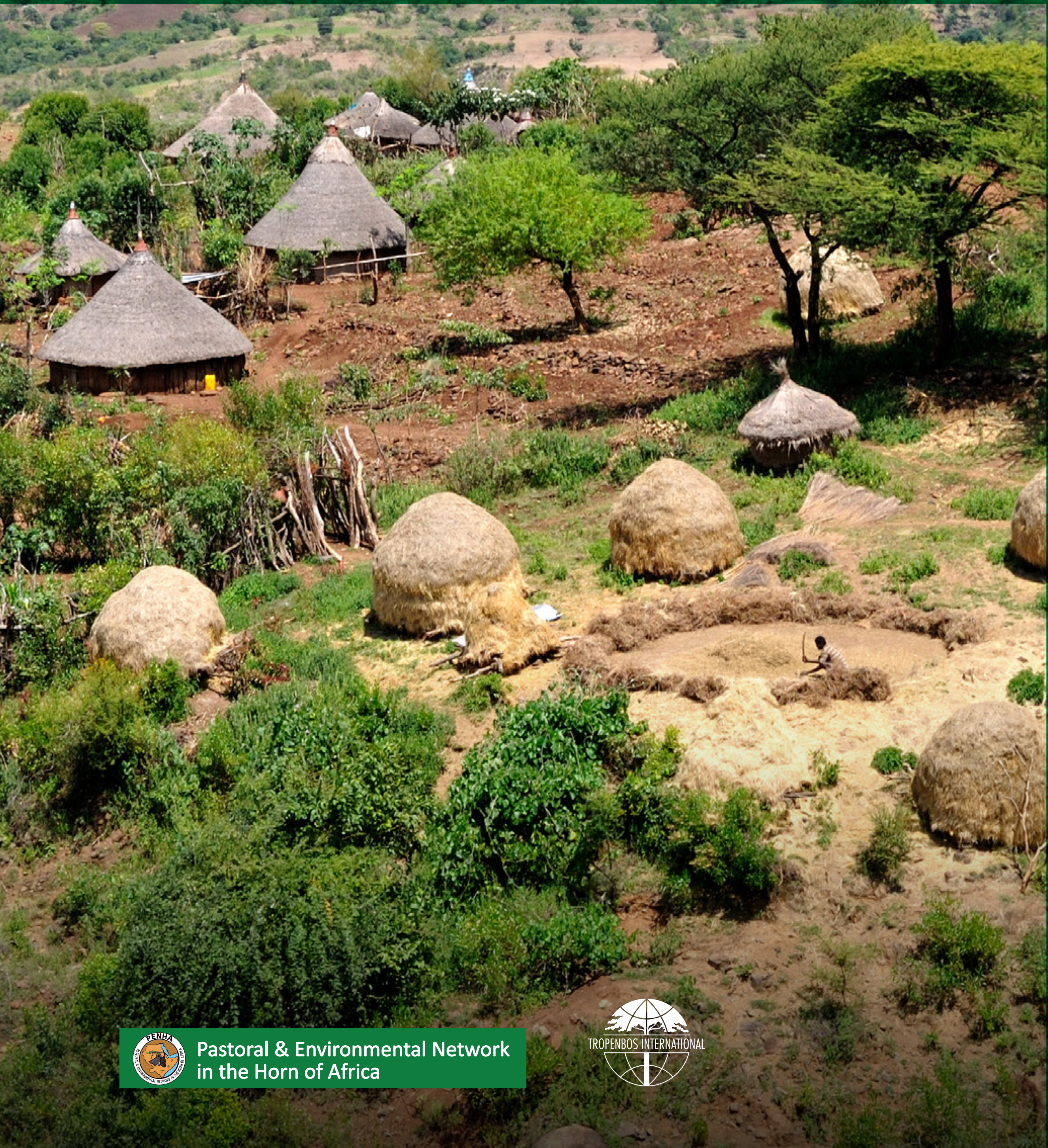
Integration of forest landscape restoration in Ethiopia's nationally determined contributions

A review, with a focus on drylands

Yitebitu Moges, Mitiku Haile and John Livingstone



Pastoral & Environmental Network in the Horn of Africa

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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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Photos: Cover - Fields and village of the tribe Derashe in Ethiopia. Photo by ©volk1945 - stock.adobe.com; page 4 - Restoration practices in Eastern Tigray Region, Ethiopia. Photo by Niguse Hagazi (ICRAF).

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Executive summary

Climate change is caused by greenhouse gas (GHG) emissions from fossil fuels and land use change. It is a global phenomenon that affects biophysical systems and human wellbeing. The UN Framework Convention on Climate Change attempts to address this by coordinating efforts by governments, the private sector and other stakeholders. The Paris Agreement is a major milestone in the Convention's negotiation history. Its objective was to limit the average global temperature increase to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to no more than 1.5°C. By keeping to this target, signatory parties aim to prevent dangerous interference in the global climate system while ensuring sustainable food production and economic development. Each party has an obligation to prepare, communicate and maintain the successive nationally determined contributions (NDCs) that they intend to achieve through domestic mitigation measures (UNFCCC: Article 4, Paragraph 2).

Global analysis highlights the need for increased national commitments and international support for actions that require large scale transformations of the forest sector and ecosystem restoration efforts in developing countries. Many developing countries now recognize that integrated forest and land-based solutions play a prominent role in their NDC mitigation contributions, and in ensuring their sustainable development in the future, besides the contribution to their climate change mitigation goals. There are approximately 2 billion hectares of degraded land around the world. In addition to threatening the survival of many species and ecosystems, such wide scale degradation poses serious obstacles to poverty reduction and sustainable development.

In response to this global call to restore the large areas of degraded land on the planet, many countries have included restoration activities as part of their NDCs towards the Paris Agreement, and in their strategies to reduce emissions from deforestation and forest degradation (REDD+). According to IUCN, 186 Parties have submitted their first NDCs, and from the 166 NDCs analysed, 128 have quantitative and/or qualitative forest landscape restoration (FLR)-aligned targets. But of these, only 49 NDCs have quantitative FLR-aligned targets, of 57 million hectares for mitigation and/or adaptation (IUCN, 2020). If all countries were to incorporate their voluntary Bonn Challenge targets into their 2020 NDCs, 205.78 million hectares of increased climate ambition could be generated from the forest and land sector.

Ethiopia is among the countries that have effectively integrated forest restoration in a most ambitious NDC by global standards, though 80% of implementation is conditional on support from the international community. The newly updated NDC aims to reduce national emissions by 68.8% by 2030. It is largely forest-based, in which the land use change and forestry (LUCF) sector represents over 85% of the mitigation potential of the country. The rational for choice of forestry/LUCF interventions in the NDC at this scale is primarily to address the impacts of alarming deforestation and land degradation on communities and the economy, while contributing to climate change mitigation. As a drought prone country, Ethiopia recognizes that forests and other native vegetation play a modulating role in the regional climate and hydrological cycle, with improved and reliable rainfall enhancement as a major outcome. For example, connections between the Congo forest basin and rainfall distribution in the

Ethiopian highlands has been established in recent studies. Increased forest cover in this mountainous country will also help to reduce flooding and surface runoff, thereby increasing infiltration and water availability, and reduce the vulnerability to droughts. Reforestation will also help to increase the productivity of land, reduce soil erosion, repair degraded riparian ecosystems, enhance water availability along watercourses, protect water bodies and lakes, and increase water tables thereby increasing availability in general. These and other multiple co-benefits gained from forestry development for sustainable development is weighed against other interventions during the formulation and revision of Ethiopia's NDCs.

Ethiopia's ambitious and forest-based NDC is a demonstration of the government of Ethiopia's commitment to addressing environmental degradation and climate change. It aims to focus on the conservation of 17.2 million hectares of remaining native forests and the reforestation of 8 million hectares of new forest by 2030. The main proposed forestry measures are reforestation, forest restoration, alternatives to use of wood as fuel, whilst addressing deforestation and forest degradation through its ongoing national REDD+ program. These reforestation and restoration activities have primarily targeted the drylands, with about 80% of the reforestation and 90% of forest restoration set to be implemented in Ethiopia's drylands.

For countries to express a willingness for large scale reforestation and restoration programs is just one step forward. But as a follow up, countries need to make concrete assessments of their readiness to be able to achieve their reforestation and restoration ambitions. Thus, an in-depth situation analysis must be undertaken on the circumstances, in particular focusing on key drivers and indicators of reforestation success. This analysis will help to identify gaps and measures required for that readiness, to ensure that their efforts will eventually pay off. A number of qualitative and quantitative indicators have been proposed in the literature for the assessment of reforestation success. The most commonly used to assess at forest establishment and maturity are in three stages. (1) Forest establishment that refers to as a three-to-five-year period from when seed or seedlings are planted to when young trees have 'captured' the site, forming a relatively closed canopy suppressing weeds. (2) Forest growth (building phase) where the focus of success is on tree growth, stand density, stem form (in the case of timber trees) and the production of non-timber forest products (such as fruit and resins). (3) Whether or not the forests created are providing the targeted services or products.

Restoring environmental values, ecosystem functions and ecosystem services can be important long term objectives of most reforestation projects. In assessing the environmental performance of forests, three major ecosystem attributes are assessed – vegetation structure, species diversity and ecosystem functions such as soil protection and water regulation. If socioeconomic objectives are pursued, reforestation should be attractive to local communities, and as such, needs to provide socioeconomic benefits. As a pre-requisite for achieving long term reforestation success, local people must receive benefits exceeding those from alternative land uses, otherwise reforested areas will continue to be cleared. The socioeconomic benefits of reforestation do not necessarily have to be direct and can include 'avoided negative impacts' (e.g. landslide prevention or preservation of timber reserves). The most common socioeconomic indicators are local income, employment opportunities, other livelihood opportunities, provision of food and fibre, stability of market prices of locally produced commodities, local empowerment and capacity building.

While indicators are required to measure reforestation success, they alone do not account for the circumstances that influence or contribute to this. The literature makes it clear that a wide range of factors influence reforestation success, and that it cannot be explained by a single reason. Rather, those from a number of biophysical, technical, institutional, management and socioeconomic drivers act together. The technical and biophysical factors for reforestation success include climate and soils, species section, species-site matching, site quality, site preparation, seed and seedling quality, time of planting, post-planting silviculture, and the technical capability of implementers. The socioeconomic factors that determine success of reforestation and forest restoration are a projects' ability to seriously consider local people's interest and their degree of dependency on traditional forest products, winning the participation and action of local communities, economic and financial viability of project interventions, adequate packages for socioeconomic incentives by integrating livelihoods in planning, marketing prospects, efforts in addressing initial drivers of forest loss and degradation, and increasing income opportunities through payment for ecosystem services. The key institutional, policy and management factors of success include the relative quantity of forest resources in an area or country (scarcity creating motivation), good institutional arrangements and associated strong legislation, consistent policies, effective governance, tenure security, long term forestry support programs, presence of community based institutions with strong leadership, reliable and long term project funding, and project characteristics (large publicly funded, or smaller private or community projects).

What is reassuring to countries that intend to make large scale reforestation is that there are effective and positive experiences in reforestation and ecological restoration all over the world. Most developed countries converted most of their original native forests in the past. However, USA, Canada, Australia and European countries, at some point in their history, made critical policy and investment measures to reverse and restore their declining forest resources. Recently, a model large scale reforestation experience comes from South Korea, that made reforestation a top national priority, leading to significant achievements. With consistent planning and implementation of a national reforestation program, supported with adequate institutional, legislative and scientific factors, resulted an increase of forest cover from 3.5 million hectares in the mid-1950s to 6.5 million hectares in just 40 years, with significant forest quality improvements. There are also other exemplary reforestation success stories from developing countries in Asia and Africa. Experiences and lessons from South Korea, Nepal, Kenya and Tanzania are summarized in this review. The Nepalese community forestry case has been elaborated, as many countries could adopt a similar approach to bring about a transformation in landscapes and livelihoods, while mitigating climate change.

Countries that have expressed ambitions towards large scale reforestation in their NDCs have much to learn and adopt from the experiences and lessons of the case countries, while taking adequate measures in the enabling conditions for reforestation success. It is also important that countries should understand that the integration of forest restoration in their NDCs is just one step forward. They need to analyse their situations (biophysical, legislative, institutional and socioeconomic conditions) and make themselves ready before embarking on such large scale interventions. Similarly, Ethiopia needs to assess the situations and identify and address its gaps with respect to large scale implementation of forest restoration and thereby ensure readiness of the country for successful implementation of such large scale reforestation programs in the short term. This review aims to add to the body of knowledge by identifying such gaps and how to best address them.

Finally, Ethiopia is largely a dryland country, and given the significance of drylands for policy interventions in LUCF and livestock sectors, it is crucial to ensure that a coherent policy framework takes into account the specific sociocultural conditions in these areas and is implemented. The historic lack of policy attention and inadequate institutional arrangement for the development of pastoral areas, might challenge the country in implementing the planned forest restoration. Supporting communities, capacity development and revitalization of traditional conservation practices such as undertaken in Tanzania, are some of the measures that could be made in dryland pastoralist areas.

