measures

Developing and enforcing effective national and regional land use plans appears to be the first priority for the sustainable management and utilization of dryland forests and enhanced biodiversity conservation. In areas designated as protected or production forests, relevant policies, laws and regulations, and international agreements and commitments, need to be respected to ensure that biodiversity conservation is adequately addressed. Inconsistent or contradictory forest, environment and land-use policies and laws at national and regional level must be identified, reviewed and modified accordingly (Atmadja et al., 2019).

The 2018 Forest Proclamation provides the framework for communities and associations to sustainably utilize and manage ‘their’ forests, by having provisions for forest ownership. These provisions need to be translated into institutions, regulations and clear procedures on exactly how non-state actors can gain ownership rights over forests. In particular, the proclamation states that any forest ownership must be located in areas designated by the government as forest land, but this can be a severe bottleneck and could lead to less involvement of communities in forest management if the process is not managed effectively. In particular, there are overlaps in definitions and authority over “rural land” as stipulated in the 2005 Rural Land Administration and Land Use Proclamation, and “forest lands” in the 2018 Forest Proclamation. The Land Proclamation is geared towards land ownership for agriculture, pastoralism and agropastoralism, but has no specific provisions for forestry despite including forests as part of the definition of rural lands. Ethiopia can build on the experience of implementing programmes to provide certificates for agricultural land, which have been successfully rolled out in several regions (Atmadja et al., 2019).

But putting policy into practice requires strong forestry institutions. A strong forest institution needs to be adequately staffed with skilled professionals who can design, implement and scale up best forest management practices. A training plan has to be developed for new employees of these institutions so that they are equipped to carry out their responsibilities. The provision of adequate funding for their activities is also essential, requiring political will and commitment to promote forestry development (CIFOR,

2015). It is also imperative to improve forest product value chains, to include improved processing and marketing, especially of NTFPs. This will create forest based employment opportunities for youth and women, including in tree seed collection, processing and distribution, and in the production of seedlings.

Legal frameworks and law enforcement

Main challenges

Existing policies and legal frameworks lack comprehensive directives and legal instruments for the effective implementation of current laws, legislation, proclamations and strategies, even though these have been in place for a number of years. There are no guidelines, and directives still appear to facilitate the implementation of different programmes with opposing goals. These deficiencies are compounded by the absence of provisions for effective law enforcement, which hampers progress towards sustainable dry forest management, and in particular the development of gums and resins production and sale. For example, there are several provisions and prohibitions in Proclamation No. 542/2007 and Proclamation No. 1065/2018, but due to the low-level of awareness among law implementing agents, illegal activities in forests are widespread, including free grazing, fuelwood collection and charcoal production. The enforcement of penalties is equally limited by bureaucratic issues, ultimately leading to an unfair distribution of benefits as well as to resource degradation. Together, inadequate institutional capacity, the lack of financial and human resources, the absence of proper implementation of guidelines, and the counter-productively complex restructuring of forestry institutions at national and regional levels, all undermine the ability of forestry sector institutions to implement existing legal frameworks and policies.

Mitigation measures

Strong enforcement of existing and new laws and proclamations is required for the sustainable management of dry forests. It is also necessary to integrate and harmonize existing forest legal and policy frameworks with those of other sectors, as policies and regulations in other sectors may affect the management of forest resources. The following actions can improve inter-sectoral integration and coordination (Atmadja et al., 2019):

- Harmonize forest-related policies and proclamations with policies and legislation of other sectors, including those of agriculture, energy, and industrial development.
- Increase coordination and cooperation across relevant sectors at different levels, with inter alia memorandums of cooperation across ministries and their regional offices, joint conferences, workshops and training events, and the establishment of inter-sectoral working groups or forums.

- Revise and integrate existing forest policies into national development and poverty reduction policies, while also integrating national climate change, food security and poverty reduction objectives into national forest programmes.

State agencies at different levels, federal, regional, woreda (district) and kebele (neighbourhood), need to create an appropriate legal and regulatory framework for managing forest resources in order to maximize benefits from all potential uses of forests, and to grant use and management rights and responsibilities to forest users with concomitant responsibility for sustainable management (CIFOR, 2015).

Conclusions

Ethiopian drylands contain highly resilient species adapted to the seasonal pattern of rainfall and recurrent droughts, and the dry forests provide many socioeconomic and ecological benefits, but are poorly managed and have received limited attention to date. The Government of Ethiopia has given due attention to forest development through the development of different policies, programmes and regulations. However, there has been inadequate attention to dry forest management in general, and to gums and resins production, processing and trade in particular. Existing regulations on the use and management of dry forest gums and resins production from public forests refer only to a concession system for commercial companies (Teshale, 2011). Dry woodlands are often labelled as less productive and less attractive for forest-based development, implying that their benefits are overlooked. Unless these inaccurate perceptions are overturned, more dry forests will be converted into farmland (Lemenih et al., 2007).

A number of challenges critically affect the forest sector, the most important of which is deforestation and forest degradation. Thus, the government must give priority to actions in the forest sector in general and dry forest resources in particular, with the following key elements:

1. Strengthening government institutions involved in development, extension, research and education.
2. Implement federal and regional land use planning, and enforce forest ownership and environmental policies with special attention given to areas where large-scale investments are proposed.
3. Establish area exclosures in selected degraded dry forests, with appropriate afforestation and reforestation programmes, and the introduction of appropriate dry forest silvicultural practices.
4. Promote value addition through enhanced processing and marketing opportunities for forest products, aiming to promote exports and the substitution of imported forest products.

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Dry forests types and composition in Ethiopia: characteristics, threats and policies

Yitebitu Moges

Introduction

Drylands in Ethiopia cover more than 70% of the country's territory, or 17 million hectares (Atmadja et al., 2019), supporting one third of the livestock population and about one sixth of its people, and enabling the provision of diverse products and services. However, despite their extent and their ecological, economic and social significance, the values of dry forests are underestimated and their ecology still poorly known, and unlike forests in other regions, they receive little attention in national discourse on environmental policies. Though dry forests store more than 80% of national forest carbon (Moges et al., 2010), they are threatened by conversion to agriculture, fire, unsustainable charcoal and fuelwood harvesting, and invasion by alien species such as *Prosopis juliflora*. And, it is important to note, about half of national forest carbon emissions originate from dryland forests (EFCCC, 2017).

Drylands also host a rich and unique biodiversity. Most of the country's national parks and protected areas are found in the drylands. Moreover, the drylands act as a wall against the expansion of deserts from the Sahelian zones into the highlands, safeguarding the livelihoods of tens of millions of Ethiopians. Dryland forests contribute to local economies through economically important products such as gums and resins, as well as providing what amounts to a safety net for local populations, a buffer against environmental disasters and livelihoods crises, through charcoal and fuelwood sales.

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Trees and forests in the drylands lands help mitigate economic challenges and they also provide vital environmental services such as habitats for biodiversity, the prevention of erosion and desertification, and the regulation of water, microclimates and soil fertility. However, dryland ecosystems are vulnerable to water shortage, drought, desertification, land-use change and degradation and climate change impacts, with dangerous ramifications for the food security, livelihoods and wellbeing of their populations. Confronted frequently with the impacts of drought, famine and conflict in the drylands, the Government of Ethiopia has endeavored to improve the lives of people in the drylands, undertaking very substantial development and safety net programs, but these efforts have produced inadequate impacts and limited success. Nevertheless, these efforts to promote sustainable development in the drylands need to continue, supported by adequate investments, as well as efforts to promote sound environmental management, informed by a deep understanding of local conditions, in order to safeguard these vulnerable ecosystems.

Natural vegetation

With a complex physiography (land form, altitude and terrain) and monsoon rainfall systems, western Ethiopia receives higher rainfall due to its exposure to the longer African monsoon. Eastern Ethiopia is largely under the influence of the short-lived Indian monsoon. It also receives moisture from southwestern African monsoon winds, but this is largely blocked by being in the Ethiopian massif rain shadow.

There are estimated to be 6500-7000 higher plant species in Ethiopia, that live in one or more of 12 major biomes (Ib et al., 2010). These include: (1) desert and semi-desert scrubland, (2) *Acacia-Commiphora* woodland and bushland, (3) wooded grassland of western Gambella, (4) *Combretum-Terminalia* woodland and wooded grassland, (5) dry evergreen Afromontane forest and grassland, (6) moist evergreen Afromontane forest, (7) transitional rainforest, (8) the ericaceous belt, (9) the Afro-Alpine belt, (10) riverine vegetation, (11) freshwater lakes, marsh and floodplain vegetation, and (12) salt lakes, marshes and pan vegetation.

Though estimates for the extent of dry forests in Ethiopia have not yet been systematically assessed, they are estimated to comprise more than two-thirds of the total forested areas of the country. Preliminary estimates by EFCCC (2013) state that there are 12 million hectares of dry forests, or 17.3 million hectares according to Atmadja et al. (2019). Dryland forests are present in three of the biomes listed above: in *Acacia-Commiphora* woodland and bushland, in *Combretum-Terminalia* woodland and wooded grassland, and in dry evergreen Afromontane forest, and sometimes the wooded grassland of western Gambella is also included in this category (Atmadja et al., 2019; Mengist, 2020). *Acacia-Commiphora* (small-leaved) deciduous woodlands and shrublands are found in the deserts of Afar and Somali regions (in the Ogaden). *Combretum-Terminalia* (broadleaved) decid-

uous woodlands are found in the western lowlands, while dry Afromontane forests occur in parts of the central highlands having dry sub-humid Afromontane ecosystems.

Acacia-Commiphora woodland and bushland forest vegetation

This vegetation type is common over large lowland areas (900-1900 masl), divided into two subtypes, one in the Rift Valley, and the other in eastern and southern Ethiopia (Ib et al., 2010). *Acacia-Commiphora* woodland and bushland vegetation is dominated by drought-resistant trees and shrubs, with deciduous or small evergreen leaves. The most common are *Acacia bussei*, *A. drepanolobium*, *A. hamulosa*, *A. ogadensis*, *A. prasinata* (endemic), *A. reficiens*, *A. tortilis*, *A. zizyphispina*, *Boswellia microphylla*, *B. neglecta*, *Commiphora alaticaulis*, *C. albiflora*, *C. ancistrophora*, amongst others. Some endemic succulents are prominent, e.g. *Euphorbia awashensis*, *E. monacantha*, *E. burgeri*, *E. ctyptocaulis*, *E. dalettiensis*, *E. gymnocalycioides*, *E. longispina*, (Ib et al., 2010; Liao et al., 2018).

The Acacia wooded grassland of the Rift Valley extends from the Upper Awash in the north to Konso town in the south, including the Rift Valley lakes. It resembles the Acacia-dominated wooded grasslands of Gambella, but differs by the absence of flooding and grass fire, and in the presence of *Faidherbia albida* and *Acacia tortilis* (Ib et al., 2010), and species including *A. etbaica*, *A. seyal*, *A. senegal*. Other species include *Croton dichogamus*, *Euphorbia* spp. and grasses of the genera *Heteropogon*, *Setaria*, *Sporobolus* and *Panicum*. There are also succulents like *Aloe trichosantha*, *A. gilbertii* subsp. *gilbertii* and *Euphorbia nigrispinioides* (Ib et al., 2010).

The bushland subtype in the lowlands (400-1900 masl) of southern, southeastern and some western parts of Ethiopia (Ib et al., 2010) is found in shallow soils, on hills, escarpments, mountains and gorge slopes. At the slope bases, it is dominated by grasses or forms bush-grass complexes. The dominant woody species are *Maytenus senegalensis*, *Carissa spinarum*, *Clausena anisata*, *Clerodendrum myricoides*, *Grewia ferruginea*, *Caesalpinia decapetala*, *Ficus verruculosa*, *Calpurnia aurea*, *Erica arborea*, *Hypericum revolutum*, *Vernonia* spp., *Senna* spp., *Cordia* spp., *Acacia* spp., *Commiphora africana*, and *Indigofera* spp.

Combretum-Terminalia woodland and wooded grassland vegetation

This vegetation type is found in the western escarpment of the Ethiopian plateau from the Eritrea border to western Kefa and Omo Zone, also in Benshangul-Gumuz and Gambela, the Didesa valley, and in northern, eastern, central and southwestern and parts of the country. It is dominated by small to moderate-sized trees with large deciduous leaves, from the Combretaceae family, with woody legumes but few *Acacia* spp., which are only found on vertisols in more humid lowland areas or river valleys. The understory is a mixture of herbs and grasses including those of the genera *Hyparrhenia*, *Panicum* and

Pennisetum, which tend to be burnt off during the dry season to promote resprouting (Ib et al., 2010; Addi et al., 2016). This vegetation type includes a total of 199 identified species, subspecies and varieties of woody plants, of which 81 are recorded only in this ecosystem.

Common woody species include *Combretum adenogonium*, *C. hartmannianum*, *C. molle*, *C. rochetianum* and *C. collinum*, and *Terminalia laxiflora*, *T. macroptera*, and *T. schimperiana*. Other species are *Cussonia arborea*, *Boswellia papyrifera*, *Anogeissus leiocarpa*, *Lonchocarpus laxiflorus*, *Pterocarpus lucens*, *Dalbergia melanoxylon*, *Piliostigma thonningii*, *Balanites aegyptiaca*, *Stereospermum kunthianum*, *Lannea barteri*, *L. Jruticosa*, *L. schimperiana* and *L. schweinfurthii*, *Ozoroa pulcherrima*, *Sclerocarya birrea* subsp. *birrea*, *Vitex doniana*, *Acacia hockii*, and *Grewia mollis*. The number of woody species is fewer than 100, fewer than in *Acacia-Commiphora* woodland, and shrubby herb species are less common than in other vegetation categories (Ib et al., 2010).

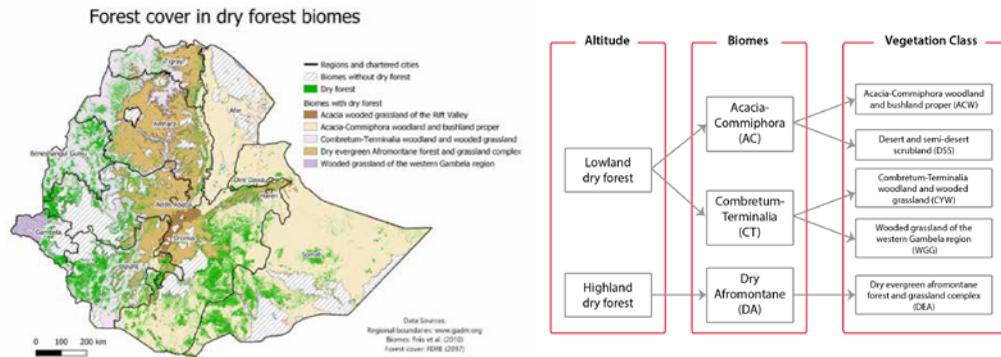


Figure 1: Dry forest biomes and subtypes in Ethiopia. Source: Antmadja et al., 2019.

Dry evergreen Afromontane forest and grassland

This is found in highland areas (1800-3000 m altitude, 400-1700 mm mar). In higher rainfall areas in the west and southeast, there is moist Afromontane forest with at least six months of rainfall and annual precipitation of >1700 mm (Bekele, 1993). This biome is a complex vegetation type, including grassland, shrubs, various sized trees and closed canopy forest with various strata. A total of 128 recorded are recorded only from this vegetation type, and based on floristic diversity, it is the second more diverse dryland vegetation type after *Acacia-Commiphora* woodland and bushland.

It is dominated by *Juniperus procera*, with a substantial proportion of *Olea europaea* subsp. *cuspidata* and *Podocarpus falcatus*. Vegetation is divided into distinct groups: Afromontane forest with either *Podocarpus*, *Juniperus* or mixed forest, Afromontane woodland, wooded grassland and grassland, and a transition type between Afromontane

and *Acacia-Commiphora* bushland on eastern escarpments (Ib et al., 2010). However, agricultural has seriously affected this ecosystem in northern Ethiopia, and many south-western areas have been cleared for subsistence farming, coffee and tea plantations, and resettlement programmes (Ib et al., 2010; Addi et al., 2016).

National measures to address dryland forest challenges

There are six major issues surrounding dryland forest management and sustainable dryland development.

- Deforestation, land degradation and desertification: Increasing populations with growing needs for resources, together with the unsustainable exploitation of natural resources, mainly land and fuel, coupled with poor agricultural and livestock husbandry, leading to further degradation and desertification.
- Climate change: The drylands are vulnerable and have expanded significantly over the past 60 years and continue to do so.
- Social conflict and migration: Land degradation and desertification, combined with drought, hunger, violence and water scarcity, lead to migration out of dryland regions.
- Invisibility of drylands to public policy making: Drylands and their forests have not attracted the same level of interest and investment as humid tropical forests.
- Invasive species: Due to high levels of ecological disturbance and degradation, drylands are very vulnerable to invasive species.
- Limited knowledge base: There is insufficient knowledge of the resources that exist in the drylands, as well as low institutional capabilities in the forestry sector. It is imperative to address these gaps, with an expanded research effort as well as intensified policy analysis and debate on the drylands and dryland forests.

The Ethiopian government's forest restoration plans are very bold, following on from international initiatives such as the Bonn Challenge, AFR100, and the New York Declaration on Forests. In response, Ethiopia has pledged to meet an ambitious national target of restoring 15 million ha of degraded land into forest by 2030. This reflects an increasingly strong political will backing the goal of sustainably protecting and managing Ethiopian forests, including dry forests. The National REDD+ Strategy (2016-2030) and the 10-Year National Forest Sector Program aim to protect the existing 17.3 million hectares of natural forests, and two-thirds of this is dry forest. With the stated priorities of saving carbon and protecting biodiversity rich forests in the southwest, the REDD+ strategy will also implement policy and investment measures in dryland forests in order to address threats from conversion to agriculture and unsustainable firewood harvesting and charcoal production. Moist forests in southwest Ethiopia are prioritized for conservation through the implementation of participatory forest management, with two other large scale REDD+ programmes: the REDD+ Investment Program, and the

Oromia Forested Landscape Program, covering over 140 woredas in Oromia, SNNP and Gambella regions. In parallel, the government has supported the establishment of 4 million hectares of area exclosures, preventing further ecosystem degradation, promoting forest regeneration, and restoring the overall ecology of the areas.

A range of additional sustainable land management activities, going beyond just passively closing off an area, are also implemented in order to improve restoration and livelihoods outcomes. These include: (i) tree planting and sowing grass seed, (ii) pruning young trees, (iii) establishment of physical soil and water conservation structures, and (iv) rain-water harvesting and supporting small-scale irrigation outside of area exclosures.

At the policy level, the government has integrated forests in key national documents that guide policies, regulations, and actions, including these measures amongst others relevant to the sustainable management of the drylands.

- The Climate Resilient Green Economy (CRGE) strategy
- Ethiopia's nationally determined contributions (NDCs), the country's overarching international commitment, based on sectoral analysis.
- The Growth and Transformation Plan 2 (GTP2)
- The National REDD+ strategy
- The Forest Sector Development Program
- The 10 Years Perspective Plan
- The National Adaptation Plan

In addition, as a signatory to the UNFCCC, UNCCD and UNCBD, Ethiopia attempts to draw technical capacity and finances from the international community, to address deforestation and forest degradation in its remaining forests (through REDD+, under UNFCCC), forest restoration (under the Bonn Challenge – consisting of assisted natural regeneration and area exclosures), and tree planting (under the government's Green Legacy Initiative, covering sub-humid climates). Furthermore, the government promotes institutional and legal measures domestically (led by the EFCCC, with the revised forest proclamation and related regulations), as well as interventions involving the mobilization of people and resources in soil and water conservation across the country, and public awareness campaigns on the significance of forests and woodlands;

Conclusions and way forward

Drylands are uniquely rich in floral and faunal diversity and suitable for game reserves and national parks, and their regenerative potential is high, given reduced pressure from human and livestock populations. But dry forests, despite their important socioeconomic

and ecological benefits, receive little attention and are poorly managed. As such, the following are recommended as a way forward.

- Create enabling frameworks for improving dryland forest management, develop appropriate policies, updating laws and regulations, and build stronger and more sustainable institutions, in order to make it possible to expand forest cover through restoration and optimize forest landscape conservation.
- Improve conditions for actors in the forestry and range management sectors to implement interventions to reduce degradation and the loss of dryland forests and biodiversity, including the introduction of alternatives to fuelwood and charcoal, the promotion of efficient biomass burning technologies and use of efficient kilns.
- Regularly assess and improve the economic environment for forest production, assess and monitor the demand for non-wood forest products, encourage measures to adjust production in line with demand, and promote the private sector's participation in enhancing production.
- Identify protection forests and areas for forest plantations in irrigable areas, and incorporate them into land-use management and village level planning, for environmental conservation, desertification control and improved incomes and livelihoods.
- Implement sustainable forest management practices, selecting the most appropriate species for planting and promoting natural regeneration, as part of a locally tailored set of actions to include assisted natural regeneration, enrichment planting, vegetative propagation, and ploughing to increase rain infiltration.
- Enhance awareness, and strengthen education and knowledge around drylands issues, build related capacity, and take steps to increase the salience of dry forest development among the public and policy makers.
- Support traditional conservation and management methods, building on local people's knowledge and institutions, and promote benefit sharing from conservation revenues, developing inclusive mechanisms for this.

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Dryland development through resource base restoration in Ethiopia and beyond

Kidane Georgis

Introduction

Drylands in Ethiopia cover about 75% of the land mass and agro-pastoral systems are among the major production systems in the country (Georgis, 2015; 2010). But the drylands are degrading, leading to declining agricultural production, food and feed security. Significant economic problems are associated with reduced livelihood options. The major causes of land degradation are complex and attributed to a combination of biophysical, social, economic and political factors. It is important to note, here, that drylands include all areas where the climate is classified as dry sub-humid, semi-arid and arid (MoA, 2005), encompassing a great deal of ecological diversity and varying potential for production.

This paper outlines strategies to restore the resource base of drylands through conservation-oriented management including forestry and agroforestry, and soil, water and vegetation conservation. Best practices are proposed such as conservation tillage, residue management, crop rotation, terracing, and the use of organic fertilizers. But many policy makers and planners, and even research managers and development workers, do not have a good understanding of the resource base in the drylands, and the associated productive potential. There has been a strong tendency to view the drylands as barren and unproductive, with very limited economic potential. In the past, this misunderstanding has led to the marginalizing of these areas in research and development. As a result, the huge dryland resources that exist are underutilized, and

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degrading due to improper practices. The first issue is to understand and put in place the policies and practices that make it possible to appropriately utilize the resources, and restore them, while improving production to provide food and feed security.

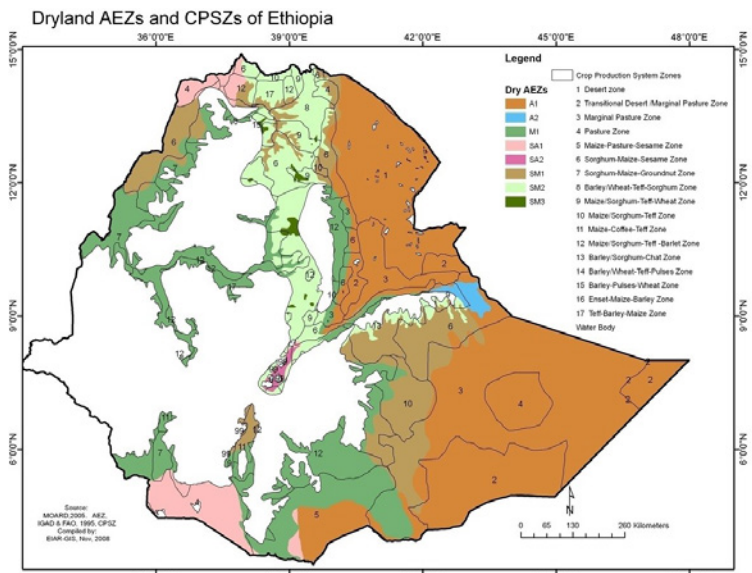


Figure 1. The main dryland agroecological zones in Ethiopia.

The natural resource base

Ethiopian biodiversity is notable, with at least 7000 species of higher plants of which some 600 are endemic. Drylands and rangelands are important in providing forage for livestock and wildlife. Ethiopia is also the centre of origin for many crops and there is a great diversity of cultivated crops, including sorghum, finger millet, field peas, chickpea, cowpea, perennial cotton, safflower, castor bean, and sesame. There are also 120 species of plants recorded as wild food plants in Ethiopia, and 50 of these have been listed and classified as famine foods. Many pastoralists do not store and carry food over long distances, but rely on the seasonal products of forested areas, as exemplified by the Afar pastoralists (Georgis, 2015). A number of forest-food plants are of economic value and are traded in certain areas of Ethiopia (Lemenih, 2005). In remote areas in the Tekeze River lowlands and the Simien Mountains of North Gonder and Wag Hamera, a considerable variety of forest-food plants are offered on local markets (Georgis, 2015). There are also 600 species of medicinal plants, constituting a little over ten percent of Ethiopia's vascular flora. Ethiopia is also endowed with wild spice plants, significant contributors to exports and local economic development.

The drylands, where pastoral livestock keeping dominates production, are also home to an important and diverse stock of animal genetic resources. Examples include the Borana and Jijiga cattle, the black headed Ogaden sheep, the Afar goat, the Somali goat and the different camel breeds. Their conservation and utilization deserve need to be understood and better analysis. Ethiopia also possesses valuable wildlife resources, which have hitherto been little developed, in sharp contrast to those of some of its neighbours, particularly Kenya. There, tourism contributes to around a quarter of GDP and wildlife tourism accounts for the bulk of Kenya's tourism revenue. Ethiopia's drylands have similar, unexploited, potential. More than 277 species of wild mammals and over 886 species of birds have been identified in the major national parks, including those of Awash, the Simien mountains, Rift Valley lakes, Bale mountains and Nechisar. In most cases, the endemic bird areas, game reserves and controlled hunting areas lie in the drylands.

Abiotic resources include water, energy and minerals resources. Ethiopia has vast water resources and the Ethiopian highlands are the source of many rivers of international importance, such as the Blue Nile and the Wabi Shebele, all crossing through dryland areas. Water flows from the highlands, across the Ethiopian drylands, to the Indian Ocean, virtually untapped. There are substantial energy resources, including gas, petroleum and geo-thermal sources in the Rift Valley, as well as mineral resources in several parts. The lowlands are also rich sources of solar and wind energy, in addition to geo-thermal and fossil fuels such as gas, and there are important mineral resources, including limestone, marble, salt, potash (a valuable fertilizer) and gold deposits. Energy reserves have tremendous potential for economic development, but these reserves have barely been explored and tapped.