1. Introduction

Partil view of Abreha We Atsbeha (Tigray) catchment during the dry season. Photo by Niguse Hagazi (ICRAF)

Climate change is caused by greenhouse gas (GHG) emissions, from fossil fuels and land use change. It is a global phenomenon that affects biophysical systems and human wellbeing. The UN Framework Convention on Climate Change attempts to address climate change by coordinating efforts by governments, the private sector and other stakeholders. The Paris Agreement is a major milestone in the Convention's negotiation history. Its objective was to limit the average global temperature increase to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to no more than 1.5°C above (UNFCCC, 2015). By keeping to this target, signatory parties aim to prevent dangerous interference in the global climate system while ensuring sustainable food production and economic development (UNFCCC, 1992; Knutti et al., 2016). Each party has an obligation to prepare, communicate and maintain the successive nationally determined contributions (NDCs) that they intend to achieve through domestic mitigation measures (UNFCCC: Article 4, Paragraph 2).

Globally, about three quarters of GHG emissions originate from the burning of fossil fuels, while deforestation and forest degradation, together with agriculture, account for about a quarter of total emissions (Pearson et al., 2017). Forest degradation accounted for 25% of the total emissions from deforestation and forest degradation, but for 28 of the 74 countries assessed, emissions from forest degradation exceed those from deforestation (Pearson et al., 2017). The international community is working to address tropical deforestation and forest degradation through the REDD+ mechanism, with a heavy emphasis on deforestation partly due to the simplicity in monitoring impacts of climate measures (Pearson et al., 2017). Nevertheless, global analyses highlight the need for increased national commitments and international support for actions that require large scale transformations of the forest sector regarding ecosystem restoration efforts.

The importance of land use change in climate change was further recognized in the 21st Conference of the Parties in Paris. It is recognized that protecting tropical ecosystems and reversing the impacts of deforestation and forest degradation through effective restoration and sustainable management of forests is crucial to achieve the adaptation and mitigation goals of the Paris Agreement. It is also recognized that protecting standing tropical forests contributes to the achievement of Sustainable Development Goals related to food, water, health, energy, human safety, and biological diversity. Additionally, there is currently a global process to support governments to address restoration and integrate it in their climate policy frameworks, by making it an integral part of their NDCs. According to IUCN (2020), 186 Parties have submitted their first NDCs, and from the 166 NDCs analysed, 128 have quantitative and/or qualitative forest landscape restoration (FLR)-aligned targets. Among these, only 49 NDCs have quantitative FLR-aligned targets, of about 57 million hectares for mitigation and/or adaptation. If all countries were to incorporate their voluntary Bonn Challenge targets into their 2020 NDCs, 205.78 million hectares of increased climate ambition could be generated from the forest and land sector in developing countries.

Ethiopia is among several countries that have effectively integrated forest restoration in its NDC, with LUCF representing over 80% of its mitigation contribution. This report describes in detail Ethiopia's climate policy and its new enhanced NDC, largely focused on land use change and forestry (LUCF). In addition, the report includes the global response on integration of forestry and forest restoration in countries' NDCs, the challenges and drivers of success in forest restoration, and best practices from selected countries. The review documents knowledge on the integration of forest restoration in NDCs, and shares positive factors affecting forest restoration experiences and the lessons learned to a global audience.

2. Ethiopia's climate policy

The landscape in Naeder Adet District, showing terraces that support land restoration. Photo by: Dawit Gebregziabher

2.1. Reasons for choosing a green development pathway

Ethiopia is a landlocked country in the Horn of Africa. Its topography is characterized by large regional differences which are reflected in its climates, vegetation types and land use practices. The lowlands in the southeast and northeast, covering approximately 55% of the country, are tropical with average temperatures of 25-30°C (FDRE, 2021). The central highlands, rising over 1500 m in elevation, cover about 45% of the country. The highlands are much cooler with average temperatures around 15-20°C. The East African Rift Valley divides the highland plateaus in the west and east. Mean annual rainfall ranges from less than 300 mm in the southeastern and northwestern lowlands to over 2,000 mm in the southwestern highlands (FDRE, 2021). Areas that receive below 1000 mm annual rainfall are categorized as drylands, and a large part of Ethiopia's is dryland, representing over 65% of its territory (Camberlin, 2018). Generally, because of both latitudinal and altitudinal contrasts, the climate and vegetation system is extraordinarily complex.

Ethiopia, the second most populous country in Africa with a population of more than 100 million (CSA, 2013), is also one of the least developed countries in the world. However, recent development efforts have changed the socioeconomic status of the country due to the rapidly growing economy in the past decade, with a growth rate averaging 9.2% a year from 2010/11 to 2019/20 compared to a regional average of 5.4% (PDC, 2021). The high growth rate has also been accompanied by structural transformation, as evidenced by the share of the agricultural sector to GDP having decreased to 32.7% in 2019/20 from 45.7% in 2010/11, while the construction and service sectors made up the majority of the growth, reaching 21.1% and 39.5% of GDP, respectively, in 2019/20. Similarly, the rate of poverty has declined from 29.6% in 2010/11, to 23.5% in 2019/20 (PDC, 2021).

In recent decades, Ethiopia has invested heavily in road and railway infrastructure, industrial parks, universities, and the energy sector. The 10-year development plan (10YDP) from 2021 to 2030 aims to build on the enhanced physical infrastructure to promote the industrial sector and achieve economic transformation. It envisions increasing the share of manufacturing from the current level of 6.9% to 17.2% of GDP by 2030, and to achieve an average economic growth of 10% in the coming ten years (PDC, 2021). Agriculture, manufacturing, tourism, urban development and mining are priority sectors. The plan has also mainstreamed the Sustainable Development Goals (SDGs) and a climate resilient green economy in different sectors, ensuring that, despite the on-going major political and economic reforms being made, the legacy of the green economic development path will extend into the future.

2.2. Impacts of climate change

Ethiopia is highly vulnerable to the impacts of climate change, despite its low contribution to the global GHG emission, estimated at 0.04% (Crippa, 2019). There is considerable evidence of climate change impacts over the last 50 years. At the national level, temperatures have increased by an average of around 1°C since the 1960s. Rainfall is subject to high inter-annual and intra-annual variability, with annual variation around mean rainfall of 25% and can increase to 50% in some parts of the country. Despite this complexity, there is evidence of a 20% decrease in rainfall in the south-central region of the country. Extreme weather events are common, especially droughts and floods, with indications that their frequency of occurrence has increased in the last ten years, relative to the decade before.

Ethiopia's dependence on natural resources and its relatively low adaptive capacity makes it among very vulnerable to climate change impacts. The impact of climate change and variability is already being experienced in almost all sectors with different intensities across the country, including the water, agriculture, infrastructure, forestry and public health sectors. The high vulnerability of the agriculture sector and its socioeconomic impacts is due to its high dependence on rainfed farming. Water scarcity and drought conditions are expected to increase risks of food insecurity, and may exacerbate conflict situations over scarce resources and from population movements. Heavy rains, flooding and soil erosion put both urban and rural infrastructure at risk, particularly for poor and vulnerable groups. Increased occurrences of droughts and reduced rainfall across much of the country will further impact agriculture, livestock, food security and human health. Climate change impacts combined with continued environmental degradation, depleted water resources and the loss of biodiversity, resulting in declining ecosystem services, all constitute serious obstacles to the country's continued development and to its poverty reduction efforts. The increasing vulnerability to these risks and hazards underscores the importance of taking sustainable adaptation and resilience measures sooner rather than later.

Therefore, recognizing the existing and increasing threats of climate change and environmental degradation on the economy and the environment, Ethiopia has taken policy and institutional measures in recent years. These quick, ambitious and serious responses make Ethiopia A leading country in Africa, with a series of climate change mitigation and adaptation policies and plans outlining what is required to minimize impacts and vulnerability to climate change. These are summarized in the updated NDC completed in July 2021 (FDRE, 2021).

2.3. Policy, legal and Institutional frameworks

Ethiopia's policy framework for climate change mitigation and adaptation has progressively evolved since ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. As part of its commitment to the Climate Change Convention, Ethiopia submitted its Initial National Communication (INC) to the UNFCCC in 2001 and its Second National Communication (SNC) in 2015. The country also launched a National Adaptation Plan of Action (NAPA) in 2007, and the Ethiopian Program of Adaptation on Climate Change and Nationally Appropriate Mitigation Actions (NAMAs) in 2010. In its bold measure on climate change, in 2011vEthiopia endorsed a Climate Resilient Green Economy (CRGE) strategy to build a green and resilient economy. Ethiopia also submitted its Intended Nationally Determined Contribution (INDC) in 2015 and ratified the Paris Agreement in March 2016, turning its INDC into its NDC. Ethiopia's first NDC aspired to reduce emissions from all sectors by 64% by 2030 from a business as usual (BAU) scenario. As part of the endeavour to bolster national adaptive capacity, Ethiopia reviewed its adaptation responses and developed a National Adaptation Plan (NAP-ETH) in 2017. The National Adaptation Plan (NAP) Implementation Roadmap and NAP-ETH Resource Mobilization strategy were then developed between 2018 and 2020.

Apart from these national plans, sectoral policies and strategies have been formulated to provide tailored and sector specific strategic interventions. These include the Climate Resilience Strategy for Agriculture and Forestry (2015), the Climate Resilience Strategy for Energy and Water (2015), the Climate Resilient Strategy for the Transport Sector (2015), the National Health Adaptation Plan to Climate Change (H-NAP, 2017), and the Climate Resilience Strategy for Urban Development and Housing (2017).

Ethiopia has been implementing its climate change policy by mainstreaming it into national development plans. In this regard, the CRGE strategy was mainstreamed into the Second Growth and Transformation Plan (GTP II) for the 2015-2020 period. The newly endorsed ten year development plan (10YDP) has also set building a climate resilient green economy as one of its strategic pillars. Ethiopia remains committed to an ambitious contribution towards the Paris Agreement goals of containing the global average temperature increase below 2°C above pre-industrial levels and pursuing efforts to limit temperature increases to 1.5°C. This is demonstrated through its recently updated NDC (FDRE, 2021).

Besides developing successive policy measures, Ethiopia has progressively put in place an institutional architecture which follows a sectoral approach to implementing CRGE/NDC interventions. In this regard, the Environment, Forest and Climate Change Commission (EFCCC), is mandated as the lead agency for the coordination of Ethiopia's response to climate change, and is the national focal point for the UNFCCC. EFCCC formulates environmental laws and standards, and develops, coordinates and guarantees the implementation of sectoral programs and plans. A CRGE Facility was established in 2013, overseen by the Ministry of Finance, which is responsible for financial aspects of CRGE implementation. EFCCC is, on the other hand, responsible for technical elements and day to day administration, as well as developing guidance and rules for CRGE implementation. The institutional arrangements reflect a cross-sectoral, multidisciplinary approach organized through bodies like the inter-ministerial and management committee, and allows for regional engagement. Most relevant line ministries have in-house CRGE directorates, units or bureaus that focus on climate change policy implementation.

Ethiopia has now updated its NDC, building on the 10YDP and with extensive review and participation of relevant stakeholders. The updated NDC represents a clear progression in ambition, with 68.8% emissions reduction target by 2030 from the business as usual (BAU) scenario, and which also seeks to inspire others to increase their contributions to this collective effort. Full implementation of the NDC is conditional on an ambitious multilateral agreement among parties, enabling Ethiopia access to international support in the form of finance, capacity building and technology transfer.

The influence and role of the forestry and agriculture sectors came out very strongly in the updated NDC. While addressing deforestation and forest degradation in the forest sector, the new NDC made forest restoration through landscape approaches an integral part of the identified strategies and policies. Forest restoration through natural regeneration and tree planting are among the major LUCF measures, and primarily target dryland areas. The updated NDC is described in detail in the next chapter.

3. Ethiopia's updated NDC

Converting a big gully or river valley at Gergera watershed through innovative reclamation practices.
Photo by Niguse Hagazi (ICRAF)

3.1. An ambitious NDC as a response to the global call

The Federal Democratic Republic of Ethiopia remains committed to an ambitious contribution towards the Paris Agreement goals of containing the global average temperature increase below 2°C above pre-industrial levels and pursuing efforts to limit temperature increases to 1.5°C. In response to the global call for increasing ambitions and narrowing the mitigation gap, Ethiopia has updated its nationally determined contributions (NDC). Recognizing Ethiopia's national circumstances and capabilities, the updated NDC, represents a clear progression in ambition, with a 68.8% emissions reduction target by 2030, compared to a business as usual (BAU) scenario, and that seeks to inspire others to increase their contribution to this collective effort. The updated NDC reflects Ethiopia's highest possible ambition, and that considers its capabilities and national circumstances. The current NDC integrated in the national 10 year development plan provides a wide range of opportunities for economic development and other co-benefits. This NDC is built on the Climate Resilience and Green Economy Strategy (CRGE), NAP-ETH and sectoral climate plans, and sets out an ambitious development trajectory that aims to create a resilient and middle-income economy by 2030 following the green growth path.

The updated NDC provides a suite of sectoral priority interventions that will guide sectors, development partners, development financing institutions, the private sector and other stakeholders, in implementing the activities set out in this document. Ethiopia can achieve the ambitious vision presented in this updated NDC only in cooperation with its partners. The updated NDC made a clear distinction between unconditional and conditional contributions, clarifying to all stakeholders that the realization of this ambitious updated NDC is subject to international financial and technical support.

3.2. Mitigation contribution of the NDC

3.2.1. Methodological approach

The preparation of the updated BAU GHG emission pathways as well as the conditional and unconditional mitigation pathways until 2030 was undertaken using the Green Economy Model (GEM), developed by the World Resources Institute (WRI). The GEM is an integrated assessment model that goes beyond a linear representation of changes in emissions, to incorporating socioeconomic and environmental trends based on system dynamics modelling, to provide a simulation of the whole Ethiopian economy and its interactions regarding emissions. This means that the GEM considers feedback mechanisms between the Ethiopian economy and the various social and ecological subsystems in which it is embedded.

The GEM is a representation of Ethiopia's economy as a complex adaptive system, including demographics, labour supply, fiscal space, domestic and external sectors, as well as biophysical modules such as carbon stock and land cover. Due to the modular set-up of the model, it is adaptable to changes in policy making, but also external shocks such as the Covid-19 crisis which may heavily affect economic growth in Ethiopia. This represents a significant improvement on the modelling used to underpin the CRGE or the first NDC BAU projections. These projections were Excel-based and typically relied on linear growth rates, informed by sector-specific or economy-wide strategy documents or inputs by line ministries. Another improvement of the GEM over previous modelling is that it includes emissions from land use change in accordance with the 2006 Intergovernmental Panel on Climate Change (IPCC) inventory guidance, accounted for under the land use change and forestry (LUCF) Sector. Further, the GEM covers nearly all relevant key categories identified in the GHG inventory communicated as part of the second National Communication (NC2).

Besides choice of base year and parametrization, an important methodological aspect in updating the NDC concerns the completeness of emission sources contained in future projections. The completeness of emission sources was verified, one by one, by comparing the key categories identified from the GHG inventory conducted for the most recent (second) National Communication and the 3-year inventory for 2014-2016. Unlike the underlying model of the CRGE strategy, the GEM fully accounts for emissions from land use and land use change (LULUCF). Given the importance of agriculture in sectoral aggregation, it was decided to separate the 'land use' (managed soils and livestock) category from 'land use change' (LUCF), and which includes net changes in carbon stock from land conversion and forestry.

Sectoral aggregation of the Green Economy Model follows the key categories of recent inventories which are used as input data for emission projections. Some categories for which no stock flow data is available needed to be dropped in the GEM. This is the case, for instance, for the subcategory of waste incineration. In addition, the GEM does not disaggregate the industry sector into subsectors with different emission intensities. The approach used in the GEM relies on emission data sourced from inventories and determines GHG intensity of real industrial GDP with industry-wide inventory data. Concurrently, energy emissions are calculated by type of fuel used for combustion, and total energy emissions depend, in turn, on growth rates for those sectors which present non-zero mobile or stationary emissions from fossil fuel combustion. Data used comes from the International Energy Agency and includes coal, petroleum, natural gas, electricity and biofuels.

While this approach is in line with the 2006 IPCC guidelines and recognized as international best practice for GHG inventories, the output produced does not distinguish between the emission intensity of subsectors using energy, e.g. the respective contributions of transport emissions vis-à-vis emissions from the combustion of fossil fuels for power generation. The land and managed soils sector includes non-livestock agricultural activities as well as forestry. As with industry, real agricultural GDP and emission data from the inventories constitute the GHG-intensity of agricultural GDP and are driven by simulated growth rates, both of agricultural GDP and emission trends. In the livestock sector, the most recent (unpublished) inventory data, including emission factors calculated with Tier-2 methodologies have been used. Lastly, in the waste sector, emissions from solid waste generation are considered, following the 'first order decay' method according to IPCC best practice. Table 1 below illustrates major commonalities and differences between the underlying model of the CRGE and the GEM by IPCC sectors.

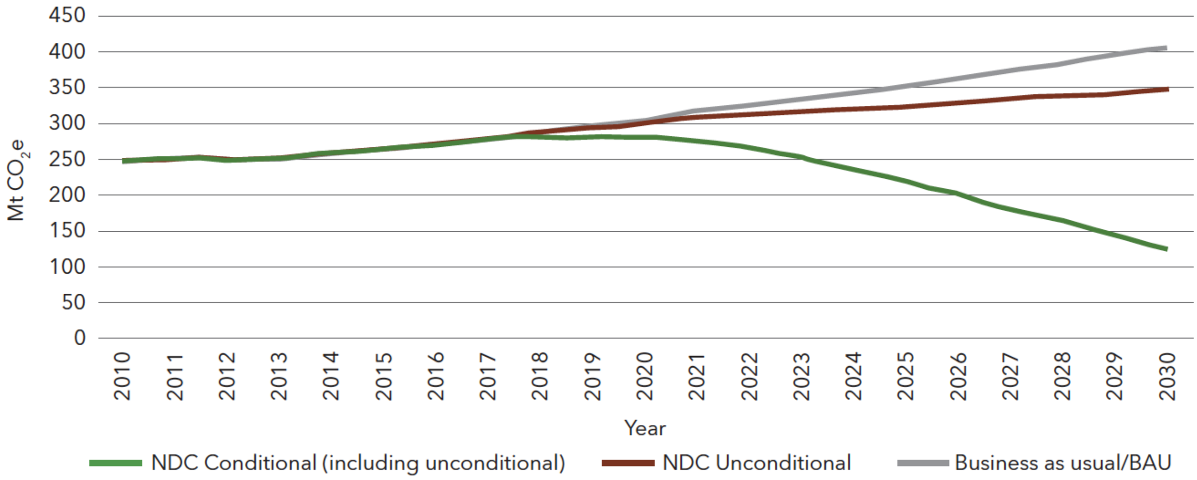
Table 1[1]: Brief comparison of between the underlying model of the Climate Resilient Green Economy (CRGE) strategy and the Green Economy Model (GEM) by IPCC sector denominator and stylized facts.

Emission sources	CRGE	GEM
1 – Energy (emissions from stationary and mobile combustion of fossil fuels)	• Individually reported in Transport, Industry, Power and Green Cities. • Non-exhaustive coverage of fuels. • Case by case selection of methods with different use of units.	• Considers energy-related emissions exclusively in the energy sector. • Includes fuels: coal, petroleum, natural gas and electricity. • Distinction of demand into residential, industrial, commercial and transport. • Unit: TJ/year with respective emission factors.
2 – IPPU (industrial processing and product use)	• Detailed distinction of the industry sector into sub-components using a bottom-up approach. • Considers both emissions from industrial production, processes, and energy consumption under 'Industry'. • Counting of stationary fossil fuel combustion as industry emissions (as opposed to IPCC-2006 methodology)	• Extrapolates IPPU emissions from inventories (NC2 and 3-year inventory) and derived GHG-intensity of industrial GDP under 'Industry'. • Only process-related emissions are considered for BAU and mitigation scenarios.
3 – AFOLU (agriculture, forestry and other land use)	• Includes emissions from agriculture (livestock and soil) and forestry. • Does not include key categories 3B.1-3B.5 concerning land use change (see Pegasys (2020)).	• Distinction into managed soils, livestock and LUCF. • Includes all relevant types of land classes and estimates emissions from the effect of land conversion on the net carbon stock. • LUCF includes emissions from household biomass energy use.
4 – Waste	• Liquid and solid waste covered. • Use of the 'first order decay' method, but only considers marginal waste (no consideration of emissions from accumulated waste).	• Considers solid municipal waste as well as CH4 emissions from wastewater. • Waste incineration and open burning absent due to lack of data. • Far higher level of complexity and detail than CRGE, in closer accordance with IPCC. • Misses data for the final uses of waste (waste flow).

1 Source of tables and figures in this chapter are from the authors of the updated NDC (FDRE, 2021).

3.2.2. Mitigation estimates

In the updated NDC's mitigation contribution analysis, the base year emissions in 2010 are estimated at 247 million tonnes of carbon dioxide equivalent (Mt CO2e), and which are projected to increase to 403.5 Mt CO2e in the BAU scenario in 2030. The projections are further divided into three pathways: unconditional, conditional and BAU. The unconditional pathway is calculated to result in absolute emission levels of 347.3 Mt CO2e in 2030, which represents a reduction against the revised BAU of 14% (-56 Mt CO2e). The impact of further policy interventions proposed under the conditional pathway decrease absolute emission levels to 125.8 Mt CO2e, such that the combined impact of unconditional and conditional contributions represents a reduction of 68.8% (-277.7 Mt CO2e) in comparison with the revised BAU emissions in 2030 (Figure 1). This ambitious pathway is conditional on international support, and includes Ethiopia´s unconditional efforts.



Note: *The graph "NDC Conditional" represents the combined impact of unconditional and conditional elements.*

Figure 1: Ethiopia's BAU, unconditional and conditional emission pathways

The 10YDP signifies that the Ethiopian economy will undergo structural change in the coming years. The base of the economy will be anchored on the manufacturing sector and there will be a high pace of urbanization. These emerging realities will have their own cumulative repercussion on the pattern of emissions. Thus, emissions from industry and energy are expected to increase by a larger percentage compared to other sectors (Table 2). Nevertheless, the agricultural sector, particularly livestock, will remain as the main contributor to GHG emission in the coming years, followed by the land use and forestry (LUCF) sector. Both sectors together represent 83% (LUCF 35% and livestock 48%) of total BAU emissions in 2030. Important to note is that LUCF accounts for emissions from biomass use as well, e.g. for cooking and baking. Biomass use as an energy resource is the single largest driver of LUCF-related emissions, while conversion of forests into agricultural land also plays an important role in emissions in the forestry sector in the coming years.

Based on the assessment of specific mitigation interventions from continuous consultations, the final set of policy interventions have eventually been chosen from those included in the underlying model of the CRGE strategy. The impact of these mitigation policies against the overall GHG pathway leads to the outcomes illustrated in Figure 2.

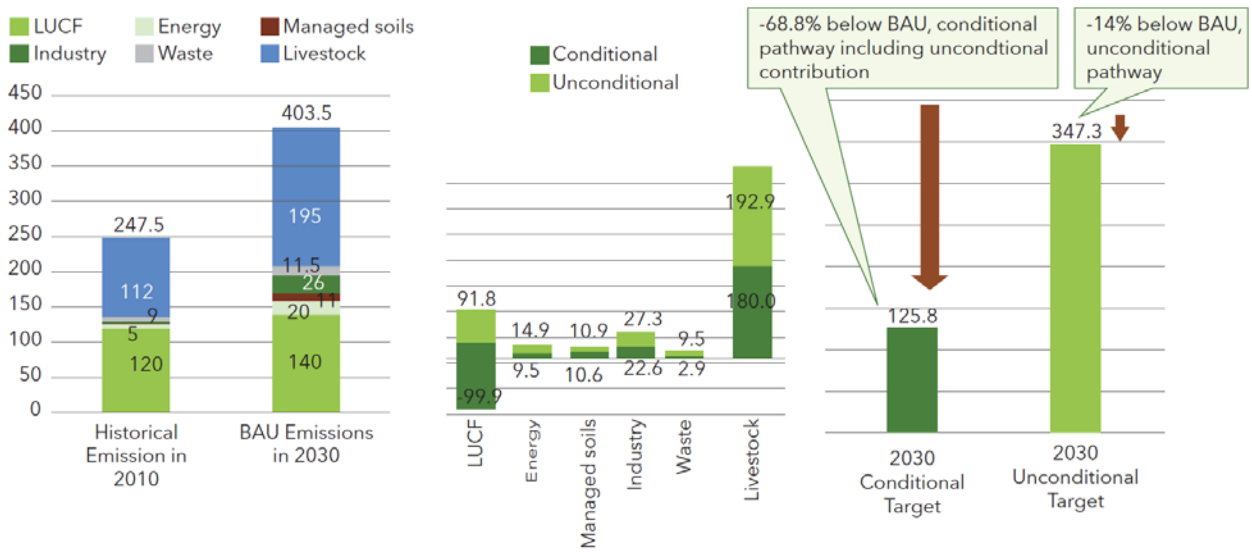


Figure 2: Overview of sectoral contributions to Ethiopia's GHG mitigation targets

Table 2 describes the contribution of each sector and sub-sector to aggregate unconditional and conditional emission reduction targets, ordered by mitigation potential in each of the respective sector categories. It should be noted that whereas the mitigation potentials are represented at sector level considering all sector-relevant policies and variables as underlying interlinked drivers of emissions, activity level emission reductions are monitored and verified through sectoral MRV systems upon implementation of each activity in the context of the 10YDP. Attention is drawn to LUCF becoming a net sink of 99.9 Mt CO2e under the conditional pathway.