Challenges and drivers of dryland degradation

The cost of land degradation to the country over 2001-2009 was estimated to be some US\$35 billion (Haile et al., 2006). In most dryland areas, food demand outstrips production due rapid increases in both human and livestock numbers. The major challenges threatening dryland communities are related to degradation of the natural resource base and associated climate change and variability, leading to soil and vegetation loss, and the drying of lakes and rivers. A quarter of Ethiopia is degraded or subject to a high rate of degradation, affecting one third of the population. The pressure on land resources is expected to increase in the next decade, leading to an expansion of low-productivity farming onto marginal lands and the cultivation of land unsuitable for crop production, with poor soil and water management (Georgis, 2003).

Water shortages, drought, soil salinity, grazing pressure, crop and livestock pests and diseases are the main problems. Particular attention should be paid to weeds and invasives, particularly the exotic *Prosopis juliflora* and *Parthenium hysterophorus*. Bush encroach-

ment of native species is also a major problem, and impacts the ability of pastoralists to provide enough grazing for their herds, thereby severely affecting their livelihoods.

Policymakers have long sought to protect the natural resource base by limiting human exploitation. The old view was to set aside land for wildlife sanctuaries and forest reserves, at the expense of local livelihoods and economic development. But this view is giving way to a growing awareness that natural resources in general, and biodiversity conservation in particular, must benefit and serve communities, who ultimately must be the custodians of their own natural wealth. It is now evident that protectionism alone is not adequate to sustain Africa's spectacular biodiversity. Now, it is vital to show how can we restore dryland resources and enable the sustainable growth of agricultural production, with improved local livelihoods.

In providing solutions, agriculture must undergo a paradigm shift in both research and development if Ethiopia's growing population is to be fed and the natural resource base that underpins food and feed production is to be sustained. Business as usual is no longer an option. With a transition to climate resilient, low emitting production systems, agriculture can become part of the solution to sustainable development. There are identified best practices in conservation agriculture, forestry, and in particular agroforestry, as well as integrated watershed management.

Strategies to restore dryland resources

Conservation agriculture

Conservation agriculture relies on three principles: minimum soil disturbance zero tillage, permanent soil cover, and crop rotation and/or mixed cropping. It also includes alley cropping, conservation tillage, the use of alternative crops, organic farming, fallows, and area enclosures, all of which must be promoted. But it is important to better understand how these practices can assist in conserving land resource when natural ecosystems are transformed into agroecosystems for the production of food and fibre.

Watershed development

Watershed management has emerged as an appropriate strategy to manage natural resources and to provide sustainable livelihoods for the rural poor. The Ethiopian Government and other East African governments have adopted watershed approaches as a major strategy for natural resource conservation and management (Georgis, 2010). But this will only be achieved by adopting a system of improved land, water and vegetation management that is based on stakeholder participation. Conceptually, watershed management should integrate various aspects of forestry, agriculture, hydrology, ecology, soils, climatology and other sciences to provide guidelines and perspectives for choosing

acceptable management alternatives within the social and economic context. This is the best strategy in dryland areas, a broad, participatory approach that deploys scientific knowledge across disciplines, while working with local stakeholders to adapt and tailor practice to local conditions (Georgis, 2015; 2010).

Agroforestry

Agroforestry systems are low-cost options for sustainable agriculture. By promoting tree-based agricultural systems the country could improve the wellbeing of its people and the environment on which they depend. They play a significant role in carbon sequestration as well as providing improved agricultural sustainability than monoculture cropping. Therefore, well designed, locally adapted, systems should be promoted in order to restore the productive capacity and resilience of smallholder agriculture.

Alley cropping of woody species with crops is widely practiced by farmers in Ethiopia, with higher productivity and providing safeguards against unfavorable conditions. Experiments on alley cropping with leguminous shrubs (*Cajanus cajan*, *Leucaena leucocephala* and *Sesbania sesban*) in dryland areas in the central Rift Valley and northern Ethiopia showed promising results (Georgis, 1987). They indicated the possibility of producing two crops without reduction in yield, with both stover and grain yields of food crops from the alley cropping system being better than yields from pure stands. At Melkasa, a grain yield increase as high as 30% was obtained when haricot bean was alley cropped with *C. cajan* compared to monocropping. In addition, the shrubs produced substantial amounts of dry matter (a mean yield of 3 t/ha of *Sesbania* was obtained at Sirinka), which can be used for animal feed, fuelwood, or green manure or mulch to improve soil fertility.

Restoration of agriculture and water management

The key to success will be adapting production systems to the natural variability of the environment. Along with this, improved integrated genetic, soil and water management strategies are increasingly needed to maintain and improve productivity, reverse degradation, and restore the resource base. Therefore, it is important to focus on conservation-oriented management practices such as water harvesting and efficient water use, and renewed efforts should be undertaken by the research systems, including both federal and regional institutions, and higher learning institutes.

The way forward should be an integrated approach encompassing genetic improvement and natural resource management as a way to make major food crops more productive, nutritious, and affordable to the poor, and develop tools and techniques to manage risk and more sustainably utilize the natural resource base. Also, traditional monocropping should be converted to a diversified multiple cropping system, that will provide greater

insurance against drought, increase soil fertility without long fallow periods, diversify the family diet, even out labour requirements, and provide additional products for sale. The current dominance of cereal crops, pulses and oil seeds in the crop production system will continue into the future, although shifts in planted area should be in favour of more profitable crops.

Improving livestock production

Livestock in Ethiopia are the principal capital of the farmer, and the rural poor and landless, especially women, obtain a large share of their income from livestock. Increased consumption of even small additional amounts of meat and milk can provide the same level of nutrients, protein and calories to the poor as a large and diverse diet of vegetables and cereals. And among Sub-Saharan countries, Ethiopia has the largest pastoral and agropastoral production system in terms of area covered, as well as human and livestock populations, and resource diversification. The sector, if properly managed and utilized, has huge potential for economic development.

The major problems of livestock production in pastoral areas are rangeland degradation, shortage of feed and water, pests and diseases such as *trypanosomiasis*, and marketing challenges. In addition, changes in temperature and precipitation are affecting the capacity of the land to produce enough feed. Another issue is that much of the prime grazing areas in the Afar Rift Valley has been taken by the government for park development, while herders have not benefited from the associated tourism income. Their herds have been denied access to the park for grazing and this is the cause of frequent conflicts with authorities. One aspect of good practice in restoring grazing areas is the establishment of forage reserve areas. This reduces conflict between pastoralists and the state, reduces the risk of transmitting diseases between livestock and wildlife, and could help stimulate the Afar to create a collective financing mechanism that could serve as a basis for other economic activities.

It is important to document local innovation aimed at adapting to observed changes in rainfall, wind patterns, temperature, and overall climate change. The first step should be to review the best traditional practices and share knowledge or replicable good practices in climate resilient, low-emission agriculture, livestock production and fisheries, as well as the role that efficient water management can play in the integration of trees into livelihoods. Traditional livestock management practices developed by herders and pastoralists could be extended to different areas and be taken up by communities, without any additional research requirements. Changes in vegetation composition due to climate change and variability have forced pastoralists to spread risk by raising different, but easily adaptable, livestock types. Afar and Somali pastoralists who used to raise cattle currently prefer to raise camels and small ruminants. They are adapting to diminished rainfall and water availability by altering herd composition, and so tend to keep fewer thirsty cattle.

Another important traditional practice is the maintenance of dry season grazing reserves, with communities restricting access. The use of crop byproducts is another drought coping mechanism that has been promoted by the Ethiopian Institute for Agricultural Research (EIAR) and by CGIAR centres, in particular ILRI. In another response to more frequent and intensified drought, some Afar herders have recently developed their own system of cutting hay from the park and other reserved areas to supplement dry season feeding, carrying it in their hands or with horse and donkey carts for distribution among a group of herders. The availability of natural forage has also been increased, through area exclosures that allow the natural pasture to regenerate, with some enrichment plantation to fill the gaps left by natural vegetation, with several technologies and practices developed (Georgis, 2015; CRS, 2005).

Area exclosures have been found to be effective in rehabilitating land in many parts of the country, especially in the most highly degraded areas, notably in the Borena Zone of Oromia Region, in southeastern Ethiopia. Community participation was the key to success there, organized by administrations and development agents, with the advantages and disadvantages discussed with local people. At the end of a process, the communities developed a common understanding and a consensus on the need to rehabilitate degraded hillsides. This experience should be scaled out to other similar areas for wide-scale adoption by pastoralists (CRS, 2005). It is important to note here that social organization differs across pastoral regions, with distinct types of traditional institutions playing major roles in land governance. The widely acclaimed restoration success in Tigray, “the drylands in the highlands”, was achieved on the basis of mass mobilization supported by stronger local administrations and formal institutions than are commonly found in the lowlands. The Borena case is important because it shows that, even in the absence of strong support from formal institutions, traditional institutions and communities can carry out restoration efforts, with external expertise contributing to a participatory process.

Conclusions and recommendations

The national workshop organized by PENHA-TBI in 2021, with the EFCCC of the government of Ethiopia and experts from across the nation, provided a vital forum for discussing the pressing and urgent issue of the conservation and restoration of dryland agricultural, rangeland and forest production on a sustainable basis. A platform for further collaborative endeavours has been established.

A central point is that integrated soil, water and vegetation conservation practices are key for the restoration of vast the dryland areas and the sustainable use of their vast resources. The importance of agroforestry practices, such as alley cropping, in soil fertility improvement and maintenance, water conservation, the production of feed along with increased grain yields, is well established and it is vital to promote good practices

here. In the crop production aspect, the strategy of diversification, and the integration of improved crop varieties with the appropriate management or crop agronomy, has been lacking in the past. It has been demonstrated to be good practice and needs to be promoted more widely. Agroforestry, and the integration of trees into local livelihoods is an important aspect of dryland restoration, with the introduction and protection of trees that bolster farm output as well as environmental sustainability and 'economic trees' that generate incomes.

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Carbon measurement and nationally determined contributions (NDCs)

Kibebework Getachew

Introduction

Nationally Determined Contributions (NDCs) are prepared and submitted to the United Nations as part of Ethiopia's commitment as a signatory to the 2015 Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC). They represent national pledges on climate action, that seek to limit global warming to well below 2°C and preferably below 1.5°C, compared to pre-industrial levels.

In preparing the recent update of the NDC of Ethiopia, four emission pathways were taken into consideration. These were: business as usual (BAU), greenhouse gas (GHG), conditional, and unconditional, emission pathways. Analysis employed the green economy model (GEM), used to develop GHG emission projections aligned with Ethiopia's 10 Year Development Plan (2020/21-2029/30). This analysis and these pathways will also be used for Ethiopia's Low Emission Development Strategy 2050.

The results of the analysis showed that Ethiopia's revised BAU emissions in 2030 will be 412.1 Mt CO₂e. This represents an increment of 12.1 Mt CO₂e over the BAU baseline projections in 2030 that were presented in the first NDC, submitted in 2020. The emissions in the base year, 2010, were about 112 Mt CO₂e lower in the first NDC. These latter changes are largely due to methodological improvements in the inventory of GHG source data, as well as global warming potentials and 'Tier 2' country specific parameters for live-stock and biomass.

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The impact of policy interventions proposed under the unconditional scenario were estimated to result in absolute emission levels of 360.85 Mt CO₂e in 2030, which represents a reduction against the revised BAU in the same year of 12.4% (-51.1 Mt CO₂e) (see Figure 1). The combined impact of policy scenarios proposed under the conditional scenario decreases absolute emission levels to 242.8 MtCO₂e, which represents a reduction of 41.1% (-169.3 Mt CO₂e) in comparison with the revised BAU. However, the conditional scenario is dependant upon on international support (MEFCC, 2020).

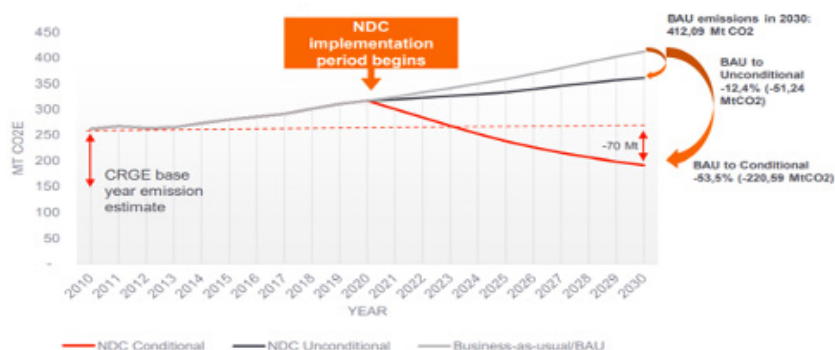


Figure 1. BAU emission projections and the mitigation contribution of Ethiopia's updated NDCs.
Source: Ethiopia's NDC updated summary, submitted to the UNFCCC (MEFCC, 2020)

Drivers and definitions

The key driver of deforestation is the expansion of agricultural land, while the collection of fuelwood and charcoal production are the main causes of the degradation of natural forest, along with overgrazing, and illegal logging for construction wood. There is of course some overlap between the drivers of deforestation and forest degradation, depending on the relative level. For example, too much livestock grazing and wood collection may eventually result in the total conversion of forest to open woodland, and perhaps to treeless landscapes. However, the expectation is that when these drivers are addressed, a positive effect will be seen on both deforestation and forest degradation.

Ethiopia's efforts towards natural forest restoration and the development of tree plantations are expected to result in a reduction of both forest degradation and deforestation. In Tigray and some parts of Amhara, there has been extensive establishment of woodlots and plantations for posts and poles on smallholder farmers' own land. This has been able to supply most of the fuelwood needed in those regions (MEFCC, 2014), and is thus assumed to have reduced the pressure on natural forests.

In February 2015, Ethiopia adopted a new definition of what constitutes a 'forest' as being "land spanning more than 0.5 ha covered by trees (including bamboo) (with a

minimum width of 20 m or not more than two-thirds of its length) attaining a height of more than 2 m and a canopy cover of more than 20% or trees with the potential to reach these thresholds in situ in due course” (MEFCC, 2015). However, this definition differs from that used for international reporting to the Global Forest Resources Assessment (FRA), and from the forest definition used in the national forest inventory (NFI), which applied the FAO definition of forests, with the threshold of 10% canopy cover, a 0.5 ha area, and a height of 5 m.

The reason for changing the definition of a forest was that a new definition was needed to better capture the natural primary state of Ethiopia’s forest vegetation. Specifically, lowering the limit of tree height from 5 m to 2 m better captures the natural forest vegetation types found in the country, such as dryland forests that commonly have a height of around 2-3 m. This change in the definition of a forest leads to the inclusion of what were previously classified as ‘dense woodlands’, which are widely distributed across the country and account for much its tree cover. Commercial agriculture is expanding mainly on dense woodlands, and the Government of Ethiopia wishes to provide REDD+ incentives for their conservation.

Carbon pools

The carbon pools included in the forest reference emission level (FRL) are above ground biomass (AGB), below ground biomass (BGB), and deadwood. The reason for selecting these pools is that they are expected to be the most significant, and primary data has been collected on these pools through the national forest inventory. A vegetation map was also developed as an input to create the base layer used to design the national forest and landscape inventory. As the Forest and Landscape Inventory is not focused only on forest strata, in 2015, a new aggregation map was proposed to better represent reliable carbon stock estimates.

The 12 identified vegetation types were used as input, and these were aggregated into four biomes, following expert judgment by Ethiopian botanical scientists. On the basis of their knowledge of the physiology of the vegetation, they suggested the following four biomes, with expected homogenous carbon contents, which were adopted to estimate carbon content for forest reference emission level purposes:

1. *Acacia-Commiphora* woodland and bushland; Acacia wooded grassland; desert and semi-desert scrubland
2. *Combretum-Terminalia* woodland and wooded grassland; wooded grassland of western Gambela.
3. Dry evergreen Afromontane forest and grassland complex; Afroalpine vegetation; ericaceous belt.
4. Moist evergreen Afromontane forest; transitional rainforest.

Based on the 2000-2013 monitoring period, annual emissions from deforestation were estimated at 17.9 MtCO₂e, with 4.8 MtCO₂e of removals from afforestation and reforestation, thus leading to a net emission of 13.1 MtCO₂e from the forestry sector.

Actors and engagement

Forest management is supported by different actors including government, NGOs, the private sector, local communities, and the international community. The government has demonstrated its strong and growing commitment in developing related strategies and plans, and is taking the lead in efforts such as the four-year Green Legacy Initiative, launched in 2019, which aims to plant 20 billion tree seedlings. Many NGOs are engaged in greening and participatory forest management (PFM) activities, that are further contributing to emission reduction targets. In addition, efforts are being made to fully implement community participation in a meaningful way, including genuine participation in every step of the process, and equitable entitlements to benefits from tree and forest resources.

To advance towards national goals, 2018's Forest Proclamation No. 1065/2018 was enacted, which engages with a wide range of actors and recognizes four types of forest ownership types. These are (i) state forests, (ii) private forests, (iii) community forests, and (iv) association forests. This is expected to significantly expand the stakeholder base, and will pave the way for their active engagement. Major ongoing interventions to manage existing forests, and also to restore degraded lands, include afforestation, reforestation, assisted natural regeneration, participatory forest management, and the Great Green Wall initiative. Some of the major actions are also carried out under the Reducing Emissions from Degradation and Deforestation (REDD+) initiative.

Continuous sensitization and awareness raising, along with mass mobilization and engagement, have fostered solidarity amongst diverse groups in rural society, and encouraged their continued commitment to engage in environmental rehabilitation activities, to which they have contributed significant amounts of 'free labour' in recent decades. Proven rehabilitation measures include three main approaches. These are (i) participatory forest management, (ii) establishment of plantations of different sizes and species, and (iii) area enclosures.

Participatory forest management is an approach whereby local communities are encouraged to actively participate in the management of forest that they live in or around, with a foundation being the establishment of a balanced system combining sustainable forest management and the (commercial) utilization of forest and tree resources. Enclosures are demarcated areas, locally agreed, that are 'socially fenced'. This means that cutting, grazing and other agricultural activities are excluded. Rules are enforced by local communities, and these promote the natural regeneration of vegetation. This approach has

proven to be very effective in rehabilitating formerly degraded lands. On the other hand, as access to and supply from natural forest decline, rural communities have been increasingly planting their own trees, also encouraged by market demand and an enabling policy environment realized through a reform in land tenure, that has allowed the legal certification of individual land rights, which in turn, promotes investment in long term activities such as the establishment of plantations.

The empowerment of local people through participatory processes is essential. Practically, this means that they take the leading role in making decisions regarding natural resource management that affect them directly and indirectly. These could involve, for example, projects on integrated watershed management or community based natural resources management, both of which are widely undertaken across the country. And, together, these approaches can contribute to the achievement of major environmental and forest rehabilitation successes.

Key issues and challenges

In order to realize Ethiopia's ambitions, envisaged in the Climate Resilient Green Economy (CRGE) Strategy and its NDCs, a number of outstanding challenges and key issues need to be addressed. The first is continued ecosystem degradation due to the expansion of large-scale commercial agriculture and of development projects, with the net national forest loss estimated at 72,000 hectares per year. Rural livelihoods in the drylands are already in a precarious position with respect to agricultural and food production, and that vulnerability reflects the dependence of these communities on land and forest resources. The resulting growing demand for land and the expansion of traditional smallholder agriculture into previously forested areas thus also implies major negative effects on carbon stocks. This trend is exacerbated by the absence of integrated comprehensive land use plans, which makes it difficult to control the conversion of land from one use to another. Moreover, the lack of proper land use plans restricts the development of land resources according to land capability and national needs, which would promote more efficient land use, thereby limiting the available land for implementing afforestation and reforestation.

Good governance, more broadly, is also fundamental to achieving sustained development outcomes in the forest sector. And progress in this would help to ensure efficiency in resource management, with an increased contribution of forests to economic development and environmental services, as well as progress towards the equitable distribution of benefits. But, unless there is strong political commitment to enforce existing governance tools, there will remain a lack of transparency, and insufficient compliance with laws, significantly hampering the development of the sector. And, in order to achieve success, any governance system must also create an enabling environment that facili-

tates broader engagement involving public, private and community partnerships. Key institutions must also have the necessary capacities to coordinate, negotiate and mediate conflicts at a landscape level in order to maintain and develop ecosystems.

Moreover, the lack of synergies and coordination between the various actions undertaken undermines effectiveness. Carbon measurement and accounting in the forest sector requires vertical and horizontal collaboration and coordination between many and various stakeholders, including investment offices and those involved in agriculture, land administration, and settlements. The lack of such coordination among relevant sectors and government agencies, along with organizational limitations, weak feedback systems, and the shortage of skilled labour and financial resources, all contribute to making carbon measurement a serious challenge. The result is a lack of comprehensive forest sector carbon accounting, notwithstanding the significance of forest related carbon emissions. And, up to now, the scope of carbon monitoring in Ethiopia has not encompassed forest degradation, which contributes to the under and overestimations of national results.

Conclusions

Institutions need to understand the needs and interests of all actors, with fully participative planning at landscape level that could lead to transformative results and bring win-win solutions. In planning strategies and interventions, the principles of optimization, rather than maximization, must be emphasized, and the associated policies and processes must aim to accommodate the needs and interests of all actors.

In addition to showing its commitment to various international initiatives, the Government of Ethiopia has been implementing multiple mitigation actions for GHG emission reduction across sectors. However, although positive measures are being adopted, realizing the carbon removal potential of the forest sector still requires greater emphasis, in terms of developing effective policy and institutional initiatives. The following summarizes the priority actions that can provide a foundation for such initiatives:

- Develop the forest resources base by controlling the allocation of forested lands for large-scale agricultural investments, and develop integrated land-use plans that take into account the future of forest development and forest-based livelihoods in view of sustainable economic development goals.
- Strengthen community and private sector participation by creating an enabling environment for wide stakeholder involvement, and provide economic incentives, with a forest extension package that incorporates technologies for the establishment forests and woodlots, and supports tending, harvesting and processing.
- Establish good governance and secure forest tenure rights for forest dependent communities, including women, so that they receive their due entitlements, and

promote their active participation ,as well as the vitally important Inclusion of producer organizations and civil society.

- Create more efficient and effective forestry institutions by improving financial and human capacity in the forestry sector at all levels, including the strengthening the capacities of regional and sub-regional level forestry entities, so that they are able to establish effective monitoring and evaluation systems.
- Improve cross-sectoral and sectoral integration and coordination by establishing mechanisms for effective horizontal coordination between and among line ministries and agencies involved in the development of forest, energy, agriculture, and other relevant sectors.
- Expand research, education and forest extension services by re-orienting research and educational approaches, and training experts at all levels in monitoring forest carbon to inform CRGE/NDC implementation as well as result-based financing.

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Tree seeds for dryland restoration in Ethiopia: issues, challenges and opportunities

Yigardu Mulatu

Introduction

Planting material is a fundamental input for afforestation, reforestation and restoration. If not properly selected, it will lead to low or no tree survival, or diminished productivity, and this is not easily corrected. Cuttings and wildlings are used, but by far the most commonly used reproductive material in Ethiopia is seed. Associated with the increasing need for tree planting, the national tree seed system has been transforming from single and simple seed supply to multiple and complex systems. About 75% of Ethiopia is categorized as dryland (Giorgis, 2014). Accordingly, adaptability and growth is highly affected by low moisture, high evapotranspiration and soil conditions. On the other hand, the use of seed collected from nearby collecting sites in dry forests contributes to higher success. A major challenge is the low quality and limited diversity of indigenous seeds sources. And to date, inadequate attention has been given to the task of identifying and demarcating seed sources for prioritized species from dryland forests. This paper highlights systems, species and seed sources that can be established and utilized in dryland areas of Ethiopia.

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Historical trends and the need to maintain quality

Plantation programs have been conducted in Ethiopia since 1973, when provision of adequate quality tree seed supply

was already considered to be important. Tree seed collection and distribution was formally started in 1974 when the then Forestry Research Center (FRC) was established, with nursery and seed provision in Gurd Shola in 1976, providing seedlings and seed for free. From 1994 to 2004, the UNDP-funded National Tree Seed Program strengthened seed supply and seed source establishment in the country.

Tree seed demand has dramatically increased since 2010, and could have not been adequately provided by a sole tree seed supplier. With the commitments made under national, regional and international policies, strategies, and pledges including the CRGE (2011), GTP (2018-2022), Ethiopian Forest Development, Protection and Utilization Proclamation (2018), the Great Green Wall Initiative and the New York Declaration on Forests, much higher amounts of tree seed are required from public organizations and the Government of Ethiopia's established tree seed centres in Hawassa (SNNPR), Dimma (Oromia), Bahir Dar (Amhara) and Mekele (Tigray). Private tree seed enterprises such as Eden-Field Agri Seed are also becoming established. These formal seed suppliers are commercially organized and linearly structured seed producers run by public or private sectors with policy and regulatory support. However, these, and the Forestry Research Center (EEFRI) are recently reported to be supplying very low amounts of the tree seed demand, with most being from informal tree seed suppliers.

In a study conducted in six woredas of Oromia for example, forest seedling nurseries received 88% of their tree seeds from informal seed dealers (Kassim et al., 2016), run by small scale, traditional farmer managed systems developed over time in response to demand for seed, as well as new local initiatives (CBOs, small-scale nursery owners and seed dealers). The informal seed sector does not, however, abide by rules and regulations, hence compromising seed quality. The seed market is often driven more by price than quality, requiring the raising of awareness on prioritizing quality over prices that are often haphazardly set by suppliers in the informal sector.

Organizations currently involved include the Ethiopian Agricultural Research Organization (EARO), Ethiopian Institute of Agricultural Research (EIAR), Oromia Forest and Wildlife Enterprise (OFWE), Amhara Forest Enterprise (AFE), the Tree Seed Center (TRC), community based organizations (CBOs), ICRAF's PATSPO (the Provision of Adequate Tree Seed Portfolio in Ethiopia project), as well as the Forestry Research Center of the Ethiopian Environmental and Forestry Research Institute (FRC-EEFRI) (Figure 1).