Table 2: GHG emission projections in BAU, unconditional and conditional pathways

Sector	BAU emission projection (Mt CO2e)			Unconditional emission projection (Mt CO2e)		Conditional emission projection (incl. unconditional) (Mt CO2e)	
	2020	2025	2030	2025	2030	2025	2030
Industry	5.9	12.7	26.1	12.9	27.3	10.2	22.6
Energy	10.7	14.4	20.0	12.7	14.9	10.4	9.5
LUCF	125.0	133.8	140.2	112.6	91.8	21.4	-99.9
Livestock	146.4	169.5	194.8	168.7	192.9	162.8	180.0
Managed soils	5.8	8.1	11.0	8.0	10.9	8.0	10.6
Waste	9.1	10.3	11.5	9.4	9.5	6.0	2.9
TOTAL (Mt CO2e)	**302.9**	**348.8**	**403.5**	**324.3**	**347.3**	**218.8**	**125.8**

The projected emission reduction potential estimates by sector and pathways are presented in detail in Table 3. The conditional targets include unconditional ones for all sectors. In the following sections, a detailed overview of sectoral emission and mitigation profiles is described.

Table 3: Sectoral emissions in the business-as-usual/BAU and mitigation potentials by sector and conditionality

Sector	BAU emission projection (Mt CO2e)		Unconditional mitigation potential (Mt CO2e)		Conditional mitigation potential (incl. unconditional) (Mt CO2e)	
	2025	**2030**	**2025**	**2030**	**2025**	**2030**
Industry	12.7	26.1	-0.2	-1.2	2.5	3.5
Energy	14.4	20.0	1.7	5.1	4.0	10.5
LUCF	133.8	140.2	21.2	48.4	112.3	240.1
Livestock	169.5	194.8	0.8	1.8	6.7	14.8
Managed soils	8.1	11.0	0.0	0.1	0.1	0.3
Waste	10.3	11.5	0.9	2.0	4.3	8.6
TOTAL (Mt CO2e)	**348.8**	**403.5**	**24.5**	**56.2**	**129.9**	**277.7**

3.2.3. Land use change and forestry

Emissions in LUCF originate from net changes in the stock of carbon in the country, largely emanating from land conversion and emissions from biomass energy use (IPCCC's and Ethiopia NDC's use and correspondence of terminologies). Unlike the first NDC which only considered forest land as a land category, this stock of carbon is determined by the dynamics among all types of land classes: wetland, forest land, grassland, crop land, settlement, and other land. Result showed that land use change and forestry (LUCF) has the largest mitigation potential (over 85%) as a result of highly ambitious reforestation and forest restoration targets (Table 4). Reforestation and restoration activities primarily target the drylands, with about 80% of reforestation and 90% of forest restoration to be implemented in these areas.

At the same time, LUCF is the second most important driver of emissions under BAU assumptions (Table 2). Policy interventions reduce emission levels in 2030 to -99.9 Mt CO2e under the conditional pathway, which turns the sector into a significant GHG sink (Table 2 and Table 4). This is equivalent to a relative reduction of emissions of 171% (-240.1 Mt CO2e) compared to BAU emissions in 2030. The unconditional pathway foresees a reduction of emission levels to 91.8 Mt CO2e, which represents a relative reduction of 34.6% of sectoral BAU emissions in 2030 (-48.4 Mt CO2e) (Table 3). The potential for net emission removals in LUCF can be realized through massive reforestation and restoration of a total of up to 15 million hectares (ha) as a long term forestry sector goal, based on strategic actions under the Ethiopia´s Forest Sector Development Plan, the Green Legacy Initiative, and Reducing Emissions from Deforestation and Forest Degradation (REDD+). Realizing this ambitious plan will increase forest cover to 30% of the national territory by 2030. The other most important driver of LUCF emissions is the use of biomass energy for cooking and baking, which according to international inventory guidelines are accounted for under LUCF. Thus, replacing or improving household biomass energy use for cooking and baking leads to substantively reduced pressure on forestry resources. The following table portrays the policy options of the LUCF sector in the coming ten years.

Table 4: Policy interventions in the land use change and forestry (LUCF) sector

Policy intervention	Indicator (unit)	Lead institution/s (responsible)
Sustainable agriculture • Increasing the share of agricultural land under sustainable management practices • Reducing pre-harvest losses and land converted for agricultural infrastructure	• Hectares of agricultural land under sustainable management practices (ha)	Ministry of Agriculture (MoA)
Grassland improvement • Carbon sequestration through grassland improvement • Lowlands Livelihoods Resilience Project	• Hectares of grassland improved (ha)	Ministry of Agriculture (MoA)
Reducing residential biomass use • Fuel switch: shift from unsustainable biomass energy demand to electric stoves, renewable biofuels (e.g. residues) • Biomass efficiency: improved cookstoves	• Energy demand shifted (Tj) • Number of improved cookstoves • Distributed and used (received by women/men) • Biomass use per (female-headed/ male-headed) household (tonnes)	Environment, Forest and Climate Change Commission (EFCCC) Ministry of Water, Irrigation and Electricity (MoWIE)
Reforestation • Reforestation of 3 million ha of land by 2030 (conditional pathway): 20% moist Afromontane, 60% dry Afromontane, 10% *Acacia-Commiphora*, 10% *Combretum-Terminalia*	• Area reforested/afforested (ha) Share of forest area of total land area (%)	Environment, Forest and Climate Change Commission (EFCCC)
Restoration • Restoration of 5 million ha of land by 2030 and 9 million ha by 2050 (conditional pathway) • 10% moist Afromontane, 60% dry Afromontane, 10% *Acacia-Commiphora*, 20% *Combretum-Terminalia*	• Area restored (ha) • Share of forest area of total land area (%)	Environment, Forest and Climate Change Commission (EFCCC)

3.2.4. Livestock sector

The livestock sector exhibits the second most important mitigation abatements. It is also one of the most significant contributors to emission sources under BAU assumptions, contributing nearly 45% of total base year emissions in 2010, and almost half of the total BAU emissions in 2030. Given the economic importance and plans for a strong expansion of the sector, emission reductions are most visible in improved emission intensities of livestock production. Policy interventions in this sector will reduce the emission level in 2030 to 180 Mt CO2e in the conditional pathway. The new estimate of current and projected heads of livestock in the country as well as other key parameters (e.g. revised emission factors) significantly elevate BAU emissions of this sector compared to the first NDC. The sector has a relative reduction of emissions of 7.6% (-14.8 Mt CO2e) compared to BAU in 2030. The unconditional pathway foresees a reduction of emission levels to 193 Mt CO2e, which represents a relative reduction of 0.92% of sectoral BAU emissions in 2030 (Table 3). Emission reductions in the livestock sector are to be achieved through packages of policy interventions combining mitigation, efficiency gains, and output growth. In this regard, sector-specific strategies as well as national development plans have imposed a huge weight to the sector in a bid to reduce emissions in the country. Thus, the Livestock Master Plan (LMP), the 10YDP and the CRGE strategy have identified optimal policy interventions, and Table 5 depicts the envisioned policies of the sector in the coming years emanating from implementation of these policies.

Table 5: Policy interventions in the livestock sector

Policy intervention	**Indicator (unit)**	**Lead institution/s (responsible)**
Dairy, red meat and poultry intervention packages • Enhancing efficiency and productivity in the livestock sector	• Number of improved cows (owned by women/men) • GHG intensity of agricultural GDP	Ministry of Agriculture (MoA)
Agricultural mechanization • Replacing cattle/oxen with tractors for farmers and smallholders	• Number of heads of livestock reduced (received by women/men) • Number of tractors distributed	Ministry of Agriculture (MoA)
Increase in the share of poultry • Replacing non-dairy cattle stock with chickens (supply side) and inducing a demand shift from beef to chicken	• Number of non-dairy cattle replaced (owned by women/men)	Ministry of Agriculture (MoA)
Oilseed feeding • Improved feeding to reduce emissions from enteric fermentation	• Improved feeding deployed (tonnes)	Ministry of Agriculture (MoA)

3.2.5. Energy sector

The energy sector has huge mitigation potential in the updated NDC, next to livestock and LUCF, though the largest share of the grid-connected electricity generation already comes from renewable sources. Moreover, the contribution from reducing biomass energy emissions has been already accounted for under the LUCF sector (Table 3). The energy sector contributes 5% of total BAU emissions in 2030. Policy interventions in this sector will reduce the emission level in 2030 to 9.5 Mt CO2e in the conditional pathway. This equals a relative reduction of emissions of 52.5% (-10.5 Mt CO2e) compared to BAU (Table 3). The unconditional pathway foresees a reduction of emission levels to 15 Mt CO2e, which represents a relative reduction of 25.5% of sectoral BAU emissions in 2030 (-5.1 Mt CO2e) (Table 3). Policy interventions in the energy sector target the energy consumed by all sectors (Table 6). For example, investments in the transport sector can contribute to reducing the demand for petroleum through moving to green mobility solutions, including e-mobility, railways and non-motorized transport. This mitigation contribution does not yet include clean energy exports to neighbouring countries, which are projected to reach more than 5,000 MW/year once the Great Ethiopian Renaissance Dam is connected to the grid. This could represent an additional significant mitigation potential of several Mt CO2e per year.

Table 6: Policy interventions in the energy sector

Policy intervention	Indicator (unit)	Lead institution/s (responsible)
Energy efficiency • Economy-wide improvements of the energy efficiency of appliances, machinery and other capital assets	• Efficiency parameters, e.g. efficiency of appliances and buildings (as a percentage)	Ministry of Water, Irrigation and Electricity (MoWIE)
Transport electrification • Shifting transport energy demand from petroleum to electricity • Increasing the share of electric vehicles	• Energy demand shifted (Tj) share of electric vehicles over total fleet (%)	Ministry of Transport (MoT)

3.2.6. Waste sector

The waste sector accounts for relevant emission sources emanating from municipal solid waste (MSW) generation, decomposition of organic components of waste on landfills, wastewater, as well as from solid waste incineration. Mitigation action in the waste sector has a significant potential to reduce emissions. The sector contributes 3% of total BAU emissions in 2030. Despite small contributions to total BAU emissions, policy interventions in the sector can be highly effective. Conditional interventions can reduce emission levels in 2030 to 2.9 Mt CO2e. This equals a relative reduction of emissions of 74.7% (-8.6 Mt CO2e) compared to BAU emissions in the waste sector. The unconditional pathway projects a reduction of emission levels to 9.5 Mt CO2e, which represents a relative reduction of 17.1% of sectoral BAU emissions in 2030 (-2.0 Mt CO2e) (Table 3). The envisioned policy interventions are depicted in Table 7.

Table 7: Policy intervention in the waste sector

Policy intervention	Indicator (unit)	Lead institution/s (responsible)
Waste management • Reducing emissions from reduced waste generation rate per capita • Reducing emissions by aggressively diverting organic materials from landfills, i.e. waste separation and composting • Reducing emissions from wastewater	• Rate of waste generation (tonnes per capita) Share of organic material per ton of waste on landfills (%) • Number of wastewater treatment plants constructed	Ministry of Urban Development and Construction Ministry of Water, Irrigation and Electricity (MoWIE)
Public transport • Shifting transport energy demand from petroleum to electricity • Increasing the share of public transport, including railways	• Energy demand shifted (Tj) by passenger distance travelled in public transport (km) (by women/men) Share of passenger kilometres travelled in public transport over total passenger kilometres travelled (%)	Ministry of Transport (MoT)
Industry fuel switches • Fuel switch 1: shift from industrial petroleum demand to electricity • Fuel switch 2: shift from industrial petroleum demand to sustainable biomass	• Energy demand shifted (Tj) by a switch in the type of fuel used	Ministry of Trade and Industry Ministry of Water, Irrigation and Electricity (MoWIE)

3.2.7. Industry sector

The share of the manufacturing industry to the national economy has been increasing over recent years, and the 10YDP portrayed that its share will reach as high as 17.2% of GDP by 2030. This in turn increases emissions from the sector, so commensurate interventions have been proposed to reduce emissions in the coming years. These will reduce emission levels to 22.6 Mt CO2e in 2030 in the conditional pathway (Table 2), equal to a reduction of emissions of 13.4% (-3.5 Mt CO2e) compared to BAU. The unconditional pathway projects a reduction of emission levels to 27.3 Mt CO2 (Table 3). Interventions will reduce emission levels to 22.6 Mt CO2e in 2030 in the conditional pathway (Table 2), equal to a reduction of emissions of 13.4% (-3.5 Mt CO2e) compared to BAU emissions. The unconditional pathway projects a reduction of emission levels to 27.3 Mt CO2 (Table 3). Most industries in Ethiopia are small and micro, so they do not emit much GHG. The cement sub-sector is the major source of process-related emissions. Apart from this, Ethiopia plans to produce fertilizer which will increase GHG emissions in the next ten years. Cognizant to this, the principal policy to mitigate process-related emissions in the cement sector is clinker substitution, with savings from increased nitrogen use efficiency

(Table 8). A shift away from synthetic fertilizer will be the prime mitigation strategy for the fertilizer sector.