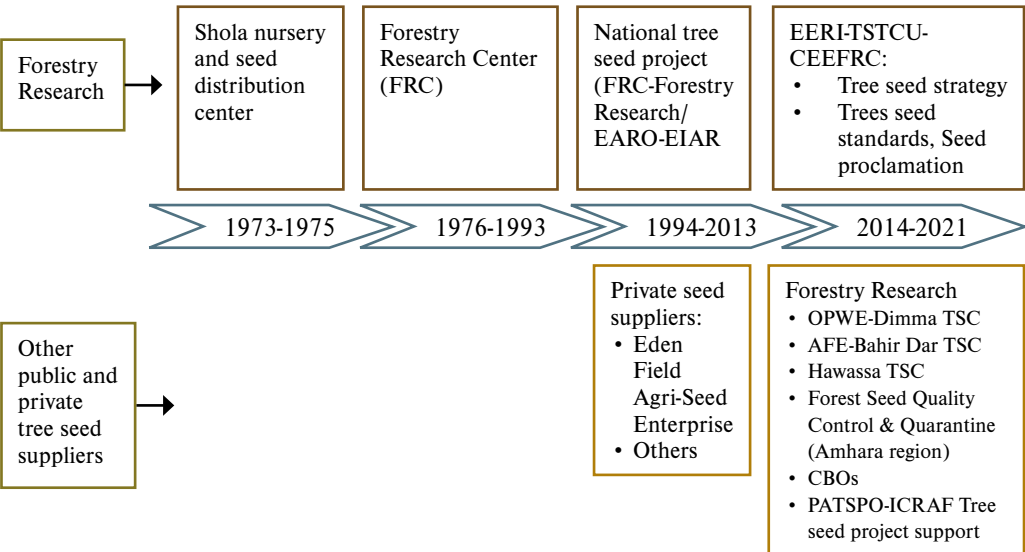


Figure 1. The tree seed system in Ethiopia: transformed from a single and simple seed supply system (1973-2018) to a complex, multiple-actor system (in 2021).

Promising tree species for dryland areas

There is a lot of research on species selection for dryland areas. For example, of species studied under direct sowing in degraded land in the rift valley of southern Ethiopia, four species were successful (Shiferaw and Hana, 2019) - *Acacia nilotica*, *Acacia seyal*, *Acacia tortilis* and *Dodonaea angustifolia*. Research by Mulatu et al. (unpublished) in eastern Amhara over 10 years, indicated that amongst 70 multipurpose tree and shrub species, *Acacia polychanta*, *Acacia nilotica*, *Acacia saligna*, *Sesbania geotzei*, *Sesbania gradndiflora*, *Sesbania sesban*, *Leucaena pallida*, *Leucaena diversifolia*, *Casuarina equisetifolia*, and *Melia azedarach* performed better in intermediate altitude dryland areas. *Acacia polychanta*, *Acacia nilotica*, *Moringa stenipetala* and *Eucalyptus camaldulensis* were promising for lowland drylands. *Acacia saligna*, *Leucaena pallida*, *Sesbania geotzei*, and *Acacia seyal* were outstanding in gullies in intermediate altitude drylands, and alongside these, *Acacia nilotica*, *Cordia africana*, *Moringa stenopetala*, *Albizia lebbeck*, *Eucalyptus saligna* and *Casuarina equisetifolia* performed well under stream eroded stony river beds.

Reports on tree seed supply in the last decade indicate that more than 30 species used in dryland areas have been distributed by EEFRI and regional seed centers (Table 2). The important issue here is identifying those species that are specific to sites such as highly degraded areas, mountains, lowland, mid altitude and highland dry areas, and integrating these trees on farmlands. While planning to plant seeds, abiotic, biotic and anthropogenic factors must be considered in order to match species to planting sites effectively (Dolos et al., 2015).

Table 1. Profile of tree species for afforestation/reforestation and restoration of dryland areas in Ethiopia

Scientific name	Agroecology	Seeds/kg	Main uses
<i>Acacia decurrens</i>	1000-2500 masl in all woina dega and dega	73,465	fuelwood, charcoal, soil conservation, fencing, shade, ornamental, windbreak
<i>Acacia melanoxylon</i>	700-2500 masl in all wet kola, woina dega and dega	84,592	fuelwood, timber, charcoal, ornamental, soil conservation, animal feed, shade, agroforestry
<i>Acacia nilotica</i>	600-1700 masl in all kola, wet kola and bereha	7,317	charcoal, fuelwood, utensils, bee forage, soil conservation, animal feed, shade, toothbrush, agroforestry
<i>Acacia polyacantha</i>	500-1600 masl in dry and wet kola	13,722	fuelwood, charcoal, gum, implements, fencing, construction, ornamental, soil conservation, windbreak, medicine, animal feed
<i>Acacia saligna</i>	dry and wet kola and woina dega	65,734	fuelwood, ornamental, charcoal, soil conservation
<i>Acacia senegal</i>	500-1700 masl in all bereha and woina dega	10,615	fuelwood, charcoal, gum, implements, animal feed, soil conservation
<i>Acacia seyal</i>	500-2100 masl in all bereha and woina dega	17,722	fuelwood, charcoal, gum
<i>Acacia tortilis</i>	300-1900 masl bereha, dry and wet kola	14,675	fuelwood, charcoal, shade, fencing, soil conservation, bee forage, animal feed
<i>Afrocarpus gracilior</i>	1500-2500 masl in dega and woina dega	1,603	fuelwood, timber, ornamental
<i>Albizia lebbeck</i>	500-1500 masl in dry and wet kola	9,454	shading, ornamental, bee forage
<i>Azadirachta indica</i>	400-1500 masl in dry and wet kola and wet woina dega	9,631	fuelwood, timber, charcoal, ornamental, bee forage, soil conservation, animal feed, medicine, shade, agroforestry
<i>Balanites aegyptiaca</i>	0-1800 masl in dry and wet kola	533	fuelwood, charcoal, soil conservation, windbreak, shade, fencing, medicine, utensil
<i>Casuarina equisetifolia</i>	0-2200 masl in kola and woina dega	117,647	timber, ornamental, fuelwood, soil conservation, shade, windbreak, electric pole, construction
<i>Cajanus cajan</i>	1000-2400 masl in dry and wet kola, woina dega and dega	7,898	fuelwood, soil conservation, windbreak, shade, basketry, animal feed, bee forage

Scientific name	Agroecology	Seeds/kg	Main uses
<i>Cordia africana</i>	900-2500 masl in dega and woina dega	6,141	fuelwood, ornamental, soil conservation, shade, bee forage, agroforestry, timber
<i>Cupressus lusitanica</i>	1500-3200 masl in dega and woina dega	156,739	soil conservation, shading, windbreak, ornamental, timber, construction
<i>Delonix regia</i>	200-1600 masl in dry and wet kola and wet woina dega	2,961	shade, ornamental
<i>Dovyalis caffra</i>	0-1800 masl in dry and wet kola	29,446	fencing, food
<i>Dodonaea angustifolia</i>	1000-2400 masl in dry and wet kola, woina dega and dega	117,259	timber, bee forage, fuelwood, medicine
<i>Eucalyptus camaldulensis</i>	1200-2800 masl in dry and wet kola, woina dega and dega	1,887,507	fuelwood, electric poles, timber
<i>Faidherbia albida</i>	1500-2600 masl in all woina dega	11,447	fuelwood, soil conservation, agroforestry, fencing, shade, construction
<i>Jacaranda mimosifolia</i>	1200-2400 masl in dega and woina dega	98,058	ornamental, fuelwood, shading
<i>Jatropha curcas</i>	200-1600 masl in dry and wet kola and wet woina dega	2,400	medicine, food, soil fertility, fuelwood
<i>Juniperus procera</i>	1500-3300 masl in wet and very wet woina dega and dega	55,850	fuelwood, timber, ornamental
<i>Leucaena leucocephala</i>	0-1600 masl in kola and woina dega	21,437	agroforestry, animal feed, soil conservation
<i>Melia azedarach</i>	0-2400 masl in kola and woina dega areas	4,695	ornamental
<i>Moringa stenopetala</i>	500-1700 masl in all bereha and woina dega	1,980	food, agroforestry
<i>Olea africana</i>	1400-3300 masl in wet and very wet woina dega and dega	10,020	fuelwood, timber, charcoal
<i>Parkinsonia aculeata</i>	300-1700 masl in all bereha and woina dega	11,282	shads, ornamental, bee forage

Scientific name	Agroecology	Seeds/kg	Main uses
<i>Prunus africana</i>	900-2600 masl in dega and woina dega	5,289	timber, fuelwood
<i>Pterolobium stellatum</i>	1200-2500 masl in dega and woina dega	34,045	agroforestry, soil fertility
<i>Schinus molle</i>	0-2400 masl in kola and woina dega	28,335	ornamental, fuelwood
<i>Sesbania aculeata</i>	300-2000 masl in dry and wet kola and wet woina dega	72,643	animal feed, medicine, soil fertility, food
<i>Spathodea nilotica</i>	dry and wet kola and woina dega	205,939	ornamental, fuelwood, shade
<i>Tamarindus indica</i>	0-1500 masl in kola and woina dega	2,174	fuelwood, charcoal, timber, food, animal feed, medicine
<i>Ziziphus macrocarpa</i>	400-1600 masl in all bereha and woina dega	2,542	food, medicine, agroforestry

Seed source types recognized in Ethiopia

According to the Ethiopian Standards Agency (ESA, 2017), a seed source is a stand of trees where seed is collected. It can be a number of single trees, a natural stand, a plantation or a seed orchard. It should yield an appropriate quantity of seed with a high physiological and genetic quality that matches the plantation site and purpose. It may be a pure stand or one species in a mixed (usually natural) stand.

The six types of seed source recognized to be applicable in Ethiopia include (1) identified seed sources, (2) selected seed stands, (3) seed production areas, (4) provenance seed stands, (5) seed orchards, and (6) farmland trees. The easiest and probably the cheapest seed sources, with lower genetic quality, but what most seed suppliers in Ethiopia are utilizing, are identified seed sources and farmland trees. Identified seed sources are any stand of average quality, occasionally used for seed collection, for which the location can be described. Farmland trees have been planted or retained for the production of other end products like shade, fences, windbreaks, fodder and timber, or other services quite apart from seed provision. Seed sources such as seed production areas, provenance seed stands and seed orchards are exclusively maintained by the Ethiopian Environment and Forest Research Institute. In 2019 and 2020, about 20 breeding seed orchards (BSOs) were established for prioritized tree species in Amhara and Oromia regions in collaboration between ICRAF-PATSPO, the two regional tree seed centers (AFE and OFWE), and EEFRI.

Seed source establishment and institutional roles

A situation analysis of the tree seed system in Ethiopia (ICRAF-PATSPO, 2009) indicated that one of the main problems is the limited supply of indigenous tree species. As profit making organizations, seed enterprises focus on easily manageable tree seeds which have no problems in their dormancy and storage. The procurers focus on accessible sources. Thus it is recommended that steps be taken to enhance the supply of indigenous species by establishing seed sources in-situ in dry forests and in plantations of native species.

Ethiopia has a high degree of tree diversity (over 1000 native trees) in different vegetation types and ecological conditions. Dry forests are larger vegetation resources as compared to high forests (WBISPP, 2004). The five dry forest vegetation types, which are amongst the twelve vegetation types of Ethiopia described by Friis (2010), include (i) *Combretum-Terminalia* (broad-leaved) deciduous woodland, lowland dry forest; (ii) Dry evergreen montane forest, (iii) *Acacia-Commiphora* woodland; (iv) desert and semi-desert scrubland, and (v) the wooded grassland of western Gambela region (Table 2). They encompass many characteristic species that have economic and ecological significance. As the diversity in dryland forests is high and capacity in seed source establishment might be limited, it becomes imperative to prioritize species and establish in-situ seed sources for selected ones, considering the best species for targeted end products and uses, e.g. land rehabilitation and protection, industrial uses, fuelwood, fodder and fruit, as well as demand, and the conservation status of species that varies from critically endangered to low risk, and keeping in mind endemic species.

Table 2: Characteristic tree species of dry forest and potential seed source types to be established in-situ

Dry forest vegetation type	Characteristic species
Combretum-Terminalia (broad-leaved) deciduous woodland	<i>Boswellia papyrifera</i> , <i>Terminalia laxiflora</i> , <i>Acacia polycantha</i> , <i>Grewia</i> spp., <i>Stereospermum kunthianum</i> , <i>Sterculia setigera</i> , <i>Oxytenanthera abyssinica</i> , <i>Balanites aegyptiaca</i> , <i>Annona senegalensis</i> , <i>Acacia senegal</i> , <i>Acacia seyal</i> , <i>Combretum adenogonium</i> , <i>Combretum collinum</i> , <i>Combretum molle</i>
Dry evergreen montane forest	<i>Juniperus procera</i> , <i>Afrocarpus falcatus</i> , <i>Prunus africana</i> , <i>Ekebergia capensis</i> , <i>Olea</i> spp., <i>Apodytes dimidiata</i> , <i>Allophylus abyssinica</i> , <i>Euphorbia ampliphylla</i> , <i>Olinia rochetiana</i> , <i>Myrsine melanophloeos</i> , <i>Dovyalis abyssinica</i> , <i>Myrsine africana</i> , <i>Calpurnia aurea</i>
Acacia Commiphora woodland	<i>Acacia tortilis</i> , <i>Acacia mellifera</i> , <i>Balanites aegyptiaca</i> , <i>Acalypha</i> spp., <i>Aerva</i> sp., <i>Combretum</i> spp., <i>Terminalia</i> spp., <i>Capparis</i> spp., <i>Codeauxia edulis</i> , and several species of <i>Boswellia</i> and <i>Commiphora</i> ,

Dry forest vegetation type	Characteristic species
Desert and semi-desert scrubland	Drought tolerant species: <i>Acacia</i> spp., <i>Boscia</i> sp., <i>Cadaba</i> sp., <i>Commiphora</i> sp., <i>Maerua</i> sp., <i>Ziziphus</i> sp., <i>Aloe</i> sp., <i>Commelina</i> sp., <i>Dactyloctenium</i> sp., <i>Euphorbia</i> ..., etc; endangered endemic plant species of the ecosystem
Wooded grassland of western Gambela region	Different <i>Acacia</i> species

Thus strengthening the tree seed supply system by identifying, demarcating, registering and managing seed sources from dry forests and procuring high quality seed, is essential in order to establish successful seed supply for restoration of dry areas. The actors or institutions in the tree seed system have their own, distinct roles (Figure 2) in the delivery of quality tree seeds in Ethiopia.

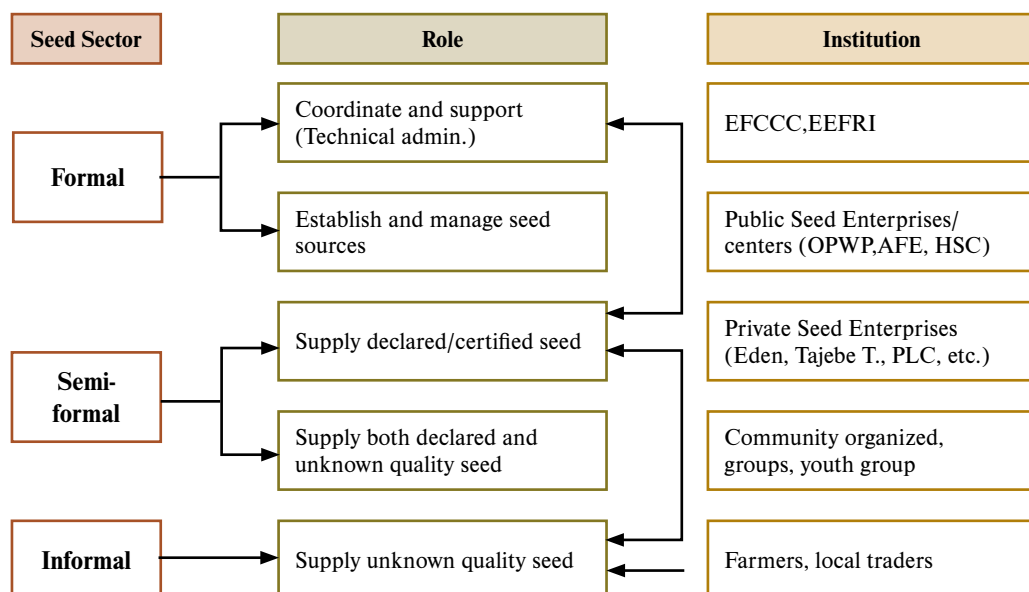


Figure 2: The formal, semi-formal and informal tree seed sectors in Ethiopia
(AFE=Amhara Forest Enterprise; HSC=Hawasa seed center; OFWE=Oromia Forest and Wildlife Enterprise)

Conclusions

The tree seed system in Ethiopia is transforming from a simple single seed supplier system to a multi-actor and complex supply system. There are many possible tree species that can be used for afforestation, reforestation and restoration of specific dryland sites. However, the issues of seed quality and species diversity (identifying species that best fit

dry land areas) have received limited attention. Thus, it is strongly recommended that the actors in the tree seed system look into the five different dryland vegetation types and prioritize species based on their suitability to planting sites, considering seed quality parameters (genetic, physical and physiological). In so doing, identified seed sources and trees on farmlands can be identified, demarcated and registered by the local administrations and concerned offices. Restoration of dryland areas should be undertaken with careful attention to the biotic and abiotic conditions of planting sites and performance of the selected species under the seed collection sites.

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Innovative feed solutions – the Ethio-Feed Plc experience

Beruk Yemane

Introduction

Enhanced livestock productivity is possible with the involvement of the private sector as part of an integrated approach to drylands development. Landscape restoration in drylands depends on economic sustainability. Local people and communities who agree to forego incomes that they would otherwise generate from use of protected areas and area enclosures, must be able to generate new, alternative livelihoods or to increase productivity and incomes from existing livelihoods. In dryland, most livelihoods depend on livestock keeping. And this is typically traditional, low-input, partly mobile livestock keeping. Livelihoods in drylands are also vulnerable to drought, increasingly frequent and severe, and suffer from the impacts of climate change.

It is vital to make livestock-based livelihoods in drylands more resilient to drought. Climate smart agriculture is one important aspect and it is important to adopt an integrated approach to dryland development, that combines farming, livestock, trees and enhanced water management and utilization, as well as the development of urban centres, as sources of services and skills that can be applied in collaboration with local farmers, pastoralists and resource users. Successful participatory approaches involve local communities, drawing on local knowledge, working with local government, and international and local NGOs and development agencies. But too often, the private sector has been left out, or is seen as a threat to local livelihoods, taking land with damaging envi-

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ronmental and social impacts. But the private sector, particularly domestic companies and investors, can be important and valuable development partners, and must play an important role in a new development path for the drylands, bringing increased productivity, incomes and employment and the capacity to introduce and scale up innovations.

The experience of Ethio-Feed Plc is offered as an example of what is possible with a particular model of private sector development. Ethio-Feed, as the name might suggest, aims to supply animal feeds that can bolster livestock productivity as well as livestock survival harsh dry seasons and drought, thus strengthening livelihoods and resilience in the drylands, as well as, potentially, addressing the problem of free grazing on area exclosures and helping to increase tree seedling survival rates. The following general points must be emphasized.

- Livestock will remain fundamental to livelihoods in the drylands and enhanced, 'drought-proof' feed supplies can do much to bolster livelihoods, productivity and incomes.
- Strengthened pastoral livelihoods and incomes can reduce pressure on landscape restoration schemes in the drylands and reduce the reliance on charcoal production for income generation.
- An integrated approach to drylands development must combine livestock, farming, trees, water management and urban development.
- And the private sector, often cast as the bad guy, grabbing land and undermining local livelihoods, can actually support and strengthen local livelihoods and must play a positive role in drylands development.
- Private companies can have bigger and broader positive impacts, socioeconomic and environmental, than local micro-enterprises, and they can work with local people and groups in participatory ways to develop and introduce new products and productivity-enhancing innovations.
- The invasive tree species *Prosopis juliflora*, whose spread across the drylands has seriously undermined pastoral livelihoods, can be a valuable feed source, while the use of its pods in feed products can help to control its spread.

The last point is specific about what Ethio-Feed plc does - the rest are general about livestock production and integrated dryland development and landscape restoration, and a new role for the private sector. Beyond animal feed supply, the private sector is expanding its role. Private companies have grown to take on a big role in seed supply in Ethiopia, and could work more with communities and organizations to develop and distribute the right seeds for drylands. Moreover, development agencies and NGOs are increasingly seeking to promote private sector development or to introduce a profitability element into some programs, as a route to increased efficiency and program sustainability.

Ethio-Feed Plc

Ethio-Feed plc is private livestock feed manufacturing company established by concerned professionals engaged in the sector, with four driving factors. These were to (i) contribute to increased productivity of milk, meat and eggs, (ii) ensure survival of core breeding stock during drought in pastoral and agropastoral areas, (iii) improve performance of draft oxen, and (iv) improve health and performance of horses and donkeys. Currently, the company produces and markets quality livestock feed products for dairy production, livestock fattening, poultry and equines as well as drought affected livestock. The unique selling point of the company is its 'innovative feed solution' model and approach to the production and marketing of different types of livestock feed products.

The integrated, innovative and holistic approaches include the following.

- Production of quality and affordable total mixed rations, and multi-nutrient mineral blocks.
- Use of organic and environmentally friendly, effective micro-organisms.
- Converting poorly utilized or wasted agricultural by-products into affordable quality livestock feed.
- Use of bentonite as an aflatoxin binder in commercial feed production.
- Piloting new business models and approaches that address social and environmental responsibilities.
- Organizing and conducting practical training in animal feed production.

Ethio-Feed plc employs different market development and promotion strategies to be competitive in the commercial feed market, including partnerships with processors, wholesalers, retailers and franchise partners. It actively markets products in Adama and the surrounding areas, in East Shoa, Arssi, Bale, East and West Hararaghe and Borena Zones of Oromia Region, and Afar, Somali, Dire Dawa and SNNPR Regional States. Ethio-Feed has grown to the point where it is able to supply emergency feed rations during the last major drought in 2017, mitigating severe livestock losses that occurred and saving livelihoods. Local franchises have enabled the company to expand the scale of its operations focusing on long term franchisee business partnerships, based on innovative business models and approaches that promote interests of both parties and encourage long term joint ventures.

Challenges faced by the sector include heavy dependency of traditional livestock production on natural rangelands and pasture, and on conventional commercial feed products susceptible to frequent price variation, with limited practical knowledge in the use of locally available resources such as crop by-products for production of affordable quality livestock feed. Major recommendations for the way forward in the sector include the development of new feed products, the production of prosopis-based livestock feed, the use of bentonite in feeds, piloting new business models, and addressing social and environmental responsibilities and concerns.

Ethio-Feed Plc innovations

The company has four main objectives.

1. Produce affordable quality livestock feed in the form of total mixed rations, concentrates and blocks in order to improve production, and ensure the survival of core breeding stock through emergency supplementary drought feed.
2. Convert poorly utilized or agro-industrial byproducts such as maize and sorghum stalks and cobs, dry grass hay, wheat and barley straw, as well as and other available resources such as *Prosopis juliflora* pods, moringa and opuntia cactus.
3. Implement franchisee business models (enabling expansion across rural and dry-land towns) and tailored approaches for the production and marketing of different livestock feed products.
4. Support local capacity that will enhance job creation for the youth and contribute to the development of the green economy, expanding production in an environmentally responsible manner.

Innovations include the following major elements that distinguish Ethio-Feed Plc.

(a) Production of quality and affordable total mixed ration and multi-nutrient blocks with a good mix of roughage from locally available crop byproducts and concentrate from flour and oil mill by-products for ruminant livestock, as shown in photos 1 and 2 below.

(b) Use of organic and environmentally friendly effective micro-organisms bio-technology for the production of livestock feed that will increase the production and productivity of milk and meat. In addition, EM will improve livestock body condition and reproduction. All Ethio-Feed TMR and concentrate feed products are blended with EM.

(c) Production of affordable quality feed by converting poorly utilized agro by-products such as maize stalk and cobs, sorghum stalks, straws of wheat, barley and teff, as well as *Prosopis* branches and cactus into quality and affordable feed products. The products will be properly chopped, milled and mixed with high quality commercially available protein, energy and mineral sources for the production of high quality and affordable animal feed products for dairy, and fattening, as shown in the photos below.

(d) Production of mineral blocks for dairy animals. Domestically produced mineral blocks, will improve milk production and substitute for imports, and enhance the capacity of the national feed industry. It will also enable Ethio-Feed plc to diversify its commercial feed products for domestic and export markets in the near future.

(e) Implementing the ‘franchisee business partnership’ model with the private sector, youth groups and cooperative unions. Currently, Ethio-feed plc has established business partnerships with five partners. Based on Ethio-Feed’s experience, there are four

advantages to working with franchisee partners and producing different feeds in different localities. This includes a reduction in production costs by 10-15%, lowering transportation costs by 20-25%, enhancing local capacity by transferring technology in modern and Innovative feed production and marketing, and creating job opportunities for youth groups. Evidently, the types of feed ingredients that are cheaply available locally vary widely, making it necessary to invest some time in developing suitable products in each region or local area. The range of available materials is more limited in the drylands, but it has been possible to develop a good quality of products in each region. The aim is to develop a tailored franchisee marketing strategy as well as a long-term, collaborative partnership that is oriented towards business and product development and based on a shared vision.

(f) The use of bentonite as an aflatoxin binder in commercial feed production. Ethio-Feed plc is the only company that uses locally produced bentonite as an aflatoxin binder in its different feed products, tested by the International Livestock Research Institute (ILRI) for its appropriateness as a binder, also free from heavy metals.

(g) Organizing and facilitating practical training and experience sharing visits: Training encompasses different aspects of commercial feed production and is delivered in stand-alone and package form, covering conservation and utilization of agro-industrial by-products using effective micro-organisms, forage production and management and commercial feed production and management. Training is provided for small, medium and commercial dairy, fattening and poultry owners, government and NGO development workers, farmers, pastoral and agropastoral cooperatives and unions.

Addressing social and environmental concerns

In line with its approach to social responsibility, Ethio-Feed is engaged in job creation for youth, environmental conservation and rehabilitation initiatives. This includes sourcing crop by-products from farmers and youth for production of livestock feed, encouraging youth and women in agroforestry, and to plant drought resistant moringa. Ethio-Feed plc has also enabled permanent staff members to become shareholders in the company. This has greatly contributed to the development of a real commitment, based on a sense of ownership and a harmonious team building spirit, solidifying the company's long term vision. The dependency of local livestock keepers on grazing from natural rangeland/pasture and on expensive conventional commercial feed products remain major challenges, that can only be addressed progressively over time by expansion and the uptake of similar approaches by others. And, of course, livestock need water as well as feed, so from the perspective of enhanced and integrated dryland development, greater feed availability and affordability must be accompanied by more efficient and effective water management, utilizing above and below ground sources.

Conclusions and recommendations

Studies indicate that feed contributes 65-70% of the production costs of milk, meat and eggs (Tolera et al., 2012), and a strong attachment to and dependence on conventional commercial feeds has failed to bring measurable positive impacts on livestock production and productivity. This could be associated with the soaring prices of concentrate feed ingredients resulting in high price of finished feed or the low-quality of feed products and their limited availability. On the other hand, the production of livestock feed from other sources such as crop by-products, high quality forage and mineral sources and application of modern and organic bio-technology is not commonly practiced. Piloting new business partnership models for the production and marketing of commercial feed is in its infancy. And the required training of livestock owners, development extension officers and livestock marketing individuals and groups as well as feed ingredient suppliers and traders in practical livestock feed production and marketing, in “innovative feed solutions” in particular, has not been widely undertaken.

In general, the productivity of livestock and development of commercial feed industries are strongly interrelated and both will show incremental growth and profitability if the latter can produce affordable, quality feed products. The development and implementation of “innovative feed solutions” is thus vital. The following are recommendations for development of the feed industry in particular and the livestock sector in general.

New feed product development. There is a need to move away from conventional feed ingredients and develop new products from locally available sources. These include crop by-products such as maize stover and cobs, sorghum stalk, straw (of teff, wheat, barley), prosopis pods, cactus, molasses, bagasse, cane tops and green fodder. The use of locally available feed ingredients mixed with commercial feed ingredients will enable the production of affordable quality total mixed ration and multi-nutrient blocks and pellets that can be easily purchased and used by smallholders to improve milk and meat production.

The production of prosopis livestock feed: The common practice has been to use pods as a feed ingredient in for dairy and fattening. However, based on the experience of ‘bush feed’ observed in Namibia, we have expanded our horizons to include the use of branches, with pods and leaves together as a feed ingredient. Prosopis based feed can be widely introduced in the Afar and Somali Regions and in other invaded parts of the country where the huge potential of Prosopis can be utilized to produce feed that enhance productivity and drought resilience, with wider environmental benefits.

Commercialization of diversified feed products and use of betnonite in feeds: The use of mineral blocks has not been widely popularized. This innovative approach, besides contributing to mineral requirements of dairy animals, will also substitute for imports. The

use of bentonite as an aflatoxin binder in dairy feed has not been properly addressed. This calls for research to conduct studies on different products, coupled with animal trials and definitively assess the effect of using bentonite in minimizing aflatoxin in milk.

Piloting new partnership business models: The production and marketing of different livestock feeds with business models such as Ethio-Feed's models need to be studied with a view to promoting a wider uptake of collaborative and inclusive business concepts that enable business expansion in drylands where private sector development is relatively thin. The Ethio-Feed model, besides allowing for the utilization of locally available feed ingredients, reduces production and transport costs for feed ingredients, and encourages skills and technology transfer to local level, enhancing capacity and generating employment for youth. This approach has wider applicability, and might be adopted in management of tree nurseries and supply of seeds suitable for drylands. Partnerships between urban partners with access to finance, knowledge and technical expertise, and local partners with an intimate understanding of conditions and social networks, could provide a new way forward in dryland development. Such a combination of internationally-derived expertise and local knowledge might also help to avert the kinds of tensions and conflicts that have often been associated with private investment in drylands.

Addressing social and environmental responsibility and concerns: Job creation for youth and rehabilitation of environments have become very real and pressing concerns. Social scientists and environmental researchers, in collaboration with different market actors and development agencies, need to identify a agenda in relation to issues outlined above with the aim of producing socially and environmentally sound solutions to these challenges.

Overall, the development of innovative feed solutions is an important aspect of an integrated approach to dryland development that is urgently required in Ethiopia. At the landscape, regional and policy levels, environmental rehabilitation and management requires a coherent set of actions, encompassing livestock, water, trees, agriculture and urban development, with the collaborative engagement of all stakeholders, including the private sector. Ethio-Feed's experience shows that positive and effective collaboration can produce results, with commercial viable solutions to longstanding problems, and points to the potential that exists in the drylands of Ethiopia.

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Conservation and propagation of frankincense (*Boswellia papyrifera*) trees

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Introduction

Climate change and natural resource degradation, in particular the rapid decline of forest and other vegetation in the drylands of Ethiopia, continue to be the major constraining factor in livelihoods development, with local people often exposed to food insecurity and environmental risks. But, despite all the challenges, these drylands are rich in terms of tree and shrub species that supply commercial resins, incense and gums that have local, national, and international significance. A central element of a strategic approach to developing the drylands is income and livelihood diversification, involving the design of adaptive production systems that enable people to develop, manage and utilize their natural and vegetation resources, including resin and gum producing trees.

Different *Boswellia* species are widespread in Ethiopia, in the regional states of Afar, Amhara, Beneshangul-Gumuz, Gambella, Oromia, Somali and Tigray (Kindeya et al., 2003). Of the species, *B. papyrifera* is highly valued for its products and ecosystem service functions. Traditionally, uses include wood for making farm implements and household furniture, forage for livestock and honey bees (Abeje, 2002), and the frankincense resin commonly used in religious ceremonies in churches, mosques, homes and other places (Tilahun, 1997). There is also a large and growing international market for its use as a fragrance and flavouring in the perfume and food industries, and this earns a significant amount of foreign currency (Kindeya et al., 2003).

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The most widely collected and traded resin in Ethiopia is frankincense, produced by *Boswellia papyrifera*, a key dryland plant with ecological, environmental, socioeconomic and cultural values in its native range that covers Eritrea, Ethiopia and Sudan. *B. papyrifera* is already considered to be endangered in parts of its native range, declining due to anthropogenic and natural factors, with calls for the immediate introduction of conservation efforts. Local and international organizations, concerned scholars, and local farmers and pastoralists, have for many years been voicing their serious concerns over the fast decline in numbers of *B. papyrifera* trees and other economically and ecologically important dryland species in Ethiopia and the region. This article outlines the main players, activities and successes, outstanding issues and challenges, and next steps to overcome these, leading to the sustainable development and conservation of *B. papyrifera* so that it can better contribute to ongoing and future dryland restoration and dry forest management in Ethiopia and beyond.

A method to regenerate frankincense

For decades, awareness raising events were organized in different regions to try and protect existing stands of *B. papyrifera* from overexploitation and destruction, though there were only limited successes regarding propagation and increasing the number of young trees. However, natural regeneration of *B. papyrifera* through seed is not encouraging as establishment is poor (Ogbazghi et al., 2006). As such, many attempts were made to propagate the tree using different methods – seedlings, wildlings, cuttings and tissue culture – and of these, vegetative propagation using 1-2 m long branch cuttings gave the best results in Tigray (Hagazi, 2008). One field experiment started in 2007 that used *B. papyrifera* branch cuttings to establish a plantation under rainfed conditions in Tselemti district, Tigray. Results showed that planting season/time and cutting size determine establishment success. Highest survival rates were obtained from cuttings planted in March (95%) and April (92%), using cuttings 90-220 cm long and 18-28 cm in circumference (Hagazi, 2008). Following these successes, further research showed that resin production and quality, assessed by chemical composition, from 12-year-old trees in this plantation were equivalent to those from natural stands (Gebretsadik, 2020).

For the establishment of *B. papyrifera* plantations using branch cuttings, research showed the following process to be successful. First, dig planting pits at least 50 cm deep and 30 cm wide several months before the first rains are expected. Branch cuttings around 1-2 metres long and 18-28 cm circumference should be taken from healthy trees, but with no more than one third of branches to be taken from any single tree. Care should be taken not to damage the cuttings on harvesting, i.e. not letting them fall directly to the ground, then they are delimbed, cut to the required size, and transported with attention. At planting, use a sharp axe to trim again and make a slanted cut at the base. Put the cutting in the hole at an angle and start filling with fine soil. Then as the pit is filled, move the cutting

until it is upright and ensure that the soil is rammed thoroughly to eliminate air voids. Then paint the upper cut and other scratched parts of each planted cutting with synthetic white oil to avoid dehydration and possible fungoid and insect attack.

Key challenges and their resolution

Beyond their socioeconomic importance, *Boswellia* trees contribute to combating desertification, to biodiversity conservation, and to reducing environmental impacts associated with dryland degradation (Mulugeta and Dermal, 2003). Key challenges for conserving and developing *Boswellia* are, however, the lack of information on options and technologies, with no viable strategy yet developed, so that in actuality, a mix of natural and human induced factors are threatening sustained production of the goods and services it supplies. But, there has been little coordination between organizations and cooperatives involved in the collection, processing and marketing of frankincense.

Sadly, there has been little attention given to the health of the trees, and the need to allow adequate periods of 'rest', rather than the usual overtapping. Also, the expansion of agricultural lands into *B. papyrifera* forests, overgrazing, fire, pests and diseases and the absence of any land use policy have also contributed to decline (Abeje, 2002). Producers will be encouraged to conserve the species from overexploitation if provided with alternative conservation and development technologies, including new propagation methods, with incentives. To translate the requirements into action, various actors must be involved, in order to meet local needs and national commitments in the conservation and development of *B. papyrifera* and other resin and gum producing trees species. Four groups of key actors play a role.

Producers, processors and traders. These are the key actors and beneficiaries, but are often blamed for decline because of their tendency towards overexploitation of *B. papyrifera* resin through continuous and unsustainable tapping. Also, farmers who have *Boswellia* trees on their own land do not always benefit equitably from the sale of resin. These problems require serious attention and a commitment to sustain the development of *B. papyrifera*, entailing the following actions.

- Design appropriate benefit sharing and incentive mechanisms for farmers who own, protect, and manage *B. papyrifera* trees/stands in their farms
- Build the skills and knowledge of tappers and cooperatives on various tapping and protection techniques by availing the proper tools/equipment and materials.
- Allocate enough resources for the proper protection, management, and development of *B. papyrifera* stands and other resin and gum producing trees.
- Create synergies and collaboration to mobilize resources and establish processing plants to promote value addition and to contribute to the sustainable conservation and development of *B. papyrifera*.

- Organize producers into legalized cooperatives, youth groups or farmer associations, and build their capacity to sustainably harvest, process and trade tree products.
- Create new partnerships for value addition and resource allocation for capacity building, to include the construction of basic infrastructure at local level.

Government. The Forest Transformation Sector (FTS) of the Environment, Forest, and Climate Change Commission (EFCCC), the Natural Resources Management and Development (NRMD) section of the Ministry of Agriculture (MoA), and their respective regional sectoral offices and authorities are key actors. They are required to engage in coordination, resources allocation, and the development of strategies, laws and implementation modalities. Moreover, they are responsible for establishing coordination and monitoring units and systems at various levels, as well as scaling up successes in *B. papyrifera* conservation and development activities. Both the EFCCC and MoA have national level projects and programmes, such as the Sustainable Land Management Program (SLMP) and the REDD+ program. The development of *B. papyrifera* and dry forest restoration could stand alone, and be converted into a national programme, or be embedded into existing flagship programmes.

Institutions of higher learning and research institutes. These institutions are required to engage in *B. papyrifera* conservation and development endeavours. Their key roles include capacity development, action research to generate new knowledge and technologies, and the establishment of learning sites, as well as the development of manuals and provision of advisory services. Mekelle University and the Wondo Genet College of Forestry and Natural Resources have been active, also the Tigray Agricultural Research Institute (TARI), the Ethiopian Environment and Forest Research Institute (EEFRI), and the Ethiopian offices of the Centre for International Forestry Research (CIFOR) and World Agroforestry (ICRAF).

Networks and platforms. A number of these exist, such as the Pastoral and Environmental Network in the Horn of Africa (PENHA), and have been engaged in advocating for dryland restoration, conservation, and the development of resin and gum trees, including *B. papyrifera*, over many years. These should continue to facilitate and organize forums and events for capacity development and knowledge sharing. Such efforts can contribute significantly to dryland restoration and dry forest management initiatives, and specifically, to the conservation and development of gum and resin producing trees, by highlighting and promoting understanding of the issues and by catalyzing action. Other platforms with which there is a considerable degree of overlap, for example the Ministry of Agriculture's National Watershed and Agroforestry Multi-stakeholder Platform (NWAMP), could also play key roles.

Conclusions and recommendations

The lack of appropriate technologies and capacity and the lack of skills and knowledge, alongside coordination gaps, are some of the key developmental barriers to effective dryland forest management and particularly to the sustainable management of existing *B. papyrifera* stands. Addressing these major challenges, together with the development of appropriate policies and strategies, will help to promote the conservation and development of *B. papyrifera* in Ethiopia and beyond. Therefore, the following are suggested as next steps, and for actors to act accordingly with full accountability and commitment.

- Ensure individual ownership of *B. papyrifera* trees on farmland, with smallholders as the ultimate beneficiaries, and encourage and incentivize people to plant *B. papyrifera* on their own farms.
- Establish an inclusive, and participatory planning mechanism to encourage resin producers and traders to engage in and invest in *B. papyrifera* development.
- Strengthen capacity, coordination and synergies among key actors/players.
- Document lessons learned and generate an evidence base that makes it possible to take success to scale.
- Set up empowered coordination units at national, regional and local levels, and allocate adequate resources for research, development, monitoring and evaluation activities.
- Develop supportive and actionable policies and strategies.
- Devise and implement responsive monitoring, evaluation, and reporting systems.
- Empower networks and platforms and cascade these down to local levels.
- Provide practically oriented training on *B. papyrifera* propagation using branch cuttings, supported by the production of guidelines, manuals and briefs, and further research that enhances methods and technologies.

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Reversing land degradation and poverty through hands-on forest and landscape restoration

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Introduction

The loss of trees and degradation of forests in the drylands of Ethiopia is caused by a combination of poverty, population pressure and overgrazing, climate change, war and continuous conflict, and unplanned land use changes. The consequences are disastrous: flooding and topsoil loss, biodiversity extinction, and declining agricultural and animal productivity, leading to major food insecurity. Since 2016, WeForest's forest and landscape restoration programme in northern Ethiopia has emphasized three main components: (i) ecological restoration and conservation of degraded forests and soils, (ii) livelihood improvement of local communities, and (iii) capacity building, research, knowledge dissemination and scaling up best practices. And to ensure long-term success, there is a strong focus on gender equity and an effort to establish strong links between governmental, non-governmental and private stakeholders in the landscape.

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WeForest is an international non-profit organization working to advance innovative, scalable, and long-lasting solutions to restore degraded forest and landscapes for climate, people and planet. In Ethiopia, WeForest's work on forest restoration supports the country's Climate Resilient Green Economy (CRGE) strategy and Growth Transformation

Plan (GTP). In 2017-2020, over 7000 ha of land has started to be restored, benefiting over 9000 households. By 2030, the goal is to restore over 50,000 ha, benefiting around 35,000 households.

Project location and descriptions

Project locations

The first project site was in eastern Tigray, along the western escarpment of the Great Rift Valley forest, covering a dry forest locally known as *Desa'a* by highlanders from Tigray, and *Dat' garab* by lowlanders from Afar Region who live on the eastern side. This is one of the few remaining dry Afromontane forests in northern Ethiopia and an eastern African biodiversity hotspot, with several threatened plant species (including *Dracaena ombet*) and animal species (e.g. *Emberiza cineracea*). The forest is critical for precipitation in the highlands and water availability downstream for Afar agropastoralists, and clear risks of desertification are now present. Here, the goal is to protect and restore over 38,000 ha by 2030. The second project site is in Dogua' Temben district, on highly degraded steep slopes at around 2800 m altitude in the highlands of southeastern Tigray, with only around 10% of forest cover left, where much topsoil and even some subsoil have already been washed away. The third project site is in Machakel district, Eastern Gojam, Amhara, in an area characterized by severe soil degradation and fertility loss.

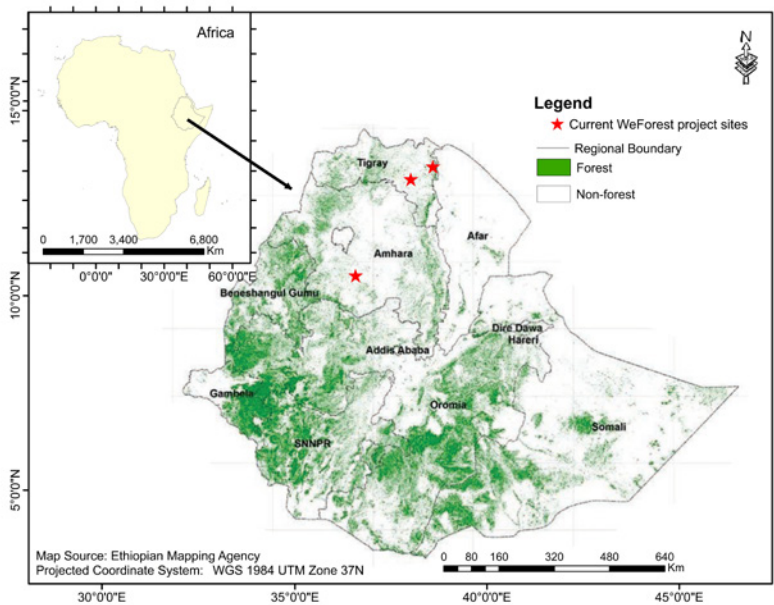


Figure 1: Forest cover in Ethiopia and WeForest current project locations. Source: MEFCC, 2018.

Forest status of project locations

Most of the remaining high primary forests in Ethiopia are in remote southern and southwestern areas (Gashaw, 2015), while forests in central and northern Ethiopia have almost completely disappeared (Feoli et al., 2002). The rugged western escarpment of the Great Rift Valley in Afar, Amhara and Tigray, and certain places considered to be sacred, are the only remaining forested areas in northern Ethiopia (Aerts et al., 2006, 2007; Wassi et al., 2009). In Amhara, most forest follows the Blue Nile in the west (Figure 1). Pre-era archaeology study shows that primary *Podocarpus-Juniperus* forest was converted to a secondary area of *Dodonaea angustifolia* scrub and grasslands that now dominates most of the Tigray mountains and hills (Darbyshire et al., 2003). *Juniperus*, *Olea* and *Celtis* species exist only in a few fragmented forest patches. Vegetation survey reports estimate national forest cover of 15.5% (MEFCC, 2018), with 22% in Amhara, 15% in Tigray, and 5% in Afar, including shrubs and scrublands where high forest area is exceptionally low (Sisay et al., 2017).

Major challenges and constraints

Uncontrolled livestock grazing is a major challenge, reducing regeneration and survival of planted seedlings. Furthermore, the population is growing rapidly, with an annual population growth rate of over 2.5%, and is expected to reach 172 million by 2050 (Bekele and Lakew, 2014). Dependency wood for fuel is extremely high, with 83% of the population in Ethiopia in the rural areas where more than 90% of energy requirements come from forests and agricultural waste (Girmay and Gebreegziabher, 2019). Moisture stress is also a key constraint for restoration, and rainfall in most of northern Ethiopia is erratic with low annual rainfall (Birhanu et al., 2014). This means a planned and well executed *in situ* and *ex situ* water harvesting scheme is critical to secure enough water during the rainy months to support seedling survival. Finally, the lack of appropriate or up-to-date forest and land use management plans is a major obstacle to success.

Socioeconomic status in the project area

Subsistence agriculture and animal husbandry in mixed rainfed farming systems constitute the main livelihood in northern Ethiopia, yet rainfall in the area is highly unreliable. Most people in communities live below the poverty line, with an income less than US\$1.95 per day (Teka et al., 2019). In the dry lowlands such as Afar, subsistence goat, sheep and camel husbandry are the primary activities, with salt mining for providing incomes from casual labour in a few villages, such as Dallol and Berhale.

Project achievements

Existing forest conservation and enrichment planting

Since 2017, the programme has protected and restored about 6787 ha of degraded forests and community managed lands, and 5.8 million trees have been planted, primarily the climax species *Olea europaea* and *Juniperus procera* in the dry rift valley Afromontane programme.

Restoration of degraded communal lands

Through a community-led participatory approach, rural communities are being trained and equipped with the skills they need to restore and protect nearby degraded communal lands for long-term benefits. Since 2017 WeForest, in collaboration with its local partners (The Hunger Project, Amhara regional state and the Bureau of Agriculture and Rural Development), has restored a total of 1084 ha and planted over 2.1 million trees in East Gojam zone and 56 ha of area enclosure (land protected by communities) in southeast Tigray. Mixed tree species planting is delivering multiple ecosystem services and functions, where economically and ecologically important, fast growing exotic tree species are integrated with native trees in a defined spacing to avoid competition. Exotic tree species also serve as the shade required for slow growing native tree species like *Juniperus procera* and *Olea europaea* for the first few years.

Livelihood support and income diversification

Significant and long-lasting change for rural communities requires a holistic approach to developing alternative, forest-friendly incomes, which must be fully integrated into forest restoration programs. Our work is in its early stages, but already shows very promising results for local households. The progress and impacts of the programme will be monitored over time. To date, a total of 9822 households are directly benefiting from the project, either through income diversification (micro-enterprise) or through casual and long-term paid employment. 5327 of these households (1570 women-headed) are engaged in the income diversification component that supports vulnerable and women headed households and poor community members in agroforestry and irrigation, beekeeping, poultry production, small ruminant rearing, and other eco-friendly business and forestry activities. Some farmers have already started harvesting products and earning incomes.

Public awareness and capacity building

Long term and short term training improves the knowledge and skills base of local communities and experts on forest management and livelihood improvement programmes. This includes regular community consultations and training at all levels from local to

Ferede Yihune is a farmer in Amhara. “My small agroforestry plot [0.125 ha] is rewarding me more than the hectare I used to grow maize on. My gesho [shiny leaf buckthorn, *Rhamnus prinoides*] planted in 2018 grew fast and yielded plenty of leaves that I sold in the local market. Every two months I harvest 200 kg for making local beer, and earn US\$188. I am happy receiving these seedlings and training provided by the project. The beginning of 2021 surprised me too with some fruits of my planted coffee trees and most of the branches are already well flourished. This helps me to earn more money to support my mother and my two sisters”.

The **Kiros** and **Makeleche families** are involved in the beekeeping project in Tigray. “This is the first honey we harvested in July 2020 after receiving beehives and colony from WeForest. We harvested 13 kg per hive, and hope to get up to 18 kg in the second harvest”.

national. To date, 8239 households (with 1689 female-headed households) have received training on forest management and forest-friendly income generating activities.

Soil and water harvesting structures

Northern Ethiopia endures a 8-month dry season, with rains in June-August. During the long dry season, the survival of newly planted seedlings is often low to very low. In contrast, the intense rainfall during the short rains causes soil erosion and topsoil loss manifested in the formation of rills, gullies, and exposed tree roots. This can destroy pasture land, farmland, settlements, and other valuable ecosystems. Soil and water management is also critical. Every planting pit for seedlings is combined with a micro-basin to capture as much water as possible during the wet season. Following the contours and slope of the area, different soil and water harvesting structures are installed in restoration sites to reduce runoff and effectively utilize water.

Alternative energy sources

Wood is the primary source of energy for most communities in project sites, and investment in technologies that increase the efficiency of energy utilization is imperative, such as solar panels and lighting, and locally assembled cooking stoves. Since 2018, in collaboration with local government and private producers, WeForest provided 4592 households with efficient cookstoves and 1399 solar lights in eastern Tigray.

Conclusions

Forest landscape restoration is a process of reversing the degradation of soils, agricultural areas, forests, and other interlinked ecosystems, regaining ecological functionality, and enhance human wellbeing (Besseau et al., 2018; IUCN and WRI, 2014, Di Sacco et

al., 2021). Success in this process requires the following set of essential elements, upon which the WeForest programme is based.

Protect and manage existing forests: Existing forests provide ecosystem services and functions.

Place local people at the heart and engage key stakeholders: Community involvement is crucial at all stages to be successful, requiring capacity strengthening of local communities and stakeholders to nurture a culture of sustainable forest management and forest stewardship.

Ensure that restoration is holistic: Restoration considers the whole landscape, so approaches must account for the interactions of different ecosystems and functions, and combine different ecological, social, and economic components to assure both ecological and human wellbeing.

Take advantage of natural regrowth whenever possible: Letting trees grow back naturally can be cheaper and more efficient than planting trees, since natural regeneration often has much higher survival rates than tree planting.

Select the right land, the right trees, and plant the right way: Not all land is suitable for tree planting, so WeForest plants in degraded areas that were historically forested. The right species depends on purpose and location, and a mixture of native and exotic species can deliver economic, social and ecological benefits.

Learn by doing and monitor changes: It is important to combine scientific knowledge with local knowledge for planning, implementation and monitoring, and ensuring results are shared and discussed with stakeholders.

Plan ahead and consult with key stakeholders: Seasonality is a critical constraint in this region and requires excellent site selection and preparation, species selection, seed sourcing, tree nursery establishment and seeding production. Getting it wrong can mean missing a whole planting season.

Create value for communities: The sustainability of restoration depends on short term and long term value, particularly for the poorest community members. This needs to be balanced with expectations of value from investors (e.g. for carbon credits) and funders of large scale programmes.

Maintain long term involvement: Forest and landscape restoration takes decades, and a tree planting project alone requires a minimum of ten years to ensure the local commu-

nity sees the benefits of managing planted trees and that they have attained a certain size to give the forest structure and composition.

Tailor approaches and scale up best practices: There are proven traditional and modern technologies including soil and water management structures, conservation agriculture, exclosure management, agroforestry, integrated livestock management, and participatory forest management. . These need to be applied in a participatory way, and scaled up.

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Dryland forest resource and management practices in Afar Regional State

Mohammed Shumbahri & Mohammed Idris

Introduction

The physiographic and climatic heterogeneity of Ethiopia allows a vast plant diversity, from alpine to desert communities (Eshetu, 2014). Ethiopia hosts two biodiversity hotspots (Eastern Afromontane, and the Horn of Africa) (Gebrehiwot, 2020; Hoffman et al., 2016; Mittermeier et al., 2004), which are regarded as major centres of diversity and endemism. The Afar Region is part of the arid Horn biodiversity hotspot. However, more than 85% of land is degraded to various degrees, posing a chronic problem (Gebreselassie et al., 2016). Forest degradation and conversion to cropland have brought about the destruction of forests between 2000 and 2013, with heavy pressure on biodiversity and human livelihoods (Betru et al., 2019; Eshetu, 2014; MEFC, 2017).