Table 8: Policy intervention in the industry sector

Policy intervention	Indicator (unit)	Lead institution/s (responsible)
Clinker substitution • Replacing clinker in cement with adequate and available materials without compromising cement properties	Share of clinker in cement (%)	Ministry of Trade and Industry

3.2.8. Managed soils sector

The main drivers of emissions from managed soils are linked to the use of fertilizers, crop residues, as well as urine and dung. Thus, the sector is directly linked to the livestock sector which comprises all emission relevant policy interventions. Managed soils are represented as a separate sector to distinguish between livestock and crop production, and to align with IPCC guidance. While livestock-related agriculture represents 48% of BAU emissions in 2030, GHG emissions from crop production on managed soils contribute 3%.

3.3. Adaptation contribution of the NDC

Over the last decade, Ethiopia has been putting in place various policy actions that enhance the implementation of climate change adaptation. Core policy and institutional measures have been materialized by mainstreaming climate change adaptation into national and sectoral plans with an emphasis on implementing identified adaptation options across selected sectors. Given the vulnerability of the country and the low adaptative capacity to absorb external shocks emanated from the devasting effects of climate change and variability including droughts and floods, the government of Ethiopia has made adaptation a priority. Within this context, prioritization of adaptation interventions becomes a powerful approach to ensure the effective and efficient utilization of the scarce resources available. Whilst Ethiopia's initial national climate change strategy – the CRGE strategy – did not sufficiently contain adaptation and resilience measures, several sectors have affirmed the importance of building adaptive capacity and reducing their vulnerability as adaptation interventions under consideration and this has grown substantially.

Most recently, Ethiopia's NAP formulated in 2017, spanning the agriculture, forestry, health, transport, energy, industry, water and urban sectors, reaffirmed this importance. Furthermore, the NAP Implementation Roadmap expanded the options outlined in the NAP with actions, categorized into short term priorities (such as capacity building, strengthening the enabling environment, and promoting research) for the 2020-2022 period, and long term priorities (with sector-specific activities) for the 2025-2030 period. With the addition of the long term priorities from the NAP Implementation Roadmap, there are 52f potential adaptation commitments to consider for inclusion in the NDC. While the selection of 18 adaptation options under the NAP and the numerous adaptation actions under the Implementation Roadmap already reflect a lengthy, rigorous and officially endorsed prioritization process that entailed in-depth stakeholder participation (as detailed in the NAP's methodology), and was informed by an extremely broad range of national, sectoral, and technical studies (as noted in the NAP Implementation Roadmap methodology), attempts were made to further prioritize a sub-set of interventions in the updated NDC.

Prioritization criteria were developed to select the optimal interventions from within the NAP's adaptation options and the NAP Implementation Roadmap's supplementary adaptation actions. The internationally recognized and widely used PESTLE framework (an analytical framework for multicriteria decision making) was applied for each of the PESTLE categories – political, economic (and financial), social, technological, legal (and institutional), and environmental – defined with four relevant criteria. In using the prioritization criteria to evaluate each adaptation option (from the NAP) and each long term adaptation action (from the NAP Implementation Roadmap), 20 steps were taken for each of the 52 interventions screened, ranging from cross-referencing with the 10YDP, NAP-ETH, relevant sectoral climate resilience or adaptation strategies, the NAP Implementation Roadmap to aligning with the Sendai Framework for Disaster Risk Reduction, the African Union's Agenda 2063, and the AU's draft strategy on climate change 2015.

Ethiopia's major climate change adaptation commitments are in the sectors of agriculture, land use and forestry, with additional adaptation contributions in water, health, energy, transport, and urban settlements (Annex 1). Agriculture, forestry and other land use (AFOLU) adaptation actions represent the bulk of the updated NDC's commitments for strengthening Ethiopia's resilience to climate change. Ethiopia has already undertaken important adaptation efforts in these sectors, and will further expand and prioritize measures such as climate-smart agriculture, livestock diversification, drought-resistant animal breeding, rangeland management, improved drought-resistant crop varieties, crop and livestock insurance, watershed management and rehabilitation, ecosystem-based adaptation, sustainable forest management, community-based forest management and conservation, as well as afforestation and reforestation programs.

The updated NDC has identified 40 adaptation interventions with a clear demarcation between unconditional and conditional, covering sectors such as agriculture, forestry, water, transport, urban, health, land use and natural resource management, and climate services and disaster risk reduction (Figure 3). This includes mitigation interventions that have adaptation co-benefits and vice versa. A quantified baseline (2018) and 2030 target for each adaptation intervention has been identified for guidance on implementation and monitoring of the updated NDC. To enhance inclusiveness of adaptation interventions, gender considerations and other cross-cutting issues have been included.

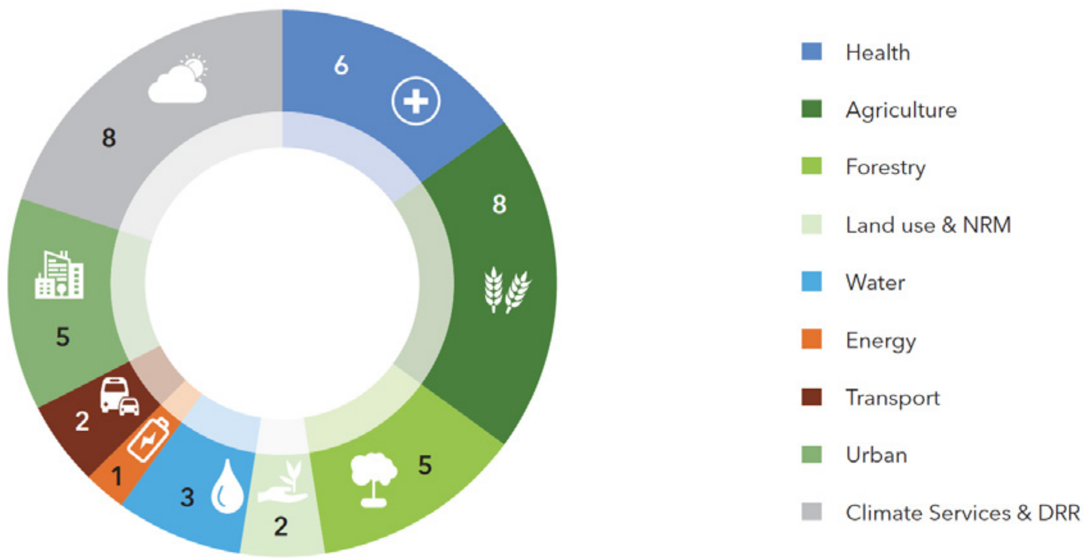


Figure 3: Number of adaptation interventions per sector

Adaptation interventions in the agriculture, forestry and other land use (AFOLU) sector will be complemented with strategic adaptation actions in other sectors such as water (improving resilience of water sources and access to potable water), energy (energy diversity through alternatives and renewables), transport (climate resilient design of sustainable transportation systems, integrating climate change into transportation planning and development), urban settlements (urban greenery, adaptive urban planning), health (integrated environment and health surveillance protocols, improvements in basic health services and emergency medical services), and disaster risk reduction (improvement in early warning systems, improvement in disaster risk planning and preparedness).

3.4. Conditionality of mitigation actions and cost estimates

The level of ambition that can be achieved unconditionally, and the level of international support required to achieve conditional targets, indicates noteworthy progress in this updated NDC. The proposed NDC's policy interventions are sector-wide programmatic actions, comprising many different activities requiring both domestic and international investment. Based on the experience of other countries and the economic realities of Ethiopia, it is proposed that 20% of the total reduction will be domestically financed while the remaining 80% shall be financed through international support. Although exceptions have been applied where mitigation interventions rely fully on international support, these percentages are regarded as appropriate when considering Ethiopia's marginal historical responsibility, its status as a least developed country (LDC), domestic resource availability, and sustainable development priorities. This split assumes that Ethiopia will implement the least-cost mitigation actions first to achieve its unconditional targets.

The financial resources required to implement the updated NDC in the next 10 years is estimated to be US$316 billion. The mitigation interventions identified in the updated NDC require US$275.5 billion, and adaptation actions require US$40.5 billion. These financial estimates are derived from climate resilience plans of different sectors, and Ethiopia's Ten Years Development Plan which aims to build a climate resilient green economy by 2030.

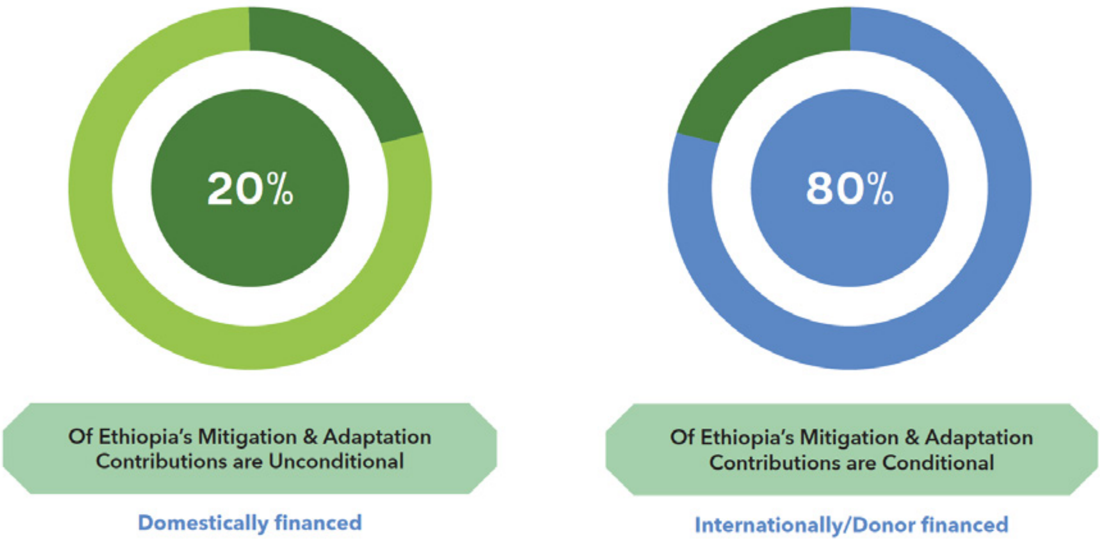


Figure 4: Unconditional and conditional elements of NDC funding

Similarly, for achieving the GHG emission reduction targets, 20% of the total estimated finance is unconditional while 80% is conditional. Ethiopia is committed to investing US$63.2 billion on climate change mitigation and adaption actions from domestic sources, which is equivalent to an average annual investment of US$6.32 billion by 2030. The conditional finance, which is equivalent to US$252.8 billion, should be received from international climate finance sources.

4. Global responses on integration of forest restoration in NDCs

Degraded grazing area under restoration through FMNR in Abreha We Atsbeha. Photo by Niguse Hagazi (ICRAF)

4.1. Rationale for integration of forest restoration in NDCs

Population growth and the parallel appetite for economic growth, exacerbates damage to native vegetation and natural capital. Population growth brings with it an increasing demand for food, energy and water, to a point that may be beyond carrying capacity, alongside increased rates of deforestation and forest degradation, and reduced land productivity. Forestry and land use are also a major source of emissions in developing countries. Today, the impacts of the on-going losses of forests paired with continued loss of ecosystem services in developing countries has raised global interest in the conservation of remaining forests, while at the same time, increasing efforts in restoring those previously degraded or deforested. In response, the international community seeks to mitigate losses, restore what has been lost, and promote sustainable use of forests in the face of a growing global population and increasing demand for land and resources (Aerts and Honnay, 2011; Sabogal et al., 2015; Chazdon and Uriarte, 2016).

The Paris Agreement sets an objective to limit the global temperature increase to "well below 2°C" and to pursue "efforts to limit the temperature increase to 1.5°C". Nationally determined contributions (NDCs) form the foundation of the Paris Agreement, and actions contained in national NDCs together add up to a collective global effort towards achieving the long term goal. In Article 5 of the Paris Agreement, countries (referred to as Parties in the Agreement) are invited to include forest based solutions to addressing the negative effects of climate change in the formulation of their NDCs. These include conservation and enhancement of sinks and reservoirs of greenhouse gases (GHGs), sustainable management of forests and enhancement of carbon stocks in developing countries, more effective implementation of REDD+, and good practices for land use, land use change and forestry (LULUCF) aimed at achieving long term low carbon and climate resilient development.

Developing countries recognize that integrated forest and land based solutions play a prominent role in their NDC mitigation contributions, and in ensuring their sustainable development in the future. African countries place significant emphasis on adaptation in their NDCs, given their vulnerability to the impacts of climate change. Sustainable forest and land management are a means to reducing emissions as well as playing a crucial role in lessening the impact of climate change on livelihoods, especially those of subsistence farmers and forest dependent communities. The REDD+ mechanism focuses more on addressing the loss of existing natural forests in tropical countries. Forest restoration should also receive equal importance, especially in many forest scarce countries having vast areas of degraded land. There are approximately 2 billion hectares of degraded land around the world (Minnemeyer et al., 2011). In addition to threatening the existence of many species and ecosystems, such wide scale degradation poses serious obstacles to poverty elimination and sustainable development (Díaz et al., 2015; Isbell et al., 2015). Increases in degraded land also affect regional climates through their impact on surface fluxes of radiation, heat and moisture (Betts, 2005). Thus, an effective integrated solution to global climate change must include action on land use policy and ecosystem restoration.