Drylands are found especially in Afar and Somali regions, with desert and semi-desert scrub intermixed with patches of *Commiphora* and *Boswellia* species (Lawry et al., 2015). Despite their socioeconomic and ecological importance, drylands are poorly managed and have received little attention in policymaking and research (Lemenih and Bongers, 2011). Charcoal is produced by almost all rural households as one of the core livelihood or income generation strategies, further promoting deforestation and forest degradation (MEFC, 2017). In addition, agricultural expansion, grazing, drought and unsustainable fuelwood harvesting, intensified by refugee camps, are some of the other threats (Lemenih and Bongers,

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2011). As a result, dryland forests are highly fragmented, with low regeneration, and degraded in terms of both species composition and productivity.

Dryland forests can support sustainable and resilient rural and urban livelihoods (Amanuel et al., 2019; Lawry et al., 2015). Forest-related incomes can bridge gaps and transcend their relative economic importance to household income under the prevailing circumstances, contributing to enhanced resilience (Lawry et al., 2015). Income from dry forests makes up 15% of total income, with additional importance in drought years (Amanuel et al., 2019).

Human pressure is a major factor in the deterioration of forests (SERI and IUCN, 2004). But forests are still supporting a broad set of rural agrarian as well as pastoral and agropastoral livelihoods, though their value is declining due to overgrazing (Lemenih and Tadesse, 2008; Eriksen and Marin, 2011). For instance, *Dobera glabra*, which is a valuable resource in terms of food security for Afar pastoralists as well as those across the Horn of Africa, is fast disappearing as a result of anthropogenic factors (Tsegaye, 2010). Afar rangelands are degraded, leading to reduced availability of animal feed and the loss of wild animals (ANRS, 2011). (The latter are an important element in the region's tourism potential, with implications for livelihoods.) This degradation is evidenced by studies of the floristic composition of woody species, which reported that these areas are now much lower in species composition and diversity (Shumbahir and Gebrehiwot, 2016; Tefera et al., 2015). Thus, there is an urgent need to develop and apply forest resource conservation and rehabilitation strategies.

Use of forest resources

Reports show that significant changes in the status of many resources have occurred over the past 50 years. Forests have been depleted while invasive plants have expanded, stifling native species. Pastoralists' access to key grazing has been curtailed by the establishment and expansion of state cotton and sugarcane farms. As is the case with most pastoralists elsewhere, the Afar do not own or benefit from these new agro-enterprises. Pastoralists have turned to alternatives, with fodder collected during the dry season and fed to livestock kept around homesteads, to supplement grazing (Alemu and Flintan, 2007). This expansion of fodder production implies a knock-on effect of forests, as part of the broader expansion of farming onto a greater area of land, rather than its intensification on (pre-) existing farmland.

Forest and trees have long been an integral part of pastoralist livelihood systems and the pastoral way of life, providing important food and household supplies for Afar pastoralists. Plants like *Ficus carica* and *Solanum incanum* are used for coagulating milk (Desta et al., 2020). Among woody species, *Dobera glabra* is valuable as a food source in times

of drought or harsh dry seasons (Tsegaye et al., 2010). Both humans and livestock consume a variety of fruits and leaves. Several trees have multiple purposes. For example, the fruits of *Wangeyo* trees are used as feed for goats. The dry wood is used for fuel and green branches for construction. The wild date palm (*Hyphaene thebaica*) is also used for different purposes, and leaves for *aunga* (mat) making provide an important income generation source for women. Shrubs with edible fruits include *aeka*, *oudukeble* and *mud-guard*. *Kiltu* has a milky fluid and is used as a chewing gum. It has a sweet taste and is elastic. Natural chewing gum is also derived from *bedero* trees, which also have edible fruits. Pastoralists protect these trees from destruction, as they believe that cutting them will result in poor rainfall (Alemu and Flintan, 2007). Moreover, traditional institutions and laws, in Afar as well as Somali society, established strong social sanctions and penalties for tree cutting. These have, however, been eroded by social and economic change.

Medicinal plants are used to treat snakebites, liver diseases and skin problems. *Acacia abyssinica* (*kesselto*) is ground and boiled to treat gastric complaints and applied to the skin of livestock. *Salvadora persica* (*adayetu*) and *Balanites rotundifolia* (*alayto*) species are important in healing malaria in the area around Abala, at the Afar-Tigray border in the north (Gebrehiwot et al., 2019). Medicinal plants and products are not only used within the household but are also sold, thus being important sources of income. Pastoralists still greatly rely on them for everyday use and particularly in dry seasons and droughts (Alemu and Flintan, 2007).

Changes in resource availability over time

Dryland forests

Forests and trees that existed twenty years ago have been rapidly disappearing. For example, *adedo*, *eeab* and *keselto* trees have all declined in numbers, and those that are left have stopped producing fruit. Moreover, large areas of land have been covered with *adayetu*, a tree used for tooth cleaning, and scrub (Alemu and Flintan, 2007). Pastoral areas are rich in plants of good grazing value, and were until fairly recently free of invasive woody plants. But now indigenous species have declined. This shift in vegetation composition has serious consequences for pastoralists and their livestock. Plants with insignificant forage value such as *aburi* (*Amaranthus dubius*) and *ashara* (*Spergula arvensis*) have replaced preferred plants. Similarly, multipurpose trees such as *uddaito* (*Balanites aegyptiaca*), *mederto* (*Cordia sinensis*) and *kusrailto* (*Zizyphus spina-christi*) are declining because of the introduction of new plant species (PFE, 2010).

Invasive species

The impact of invasive species in dryland ecosystems is devastating. Almost all invasive and potentially invasive species reported in Ethiopia are found in Afar Region. These

include *Prosopis juliflora*, *Parthenium hysterophorus*, *Nicotiana glauca*, *Calotropis procera*, and *Cryptostegia grandiflora* (*halimero*), a toxic liana that kills livestock. According to elders, *halimero* entered the Afar ranges 50 years ago and today it is associated with the arrival of outsiders coming in to establish state farms (Alemu and Flintan, 2007). There is also the example of *welahauel*, an invasive weed introduced with commercial fertilizers.

P. juliflora in particular, modifies ecosystems by rapidly invading huge area (Shiferaw et al., 2019), severely affecting indigenous and endemic plants. Grazing areas that were dense before the fall of the Derg regime are now covered by *Prosopis juliflora* (known locally as *woyane cara*). Though attempts have been made to control *Prosopis*, it is rapidly taking over rangelands. One scheme started by a youth group to turn *Prosopis* into charcoal was thwarted by the local government who refused to provide a license for its operations. However in other parts of the region, the NGO Farm Africa had more success with *prosopis*-utilizing charcoal production, but still faces bureaucratic restrictions on its sale. At the moment, communities feel that they do not have the requisite knowledge or expertise to deal with these invasive species nor to halt forest and rangeland degradation. As such, nothing is being done to address these problems. But it is important to promote interventions and changes in practice that are in line with the changing needs of local people and build on the existing practices of the pastoralists themselves, rather than externally designed and delivered interventions (Alemu and Flintan, 2007).

Pasture and soil

Pasture availability has declined for a number of reasons. Increased animal and human population density, increased or expanded cultivation, droughts, encroachment across pasture land by weeds and invasives, especially *Prosopis*, have together lead to a reduction of pasture (Philpott et al., 2005). Excessive grazing and trampling by livestock reduces vegetation cover and increases exposure of soil to erosion. The expansion of irrigated agriculture also increases the vulnerability of lowlands to flooding and the effects of increased salinity. In the Awash valley, exposure to flooding coupled with salinity has affected the vegetation and soil over a wide area. *Prosopis juliflora* was introduced to deal with the problem, but has only worsened the situation (PFE, 2010).

Challenges facing pastoralists

Pastoralists face many threats to their livelihoods, both internal and external. Internal factors include the drought-related loss of livestock and shrinking rangelands. Climate change and recurrent drought are among the external factors (PFE, 2010). However, recent changes in land use and associated impacts on biodiversity and peoples' livelihoods have contributed to the growing crisis of pastoralists and agropastoralists (Tsegaye, 2010).

The region is vulnerable to climatic variability and climate change is likely to increase the frequency and magnitude of extreme weather events that may lead to a greater incidence of disease, water scarcity, shortage of feed, flooding, and further range degradation (ANRS, 2010; Belay et al., 2005). Current evidence strongly indicates that rural development and economic and social progress are adversely affected by climate change (ANRS, 2010). Pastoralist and agropastoralist areas of Afar are noted for their highly variable and uncertain rainfall and are prone to drought and food shortages (PFE, 2010). Further research and analysis are needed to come up with solutions that make it possible to overcome these issues and increase the resilience of people and their animals. The restoration of dryland forests and the sustainable growth of tree-based livelihoods should be a part of this.

Dryland forest management, conservation and restoration

Based on lessons learned from piloted interventions and experiences from other countries, and in consultation with local stakeholders, the Afar National Regional State Pastoral, Agriculture, and Rural Development Bureau (PARDB) drafted regulations to guide *Prosopis* management. The regulations outlined possible strategies to prevent the further spread of *Prosopis juliflora* and to rehabilitate invaded areas. The regulations also identified institutions responsible for leading this effort at different levels. The regulations are awaiting approval from the regional council. Once they are endorsed, it will be necessary to prepare a detailed implementation plan and mobilize stakeholders. It is understood here that *Prosopis* trees and bushes can be a productive resource, if controlled and managed effectively.

A dry forest restoration program was conducted by Samara University in the Garraf watershed in Koneba District in 2013, covering 600 ha in Uruh/Dekhanu kebele and 4000 ha in Wahdes kebele. Prior to this, local people had said that they wanted to be involved in conservation programs and undertake conservation practices in order to address the impacts of severe flooding and drought, as well as the reduction in the number of plant species and wild animals in the area. The district administrator, elders and local people agreed to work together towards this goal. To protect the site, 15 guards were recruited by Samara University, and a nursery was established. Following rehabilitation work, the site is now restored with more dry forest species including *Acacia*, *Olea* and different grasses and wild animals returning to the site. The success of this program, albeit on a relatively small scale, gives grounds for optimism about the potential to restore the region's drylands and dry forests.

Conclusions and recommendations

No significant work has been undertaken in managing, conserving or rehabilitating dryland forest resources in Afar Regional State, and as a result, they are in a critical condition. In dryland areas, there is a close relationship between pastoralism and the natural environment, and pastoralist communities have devised adaptation methods, with their own innovations and ways of doing things that are worth building on. Pastoralists have a wealth of indigenous technical knowledge that, combined with highly efficient rangeland management methods, enables them to maintain the health and size of their herds. Pastoralists have long been highly effective managers of natural resources, animal, rangelands, water and trees. And it is important to recognize that the current crisis is largely a consequence of modern, externally driven resource pressures.

Pastoral communities assume that the fundamental threats to pastoral systems are the increasing marginalization of their drought-response mechanisms. However, there are many impacts, such as increased land degradation and soil erosion, changes in water availability, biodiversity loss, more frequent and intense pest and disease outbreaks that need to be addressed which require awareness creation, and the development of new practices, among pastoralists. Grazing management is also necessary in order to rehabilitate rangeland, and traditional customary institutions can play a great role in managing resources. Government, NGOs and local people should all be involved in the management, conservation and rehabilitation of the drylands and of forest resources.

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The status of dryland forests in Amhara Regional State

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Introduction

Amhara National Regional State is the second most populous region in the country with 23-25 million people, of which 87% are rural (CSA, 2007). It is home to many ethnic groups including the Amhara, Agew, Awi, Oromo and Qimant amongst others. Covering 170,052 km², the region has a wide ecological range due to variability in altitude, topography, climate and landscapes, and is rich in biodiversity, food crops, livestock, forests and wild animals. Ras Dejen, the highest mountain in Ethiopia is found here along with many masifs, and Lake Tana, Ethiopia's largest lake and the source of the Blue Nile. Excepting the plains in the mid highlands and lowlands, the region predominantly consists of a rugged, hilly landscape. 34% of the land has a slope of over 35%. This rugged landscape coupled with improper natural resource utilization have made it prone to severe land degradation and soil nutrient depletion, especially in the highlands.

Agriculture is the dominant livelihood and source of income, but average land holdings per household are less than one hectare. As a result of this hunger for land, with a rapidly growing population, there is migration to the drylands, being the only places where landless youth can migrate and settle, with towns booming. Dryland areas, which once were neglected, are now becoming an important source of agricultural exports, including sesame, soya, honey, gum and incense, and cattle. Given their growing populations, rising

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economy and environmental significance, dryland areas need to be properly developed, protected and efficiently utilized.

Spatial distribution and floral composition

The Amhara National Regional State Agriculture Bureau estimated a 14% forest cover (EFCCC, 2016). Forest biomes include Afroalpine, sub-Afroalpine, dry Afromontane forest and scrub, moist Afromontane, *Combretum-Terminalia* woodland, *Acacia-Commiphora* woodland, high and lowland bamboo, agroforestry and plantations (Limenh and Kassa, 2010). But, whatever definition or methodology is used, the natural forest resources of the region are dwindling, and almost gone in the highlands except for patches on mountain ridges, inaccessible areas and sacred places like churches, with the most pressing deforestation in dryland areas where agricultural investment is booming.

However, in some areas forest is increasing as plantations are established, especially of *Eucalyptus* spp. and *Acacia decurrens* in Gojam, Wollo, North Shoa and South Gondar. In Awi zone, forest cover has grown to 36%, and Fogta Lekoma district has a forest cover of 76%, mainly *Acacia decurrens*, showing a major shift from agriculture to a forestry led economy. The annual trade in forest products in Awi zone alone is estimated to be 1.5 billion birr (US\$35 million) per annum (EFWPDA, 2020), and royalties that traders pay to the government almost doubled from 2010 to 2013 (Figure 1).

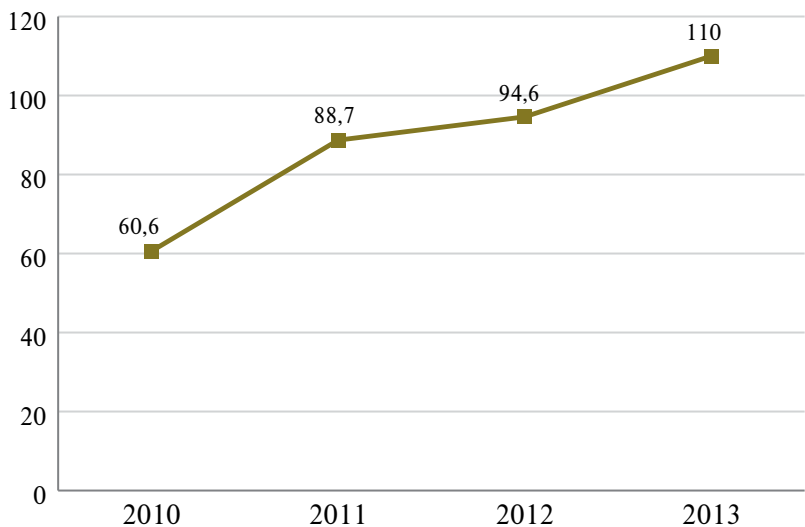


Figure 1. Royalty fees collected from the sale of forest products in Amhara (2010-2013).
Source: Adapted from EFWPDA (2020)

The dominant dryland forest types in Amhara are *Acacia-Commiphora* woodland, *Combretum-Terminalia* woodland, and dry Afromontane vegetation on the western escarpment (IBC, 2005). Common trees in *Acacia-Commiphora* woodland include *Acacia tortilis*, *A. mellifera*, *Balanites aegyptiaca*, *Acalypha* spp., *Aerva* spp. and *Capparis* spp. Those in *Combretum-Terminalia* woodland include *Combretum* spp., *Terminalia* spp., *Oxytenanthera abyssinica*, *Boswellia papyrifera*, *Anogeissus lieocarpa*, *Sterospermum kun-tianum*, *Pterocarpus lucens*, *Lonchocarpus laxiflorus*, *Lannea* species, *Albizia malacophylla* and *Enatada africana*.

Dryland forests in Amhara are found along the Sudan border, and the Abay and Tekeze valleys, and dry forests are dominant in around half of the 13 administrative zones - in Awi Zone (Banja and Jawi woredas), West Gondar zone (Quara, West Armachiho and Metema woredas), Central Gondar Zone (Lay and Tach Armachiho, Tegedie and Chilga woredas), Wag Hemra (all woredas), West and East Gojam (all woredas adjacent to Abay Gorge) and Wollo valley (from Raya to Shewa Robit). *Acacia-Commiphora* woodlands dominates in the Wollo valley, with *Acacia seyal* spreading in farmland, grazing areas and homesteads in Raya-Kobo, Mersa, Urgessa, Gubalafto, Tehuwledre, Kalu, Dawa Chefa, Efratana Gidim and Shewarobit valley. The increasing extent of *A. seyal* has improved land quality where land was degraded, providing hope to local communities, as the trees supply fuel, fodder, construction wood and shade.

Amhara region is rich in gum and incense producing trees, although management is poor. In East Gojam zone there are 40,000 ha of forest dominated by *Boswellia papyrifera*, following the Abay Gorge (Hulet Eju Enesie, Shebel Berenta, Debre Elias and Gozamn woredas); with 11,000 ha in West Gojam (Wonberima, Burie and South Achefer); 35,000 ha in Awi zone (Zigem and Jawi woredas); and 7000 ha in Central Gondar (Alefa, Takusa, Tegedie, Tach Armachiho, Kinfaz and East Belesa woredas). There is more than 30,000 ha of *Boswellia* forest in Adarkay woreda alone (North Gondar Zone); 95,000 ha in Qura, Metema and West Armachiho woredas (West Gonder zone); and 11,000 ha in Meketewa, Lay Gaynt, Ebinat, Ayna Bugna, Dehana, Ziquala, Wogdi and Mekdela woredas.

Contribution of dryland forests

Lowland dryland forests provide environmental protection and valuable resources to local people and those in adjacent highland areas. Their environmental functions in western Amhara region are crucial, and the role they play in buffering the highlands from the extreme heat to the east and filtering the sand that blows off the Sudano-Sahelian desert. In spite of their importance, mismanagement has led to the increased occurrence of sand dust, almost annual, in Gondar and Gojam, which used to be observable once every ten years on average.

The economic contribution of these dryland areas is also very significant. Non-timber forest products (NTFPs) are the most important products, including gum and incense, medicine, honey, fodder, and foliage used for smoking houses. In 10 zones and 28 woredas in Amhara, more than 228,553 ha of dry forest is being used for gum and incense production. Of this, 138,886 ha is managed by 2,643 youth, members of a total of 27 associations, with 7 commercial investors in gum and incense production (EFWPDA, 2020). Up to 2013, about 12,704 quintals (1270 tonnes) of gum and incense had been produced, mostly for the domestic market, with 1061 quintals (8%, about 100 tonnes) reported to have been exported.

In Metema and Quara woredas, data collected from 450 households showed that income collected from the sale of NTFPs made up almost a quarter of their incomes (Table 1), of which gum and resin contribute about 60% (Walle and Nayak, 2020). Income from NTFPs also helps 20% of households to remain above the poverty line. However, beyond the evident economic contribution to the local community, further studies are needed to also evaluate indirect benefits along the whole value chain.

Table 1: Mean annual income per household and capita, and relative income share (mean of 450 persons)

Income source	Mean annual income per household		Mean income per capita		% of total
	Birr	US\$	Birr	US\$	
Crop production	40,565	950	9,410	220	50
Non-timber forest products	18,602	435	4,180	98	23
Livestock production	16,697	391	3,912	92	21
Off-farm income	4,122	96	936	22	5
Transfer payments	567	13	132	3	1
Total	80,554	1,887	18,570	435	100

Source: Walle and Nayak (2020)

Existing challenges in dryland forests

Institutional issues

Actions to protect dry forests from deforestation have been more rhetoric than reality, and this is manifested in the inefficient institutional arrangements and lack of coordination within the agriculture bureau. For example, the primary mission of the agriculture bureau is to enhance agricultural productivity by land expansion and agricultural intensification on the existing areas of farmed land. But the bureau is also mandated to manage forests, though some are being cleared for crop production. A new Environment, Forest

and Wildlife Protection and Development Office was established at zone and woreda level in March 2021, but the resources allocated to it are insufficient to enable this agency to protect the dryland forests from the ongoing threats.

Agricultural investment

Agricultural expansion is the most important cause of the loss of dryland forests in Amhara, with more than 300 investments in 2021 alone, often associated with woodland clearance. Although investors must submit environmental impact assessments prior to commencing operations, they are rarely followed. There is inefficient monitoring and limited auditing capacity in the competent authorities and poor support from the local government. Some investors, it has been observed, after obtaining land for agricultural purposes, simply cut down all the trees on the land allocated and make charcoal, then abandon the land. These incidents are alarming and call for immediate intervention if dryland forests are to be conserved.

Inefficient resource utilization

Mismanagement is exemplified by the production of gum and incense. According to Forest Development, Protection and Utilization Directive 002/2010 of Amhara Region, a *Boswellia* tree tapped for gum for five consecutive years should then be given a recovery period of three years, and the bleeding depth should not jeopardize the normal physiology of the plant, and no bark should be removed when harvesting. However, producers never let the tree rest and trees are being bled until the bark and even the sapwood are removed together with gum. Attributable to these malpractices, significant numbers of trees are being affected by insects and pests that finally lead to the loss of the trees. This calls for the proper training of producers and the introduction of measures to enforce the Directive.

Illegal cutting, free grazing and fire

Illegal cutting and overexploitation of forests for firewood and charcoal is common throughout the country, especially where ill-defined ownership and remoteness means that dry forests are considered 'free' resources. In addition, highlanders from Gonder Zuriya, Chilga and Wogera woredas, for example, move their livestock to graze in dry forest areas during the summer, preventing the regeneration of young trees and adding to land degradation. Forest fires are also an increasingly common phenomenon in dryland forests. In 2021, wildfires were observed in more than 10 areas leading to significant ecosystem damage, as the capacity to monitor and control fires is very poor. Other than human manpower, there are no tools or equipment for dealing with forest fires. It was only during the 2018 Simian Mountain National Park fire disaster that the government hired a fire-fighting helicopter. The wildfire in Wofwasha forest in 2021 was another

example of a fire that was not controlled, with the challenge also exacerbated by the steep terrain. Increased capacity to manage wildfires, and to reduce the risks of them starting in the first place, are urgently required.

Opportunities for dry forest conservation

In the past five years, significant measures have been taken to gazette more dryland forests as national parks. Some 150,000 ha have been gazetted, including Godebe National Park (>15,000 ha) and Altash National Park (>50,000 ha) in West Gondar, Woleka National Park (>15,000 ha) in South Wollo, Bakusa National Park (>50,000 ha) in Jawi area, and Mahier Selasie Andinet Gedam dry forest (>10,000 ha).

The Environment, Forest and Wildlife Protection and Development Authority (EFWPDA) was established in 2017 at regional level. However, it does not yet have any branch offices at the zone and woreda levels, with just a small department with very few employees working with zone and woreda land administration offices. After measures the regional government introduced in 2021, branch offices at zone and woreda level are now to be established independently, which is a significant step that creates an enabling environment for those responsible for forest conservation and management.

The National Green Legacy Initiative established by Prime Minister Abiy Ahmed sets important governmental goals. It focuses on planting more trees, but conserving remaining forest areas can be considered to be another activity supported by the initiative. Concerned professionals and relevant forestry authorities should also lobby for and solicit funds for restoring dryland forests, including the forestry department at Gondar University that is conducting relevant research, and other higher learning institutions.

Conclusions

Dryland forests are an important in Amhara for many reasons, with a variety of *Acacia*, *Boswellia*, *Combretum* and other trees that support many communities that are dependent on forest resources for food, feed and fuel. But despite the economic and environmental significance dry forests have for the region and for the nation at large, current management practices are not appropriate for sustaining and conserving the resource, with severe over exploitation ongoing. Furthermore, natural regeneration and recovery of forests cannot keep up with the ongoing deforestation, burning and overgrazing.

The challenge is to conserve the remaining forests and restore degraded forests, and this requires major interventions as well as substantive policy changes. But, equally important are the ongoing, smaller initiatives that could be used as a springboard for further actions. Although investments in dryland areas are appreciated and necessary, they are often implemented at the expense of forested areas, and do not comply with national

and regional standards. Illegal settlements are also being established and these pose serious threats to the wellbeing of forests. And management practices need improvement in almost all respects. In light of all this, urgent action is needed to protect dryland forests from further loss, and the relevant authorities should play their role. The resource base has to be studied, management plans developed, and the capacity of forest conservation and development staff and institutions has to be strengthened. Strategic environmental planning should be introduced in the region, alongside closer follow up and monitoring.

Despite the increasing recognition of the role of dry forests in climate change adaptation and mitigation, these versatile resources still do not receive adequate attention in regional planning, which might enable them to realise their potential to enhance their contribution to the local economy and to sustainable environmental management. The value of dry forests must be fully recognized and this is imperative is all the more evident when one considers the increasing number of agricultural investment initiatives which base their existence on the loss of these dryland forests.

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Dryland restoration and dry forest management in Benishangul-Gumuz

Abeje Eshete & Bekele Guta

Introduction

Benishangul-Gumuz Regional State, with an area of 51,000 km², occupies 4.6% of the total land area of Ethiopia. It is divided into three administrative zones, 19 woredas, and 33 kebeles. Mean annual rainfall is 860-1275 mm, with rainfall related to altitude (NMSA, 1996), which ranges from 600 m where the Blue Nile crosses the Sudan border, to over 2500 m on the Belaya plateau in Dangur woreda. Temperatures reach a daily maximum of 20-25°C in the wet season (April-November) and 35- 40°C in the dry season, being hottest in February-April (BGRS, 2004). The main agroecological zones are the lowland '*kola*' which covers 75% of the region (<1500 m) and the midland '*woynadega*' (1500-2500 m), covering 24% of the region. The highland '*dega*' (>2500 m) covers 1% of the land area (BGRS, 2007; BoFED, 2017; Moreda, 2013). Bushes and shrubs are the dominant vegetation (77%), followed by forest land (11%), cultivated land (5%), grazing land (3%) and marginal land (2%).