In response to the call to restore such large areas of degraded land globally, international restoration programs have been growing, engaging country governments, the private sector and civil society organizations to re-establish tree cover across landscapes (Chazdon, 2016; Chazdon et al., 2017). Most notably, under the Bonn Challenge, more than 47 countries have committed to restore a total of 150 million hectares by 2020, and 350 million hectares by 2030. The Bonn Challenge was endorsed and extended in 2014 by the New York Declaration on Forests (UNDP, 2018), pledging to cut 16.5–32.3 Gt CO_2 of annual emissions from natural forest loss.

Many countries have included restoration activities as part of their nationally determined contributions (NDCs) towards the 2014 UNFCCC Paris Agreement, and in their strategies to reduce emissions from deforestation and forest degradation (REDD+). According to IUCN, 186 Parties have submitted their first NDCs, and from the 166 NDCs analysed, 128 have quantitative and/or qualitative FLR-aligned targets, though only 49 NDCs have quantitative FLR-aligned targets, of 57 million hectares for mitigation and/or adaptation (IUCN, 2020). If all countries were to incorporate their voluntary Bonn Challenge targets into their NDCs, 205.78 million hectares of increased climate ambition could be generated from the forest and land sector.

Forest landscape restoration has been adopted by governments and practitioners across the globe to mitigate and adapt to climate change and restore ecological functions across degraded landscapes. There are however, critical issues that should be addressed to help restoration address global climate and sustainable development challenges. Issues that relate to successful restoration include, among others, its technical feasibility, financial viability, involvement and participation of local people, good governance, policy, legislative and institutional support, long term funding, documenting best practices and scaling up, and research and innovations. Restoration efforts must address both environmental integrity and human wellbeing in developing nations.

4.2. Integration of forest restoration in Ethiopia's NDC

4.2.1. An alarming level of environmental degradation in Ethiopia

The early human occupation of Ethiopia's landscapes going back to thousands of years ago, and recent agricultural expansion have resulted in loss of large areas of forest and non-forest ecosystems. Unsustainable agricultural practices are often considered as the major and continuing cause for loss of native vegetation and further land degradation. The direct effects of deforestation are decreased areas of forest and woodland, impacts on the structure of the remaining forests, and their fragmentation into smaller and more isolated blocks. The consequences of these changes are seen both on-site and off-site, and include on-site reductions in landscape productivity because of increasing losses of nutrients and soil, downstream impacts through reductions in water quality increasing sedimentation, changes in water yield, and widespread reductions in biodiversity and the supply of ecological goods and services (Vitousek et al., 1997; Tilman et al., 2001). A further consequence is the poor performance of the largely agrarian economy over many decades, leading to further impoverishment of rural communities.

It should be noted that Ethiopia is a regional 'water tower'. Therefore, it is very likely that environmental degradation in the country could have far reaching consequences across the East African region and beyond, in particular through its effects on drought and water availability. Continuing deforestation and land degradation affects riparian areas, with declining water availability along watercourse, shrinking water bodies and lakes, lower water tables, and diminished availability of underground water (Nosetto et al., 2005; Coe et al., 2011). Forests and other native vegetation play a modulating role in hydrological cycles, such as in the Congo basin, that impact rainfall in the highlands of Ethiopia (Sheil, 2019). Forest cover in Ethiopia helps to reduce flooding and surface runoff thereby increasing infiltration and water availability, and reducing the vulnerability of the population to droughts.

Environmental degradation coupled with the impacts of climate change are a real development challenge for Ethiopia. Thus, addressing land degradation and climate change is an urgent matter for the country. Ethiopia recognizes that integrated forest and land-based solutions play a prominent role in its NDC mitigation contributions and in ensuring sustainable development in the future. Sustainable forest and land management are a means to reducing emissions as well as playing a crucial role in lessening the impact of climate change on livelihoods, especially those of subsistence farmers and forest-dependent communities. Ethiopia focuses on forest-based solutions to addressing the negative effects of climate change, and LUCF is placed at the core of the formulation of its NDC. Forest-based solutions to climate change include conservation and enhancement of sinks and reservoirs of greenhouse gases (GHGs), including sustainable management of forests and enhancement of carbon stocks, more effective implementation of REDD+, and good practices of land use, land use change and forestry (LULUCF), aimed at achieving long term low carbon and climate resilient development.

These actions have environmental and socioeconomic benefits, besides addressing national emissions, The ambitious and forest-based NDC is a demonstration of the government of Ethiopia's commitment to addressing environmental degradation. The implementation of the NDC will ensure the conservation of remaining native forests while also resulting in the large scale restoration of degraded lands in the highlands and dryland areas.

4.2.2. Policies and measures in LUCF and the significance of forest restoration

Ethiopia is one of the countries that have effectively integrated forest restoration in a most ambitious NDC by global standards, though 80% of the implementation is conditional on support from the international community. The new NDC aims to reduce national emission by 68.8% by 2030. It is largely forest-based, in which the land use change and forestry (LUCF) sector represents over 85% of the mitigation potential of the country. The rational for choice of LUCF interventions in the NDC at this scale is primarily to address the impacts of alarming deforestation and land degradation on communities and the national economy, while contributing to mitigation of climate change. As a drought prone country, Ethiopia recognizes that forests and other native vegetation play a modulating role in the regional climate and hydrological cycle, with improved and reliable rainfall enhancement as a major outcome. Reforestation will also help to increase the productivity of land, reduce soil erosion, repair degraded riparian ecosystems, enhance water availability along watercourses, protect water bodies and lakes, and increase water tables thereby increasing availability of underground water. These and other multiple co-benefits gained from the forestry development is weighed against other interventions during the formulation of the NDC.

In alignment with the national interest, the updated NDC mitigation contribution focuses on actions that specifically target land use change and forestry (LUCF). Approximately 40% of the country was originally covered by forest ecosystems (EFAP, 1992), most of which are now converted to agriculture, are highly degraded, or are under strong pressure of conversion to other land uses. There is a huge potential for restoration in Ethiopia. A recent land assessment conducted with the technical support of the World Resources Institute showed that more than half of Ethiopia's land mass (54 million hectares) is at various levels of degradation (EFCCC, 2018), with about 11 million hectares of this categorized as a top priority for intervention. Thus, while addressing deforestation and forest degradation, Ethiopia's updated NDC has bold and ambitious targets to restore and reforest 9 million hectares of forests by 2030 for multiple uses, and to expand the range of sustainable forest management systems available for native forests. Ethiopia's NDC weighs heavily on mitigation measures in the land use and forestry (LUCF) sector.

The potential for net emission removals in the LUCF sector is huge, and is to be realized through massive reforestation and forest restoration of up to 15 million hectares as pledged in the Bonn Challenge, about 9 million of which is covered in the NDC implementation period. Ethiopia has initiated reforestation by raising of 20 billion seedlings in just four years (2019-2022). About 15 billion seedlings have been planted in the past three years under this initiative, led by the Prime Minister of Ethiopia. Reforesting degraded highlands has been taken as a long term forestry sector goal in relevant national policies, that will result in an increase in forest cover of 30% of the national territory over the long term. LUCF policy interventions also aim at replacing or improving household biomass energy use for cooking and baking, leading to substantively reduced pressure on forestry resources. It is clear that Ethiopia's NDC mitigation contributions will depend on the realization of policies in the LUCF sector. The EFCCC guidance during the NDC updating has substantively improved the representation of forestry sector, and reforestation and restoration policies in particular.

In the updated NDC, it is stated that under the conditional policy pathway, 3 million hectares of reforestation and 5-6 million hectares of restoration will be achieved by 2030. Over 80% of this targets dryland areas. The full target of 9 million additional hectares will be restored by 2050 in a stepwise approach considering the national capacities of implementation. Over the NDC implementation period, the conditional pathway could achieve an increase in total forest cover of 25.6% (or 28.2 million ha) , with the rest by 2036. The distribution of efforts over the NDC period is to achieve 25% of reforestation and restoration targets by 2025, and 75% between 2025 and 2030. The unconditional policy pathway foresees 20% of the ambition of the targets formulated under the conditional policy pathway. It is important to note the assumption in the GEM model that the full carbon stock (and therefore the contribution to sequestrating CO_2 emissions) of reforested/afforested land is only assumed to be reached over a period 30 years after land is changed to forest. Thus, a substantial share of the mitigation contributions from reforestation efforts undertaken during the NDC period (2021-2030) in the land sector will only be fully realized over the longer term.

Besides the anticipated funding from international partners, to realize these ambitious forest restoration targets Ethiopia needs to improve the existing policy and legislative framework, governance, and its institutional capacity and technical capabilities. In this regard, a review was made of knowledge and experience on drivers and indicators of large scale reforestation programs, lessons learned and best practices from selected countries, summarized in a later chapter. Ethiopia and other developing countries targeting forest restoration and reforestation as part of their national programs, including in their NDCs, will benefit from this review.

5. Drivers of reforestation success

A hillside area exclosure in Abreha We Atsbeha Photo by: Dawit Gebregziabher

5.1. Reforestation and measuring success

Governments and international organizations have been committing substantial resources in tropical countries to restoring forests (Iyyer, 2009), and this is assumed to continue at a larger scale. Despite this expenditure on reforestation, limited information exists to indicate the success of such projects in achieving ecological or socioeconomic benefits. Many reforestation projects have also partially or completely failed because the trees planted have not survived, or have been rapidly destroyed by the same pressures that caused forest loss and degradation in the first place. In others, even when planted trees have survived to maturity, they have not necessarily been welcomed by local communities, thus affecting long term success. The widespread controversy over reforestation with exotic monocultures of eucalyptus in the tropics is another reason for failure of non-acceptance by local stakeholders (Carrere and Lohmann, 1996). Successful reforestation projects must result in established stands to qualify as an offset and to be able to provide goods and services to communities. Ensuring long term success is one of the greatest challenges facing many afforestation and reforestation initiatives in developing countries. Identification of factors that influence success and in what situations reforestation projects succeed or fail is very important.

Reforestation is commonly defined as the process by which trees are returned to areas from which they have been previously cleared. Reforestation can take many forms, ranging from establishing timber plantations of fast growing exotic species, through to attempting to recreate the original forest type and structure using native species[2]. In whatever form it takes, reforestation is a long term endeavour. For example, it has been estimated that full recovery of the composition and structure typical of a rainforest starting from cleared land or highly degraded forest, would take at least 50 years in the tropics and 100 years or more in extra-tropical zones (Hopkins, 1990; Mansourian et al., 2005a).

Reforestation projects typically progress through two main stages: an initial 'establishment' phase and a long term 'building' phase (Kanowski and Catterall, 2007). Reforestation success can therefore be viewed as a continuum from the successful establishment of the initial planting through to maturation and realization of the full range of environmental and socioeconomic benefits of the forest (Reay and Norton, 1999). This means that the measures of success will differ at different stages in a reforestation project. Undertaking assessments at an early stage of a project can only indicate likely future success (Reay and Norton, 1999). As the forest matures, more information is required to make judgements about environmental and socioeconomic success (King and Keeland, 1999; Reay and Norton, 1999).

5.2. Indicators of reforestation success

A number of qualitative and quantitative indicators have been either reported or proposed in the literature for the assessment of reforestation success. The most common indicators used to assess between forest establishment and maturity are described below.

Establishment indicators: Forest establishment is generally referred to as a 3-5 year period between when seed or seedlings are planted to when young trees have 'captured' the site, forming a relatively closed canopy suppressing weeds (Kanowski and Catterall, 2007). During the establishment phase of reforestation, the survival and growth of planted trees, and the degree of canopy closure are of particular importance. The most common indicators used for measuring establishment success are the survival rate of planted trees (%) and the area planted compared to the targeted area (%). These indicators are commonly measured within months of planting but might also be monitored intensively during the first three years of reforestation to account for the ability of young trees to persist in the face of weed competition, etc. Similar indicators can be used for assessing the success of naturally regenerated forests, though they may take longer than planted forests to reach canopy closure, depending on the species and site quality.

Forest growth indicators: Once established, trees grow, reproduce, and are harvested or eventually die. Kanowski and Catterall (2007) refer to this as the building phase of revegetation. During this time, the focus of success is on tree growth, stand density, stem form (in the case of timber trees), and the production of non-timber forest products (such as fruit and resins). The importance of each of these success measures will depend on local circumstances and objectives. Indicators commonly reported are tree growth performance (measured by tree basal area, height, stem form), area remaining intact or maintained in the long term, and actual production of timber, fruit, fuelwood, etc. (measured in amount/ha).