The region is endowed with fertile land suitable for high value crops, livestock, hunting, wild food gathering, apiculture and fisheries, with significant potential for agricultural development on the 911,877 ha of arable land, of which less than half has been cultivated (BGRS, 2010). It has two major river basins, the Abay (Nile) and Baro-Akobo, with many smaller rivers with potential for hydroelectric generation, and 390,000 ha are potentially irrigable (BGRS, 2012). Crop production and livestock rearing provide most income for 92%

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of the population (Guyu, 2011), with indigenous communities using shifting cultivation, with only manual labour on half of all farms, with 45% using animal traction. In addition, hunting, wild food gathering, the production and collection of honey, artisanal gold mining, handicrafts, petty trade and the preparation and trading of charcoal are some of the other income sources (BGRS, 2004).

Dry forest resources

By far the dominant natural vegetation type is dry broadleaved deciduous forest, specifically *Combretum-Terminalia* woodland and wooded grassland between 500 and 1800 m altitude), with small areas of dry evergreen Afromontane forest, and moist evergreen Afromontane forest (Herrmann, 2007; UNDP, 2017). Vegetation is also subclassified into eight types: dense forest, riverine forest, broad-leaved deciduous woodlands, acacia woodland, bushland, shrublands, *Boswellia* woodland, and bamboo thickets (Bessie et al., 2016; INBAR, 2010). *Combretum-Terminalia* woodland and wooded grassland are characterized by small to moderately sized trees (*Combretum* spp, *Terminalia* spp, *Boswellia papyrifera*, *Sterculia setigera*, *Oxytenanthera abyssinica*, *Balanites aegyptiaca*, *Annona senegalensis*, *Acacia senegal*, *Acacia seyal*), along with shrubs, herbs, grasses and sedges. Economically important tree species include gum and resin trees, bamboo, and trees with edible fruits (e.g. *Adansonia digitata*). Vegetation is intentionally burnt in most years, with most woody species adapted to fire (Teketay, 2000).

Gum and resin trees cover 100,000 ha, with *Acacia* producing some 630 tonnes of gum arabic per year, with 260 tonnes more from *Boswellia* and *Commiphora* (Worku and Bantihun, 2018). The other dominant species is a lowland bamboo (*Oxytenanthera abyssinica*) covering an estimated 1 million hectares, with much potential as a short rotation source of construction materials and fuel. Vegetation cover also has significant roles in improving water use and ecosystem benefits, and protects watersheds from erosion. This is now critical for reducing siltation of the Great Ethiopian Renaissance Dam, the country's ambitious electrification project.

Research shows that natural vegetation includes unique flora with a high number of endemic species, with several new species of vascular plants having been collected and described in recent years. Following this, the Ethiopian Biodiversity Institute has protected selected forest areas as a conservation sites (Mosissa et al., 2020). Moist evergreen montane forest in the highlands, and riverine forests, are especially rich in biological diversity.

Dry forest management

To achieve sustainable forest management, the active involvement of local communities and other stakeholders is crucial. Local government and communities are expected to share responsibility for the management of protected areas (national parks, wildlife reserves) and conservation of natural resources and biodiversity, along with the production of timber and NTFPs, and maintenance of regeneration capacity under different land tenure systems (Bray et al., 2003; Wilkie et al., 2003). Good practices include establishing and managing exclosures, fattening livestock, participatory production of frankincense, bamboo, honey and medicinal plants through small and micro enterprises (Tolera et al., 2015).

Sustainable harvesting and trade of NTFPs and conserving forest resources are considered vital to improving rural livelihoods, by helping to fulfill subsistence needs, serving as a safety net in food insecure periods, and providing regular cash income (Walle and Nayak, 2020). Reports indicate that more than 100 community based organizations and participatory forest management cooperatives have been established. These are involved in the production of NTFPs, mainly gum and resin, forest honey, and bamboo products. Together, they manage 347,000 ha of dry forests over 7 districts and 107 kebeles. There are also a small number of private enterprises and one government enterprise engaged in gum and resin production. Some cooperatives generate a mean household income of more than 16,000 Birr (US\$370) per year from the sale of frankincense alone. Bamboo Start Agroforestry Plc manages 390,000 ha of lowland bamboo, though experts say there is no legal basis or documentation that show the transfer of land ownership to the company.

Challenges in the forest sector

Large areas of dry forests are de facto open access, though legally owned by federal, regional or local government. In most cases, the responsible government institutions lack the physical, financial and human resources to adequately implement policies and regulations, resulting in deforestation and degradation of forest resources in the region and the country (FDRE, 2017). The major driver is the expansion of activities by domestic and foreign investors in commercial farming, and also by smallholders. Other drivers include the allocation of forest land for the establishment of refugee camps, fire, overgrazing, and illegal and uncontrolled harvesting of wood for charcoal, poles, fuel and other purposes.

The underlying causes are population growth associated with self-initiated migration and government-initiated resettlement, the increased number of refugees, institutional instability and the low capacity of forestry and related institutions, the inadequacy of forest laws (and the absence of forest regulations and guidelines) and the associated poor implementation of the forest policy, strategy, programs and proclamations.

Key players

Sustainable management of forest resources requires the identification and engagement of influential stakeholders amongst the different state and non-state actors, including local communities that directly benefit from forest management. State agencies at federal, regional, district and kebele levels have different roles in the successful implementation of sustainable forest management. At federal level, this includes the EFCCC, the Ministry of Agriculture and Natural Resources and the Ministry of Peace, each represented by regional bureaus and experts. At regional level, there are the Bureau of Agriculture and Natural Resources, Bureau of Rural Land Administration and Land Utilization, Office of Cooperatives and Small and Micro Enterprises and Financial Institutions. The Bureau of Agriculture and Natural Resources is the main actor overseeing the development of forests and agriculture and implements PFM as well as the Sustainable Land Management Program (SLMP). There is also a government gum marketing and processing enterprise. The various activities of local communities are also significant. There are many communities living near or in forests, and thousands of refugees now settled in the vicinity of forests. Research and higher learning institutions are important too, with their efforts to identify, adopt and generate technologies and information relevant for sustainable forest management and to pack knowledge into extension packages to facilitate dissemination (Atmadja et al., 2019).

Non-state actors supporting sustainable forest management include NGOs (Farm Africa, Assosa Environmental Protection Association and UNHCR), community based organizations (PFM cooperatives, small and micro enterprises), and private enterprises that produce NTFPs. There are more than 107 PFM cooperatives and community groups engaged in the production and conservation of forest resources and the sale of seedlings from nurseries. And there are 20 private enterprises engaged in frankincense production and marketing, contributing to sustainable management, capacity building, technology transfer and income generation. Research institutions could better support the scaling up in coordinated efforts, including through revised curricula for relevant education programmes, such as forestry and NRM at higher learning institutions. They could play a greater role in supporting government and community initiatives for sustainable management of forest resources. On-going initiatives include: (i) the scaling up of selected best practices by Farm Africa/SOS Sahel, (ii) natural frankincense gum marketing and processing, including by some 20 private concessioners, (iv) the Bamboo Star company's commercial managing and processing of bamboo products, and (v) community groups engaged in the production and sale of seedlings from private nurseries. Such activities could be very significant in contributing to sustainable forest management, capacity building, technology transfer, local and national income generation, and the creation of marketing links.

Conclusions and recommendations

Benishangul-Gumuz Regional State is very rich in forest resources, which cover 72% of its area. The *Combretum-Terminalia* vegetation is the dominant vegetation with tree species that provide different forest products for subsistence and commercial use, and as a source of resins, honey, fodder, shade, medicine and other products and services. The vegetation also plays vitally important environmental roles, serving as a green wall to protect against the expansion of the Sahara desert, providing watershed protection, supporting water use, reducing erosion and the siltation of dams, and promoting biodiversity conservation. Despite their enormous economic and environmental importance, forests are declining due to the expansion of smallholder and commercial farmland, encroachment, human-induced fire, wood harvesting for energy and construction, shifting cultivation, and resettlement programmes.

The rapid decline of vegetation has been recognized by the regional government. Accordingly, the Benishangul-Gumuz Regional State has started to manage forest resources through forest management systems that focus on major products like gums and resins, medicinal plants and honey. Sustainable production systems for NTFPs, facilitated by NGOs such as Farm Africa and SOS Sahel, are supported financially and technically by the state's Bureau of Agriculture, as well as by the NGOs. The following are important recommendations for improving forest management in order to enhance positive impacts on the landscapes and on people's livelihoods.

- Raise awareness around the livelihood improvement potential and environmental roles of dry forest resources.
- Establish clear forest ownership rights and issue land certificates for large community managed forests.
- Demonstrate the economic contribution of dry forest products.
- Improve the value chains for timber and non-timber forest products, with specific attention to product quality as well as inclusiveness.
- Promote the sustainable management of acacia woodlands for firewood and charcoal production.
- Strengthen the capacity of forest institutions, with a view to increasing commitment within agencies and stimulating active government involvement.
- Clearly define entry and exit strategies for non-state actors such as NGOs and other project implementers.
- Intensify research and extension activities to generate technologies on the silviculture of native tree species.

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Benefit-sharing mechanisms for disbursing results-based payments from the Oromia Forested Landscape Program

Tesfaye Gonfa

Introduction

The Government of Ethiopia has embraced Reducing Emissions from Deforestation and Forest Degradation (REDD+), as well as conservation, sustainable management of forests and enhancement of forest carbon stocks, as part of its strategy to achieve a Climate Resilient Green Economy (CRGE). This strategy has identified the forest sector as one of the four priority areas for fast track investment and established a policy framework for implementing REDD+ in the country. Forestry is expected to generate over 50% of the expected 255 Mt CO₂e Emission Reduction (ER) by 2030 in the country through the CRGE strategy. The Oromia National Regional State Forested Landscape Program (OFLP), the first pilot sub-national emission reduction programme being implemented, was designed as part of Ethiopia's REDD+ Readiness Process. The results generated will contribute to the achievement of Ethiopia's CRGE Strategy.

The OFLP is a 10-year programme implemented with two financial instruments, a US\$18 million mobilization grant from the BioCarbon Fund (BioCF)-plus, and a US\$50 million Result Based Payment (RBP) from BioCF Tier 3, both facilities managed by the World Bank. The mobilization grant finances program establishment, the enhancement of a state-wide enabling environment for scaling up actions and implementation of selected on-the-ground investment activities over a period of 5-years. The programme would receive result

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based payments (RBP) for a net verified emission reduction (ER) against the program's reference level in a period of up to 10 years. The geographic scope or 'accounting area' of OFLP is the jurisdiction of Oromia National Regional State (Figure 1).

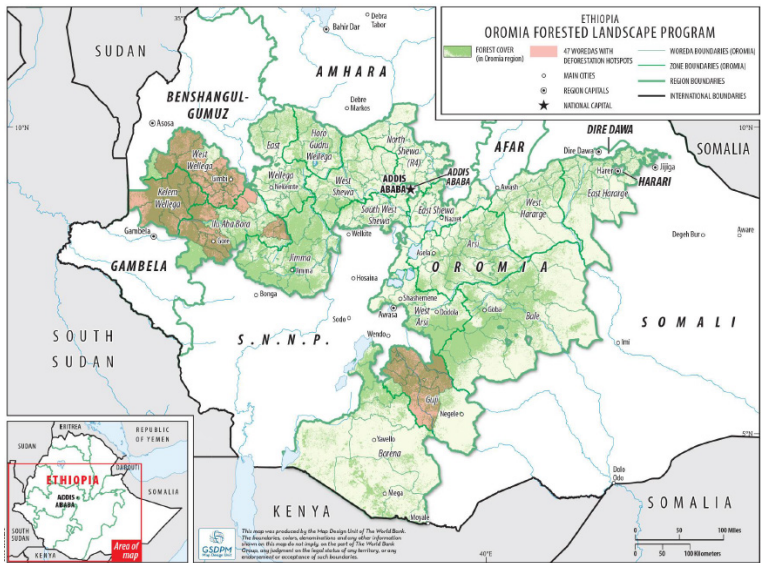


Figure 1. The Oromia Forested Landscape Programme

The emission reduction payments will come from REDD+ in the next few years and will potentially involve other sectors in later years of program implementation. The Oromia Forested Landscape Program is expected to generate financial and non-financial benefits. This article outlines the benefit sharing mechanism for emission reduction payment from the program, focusing on monetary benefits.

A step-wise process was followed to develop the benefit-sharing mechanism (Figure 2). A total of 111 consultation meetings were held with a wide range of stakeholders in 2016. Two of these were with policy makers, one at federal level and one at regional (Oromia National Regional State) level; one consultation with civil society organizations and experts in natural resources management, and the remaining 108 meetings with communities across Oromia, involving a total of 4647 community members, 1212 women and 3435 men. Each consultation meeting included an introduction to the programme, its objectives, goal, and discussion of the need for community participation. These meetings have facilitated informed and active community participation in discussions surrounding benefit-sharing, and participants in the consultation meetings proposed a mechanism that they felt was fair, equitable and effective. An extensive review of literature on national and international benefit-sharing experiences in REDD+ in particular and natural resource management in general was also conducted, and presented and discussed during the consultations.

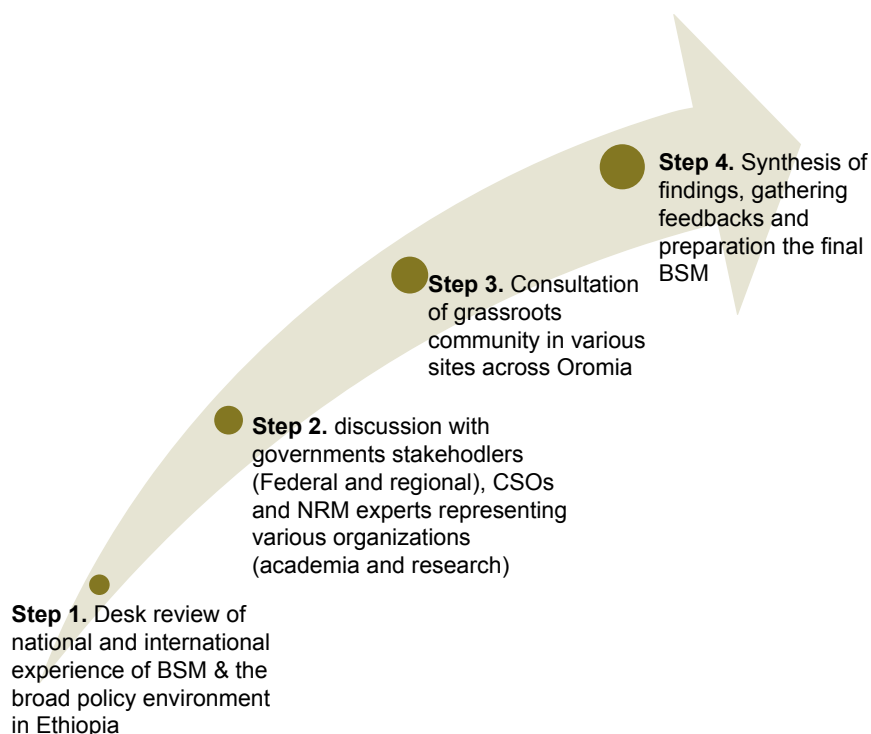


Figure 2: A step-wise process followed to develop the benefit-sharing mechanism for the Oromia Forested Landscape Program (OFLP)

Different benefits and eligible stakeholders

The OFLP generates monetary, non-monetary and non-carbon benefits. The non-carbon benefits comprise all other benefits other than payments for the emission reduction, including institutional and individual capacity building, increased income from new and improved land use practices, a more secure flow of ecosystem services, and natural resources-based small enterprise development. The socioeconomic impact from the non-carbon benefits are likely to outweigh the direct monetary benefit to be received in the form of emission reduction payments. The OFLP also generates monetary benefits in the form of emission reduction payments through avoidance of deforestation and forest degradation, and/or enhancement of forest carbon through afforestation/reforestation. This will be used as a financial incentive mechanism to reward good forest management and conservation practices for eligible stakeholders that deliver emission reductions. The terms ‘benefit’, and ‘benefit sharing’ in this article, therefore, refer specifically to the monetary benefits received in the form of result based payment (also called emission reduction payments) from the OFLP.

The benefit to be shared is the net financial benefit defined as gross emission reduction payments, minus costs incurred in the management process of the benefit sharing process. The operational cost to be covered from the emission reduction payments includes specifically those expenses related to conducting measurement, reporting and verification (MRV) and safeguarding management such as maintaining the grievance redress mechanism and safeguards audits. Moreover, a portion of the gross payment is set aside for 'carbon reversal', the amount depending on the requirements of, or agreement reached with, the carbon credit buyer. Carbon reversal will be set aside before emission reduction payments are made. The remaining balance, called the net payment, will be disbursed among the eligible beneficiaries as per the arrangement set in the benefit sharing mechanism.

The major eligible stakeholders identified for sharing benefits from the OFLP are: (i) communities that reside near and inside forests, (ii) federal and regional governments, and (iii) private forest developers. For the private sector to benefit from emission reduction payments, there are some requirements such as the allocation of a matching fund and the proper application of the OFLP's mandatory safeguarding instruments. Moreover, forests developed by a private sector entity should fulfil national definitions of what is a 'forest' (i.e. a minimum area of 0.5 ha with trees at least 2 m high and a canopy cover of at least 20%).

Sharing of benefits

Vertical sharing

This is the sharing of emission reduction payments between the federal and Oromia Regional State governments on the one hand, and on the other communities that live in and around a forest area and engage in development and management of forests either legally or customarily, as well as private forest developers that fulfil benefit sharing criteria. The major responsibility of eligible beneficiaries is mainly related to their contribution in relation to emission reductions and removal expected at Oromia State level. This vertical sharing is set at 20:75:5% (government: community: private forest developers).

Government in the context of this benefit sharing mechanism comprises several distinct entities, including the Environment, Forest and Climate Change Commission (EFCCC) at federal level and the Oromia Environment, Forest and Climate Change Authority (OEFCCA) at regional level, along with other relevant land use sector bureaus coordinating REDD+ activities at their respective levels in the governance hierarchy. The 20% government share will be further shared between these federal and regional entities according to the proportion of 5%:15% (federal: regional). Funds should be used to promote activities that will generate additional emission reductions and to coordinate activities and policies among sectors. Subsequent emission reduction payments will be made upon review and approval of technical and financial reports on use of the previous payments.

Use of the 15% share of Oromia regional state will be coordinated by OEFCCA, which is responsible for coordinating and identifying activities and actions in other sectors that reduce deforestation, forest degradation and promote forest development through afforestation/reforestation by mobilizing and coordinating the activities of all stakeholders and sector offices throughout Oromia. The underlying issue in utilization of the government share at both governance hierarchy levels (federal and regional) is to ensure that it is used for REDD+ related activities, such those that address the drivers of deforestation and forest degradation.

Horizontal sharing

The 75% community share will be dispensed among the communities across Oromia. The horizontal benefit share involves a three-step process. First is to share among administrative zones, second is to share among woredas in each zone, and the third is to share among kebeles in each woreda. This approach was chosen due to its suitability for forest governance and service provision to the forest managing communities. Based on suggestions from stakeholder consultations, performance and forest areas were selected as the criteria to determine the sharing of benefits among zones. Performance in this context refers to avoided deforestation and/or forest enhancement (afforestation/reforestation), while forest area refers to the coverage that exists in the zone at the time of performance monitoring.

Delivering performance requires commitment, time, energy and effective collective action to manage and restore forests. This should be rewarded with proportional positive incentives. Similarly, historical forest stewardship that contributed to the preservation of forests for current and future generations should be equally valued and rewarded with positive incentives, which makes existing forest areas an important criterion to consider. Performance at zonal level will be measured against a forest reference emission level (FREL) for each zone, to be determined separately. Zonal level activity data and afforestation/reforestation must be measured using the same reference level and monitoring cycle as used in evaluating performance at regional level. The weighting of 60% is used for performance, and 40% for existing forest areas, with this equation (Eq. 1) will be used to estimate share of monetary benefit at zone level.

$$\text{Share of benefit per zone} = (\text{total community share} * ((0.6 * \text{performance of the zone} / \text{total performance across Oromia}) + (0.4 * \text{forest area of the zone} / \text{forest area in Oromia}))) \dots \dots \dots$$

Eq. 1.

Sharing within zones

Whereas performance is measured and reward is provided at zonal level, forests are managed at community level, requiring a mechanism to distribute zonal level rewards among

woredas and amongst kebeles in each woreda. Hence, criteria for sharing benefit among woredas in each zone and their weighted are proposed as: area of existing forest (50%), forest development (30%), and number of forest management cooperatives (20%). These were suggested because they show community effort in forest management, and their use motivates others to organize and manage forests. The proxy for forest development is the number of planted seedlings and/or gain in forest area through rehabilitation, with seedling survival after two years a key factor. But to avoid double counting, forest area does not include forests planted or rehabilitated within the monitoring period. The data on criteria is updated through OEFCCA/OFLP field staff. Based on the criteria and weight attached to each criterion, the equation below (Eq. 2) will be used to determine the sharing of benefits between woredas.

$$\text{Share of benefit per woreda } x = \text{total community share of zone } n * ((0.5 * \text{forest area of woreda } x / \text{total forest area of zone } n) + (0.3 * \text{area of forest developed of woreda } x / \text{total area of forest developed in zone } n) + (0.2 * \text{number of forest management cooperatives in woreda } x / \text{number of forest management cooperatives in zone } n)) \dots \text{Eq. 2.}$$

For benefits to reach communities, the woreda level share needs further sharing among kebeles, using the criteria and weighting of forest area (60%) and forest development (40%). Most benefit may likely go to the forest management cooperatives or kebeles with larger areas of forest. However, non-forested kebeles may receive benefits if they engage in forest development during the monitoring period. The share per kebele is calculated using the equation below (Eq. 3).

$$\text{Share of benefit/kebele} = \text{total community share of woreda } n * ((0.6 * \text{forest area of kebele } x / \text{total forest area of woreda } n) + (0.4 * \text{area of forest developed of kebele } x / \text{total area of forest developed in woreda } n)) \dots \text{Eq. 3.}$$

The disbursement mechanism

The disbursement of funds follows government processes used for fiscal budget disbursement (Figure 2). The Ministry of Finance (MoF) receives the results-based payment in a dedicated account for this purpose. ORCU/OEFCCA officially communicates with the MoF detailing the share of all eligible stakeholders as per OFLP monitoring results. Then the MoF transfers the share of federal government funds to the EFCCC account, and the remainder to the Oromia Bureau of Finance and Economic Cooperation (BoFED). ORCU/OEFCCA communicates the amounts to the Oromia BoFED, the amount and share to each entity. BoFED then disburses operational costs, and the share of private forest developers to OEFCCA's account, and the share of forest management cooperatives to their respective accounts (subjected to the financial management capacity required by the World Bank), and the share for kebeles without forest management cooperatives

to the respective woreda Office of Finance, in accordance with community action plans and instruction provided by ORCU/OEFCCA. Action plans approved by sector offices, as decided by woreda steering committees, oversee implementation of community action plans.

BoFED will release the share for Oromia regional state based on decisions from the OFLP steering committee. OEFCCA's lower administrative level units follow up disbursement of sharing at their respective units, and ORCU/OEFCCA units at woreda level follow up on use by respective communities. The ORCU steering committee oversee the entire use of the emission reduction payments at all levels, while OEFCCA/ORCU provide annual updates to EFCCC and the World Bank on overall use of the emission reduction benefit. The transfer of benefits to eligible users depends on acceptable technical and financial reports of the preceding share. ORCU/OEFCCA will follow up and receive technical and financial reports on utilization and report to all concerned.

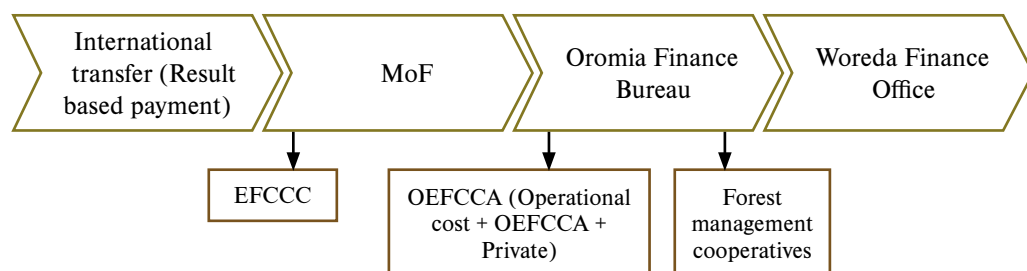


Figure 2: Flow of share of result based payment

Potential uses of the benefits

Communities identified investment options for using emission reduction payments, with consensus that the benefit will not be shared among individual households. Rather, it will be invested in activities and projects that will ensure communal or collective benefits, as well as those that will generate further emission reduction payments. The long list of investment options identified during community consultations was sorted into two categories, based on OFLP's environmental and social safeguard principles. Of all emission reduction payments to be received at community (kebele or forest management cooperative) level, 45% would be invested in social development and livelihood improvement, with 50% invested on land use and related activities that generate more emission reductions. The remaining 5% is dedicated to underserved social groups in the form of a revolving fund.

In kebeles with forest management cooperatives, all households may be members, but where some are not community members, they may still benefit from the 45% share for social development that serves all communities in the kebele and sometimes beyond. The

potential community uses of benefits screened from a long list suggested during consultations included those used to generate emission reductions, including producing tree seedlings, coffee outside forests, planting fruit tree and using fuel saving stoves, as well as social development and livelihood improvement, such as the maintenance of schools, clinics, roads and beekeeping.

Grievance redress mechanism

As part of risk mitigation measures, OFLP allows citizens to lodge complaints or grievances in a formalized, transparent and time bound manner, and everyone should be informed about how to register any concerns about OFLP activities. Recommendations arising from consultations were to resolve issues first at community level by elders, Gada and religious leaders. (The Gada is Oromia's traditional democratic governance system.) If not resolved, cases could move to the formal court system. It was emphasized that grievances must be actively managed and tracked to ensure appropriate resolutions and actions are taken in a timely manner and effectively, and documented at every stage of arbitration. Proper follow up is also needed on the implementation of proposed corrective actions, and the complainant must be informed of the outcome. Any complaint arising from benefit sharing should be lodged with the OEFCCA/ORCU at woreda level, and it is also the responsibility of the same office to follow up on the process and provide the necessary feedback to all involved.

Conclusions

A step-wise consultative process has been used to develop a benefit sharing system for result based payments under the Oromia Forested Landscape Program, back by money from the BioCarbon Fund. An important feature of this process has been the participation of communities living in and around forests in developing key aspects of the mechanism. Communities have helped to determine the appropriate distribution of financial benefits across levels of governments and among the different actors involved. The great bulk (75%) of the rewards for the actions that lead to sustainable forest management and emissions reduction goes to the communities who are responsible for those actions. At the same time, the important managerial role of local government is recognized, with money allocated to cover the costs of a range of actions that government must take in support of implementation. The role of the private sector is also recognized. Importantly, grievance mechanisms accord roles to traditional and community institutions, which are relatively strong and have historically played important roles in resource governance in Oromia. As payments begin to flow over the coming years, this benefits sharing mechanism will be tested, but the participatory nature of its development gives grounds for optimism about its likely effectiveness.

Managing bush thickening (encroachment) in degraded Borana rangelands, Oromia Regional State

Agena Anjulo, Getachew Kebede & Kibruyisfaw Sisay

Introduction

Rangelands are dominated by grass and other herbaceous species, with or without scattered woody plants (Purdom and Anderson, 1980). But in recent years, the increase in density of woody plants – known variously as bush thickening or bush encroachment – is becoming a major concern to many farmers of arid and semi-arid rangelands. To date, however, reactive intervention has been the norm (Hausmann et al., 2016). The rangelands of southern Ethiopia comprise 7.6–12.3% of the total area of the country. Of this, Borana rangelands comprise about 95,000 km², but which are threatened by the loss of perennial grasses and the increase in unpalatable herbs and bush cover (Oba and Kotile, 2001), and woody plant density has already passed the critical limit of equilibrium between shrub and grass species. Encroachment has also been linked to reduced plant and animal biodiversity and increases in human-wildlife conflicts. The proliferation of woody species can enhance above-ground carbon stocks, but the impacts on the relatively stable below ground carbon pools remains an area that requires further research.

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This encroachment is having severe impacts on pastoral livelihoods due to the increase in bush and unpalatable undergrowth, with the main woody plant species causing the thickening problem being, among others, *Acacia drepanolobium* (whistling thorn), *Acacia reficiens*, *Acacia mellifera*, *Acacia*

seyal, and *Acacia bussei*. Kibet et al. (2020) report problematic species in both Ethiopia and Kenya as *Acacia drepanolobium*, *Acacia mellifera*, *Acacia nubica*, *Acacia reficiens* and *Euclea divinorum*, whereas in Kenya alone, *Dodonaea viscosa* is also widespread and a problematic encroacher. In Ethiopia alone, Kibet et al. (2020) report in Ethiopia, *Acacia bussei*, *Acacia nilotica*, *Acacia senegal*, *Acacia seyal*, *Acacia tortilis*, *Commiphora africana* and *Dichrostachys cinerea*.

Elsewhere in Africa, bush encroachment is well known as a significant problem. It has been reported in southern Africa since the mid-1900s, with 73 million hectares now affected in South Africa and 45 million in Namibia (Kibet et al., 2020). It is also becoming an increasing threat in Kenya and elsewhere in the Greater Horn of Africa in recent decades. Although the list of encroaching species is long, *Acacia* spp. and other legumes (*Fabaceae*) dominate, and some species are common through all of these countries and many more, such as *Acacia mellifera*, probably the most widespread of encroaching species (CABI, 2020). In eastern Africa, bush encroachment is driven by overgrazing, suppression of fire, fewer large browsers, changes in rainfall patterns and increases in atmospheric CO₂, and has become a serious management challenge especially in lowland areas, including in southern Ethiopia, northern and southern Kenya, southwestern Uganda and northern Tanzania, and is an emerging issue in other areas (Kibet et al., 2020).

In Borana, Ethiopia, woody plant cover has already exceeded 40% over about 40% of the land area (Coppack, 1994; Rischkowsky et al., 2003), and this 40% plant cover is approximately equal to a density of 2400 plants per hectare (Rocques et al., 2001). Another estimate showed that plant density has reached 3014 plants per hectare and woody plants cover 52% of the land area (Gemede, 2004). One of the noted causes in Borana for bush thickening is the ban on the use of fire as a method of control. In the past, setting periodic fires in the rangeland was a bush management option used by pastoral communities. This kills bush seedlings and saplings thus maintaining a relatively constant density of woody species. However, the banning of controlled periodical burning about 40 years ago has facilitated the spread of bush species.

Testing different techniques

Traditional control techniques tried in Kenya (CABI, 2020; Kibet, 2020), collectively referred to as ‘brush management’, used prescribed burning, mechanical clearing and herbicide applications, with varying success. Integrated systems are now favoured, including manual clearance, fire and grazing management with broader aims that include biodiversity conservation and ecosystem services, with more opportunities to improve the bush control and better assess the impacts of interventions, to ensure increased benefits. Thus, it appeared that thinning bush and removal of unpalatable undergrowth in an integrated management approach will reduce the bush regrowth significantly and improve the palat-

able grass diversity and biomass with higher livestock carrying capacity per unit area. So, in the light of the above information and taking into consideration the seriousness of the rangeland problem, a research experiment was designed to improve pasture productivity by testing different and integrated bush thickening management, and test the impact of various levels of woody species selective thinning and undergrowth management on grass and browse species.

The experiment was conducted in the Borana rangelands, which extend from 3-6°N latitude 36-42°E longitude (Figure 1), dominated by semi-arid climate with bimodal rain, a long rainy season March-May and short rains September-November, with 400 mm in the south to 600 mm in the north (Negasa et.al., 2014). Annual mean temperature varies from 19 to 24°C. Altitude of the rangeland is 1000–1700 masl, having peaks up to 2000 m (Coppock, 1994).

The general objective was to contribute to enhanced food and environmental security and improved pastoralist livelihoods in Borana rangelands. The specific objectives were the following.

1. Examine integrated management intervention effect with different bush removal levels on the herbaceous and grass composition and productivity.
2. Introduce and assess the establishment and fodder biomass production potential of *Terminalia brownii*.
3. Evaluate the willingness to pay for bush thinning by pastoral communities.

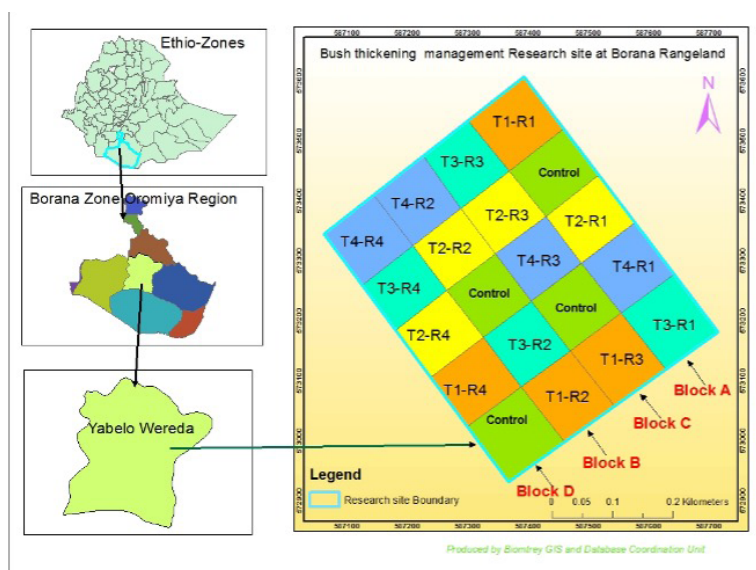


Figure 1: Experimental site and layout design details

There were five specific elements:

1. Removal of unpalatable undergrowth which hinders grass seed emergence and growth.
2. Thinning woody perennials as per experimental treatment details and reducing canopy size of existing trees/shrubs to allow light transmission to support under-canopy grass species emergence.
3. Enrichment seeding in degraded pastures after bush thinning, with palatable grasses to occupy bare ground which would have nursing function for the emergence of the native grass species from the soil seed bank.
4. To supplement grass and herbaceous dry season feed, and address shortage, *Terminalia brownii*, a broad leaved fodder tree which thrives in dry conditions and yields substantial leaf biomass, was planted in lines in the pasture.
5. Removing stump re-growth to prevent bush thickening.

The experiment was laid out in a randomized complete block design (RCBD) with four replications (with 20 plots of one hectare in size). Prior to the experimental procedures, unpalatable undergrowth was initially removed, to open up spaces between the blocks and treatment plots. Later, in the plots, only the unpalatable undergrowth was cleared, maintaining the woody perennial bushes and trees which were all counted in each of the experimental plots leading to an average density for the whole experimental area. Then, low and old bushes and trees and especially those very close to each other were removed, to keep the mean density the same in each of the treatment plots. In some plots, shrub/tree density below the mean were left for further thinning, and for assigning experimental treatments in the random blocks.

Summary of the five treatments (Figure 1):

T1 = Surface clearing of unpalatable undergrowth and scraping of dead wood and dead vegetation (at existing mean tree density)

T2 = Bush removal at 40% existing mean density + Stump regrowth removal + Enrichment grass sowing;

T3 = Bush removal at 30% existing mean density + Stump regrowth removal + Enrichment grass sowing + Integrating *Terminalia brownii*;

T4 = Bush removal at 20% existing mean density + Stump regrowth removal + Integrating *Terminalia brownii*;

T5 = Control (bush invaded pasture)

Preliminary results, key issues and challenges

All of the treatments (T1, T2, T3 and T4) in the experiment showed significant improvement in rehabilitating the degraded range with palatable pasture, as compared to the untreated control (T5). Visible differences were also observed among treatments T1,

T2, T3 and T4 in terms of grass composition and biomass per unit area (data being processed). Pastoralists were able to harvest significant amounts of grass biomass, which they stored on raised wooden beds near their houses for feeding to their animals during the dry season. About 34 grass and herbaceous species from six families palatable to livestock were identified, and about 23 browse and non-browse tree/shrub species from 12 families, in the rangeland after the bush thinning and rehabilitation operations.

The fodder tree (*Terminalia brownii*) was planted to enrich the rangeland with a palatable browse tree in two of the treatment combinations, planted over eight hectares, and they showed very good initial seedling survival of 88%. However, as it is highly palatable and attractive to livestock and equally to wildlife, trees were totally destroyed by night browsing by small ruminant wildlife during the dry season in the first year. Replanting will require another year to raise seedlings in the nursery, and protection in the open rangeland from browsing at a young age was considered not to be practically and cost-effectively feasible. As such, this enrichment option through planting fodder trees was terminated from the experiment.

Managing bush thickening with thinning and removal of unpalatable undergrowth coupled with cleaning by scraping the soil surface requires a major commitment from the pastoral community to ensure an improvement in the resource value and a reduction of rangeland degradation. In terms of the labour contribution of pastoralists and their engagement in range improvement operations it is necessary to take into account the huge requirement for finance. But will pastoralists be willing to pay for rangeland improvement? A binary logistic model and bivariate probit model were used, respectively, to evaluate factors influencing pastoralists' decisions on their willingness to pay, and to estimate their mean willingness to pay, for rangeland improvement. Results indicated that from a total number of 1080 households in two kebeles, the mean willingness to pay for the improvement was 11.86 person-days/month, which is equivalent to 830 Ethiopian Birr (ETB) per month (US\$20). And the aggregate willingness to pay for the improvement was 38,426 person-days per year, which equates to 2,689,820 ETB per year (US\$63,244). In summary, pastoralists are willing to contribute a maximum of three months of their labour per year on rangeland improvement.

Conclusions and recommendations

Much of the vast area of the Borana rangelands, of about 95,000 km², is suffering from bush thickening, otherwise known as encroachment, whereby livestock and other large ruminants will eventually be left with no grazing area for survival if nothing is done. This research provides promising results that show that by following integrated management approaches, including thinning, rangeland can be effectively rehabilitated to a much more productive state. The initial opening of the canopy increases the light available to

understory species, and scraping the debris from the ground and clearing further facilitate the germination of grass seeds suppressed in the soil seed bank.

Researchers from the Ethiopian Environment and Forest Research Institute (EEFRI), showed the results from this research over two consecutive field days, demonstrating progress to the Parliament's Agriculture Pastoral and Environment Protection Standing Committee members, Regional, Zonal, Woreda and Kebele level leadership and sector offices heads, religious leaders (*abageda*), as well as youth, women and elders of pastoral communities. All expressed their commitment to support rangeland management, and to assist in its restoration to a more productive state, thereby improving the pastoralists' livelihoods. It is hoped that leadership at all levels, including that of pastoral communities, will live up to these promises for rangeland improvement and to adopt the research outputs.

The main conclusion is to begin to extend the proven technologies to other areas. The research findings, that reducing the density of shrubs, trees and unpalatable undergrowth management, with mechanical surface scraping and removing debris, coupled with enrichment sowing of suitable grass, should be scaled out to other kebeles and woredas with similar problems, for wider application and pastoral livelihood improvement. But pastoral livelihoods will need to be supported with assistance to apply such bush thinning operations. Sectoral government offices and NGOs devoted to natural resource management and improving pastoral livelihoods need to support bush thinning. This should ensure that the minimum density of shrubs and trees is kept at an ecological balance, so there is still shade for grazing livestock, with microclimate amelioration, and the provisioning of ecosystem services.

There is serious water scarcity in rangelands, for people and livestock, and water points are also required to improve living conditions for the pastoral community. In addition, more work is needed to adapt and adopt technologies for using the woody material resulting from the thinning operations, and conversion into value added biomass energy such as charcoal and briquettes, as well as pelleting that could create hundreds of thousands of jobs for women and the youth with the judicious use of this 'free' resource.

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Dryland restoration: challenges and ways forward for Somali Regional State

Muhyadin Mohammed & Badal Kenadid

Introduction

The Somali National Regional State occupies a large geographical area in the eastern and southeastern part of Ethiopia. It lies between 4° and 11°N latitude and 40° and 48°E longitude, covering an estimated area of 316,966 km², and is the second largest region after Oromia. Jijiga is the capital city of the region, 628 km east of Addis Ababa. The topography of the region is dominated by lowland plains (about 80% of the total area) and the remaining 13% is of mid-level altitude or hilly. Some 7% is mountainous (Zerfu et al., 2010). Altitudes range from less than 300 m to around 1600 m above sea level.

Somali region falls into the arid and semi-arid agroecological climatic zone. Temperatures range from 20 to 45°C, and the average annual rainfall is between 300 and 500 mm. Evapotranspiration rates are high, ranging from 1750 to 3100 mm, with a large moisture deficit throughout the region. According to Worku (2016), there are four distinct traditional seasons in Somali Region, though the beginning and end of these seasons vary from place to place and from year to year. The main rainy season is called the *Gu* and begins in late March, extending up to early June. The *Hagaa* is the subsequent dry and windy season that starts in late June and last until early September, often bringing clouds, but only rarely does it bring rain. The *Deyr* is an important season that brings light rains after the extended dry season and occurs between mid-September and early December. The fourth season is the *Jilal* and it covers the dry and hot months between

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late December and early March. The livelihoods of the pastoral communities, featuring livestock mobility, are based on a seasonal calendar of activities.

Forest resources in Somali Region

Somali Region is predominantly characterized by dryland agroecologies, and dry forests are the main features of the landscapes of the region. Ethiopia's National Forest Inventory (MEFCC, 2018) recognizes four major vegetation types, referred to as biomes, including *Acacia-Commiphora* and *Combretum-Terminalia* woodlands and shrublands, dry Afromontane forest, and moist Afromontane forest. According to this inventory, Somali vegetation is classified into *Acacia-Commiphora*, and others, including forests, other wooded lands, and other lands. Forest and wooded land classified as *Acacia-Commiphora* comprise 28,130,178 ha, divided into forest (318,942 ha), other wooded land (27,811,236 ha) and other land (3,978,887 ha), with 824,138 ha of 'other', divided into other woodland (758,207 ha) and other land (65,931 ha) (MEFCC, 2018).

The major vegetation formations of Somali Region include: semi-humid woodland, upper semi-arid *Terminalia-Combretum* (deciduous) woodland, lowland semi-desert and desert vegetation, lower semi-arid to arid *Acacia-Commiphora* woodland and shrubland, 'tiger' bush, arid sparse shrubland, riparian (wetland) vegetation, and plantation forests.

While different authors have developed different classifications of vegetation in Somali region, the *Acacia-Commiphora* vegetation formation is certainly the most common and characteristic, and it presents diverse opportunities to enhance the socioeconomic and ecological benefits of trees (Lemenih et al., 2003). According to the new definition of forests in Ethiopia, which is land occupied by trees (natural and planted, including bamboo) than can attain a height of more than 2 m at maturity, covering an area of more than 0.5 ha, and with a canopy cover of more than 20%. *Acacia-Commiphora* woodlands meet this definition of a forest. This vegetation formation often appears in different forms in different areas. For example in the Liben zone, known for its extensive *Acacia-Commiphora* vegetation, six types of formations were recognized (Lemenih et al., 2003). These are xerophilous woodland, mixed woodland thicket, *Acacia* bushland thicket, *Acacia seyal* woodland, mixed shrubland, and undifferentiated bushland thicket. Similarly, Worku et al. (2011) identified areas in Afdher Zone where *Commiphora myrrha* and *C. guidotti* form more or less pure stands.

Although there is variation in species composition from area to area, the characteristic plant species of *Acacia-Commiphora* vegetation are drought tolerant, small-leaved trees and shrubs, such as *Acacia tortilis*, *A. seyal*, *A. senegal*, *A. etbaica*, *A. sibiriana*, *A. mellifera*, *A. sieberiana*, *A. drepanolobium*, *Commiphora africana*, *C. myrrha*, *C. fluviflor*, *C. habessinica*, *C. paolii*, *C. crenulata*, *C. boranensis*, *C. guidotti*, *C. erythraea*, *C. schimperi*, *C.*

ogadensis, *C. rostrata*, *C. serrulata*, *C. gileadensis*, *C. hildebrandtii*, *C. erosa*, *C. cyclophylla*, *C. corrugate*, *Balanites aegyptiaca*, *Maytenus senegalensis*, and four of the six *Boswellia* species recorded in Ethiopia, *Boswellia microphylla*, *B. ogadensis*, *B. neglecta* and *B. rivaeare*.

The main actors

There are a number of regional governmental bodies that are actively involved in dryland restoration, including the Agriculture and Natural Resources Development Bureau; the Environment, Forest and Climate Change Bureau; the Livestock and Pastoral Development Bureau; and the Office of the Regional President which also oversees the government's World Bank funded Lowland Livelihood Resilience Project, which aims to improve the livelihoods and resilience of Ethiopia's pastoral and agropastoral communities. Non-governmental organizations involved in dryland restoration in Somali Region include various UN bodies, international NGOs, development cooperation and development organizations, and a number of local NGOs. Amongst these are the World Food Programme (WFP), Save the Children and GIZ, while local NGOs include Save the Environment of Ethiopia (SEE)PWO, and the Organizational Welfare Development Association (OWDA). In addition to these efforts, the region's institutions of higher learning, Jigjiga University and Kabridahar University, provide research in support of dryland land restoration. With such a range of actors, collaboration and coordination are paramount.

Challenges faced in dry forest management

There are a number of factors affecting sustainable forest management and the productivity and development of forest-based value chains in Ethiopia at large, and in Somali Region in particular. Some of the main challenges are those associated with institutional arrangements and policies relating to land tenure, access to finance, technology and knowledge generation and dissemination, and materials and markets. Problems relating to institutional arrangements and human resources in Somali Region are severe. Despite the recent decision to establish the Environment and Forest Sector at bureau level, the attention given to this sector was very limited, and, moreover, mandates are still distributed across different departments such as Agriculture and Natural Resources, and the new Environment, Forest and Climate Change Bureau, amongst others.

In addition, there is a critical shortage of foresters at regional level, and the issue is more serious at the local level. At both regional and local levels, there is a dearth of information about existing policies and proclamations relating to the forest sector, and about the opportunities that exist under these policies and proclamations to facilitate and incentivize the private sector with respect to forest and value chain development. There are also no clear land use plans or policies that recognize forest land, and this is a barrier to

private sector investment in the forest sector. This could be related to communal land-ownership being widespread in the region. Particularly, existing communal land uses may continue to restrict land rent, land transactions, and the use of land as collateral, and as such remain important constraints to improved management and use of forest resources.

Another challenge is climate change, alongside severe land degradation and the scarcity of technology and skilled manpower that clearly undermine the development of high value plantation forests. For example, case studies have shown the decline in the numbers of some tree species due to poor natural regeneration, perhaps linked to increased pressure from livestock grazing, browsing and drought. Extended drought and trampling exposes soil and results in a decrease in the soil seed bank, which is a critical source of natural regeneration. In some areas, invasive species such as the exotic *Prosopis juliflora*, and encroachment of some relatively less important native species, have been replacing economically and ecological important species.

There is also a lack of forest sector research endeavours in the region, which is in contrast to the much larger amount of interest and investment in technology and knowledge in more productive agroecologies, and this has severely undermined the enhancement of forest resource productivity and the promotion of value-added forest-based businesses.

Finally, Somali remains one of the regions with the least extensive road network, for various reasons including security concerns (SCUK/DPPB, 2008). In particular, zones and districts with ample dry forest resources are poorly connected to each other, where transportation becomes a serious issue especially during rainy seasons. The poor road network also affects the engagement of private companies in the trade of forest products to other regions, thus encouraging more illegal cross-border trade.

Conclusions and recommendations

Somali Region is predominantly characterized by dryland agroecologies, and dry forests are the main vegetative features in the landscape. Improving their effective management and utilization is crucial to sustainable development in the region. To ensure this, institutionalizing the forest sector by establishing the Bureau Environment, Forest and Climate Change and efforts already being undertaken by different stakeholders are positive steps. But beside this, there is need to strengthen such efforts with capacity building, promoting environmental awareness, and encouraging local level afforestation and reforestation activities. It is important to consider the net returns from the use of dry forest resources, but also the opportunity cost of alternative uses so that the right decisions can be made on the most appropriate use in different situations. In addition, emphasis must be given to managing the large scale invasions of alien species such as *Prosopis juliflora* that significantly affect the forest resources of the region. More support should also be provided

to the universities in the region, and to the network of primary and secondary schools in rural towns. Furthermore, to enhance access and to non-forest product such as gum and incense, it is necessary to expand road networks in the region. Importantly, the region needs to create favorable working conditions for these state and non-state actors to work together and to monitor and support different activities.

The following summarizes specific recommendations for improving the sustainable development and management of dryland forest in Somali Region.

1. Conduct holistic studies on the current status of woodland forests and especially in pastoral areas.
2. Develop and enact participatory policies and strategies that promote dryland restoration.
3. Build and strengthen integrated stakeholder collaboration and coordination systems to provide spaces for the sharing of experiences and reduce resource duplication.
4. Encourage the active participation of local communities in every process of dryland restoration.
5. Strengthen local capacity in dryland restoration as one of the main focus areas.
6. Establish appropriate pastoral land administration systems through the inclusion of customary uses for securing land rights of pastoralists and vulnerable groups.
7. Promote means for alternative income generation to mitigate deforestation.
8. Efficiently utilize effective technologies to better exploit the gum and incense resources in the region.
9. Mobilize communities for clearing bush encroachment, and notably the exotic invasive *Prosopis juliflora*.

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Impacts of conflict, Covid-19, locusts, drought and floods in Tigray from a natural resource perspective

Dawit Gebregziabher

Introduction

This situation analysis, centred on Enderta woreda in eastern Tigray, aims to document and disseminate information on ongoing challenges in Tigray, looking specifically at impacts in relation to natural resources. The assessment was designed to assess the interlinked crises of the Covid pandemic and associated restrictions, Desert Locust infestations, the war in Tigray, and drought and floods in the region. It does not attempt to assess or quantify the damage to and destruction of infrastructure, crops and livestock, nor the human displacement, suffering and death brought about by the war, but it accepts that these are very significant, and these impacts of the conflict are increasingly being documented elsewhere. However, the impacts on natural resources have, understandably, received less attention. Still, these impacts will be very significant, in the short, medium and long terms. Official reports note that the total land area affected by droughts, floods, hailstorms and pests is 26,628 hectares. But this is small compared to the 120,105 hectares affected by locust infestation, and the 1,341,593 hectares affected by the conflict in Tigray (BoARD, 2021).

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It should be stated at the outset that these multiple crises feed on one another and are interlinked in a number of ways. Covid and war have weakened the ability of local agencies to respond to the locust invasion, while war and locust-induced livelihood crisis have diverted attention from the Covid

response. Climate-related challenges, drought and floods, imply the loss of incomes and livelihoods, forcing some people to turn to alternatives including the harvesting of wood for charcoal production, thus undermining conservation efforts. And the war-induced disruption of electricity provision has sharply increased the demand for charcoal, particularly in the regional capital, Mekelle.

There are a number of different agencies responsible for tracking and responding to these multiple crises. On pandemic, the Tigray Health Bureau (THB) is the main player, providing timely information through different media on Covid, its spread and related control measures, alongside the World Health Organization and the Federal Ministry of Health. A number of stakeholders played key roles during the locust infestation, including the Tigray Bureau of Agriculture and Rural Development (TBoARD), the Tigray Agricultural Research Institute (TARI), universities and agricultural colleges in Tigray, and international organizations, including FAO and the World Bank, as well as civil society organizations, notably the Global Society of Tigrean Scholars (GSTS) and WeForest. The latter is an international NGO conducting a landscape restoration programme that focuses on the Desa'a Forest.

Several Mekelle University departments play important roles in environmental management in Tigray, supporting community-led efforts and collaborating with a variety of international agencies, including the Addis offices of the CGIAR bodies, CIFOR and ICRAF. CGIAR experts collaborated in on-the-ground assessments. While often overlooked, the local community was heavily involved in information sharing on the ground and exerted great efforts in support of locust eradication efforts, using locally available resources. Traditional institutions played particularly important roles in mobilizing people for action as well as in disseminating relevant information, in collaboration with governmental and higher education institutions, enabling bottom-up and participatory responses. As for dealing with the impacts of the war, and conflict management efforts, the main players have been a mix of internal and external actors, national and international, with humanitarian agencies playing vital roles.