Environmental indicators: Restoring environmental values, ecosystem functions and ecosystem services is an important long term objective of most reforestation projects (Sala et al., 2000). In assessing the environmental performance of forests, previous studies have focused on three major ecosystem attributes: vegetation structure (Salinas and Guirado, 2002; Jones et al., 2004; Kanowski et al., 2008), species diversity (Peterson et al., 1998; Kanowski et al., 2008, 2009) and ecosystem functions (McKee and Faulkner, 2000; Davidson et al., 2004). Measures of vegetation structure provide information on

2 No distinction is made between the terms 'reforestation' and the broader 'forest restoration' here, and drivers or factors of success and indicators of success apply equally to both.

wildlife habitat suitability, ecosystem productivity, erosion resistance and the successional pathway of forests (Jones et al. 2004; Silver et al., 2004; Wang et al., 2004). Vegetation structure is usually determined by measuring vegetation cover (of trees, shrubs and ground cover) and woody plant density (Salinas and Guirado, 2002; Kruse and Groninger, 2003; Wilkins et al., 2003; Kanowski et al., 2008). These indicators are usually compared to reference sites to assess the relative structural quality of forests (Whisenant, 1999; Kentula, 2000; McCoy and Mushinsky, 2002). Measures of species diversity provide information on wildlife habitat suitability and ecosystem resilience (Nichols and Nichols, 2003). Diversity within the forest is usually measured by determining the abundance and richness of species within trophic levels (plants, herbivores, carnivores) or functional groups (trees, shrubs, saplings, herbs) (McLachlan and Bazely, 2003; Nichols and Nichols, 2003; Weiermans and Van Aarde, 2003; Benayas et al., 2009; Kanowski et al., 2009). The main ecosystem functions of forests include protection of soil from erosion, carbon sequestration, nutrient cycling and water conservation (Herrick, 2000; Herrick et al., 2006). Many authors report as essential to ecosystems the control of hydrology and nutrient cycling (Whisenant ,1999; Tongway, 2004), the capture of energy, the return of key fauna (Reive et al., 1992; Block et al., 2001), and the restoration of flows of matter, energy and information to the surrounding landscape (Bell et al., 1997; Huxel and Hastings, 1999). Surface soil stability, absence of erosion, soil organic matter and soil fertility levels are common measures used to assess the soil protection function of forests. Water quality and quantity are commonly used to assess water conservation, and biomass and soil carbon to measure carbon sequestration.

Socioeconomic indicators: For reforestation to be attractive to local communities, it needs to provide socioeconomic benefits. As a prerequisite for achieving long term reforestation success, people must receive benefits exceeding those from alternative land uses, otherwise reforested areas will continue to be cleared (Ramakrishnan et al., 1994). The socioeconomic benefits of reforestation do not necessarily have to be direct, and can include 'avoided negative impacts' (e.g. landslide prevention or preservation of timber reserves). The most common indicators used for measuring socioeconomic success of reforestation are local income, local employment opportunities, other livelihood opportunities, provision of food and fibre, stability of market prices of locally produced commodities, and local empowerment and capacity building.

5.3. Drivers of reforestation success

While indicators are required to measure reforestation success, they alone do not account for the circumstances that influence or contribute to the success (Hayword and Sparkes, 1990). The literature makes it clear that there are a wide range of influencing factors, and that success cannot be explained by a single factor (de Jong, 2008). Rather, success results from a number of biophysical, technical and socioeconomic drivers acting together (Sayer et al., 2004). In order to influence or predict the success of reforestation projects, an understanding the range of drivers is required. Many authors state the importance of socioeconomic drivers, often regarding them as more important than biophysical ones (Lamb, 1988; Walters, 1997; Crk et al., 2009). In a comprehensive study spanning six tropical countries, Chokkalingam et al. (2005) identified three requirements for sustaining reforestation efforts: (i) strengthening local organizations and their participation in projects, (ii) consideration of socioeconomic needs in choices and options, and (iii) ensuring clear and appropriate institutional support and arrangements. The same study also identified as essential elements, local knowledge of tree characteristics, planting of diverse species of ecological and economic importance, and integration of reforestation programs with regional development strategies. Using data from Chokkalingam et al. (2005), de Jong et al. (2006) identified 27 factors influencing reforestation outcomes and grouped them into six categories: (i) policies and legislation, (ii) players, actors and arrangements, (iii) funding, (iv) objectives of the reforestation, (v) technology, and (vi) extension, technical assistance and training. Le et al. (2011) attempted to group these commonly reported success drivers into four main categories:

technical and biophysical factors; socioeconomic factors; institutional, policy, and management factors; and characteristics of the reforestation project as detailed below.

5.3.1. Technical and biophysical

Technical and biophysical constraints to reforestation success commonly mentioned in the literature include site-species matching, site preparation, tree species selection, seedling production, seed and seedling quality, time of planting, technical capability of implementers, post-establishment silviculture, and site quality.

Species site matching: This is vital for the survival and growth of planted trees. Site-species matching is a prerequisite for promoting good stand growth and maintaining long term sustainability (Chokkalingam et al., 2006b). Poor site-species matching is the main technical problem leading to poor short term survival and growth of seedlings (Gilmour et al., 2000; de Jong et al., 2006; Chokkalingam et al., 2006a, 2006b; Nawir et al., 2007). However, site-species matching is often ignored in reforestation projects, with available species rather than the most suitable being planted (CIFOR Rehab Team, 2004).

Species selection: Tree species selected for reforestation can have a large influence on both the benefits derived from tree products and the ecological benefits of the forest (Montagnini, 2005). Selection of appropriate species to meet livelihood needs and that can generate additional income is key to long term sustainability of reforestation initiatives, because for farmers, reforestation means moving away from their current land use practices (CIFOR Rehab Team, 2004). Therefore, the success of any reforestation effort strongly depends on species that can fulfil the demands of local people and cope with site conditions and competing vegetation (Günter et al., 2009). Mixed plantations rather than traditional large scale monocultures could provide the goods and ecological services expected from reforestation. Mixed plantations could also contribute to diversity, while also providing production gains and reduced pest damage (Chokkalingam et al., 2006a). Multispecies plantations, especially those that incorporate those that attract birds (which act as seed dispersers), can result in improvements in floristic and wildlife diversity. Wild animals attracted by the mixed planted trees, can also disperse seeds of other tree species into planted areas. In addition, the cooler, more humid and weed-free conditions in mixed plantations created by planted trees favour seed germination and seedling establishment.

Site preparation: Species vary in their requirements for sunlight, soil moisture and nutrients to establish and grow successfully, regardless of whether they are commercially valuable species or valued for wildlife, recreation or visual beauty. Site preparation involves the suppression and removal of weeds, and sometimes cultivation and fertilization, to aid the successful establishment and growth of tree seedlings (Stringer, 2001). Site preparation can also involve the construction of fences to exclude grazing livestock. Poor site preparation has been an important contributor to low survival rates of planted trees and poor tree growth performance (Dagar et al. 2001; Stringer 2001; Zhang et al. 2002).

Seedling production: The availability of a nursery to produce seedlings is important, as well as having a good seedling preparation process. The growing of seedlings in a nursery is the main way of raising planting stock in the tropics (Evans and Turnbull, 2004). Tree nurseries can provide optimum care and attention to seedlings during their juvenile stage, resulting in the production of healthy, vigorous seedlings (Roshetko et al., 2010). However, these basic supporting facilities are often lacking in reforestation projects in developing countries. For example, Nawir et al. (2007) found that only 23% of reforestation projects in Indonesia had project nurseries and only 13% met the minimum standard for seedling production.

Seed and seedling quality: A high-quality seedling is free of disease, has a straight sturdy stem, a fibrous root system that is free from deformities, a balanced root to shoot ratio, is hardened to with-stand any adverse conditions of the planting site, with good carbohydrate reserve and nutrient content, and should be inoculated with symbiotic micro-organisms when necessary (Keys et al., 1996; Wightmann, 1999; Stape et al., 2001). Seedling quality is a combined function of genetic quality, and physical condition as it leaves the nursery (Ritchie, 1984; Wightmann, 1999; Jones, 2004). There are several reasons why it is important to use high quality seeds and seedlings in reforestation. First, the physiological quality of seeds and seedlings affects the success of establishment and subsequent growth rates (Ochsner et al., 2001). Second, for production-focused reforestation projects, genetic quality affects growth and the quality of marketable products, and therefore has significant economic consequences (Foster et al., 1995).

Time of planting: Planting at the right time is crucial because this directly affects seedling survival (Nawir et al., 2007). Typically the most appropriate time to plant tree seedlings is at the beginning or in the middle of the rainy season. However, many factors such as the late arrival of seedlings, or delayed release of project budgets can mean that seedlings are planted at an inappropriate time of year (e.g. at the end of rainy season or during the dry season).

Technical capability of implementers: This affects both the short and long term survival of planted areas, and also tree growth and the quality of tree products or services. For example Chokkalingam et al. (2006a) found that many NGOs in the Philippines felt that they had inadequate technical capability to manage reforestation projects. Therefore, effective and timely technical assistance and training is required to ensure reforestation success, particularly when projects are managed by NGOs (CIFOR Rehab Team, 2004).

Post-establishment silviculture: Silvicultural treatments applied at the establishment and early growth phase of forests are particularly important for reforestation success. For example, if not managed properly, weeds can cause failure through competition, an increased fire hazard, or by providing shelter for pest animals. Livestock grazing is also a common cause of reforestation failure in the tropics (Zhang et al., 2002) by killing or damaging seedlings and young trees. Thinning, pruning and fertilizing may also be important silvicultural treatments, especially where the production of good quality timber trees is a reforestation objective.

Site quality: Site quality is the sum of the climatic, geologic and edaphic factors that influence tree growth at a specific location by determining the availability of water and nutrients (Fox, 2002). Site index (SI), which is the height of dominant and codominant trees at a specific age, is the most common measure of site quality. Site quality also affects the species of trees that can be used for reforestation. Good quality sites tend to support the establishment of high value timber species.

5.3.2. Socioeconomical

Interest of local people: Social and economic factors are regularly reported in the literature as drivers of reforestation success. Dudley et al. (2005:6) observed that many restoration projects do not try to find out what local people really want. This is a particular problem in rural areas of developing countries because if reforestation projects do not meet community livelihood needs, then the planted trees will most likely be removed and the land either returned to agricultural production or left in a degraded state. Projects have often sought to encourage and sometimes impose tree planting without understanding why the trees disappeared in the first place, and without attempting to address the immediate or underlying causes of forest loss (Eckholm,1979). There has also often been a mismatch between social and ecological goals of conservation. Either reforestation has aimed to fulfil socioeconomic needs without reference to its wider ecological impact, or it has had a narrow conservation aim without taking into account people's needs (Dudley et al., 2005). The most important socioeconomic requirements for reforestation success appear to be enhanced livelihood planning, active participation and involvement of local people, payment for environmental services provided by forests, socioeconomic incentives, financial and economic viability, degree of dependency on traditional forest products, social equality, absence of corruption, marketing prospects, and addressing underlying causes of forest loss and degradation.

Livelihood planning: Livelihood-enhancing activities must be part of reforestation plans (de Jong et al., 2006; Chokkalingam et al., 2006a), and projects should address the needs of local people to ensure their participation and interest in sustaining the efforts. Reforestation projects have often deprived people of their original livelihoods (such as food production or the collection of non-timber forest products on land to be reforested), while not providing viable alternatives. Many cases were observed across the Philippines and Viet Nam where project beneficiaries subsequently burned the project area so that they could be re-employed in replanting (Chokkalingam et al., 2005). It is imperative to carry out a socioeconomic analysis of promising production systems and small scale trials before promoting them. Tree-based production systems that incorporate tree species with short harvesting cycles and good market prospects tend to be more widely adopted. Integrated production systems (e.g. agroforestry, livestock, and fish) can help increase food security and overcome market instability in forest products.

Local participation and involvement: Tree planting programs are most successful when local communities are involved and when people clearly perceive that to achieve success is in their own interest. Projects which worked best in Indonesia were tailored to meet the needs of local communities, with similar observations in South American case studies where a lesson learned from a survey of Peruvian restoration schemes being that project managers need to ensure active local participation from the planning phase onwards (CIFOR Rehab Team, 2006). Reforestation projects should ensure strong community and stakeholder participation in planning, management, implementation, and continuous monitoring. The most important impediment to community participation has been the half-hearted offers by reforestation projects to involve local communities in managing forests, which have caused unresolved problems and community disappointment (Nawir et al., 2007). Limited community participation can also be attributed to the unclear nature of economic incentives provided by projects, lack of consideration of social aspects in project design and implementation, and inadequate capacity building provided to community organizations (Nawir et al., 2007).

Socioeconomic incentives: Unless direct economic or indirect incentives (including environmental and social services resulting from the reforestation programs) are provided to local communities, their involvement is not likely to be sustained, and consequently the viability of reforestation programs will be reduced (Sayer et al., 2001). Chokkalingam et al. (2006a) found that in the Philippines, the long term maintenance of plantations was positively related to planned socioeconomic incentives.