Assessment of impacts

Rapid assessment of impacts of locust infestation on natural resources. Unexpectedly, forests and trees helped to reduce crop losses. The locusts tended to stay for a few days on natural forests and exclosures, consuming tree leaves and foliage in Wijg Mahg Waren, Menchare Hawelti Tsehafti, Grakahsu Higumbirda and Desa'a Forest. This allowed for a reduction in crop losses, but at the expense of damage to natural resources in protected areas. Despite the concern raised by some senior natural resource researchers, the impacts of locust invasions on natural vegetation have received less attention than the impacts on crops. These are the immediate priority in light of the region's persistent

food insecurity, but wider environmental damage, and its potential medium to long term impacts, cannot be ignored. In addition to the direct impacts of the locusts themselves, there are impacts resulting from control efforts. The anti-locust chemicals that were sprayed on the forests caused vegetative damage to trees in particular as well as negative effects on the ecosystem services provided by the forest.

Focus group discussions on impacts of Covid-19 on land restoration. Focus Group Discussions (FGDs) were conducted, both face-to-face in a Covid-secure way and remotely by mobile phone, with both farmers and development agents from the Central and Southern zones of Tigray, and a report was compiled and shared with local authorities (Mitiku et al., 2020).

Stakeholder meeting at Enderta

A meeting with a group of experts was held at the Enderta Woreda Office of Agricultural and Rural Development, eastern Tigray, including 146 stakeholders from each tabia in the woreda. Of these, 26 were from woreda level, including the administrator, and heads of security, court, justice, agriculture and rural development, and 21 rural development experts. In addition, there were five from each of the 24 tabias, including administrators, heads of agriculture and rural development, natural resource management development agents, area enclosure guards, and elders.

The meeting raised important issues, challenges and factors that are important in combating natural resources degradation in the woreda. One question was to evaluate the current status of natural resources in Tigray at this difficult time, considering the long term investment in rehabilitation over many years. Another question was to assess the possibility of raising seedlings in homesteads for out planting in the next rainy season. The meeting was organized with financial support from the Tigray Bureau of Agriculture and Rural Development.

The discussions were be grouped into six themes:

1. Natural resource degradation originating from across the border with Afar Regional State, and occurring there. There is evidence of forest degradation on the Afar side. That is beyond the scope of the tabias, and must be dealt with at the woreda level.
2. Conversion of forests and enclosures to farmland through cutting and burning, which had stopped for a number of years, but is now occurring again in some tabias.
3. Fuelwood collection and charcoal production. People in highland tabias cut trees for fuel and, following their example, people in Enderta woreda are now doing the same.

4. Technical support from development agents and extension workers related to forest/exclosure guarding and watershed management.
5. The absence of functional judiciary courts. Even though the names of those involved in illegal tree cutting are often known, it is not possible to pass judgments on them due to non-functional court offices.
6. Conversion of communal land for housing, with some tabias preparing to implement this illegal practice.

Opportunities to restore forests and exclosures

There are 14 tree nurseries in Enderta woreda, of which 12 are functional, containing a total of about 1.2 million seedlings that could be planted in the coming rainy season by collaborating organizations including Mekelle University and others involved in the REDD+ program and the Productive Safety Net Program (PSNP), the latter supporting 48,025 beneficiaries. One tabia (Menbere Kidusan) introduced social sanctions against illegal tree cutting, with the local priest denying his services to those engaged in such activities. In another tabia (Didba), the community developed a communal bylaw, stipulating that if a cow is found within an exclosure or forest, the farmer will be penalized 200 Birr (US\$4.60), and 1000 Birr (US\$23) if a farmer is caught illegally cutting trees. Also, in two tabias (May Anbesa, 45 farmers) and (Didba, 15 farmers), the names of those who were known to have participated in illegal forest/exclosure degradation were listed and announced to the community.

Two tabias set up checkpoints to confiscate fuelwood collected illegally, and then sold on the wood for 15,000 Birr (US\$35) which they gave to local churches. In some other tabias, communities agreed not to further degrade forests, and despite a 7-month delay in paying the monthly salaries of the 88 guards in the woreda, many continue to guard exclosures and forests because they consider it the responsibility of their communities to protect their own natural resources. In addition, the Abo gerebat ('fathers of the forest'), religious leaders and elders, have discussed restoration of degraded forests and exclosures within tabias, and talked by telephone with the Abo gerebat from Afar region. Traditional institutions continue to play vital roles in maintaining and expanding conservation efforts, and there is considerable scope to deepen relationships between elders across the Tigray-Afar border. An exchange of visits is planned. The availability of technical backup is important. Experts are also communicating with tabias by phone, and this has contributed to reduced forest degradation in the area, encouraging farmers and their families to dig pits for tree planting, at 2x2 m, allowing for Covid-safe social distancing. BoARD is planning to focus on planting multipurpose (fruit, forage and fuelwood) trees in homesteads in the coming rainy season, and NGOs should continue supporting the woreda with technical and financial support, such as SOS Sahel, World Vision, and Catholic and Orthodox church organizations, amongst others.

Key issues and challenges

Locusts

Quarantine measures due to Covid restricted people's movements and thus the delivery of needed equipment and inputs, hindering efforts to control locust infestations. Most of the equipment brought in by BoARD to control the locust invasion in 2020 was not returned to the bureau, and all of the equipment has now been looted. It is important to learn from this experience and take proactive measures now to reduce risks associated with future locust invasions. This includes putting in place enhanced capacity for early warning, with adequate stocks available of pesticides, spraying equipment, vehicles, and a trained labour force.

Covid

The lockdown added to pressures on local livelihoods and incomes, pushing people to encroach on forests and exclosures. The cost of living has increased, while supplemental incomes from harvests have declined. Due to the disruption of transport, farmers have been forced to sell their produce in local markets at lower prices, while the prices of imported commodities have increased. In addition, the cost of masks and sanitizers have added to household expenditure. Covid also limited the travel of development agents to the field, and community mobilization for restoration efforts has been significantly reduced. Dryland restoration in Tigray depends on 1.4 million person days of labour that are provided 'free' by community members to help build soil and water conservation structures for their own benefit. However, Covid meant that this was not possible in 2021, and as a consequence, the Tigray BoARD was unable to rehabilitate 100,000 hectares as planned (BoARD, 2021). Nursery activities were also affected by Covid and conflict, with the Tigray BoARD producing only 5 million seedlings, as against the 100 million in the 2020/21 regional plan. Many students in Tigray have also been forced to stay at home by Covid and conflict, and rather than remaining idle, some are likely to be engaged in illegal tree cutting or fuelwood collection. As a result of the pandemic, tens of thousands of young migrant workers who had been in the Arabian Gulf have been forced to return home. Household incomes have been further reduced by the loss of remittances from these workers. And beyond this impact on incomes, there are environmental impacts. These young people are generally landless, a major reason for their initial decision to migrate. Jobless, many are now demanding to be allowed to farm on area exclosures. Their activities are adding to pressures on trees and the environment.

Conflict

There is no forest or exclosures that has not been impacted by the recent war, at least to some extent. Those that have suffered particularly include Wjjg Mahg Waren, Asimba, Waldiba, Desa'a and Higumbirda Girakahsu. The war has had significant negative

impacts on natural resource management, with major increases in the harvesting of biomass for fuel and animal feed, seriously undermining conservation efforts and affecting ecosystem services. Soldiers cut trees for to meet their needs for fuel and shelter, and local communities have also been forced to increase fuelwood consumption due to repeated and extended power cuts, and the increased harvesting of wood has been further accelerated by a desperate need for additional or alternative incomes. Grakhsu Higum Berda and Waldiba forests, and Kafta-sheraro National Park, were all rendered inaccessible to BoARD during the conflict, and a full assessment is yet to be conducted. But reports suggest that some 70% of tree nurseries have been damaged by soldiers, and a number have also become camps for soldiers or the sites of military engagements. In many instances, soil and water conservation structures have been destroyed or used for military purposes. Free grazing on protected areas is also now widespread once again, as the enforcement of bylaws has collapsed in many areas. Moreover, the voices of environmental management experts have been weakened, carrying little force while war focuses attention on personal preservation and human suffering deepens. Furthermore, the main pillars of the enforcement of environmental protection laws, the police and the courts, are not functional at all levels.

Climate

Climate-related issues include drought and floods, both of which greatly undermine agricultural livelihoods and incomes, and heighten local food insecurity. Both have hit the region at different times, compounding the problems brought about by the other crises experienced, and increasing the number of local people dependent on food aid. A particular feature of flooding in the region is that water from the highlands flows down to the Afar lowlands, which bear the brunt of the impacts of severe flooding. An obvious response would be to invest in more effective water management systems, with both regions, Tigray and Afar, collaborating to control flooding at the same as sharing water resources equitably. However, such a response would require substantial investment and would not be easy to implement and manage. Donor-supported flood diversion schemes in Afar Region show promise, with the potential to increase local agricultural production. Livelihoods in Afar Region are overwhelmingly pastoral, and livestock-keeping also plays a very significant role in Tigray's mixed farming systems. Livelihoods in both regions are vulnerable to the effects of drought and need to pay greater attention to the kinds of interventions that can build resilience, including efforts to develop alternative dry season feeds and water supplies.

Conclusions and recommendations

The severe problems caused in Tigray by locusts, war, Covid, and climate extremes have had interlinked and serious effects on natural resources, even though these pale in comparison to the impacts in terms of human suffering, with hunger, forced migration and the loss of life.

Nevertheless, it is vital to address the natural resources impacts of these multiple crises, understanding that natural resources provide the basis of the livelihoods of the vast majority of the region's people. A failure to do so would result in a new crisis to follow the current one. And it should be possible to implement humanitarian crisis responses in ways that simultaneously bolster environmental rehabilitation and management efforts, moving along the relief to development continuum, as envisaged in the PSNP. Yet the Tigray BoANR currently has no natural resources policy, and NGOs tend to give less attention to this issue. In woreda agricultural offices there used to be a structured program component called 'natural resources and food security', but now the food security component does not appear, and the focus is more on food aid, which encourages the local community to remain dependent rather than secure. Difficult as it may be, policy-makers and development agents need to think beyond the current crisis and seemingly perpetual crisis management. Not enough is being done to underline the link between livelihoods and natural resource management, and to build resilience, capacity, skills and knowledge for the medium to long term. Education is also crucial to natural resource management efforts, in order to raise awareness among local communities and especially students in rural areas, on the importance of conserving exclosures and forests, and the connection between the ecosystem services they provide and local livelihoods.

Further research should be conducted to better document and analyse the impacts of locust invasions and the chemicals used in control operations, on natural vegetative and ecosystem services in forested areas and area exclosures. This can be undertaken through collaborative research conducted by the main players, such as TBoARD, TARI and agricultural colleges in universities in Tigray, the World Bank, FAO, GSTS and other interested stakeholders. And good use should be made of Mekelle University's technical capacity to map and track locust invasions. Stakeholders responsible for locust control should together provide financial and material support to BoARD, and there should be a proper evaluation of procedures before pesticides are sprayed. This should be part of a concerted effort to put in place in the tools, skills and knowledge to enable a timely and effective response to the next locust invasion.

Due to the devastating challenges in Tigray, many local people paid less attention to Covid-19, giving it little thought, despite the alarming increase in cases in Addis Ababa. Coordinated efforts should be undertaken to reverse this situation and remind people of the threat posed by the pandemic. The Tigray Health Bureau, together with the Ministry of Health and the World Health Organization should also invest in prevention measures to safeguard people from Covid-19 during this difficult period. These multiple crises must be handled simultaneously, so that, for example, food aid distribution is accompanied by awareness raising on Covid and carried out in a Covid-safe manner.

Regular, routine and in-depth consultations with a broad range of stakeholders are vital in crafting informed and participatory responses, to crises and to core development challenges. The positive experience of conducting stakeholder meetings, similar to that conducted at Enderta woreda, should be scaled up and broadened out in order to keep decisionmakers updated on ongoing activities at regional, woreda and tabia or grassroot levels. There are 1.2 million seedlings available in Enderta woreda and responsible stakeholders should exert combined effort to make homestead seedling planting in the coming rainy season possible.

The issues of natural resource management and the mitigation of climate change effects across boundaries need to be addressed alongside and as part of crisis management interventions in order to reverse the current situation in Tigray and avert another crisis. Unless proactive measures are taken to reverse forest degradation, even in the midst of the multiple ongoing challenges, further deterioration might lead to irreversible changes, and coordinated action is urgently needed. The measures undertaken to enforce community bylaws in relation to area exclosures are encouraging in this regard, demonstrating a level of understanding of what is at stake. Stakeholders responsible for security at community level and for enforcing natural resource management regulations should work together to make police, Justice and Judiciary offices functional. Further study is also needed to assess why some communities struggle to conserve their rehabilitated degraded areas, while others do not.

Multiple crises, occurring simultaneously, require a sophisticated and coordinated response, involving many agencies, local, regional, national and international. And in these crisis management efforts, it is important not to lose sight of the medium to long term development needs and the environmental management efforts that underpin local livelihoods. There are effective institutions in Tigray, made more effective by collaboration with strong traditional institutions and leaders. This gives grounds for optimism, but all of these institutions will be put to the test in the current situation.

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Landscape restoration in Tigray: experiences and challenges

Abbadi Girmay Reda

Introduction

Ethiopia is expected to be hard hit by climate change, with the most impacted sectors being agriculture, water resources, and human health. Establishing proactive approaches to managing climate risks within vulnerable rural communities and among institutions operating at community, sub-national, and national levels is a crucial step toward achieving sustainable economic development, poverty reduction and food security in Ethiopia. But, vulnerabilities are local and require location-specific adaptation and mitigation measures.

Sustainable land management (SLM), in addition to its role in adaptation, provides significant potential as a mitigation measure, with adaptation and mitigation strategies being mutually supportive and representing win-win options (NMSA, 2008; Girmay Reda, 2016). The national government's development priorities are reflected in a number of policies and strategies including the Rural Development Strategy, the Climate Resilient Green Economy (CRGE) strategy, and Reducing Emissions from Deforestation and Forest Degradation (REDD+) program. In addition, government has developed the National Adaptation Plan of Action (NAPA), Nationally Appropriate Mitigation Options (NAMO), the Climate Resilience Strategy, policies with respect to poverty alleviation, natural resources conservation-based agricultural development, gender equality, inclusiveness, and empowerment, and the Growth and Transformation Plan (GTP-II), the overarching strategy.

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Experiences from elsewhere show that the appropriate use and management of natural resources could enhance the resilience of ecosystems and improve the livelihoods of the poor in the face of climate change. The Ethiopian National Adaptation Program of Action (NAPA) also recognizes the importance of integrated natural resource management as an adaptation measure, and integrated community-based watershed management (ICBWSM) is listed as one of 20 selected high priority adaptation projects (NMSA, 2008).

Regional development policies and strategies in Tigray emanate from the federal level, and are adapted to suit the local climate, terrain and population, which all influence both land use and natural vegetation cover. The natural resource base has been continuously exploited over a long period without appropriate conservation practices for sustainable use, adding to the effects of drought and environmental degradation, and leading to decreased productivity and deep rooted poverty. Land degradation is manifested in many ways, including vegetation degradation, deforestation, habitat destruction, loss of biodiversity and species richness, increased soil erosion, declining soil fertility, low agricultural productivity, deterioration of water resources, and climatic change impacts. This has resulted in food insecurity as the major challenge, with the agricultural sector being mostly rainfed and characterized by small scale mixed farming systems. But, there is great potential. The region has diverse agroecologies, which make the area suitable for various crops, animals and tree species.

To reverse the adverse effects of land degradation and climate change in Tigray, community-based integrated watershed management and sustainable land management approaches were adopted as the main strategies to address these challenges and promote climate change adaptation and mitigation. Massive natural resource management efforts have been undertaken, with many success stories over the past 40 years. Changes in vegetation cover can affect surface energy budgets, local temperatures, moisture flux to the atmosphere, and regional rainfall, and the practices adopted constitute key adaptation measures, reducing soil erosion, and improving water retention and land productivity. Sustainable land management has both adaptation and mitigation significance as it leads to enhanced above-and below-ground carbon stocks. Also, it is multi-sectoral and multi-stakeholder, bringing communities, government and supporting institutions together on common platforms and towards shared results. The overall objective of the SLM Program is to improve the livelihoods of land users and communities through the implementation of SLM activities in the framework of community-based participatory watershed development plans.

This article assesses experiences and achievements in land restoration and rehabilitation, as well as impacts and challenges, and recommends future directions for sustainable natural resources management, development and utilization.

Restoration and rehabilitation experiences

The causes of land degradation in Ethiopia are complex and diverse, and it is made worse by natural factors such as the rugged terrain, erosive rainfall and inherently fragile soils. Immediate causes relate to unsuitable land uses and inappropriate farming and live-stock management practices, while the underlying causes relate to the more fundamental issues of land users' circumstances, such as scarcity of resources, insecure tenure over resources, poverty, and poorly functioning policies and institutions.

As noted above, massive, and sustainable, local community-based natural resources restoration, rehabilitation, and management efforts have been undertaken to reverse land degradation, with many success stories over the last 40 years in Tigray. Practices include water harvesting, irrigation (supporting crop diversification and intensification), zero grazing, afforestation/reforestation, plantations, agroforestry, area exclosures, protected forests, intensive and integrated watershed management, locally designed soil and water conservation structures, and conservation agriculture. These have resulted in reduced soil erosion, improved water retention, and improved land productivity. Such practices and climate change adaptation and mitigation strategies are, in addition, mutually supportive and represent win-win options (Girmay Reda, 2015).

Environmental rehabilitation efforts in Ethiopia have brought about reclamation of waste lands, re-vegetation of degraded hillsides, restoration of damaged pasturelands, and adoption of improved soil and water conservation and management technologies on cultivated lands. This assessment covers natural resource restoration and rehabilitation public works undertaken in Tigray from 1980 to 2018, and that in total, cover almost half of the entire land area of the region (Table 1). Public works were carried out through community mobilization, government, NGOs, and some bilateral collaboration. The approach has been under different initiatives, involving community mobilisation through "free labour" days (with community members contributing their labour), food for work schemes, managing environmental resources to enable transition (MERET) to more sustainable livelihoods, the Productive Safety Net Programme (PSNP) and the national Sustainable Land Management Project (SLMP), which brings communities, government and supporting institutions together in a collaborative effort. Its objective is to improve the livelihoods of land users and communities through implementation of activities in the framework of community-based participatory watershed development plans (Bewket, 2009).

Table 1. Natural resources interventions in Tigray (1980-2018)

Intervention	hectares
Soil and water conservation	465,477
Gully rehabilitation	5,293
Plantations	166,224
State forests	441,689
Natural forests	279,690
Exclosures	232,146
Agroforestry	105,317
Cultivated land	960,000
Total	1,791,836
Treated land out of total land	46.6%

Source: Tigray BoANR (2016), including data for the period 2009-2019

Participatory community-based integrated watershed management

The objectives of integrated watershed management (IWSM) are fourfold:

- Improve the livelihoods of rural communities and households through soil and water conservation for productive uses and rainwater harvesting for improved groundwater recharge.
- Promote sustainable farming systems and increased agricultural productivity, by adopting suitable soil, water, nutrient and crop management practices.
- Rehabilitate and reclaim marginal lands through appropriate conservation measures, such as planting trees, shrubs and grasses, depending on existing potential.
- Enhance the incomes of smallholders by diversifying agricultural practices and through income-generating activities (IGAs).

Rainwater harvesting. This includes *in situ* water harvesting, shallow and deep wells, ponds, community ponds, check dams, rock catchments, runoff diversion, shallow wells, and river diversion. This has helped to tackle the impacts of recurrent drought, to alleviate poverty and to bring about progress towards the desired agricultural transformation, with sustainable development. These development endeavours should be translated into economic terms and communities should gain economic benefits and generate incomes, with improved livelihoods. Exclosures are also widely applied in the semi-arid areas of Tigray as a means of degraded land rehabilitation, complementing rainwater harvesting efforts.

Integrated soil and water conservation. This has proved effective in reducing runoff, soil loss and over a whole catchment, improved management, implemented in participatory and inclusive ways, contributes to other collective actions, including efforts to promote gender equality. The approach is participatory, multidisciplinary and holistic, integrating physical (mechanical) and biological interventions starting upstream at the head and ending at the outlet of the catchment. Because it is participatory and effective, this approach has been popularly embraced, and significant changes have been achieved in controlling land degradation. Structures include soil bunds, stone bunds, stone-faced soil bunds, hillside terraces and tie ridging, and these have been widely implemented on agricultural fields by farmers. These structures have also been implemented on steep slopes, but here they are less efficient in conserving moisture. Other structures including bench terraces, semi-circle terraces, eyebrow basins, gully reshaping, percolation pits, trenches and deep trenches, the most important physical measures used in non-agricultural areas. These structures have the capacity to improve groundwater recharge by intercepting surface runoff and to curb floods by increasing the time of concentration. Moreover, these structures are effective in trapping eroded fertile soils from steep slopes, if constructed in a staggered position.

Exclosures. Rehabilitation of degraded land through exclosures has significantly contributed to the restoration of natural resources. Observed changes include increased vegetation cover, enhanced soil nutrient status, reduced soil erosion and improvements in soil water storage capacity. The establishment of exclosures is also a climate change-resilient practice, because carbon stocks emerging from green gas emissions can be trapped in plant leaves and the soil. Exclosures and enrichment plantations on degraded steep slopes are also effective in controlling runoff, sediment and sediment-associated nutrient losses.

Water harvesting. Water harvesting interventions have also helped greatly to improve crop production and the water balance system. Water harvesting structures including roof rain-water harvesting, flood water harvesting (spate irrigation), and water storing structures such as horeye (household water ponds) and (non-household) ponds were introduced by the government in order to improve water accessibility at the household level.

Lessons and impacts of natural resources interventions in Tigray

The overall impacts of environmental rehabilitation in Tigray include the following:

- Reclamation of gully and degraded lands into productive lands
- Enhanced surface and ground water availability
- Modification of microclimates
- Increased productivity
- Increased soil fertility and moisture availability
- Enhanced use of chemical fertilizers

- Environmental and ecological rehabilitation
- Habitat and biodiversity restoration
- Enhanced feed and water availability for livestock
- Positive impacts on household incomes and livelihood outcomes overall, and
- Enhanced resilience to adverse effects of climate change

An overall assessment shows that the physical and biological soil and water conservation practices adopted are now perceived to be sustainable for surface and groundwater enrichment, environmental rehabilitation and agricultural and economic development, which can be considered an essential lesson for scaling. However, it is also essential to point out some drawbacks associated with implementations in Tigray that should be considered when adopting this approach. Such challenges may constrain its sustainability and future acceptance by the local people who are expected to benefit. These interventions have been implemented with the twin aims of promoting environmental rehabilitation and improving food security. Collective evidence has shown that most of the degraded landscapes have been considerably restored, and vegetation cover, soil fertility and availability of water have increased over the last two decades (Medhin et al., 2017). Chief among the failings listed below has been the failure to generate the desired (level of) increases in incomes, which threatens the long term viability of the approach.

Major challenges of natural resources intervention

- There is a lack of income generation as well as problems related to ownership and benefit sharing from exclosures.
- There has been an absence of participatory land use planning, and a lack of clear management arrangements, especially when it comes to managing conflicts among land uses and land users.
- Free grazing (“free riding” on common resources), a persistent problem, is inimical to all sustainable land management efforts, impacting public investments in natural resources management, yet it also provides little benefit to livestock, as it is associated with low productivity, feed insecurity, low product quality, and poor health, and hence little benefit to the herder.
- Forest fires, in the absence of related policies and the capacity to manage fires.
- The emergence of new pests and diseases - for example, a new pest (*Plerochila australis*) has been detected on the native Africa olive in Desa’a Forest.
- Poor survival rates of seedlings, due to free grazing, poor seedling quality, improper plantation handling, limited soil depth, low moisture availability, and the lack of close follow up after planting (with the appropriate fencing, watering, cultivation), as well as lack of adequate seed or planting material, and/or the failure to select the required types of seed and planting material for particular locations.

These challenges were all exacerbated during the conflict that began in 2020, leading to uncontrolled destruction through, fire and charcoal making.

Conclusions

As a result of the achievements registered over decades of sustained restoration efforts, Tigray is widely recognized as a successful case in transforming degraded lands into stable living environments. Tigray, for example, was awarded the World Future Council's Gold Award in 2017 for its policies, with the council acknowledging that "thanks to a unique combination of collective action, voluntary labour and the involvement of youth, the people of Tigray are restoring land on a massive scale" (World Future Council, 2017). But, the lack of income generation from exclosures, problems of benefit sharing, low survival rates of planted trees, the lack of regular maintenance of existing structures, and poor use and management of fertilizers are important pitfalls of such ICM implementation programmes. An important lesson drawn from Tigray's experience is that all stakeholders should participate throughout the entire process of restoration and SWC, an element that many projects around the world lack. The Tigray experience can provide a model for approaches to implementation, resting on bringing all of the development partners on board at the planning phase. Moreover, strong commitment and ownership on the part of local government are also important success factors in efforts that seek to reach and engage with watershed communities. With the necessary refinements, this Tigrayan approach could be scaled out to regions with similar environmental, ecological, and socio-economic conditions.

The following recommendations are offered, with particular reference to Tigray, but with a view to adaptation for similar regions and ecological conditions:

- Such public (community-driven) investments in environmental management should be encouraged, globally recognized, and rewarded, noting the environmental rehabilitation that has resulted, and associated improvements in livelihoods, as well as contributions to mitigating global warming.
- The institutionalization of appropriate governance and conflict management practices is an indispensable element.
- Programs must seek to develop integration, partnerships, linkages and synergies at all levels, and link local efforts to global climate mitigation funding, using a framework for carbon accounting and trading.
- Approaches must be developed that enhance sustainable land management practices and principles, while combining biophysical and socioeconomic sustainability.
- Holistic silvicultural management should be instituted, from seed collection to post planting care.

- It is important to develop and utilize hillsides to offer job opportunities to landless youth, where this is possible and appropriate.
- A central data repository to facilitate knowledge sharing, dissemination, and management should be established.
- Agroforestry-based landscape diversification for land use optimization should be promoted, with the regeneration of *Boswellia* and *Acacia* woodlands as economic drivers.
- It is vital to strengthen capacity at grassroots level, with the creation of smart villages, and to enhance local services for agrarian transformation, taking a broader view of integrated landscape management and regional development.

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