Economic and financial viability: Economic viability is determined from the perspective of the community or society as a whole. A comprehensive economic analysis would place a value on non-financial benefits such as environmental services and employment, and is more indicative of investment viability. However, financial viability would be the appropriate metric for reforestation projects that are undertaken for private benefits (i.e. a commercial timber production). Reforestation to restore degraded lands to reduce sediment flow into rivers, improve biodiversity etc., would seldom be financially viable but may be economically viable when non-financial benefits are considered. In many cases, funding for reforestation projects is provided by aid organizations because they are not financially viable. Communities also want reforestation to improve water quality and for other environmental benefits. In cases where non-financial benefits are important, the key is that reforestation does not impose a financial burden on the community, and ideally produces financial benefits. At the operational level, Chokkalingam et al. (2006a) found that the most common financial problems with reforestation projects in the Philippines were limited or poor access to funding, as well as delayed funding releases from the government. Projects with more financial support tended to be better maintained and protected. The timely releases of funds for reforestation projects is crucial because planting has to be carried during the few wet months of the year, otherwise the risk of seedling mortality increases. Furthermore, reforestation is a long term process and requires funding over many years, ideally until income is generated from the planted forests. All too often however, overreliance on grants means that funds can only be obtained for short term projects. Chokkalingam et al. (2006a) suggested that it is better not to rely totally on short term government or foreign aid funding, although this is good as start-up money for site development and social organizing. Projects should have long term income generation and reinvestment plans from forest products or from livelihood schemes (Chokkalingam et al., 2006a).

Payment for ecosystem services (PES) schemes: Due to the dramatic loss in forest cover worldwide and the consequent loss in forest goods and services, there is much potential for carbon sequestration, watershed protection and biodiversity conservation. Reforestation is expensive, particularly in the initial stages, and payments for the supply of environmental services may be especially important for improving the financial viability of reforestation (Pagiola et al. 2002; Rietbergen-McCracken et al. 2007).

Social equity: For reforestation projects to be successful, market and non-market costs and benefits need to be shared by all stakeholders. The inadequate assessment and sharing of costs and benefits can result in community conflict and further deforestation (ITTO, 2002). Local communities are entitled to share in both the market and non-market benefits arising from reforestation activities on their land, and equally, they are entitled to compensation for any third-party reforestation activities that negatively affect them.

Degree of dependency on traditional forest products: Forest dependency stimulates people's participation in forest management. A higher level of forest dependence means that communities have a higher stake in the forest, which is reflected in their level of participation (Lise, 2000). Reforestation is more likely to be successful if reforestation projects supply valued forest goods (such as medicinal plants) that cannot be obtained from elsewhere (Rietbergen-McCracken et al., 2007).

Marketing prospects: The marketing success of forest products is influenced by the species planted, project location and the ability of the project to ensure a continual supply of forest products to customers (Harrison et al., 2004). In the Philippines, marketing of forest products is typically not included in government reforestation projects (Snelder and Lasco, 2008). It seems that insufficient consideration is often given to final products because harvest, which is generally more than 10 years from the time of planting, is generally outside the typical funding horizon of 3-5 years. Both household demand and prevailing market conditions for timber and non-timber forest products influence the success of reforestation projects. For example, implementing a reforestation project in an area that has low excess demand for forest products may lead to oversupply, driving forest product prices down and undermining the economic viability (Dewees and Saxena, 1997). However, supply in excess of local demand creates the opportunity for new livelihood opportunities based around excess timber (e.g. value adding activities such as sawmilling, furniture making and production of biofuels). However, little information is available on the size and stability of markets for timber and non-timber forest products in rural regions of developing countries. When good markets exist for products such as poles, firewood and fruit, farmers have an incentive to plant trees (Amacher et al., 1993; Dewees, 1995; Scherr, 1995; Mercer and Pattanayak, 2003). Where areas being rehabilitated are isolated from markets, harvested products should be of sufficient value to permit long distance transport (Lamb and Tomlinson, 1994), or alternatively, local processing needs to occur. Knowledge of markets for timber and other forest products and services is important to the success of reforestation. A known market (and especially an improving market) for forest goods and services will lead to greater incentives among local communities to plant trees, especially if no supplies from natural forests are available (Rietbergen-McCracken et al., 2007.

Addressing underlying causes of forest loss and degradation: Sites targeted for reforestation in the tropics are usually under pressure from logging, fuelwood collection, grazing and shifting cultivation. It is therefore important to address these causes of forest loss and degradation to ensure reforestation success (Nawir et al., 2007). For example, alternative fuel source can be a solution to reducing pressure on regrowing forests (Chokkalingam et al., 2006b).

5.3.3. Institutional, policy and management

Commonly reported policy and management success drivers reported in the literature include strong and appropriate institutional support, effective forest governance, a stable policy environment and strong support for forest production, secure land tenure and equitable land tenure systems, clear conflict resolution mechanisms, clear distribution of rights and responsibilities amongst stakeholders, long term management planning, long term maintenance and protection of reforested sites, forestry support programs, presence of community organizers and people's organizations, strong local leadership to enforce collective rules, and the risk involved.

Endowment or scarcity of forest resources: Lele et al (2000) found contrasting policy situations between forest-rich and forest-poor countries. Forest-rich countries (such as Brazil, Cameroon and Indonesia) seek to exploit their forests for development purposes, as well as for the benefit of powerful interest groups, resulting in high deforestation rates. In contrast, some forest-poor countries (such as China, Costa Rica and India) attempt to pursue forest conservation goals, and many have incorporated forest concerns into overall development planning to alleviate poverty while minimizing the loss of forest cover and biodiversity. Regional differences in forest resource endowment in a country demonstrate similar response behaviour. Lele et al. (2000) concluded that forest scarcities result in conservation-oriented policies in forest-poor countries and regions. This highlights the role of tree scarcity in influencing the development of policies that conserve forests and support reforestation.

Institutional arrangements: Forestry legislation, a forestry code, and non-formal taboos that affect how people use forest resources are all examples of institutional arrangements within the forestry sector. Strong and appropriate institutional support is critical for promoting investment and local participation and ensuring their sustainability (Chokkalingam et al., 2005). This includes clear and undisputed land tenure, a facilitating legal framework and policies, and coordination among agencies at various levels. Also important are formalized institutional arrangements with clear division of tasks, rights and responsibilities, equitable distribution of costs and benefits among multiple stakeholders, and a clear conflict resolution mechanism (Nawir et al., 2007). These arrangements help to avoid conflicts, support coordinated project management and fulfilment of assigned tasks, and ensure agreed-upon benefit flows to stakeholders and their stake in the long term success of the project. Enforcement of agreements is an important part of such institutional arrangements.

Effective governance: Governance denotes "the process of decision-making and the process by which decisions are implemented (or not implemented)" (UNESCAP, 2009). National governments make decisions and implement these through the administration of state resources and use of market mechanisms. Governance also involves working with other governments and with the private sector, including community organizations. Major characteristics of good governance are the rule of law, responsiveness, transparency, effectiveness and efficiency, consensus orientation, participation, equity and inclusiveness, and accountability (Dudley and Aldrich, 2006). Reforestation can only succeed if forest governance is effective (ITTO, 2002), and it is much easier to be successful in conditions where there is good governance and a lack of corruption (Dudley and Aldrich, 2006). Effective governance is a prerequisite to promote sustainable management and use of forests, and to prevent further degradation and inappropriate conversion to other land uses. This requires national policies and legal measures, appropriate economic governance and incentives, and appropriate institutional frameworks to support reforestation and associated livelihood projects.

Consistency in forest harvesting and other policies: These are required for management and harvesting in forests, with various types of legal status, tenure and institutional arrangements (such as watersheds, protected areas and community-based forestry management areas). Unstable policy environments and weak support for forest production will affect the long term sustainable management of reforestation projects, especially by communities and the private sector (FMB-FAO, 2003). In the Philippines for example, a Presidential Decree banned timber harvesting in critical watersheds containing infrastructure such as hydroelectric plants and irrigation systems, whilst at the same time a Letter of Intent allowed timber harvesting within these same areas (Chokkalingam et al. (2006a). This made it difficult for reforestation projects to obtain permits to harvest in critical sites despite timber marketing being approved in their initial reforestation and area development plans.

Tenure security: Unless rights and responsibilities of tenure are clearly defined and understood by all participants, reforestation is not likely to succeed (Ramakrishnan et al. 1994). Secure land tenure and land user access are fundamental to reforestation success (ITTO 2002). Tenure security over both land and its resources will go a long way towards ensuring long term management interest and investment of effort by farmers and communities (Chokkalingam et al. 2006a). Land users are only likely to participate in reforestation if they or their families will benefit (Fortmann and Bruce 1988; Rietbergen-McCracken et al. 2007), and this is unlikely if they have insecure tenure. Reforestation that results in reduced access to land that is currently available will be unattractive unless some form of compensation is available (Rietbergen-McCracken et al. 2007). Clear land tenure enables sustainable management and use of rehabilitated forests and prevents further degradation and inappropriate conversion to other land uses. In many cases, degraded forests have overlapping tenure claims involving the state, private sector and local communities. As a result, conflicts over access rights are common, often resulting in unsustainable use and further degradation. Clear land tenure means less conflict over land, higher community commitment to maintain planted trees, and is an assurance to community members that they will be able to harvest the trees that they have planted on their land (Sellers, 1988; Pasicolan et al., 1997; Zhang and Pearse, 1997; Treue, 2001; Herbohn et al., 2005).

Long term management planning and maintenance: Proper care and maintenance of reforestation sites is needed until forests are self-maintaining (if planted for conservation purposes) or reach a harvestable age if trees are planted for commercial purposes. The main causes of reforestation failure, other than inappropriate technologies, are uncontrolled grazing and fires, competition from weeds, and uncontrolled cutting for fuel, fodder, poles and timber. Therefore, continued management and protection are important factors for maintaining planted areas in the long term (Chokkalingam et al., 2006a). Long term management planning has been a relatively neglected aspect of reforestation activities however, especially after funding for a reforestation project has ended. Chokkalingam et al. (2006a) found that inadequate long term planning caused forest conversion to other land uses and forest fires in the Philippines, and having a management plan was positively correlated with the long term maintenance and protection of reforestation projects.

Forestry support programs: The availability of forestry and agroforestry extension services and the dissemination of forest management information are essential for improving reforestation success. The frequency with which farmers have contact with extension agents is important in the acquisition of skills and knowledge (Salam et al., 2000; Adesina and Chianu, 2002). Hence, the efficiency of forestry and agroforestry extension services and dissemination of information is essential in improving farmers' forest management capability. Technical assistance and training are key incentives for adopting community-based forest management (Borlagdan et al., 2001). In the Philippines, extended extension assistance was crucial in determining the likely survival and growth of trees (Baynes et al., 2011). Extended extension assistance was also important for eliminating unsuitable sites and the use of poor forest establishment practices. Where extension support was not available, farmers displayed a poor knowledge of the principles of tree growth. Besides providing extension services, government and non-government agencies can play a critical role in providing marketing support for timber and other products produced by farmers, communities and the private sector to sustain investment in reforestation. Suggested means to improve marketing include community-based market information systems, selecting species based on markets, incentives to processing firms to obtain wood from reforested areas, forming marketing associations, improving roads and transport, and certification (Austria 1995; Hartanto et al., 2002; Calderon and Nawir, 2006).

Presence of community organizers and people's organizations: Community organizing is a major activity that enables active community participation in forest development and protection (Estoria et al., 2004; Chokkalingam et al., 2005). Community organizers are employed to help establish and maintain such organizations and are critical in assisting them to comply with their forestry contracts. The role of community organizers includes facilitating the formation of organizations and providing advice about the preparation of plans and applications for permits required to establish and harvest planted areas. Community organizers also help to build the capacity of communities to establish sustainable enterprises and livelihood projects designed to provide participants with income (Emtage, 2004), and to grow trees and protect forests for the future (Estoria et al., 2004). Estoria et al. (2004) found that community organizers were a major influential factor in the success of reforestation activities in the Philippines. Conversely, the lack of attention given to community organizing has been identified as a factor hindering reforestation success. A well-organized group has a greater probability of succeeding, particularly during the phases of product harvesting, processing and commercialization. Numerous positive and negative cases exemplifying this exist across the Peruvian and Brazilian Amazon, the Philippines and Indonesia (Chokkalingam et al., 2005). Strong people's organizations also attract support from international NGOs for livelihood programs (Chokkalingam et al., 2005).

Community leadership: Strong leadership is an important requirement for reforestation success. FAO (1993) found that strong village leadership was instrumental in getting reforestation started in Peru. Unilateral decision making by leaders was however, usually not sufficient to reduce underlying resistance from the community at large. In some cases, it may have exacerbated opposition to reforestation. Furthermore, the concentration of power and knowledge of legal procedures in the hands of a few sometimes appeared to encourage abuse and even corruption. This, in turn, increased opposition to further reforestation (FAO, 1993).

Risk involved: Low cost reforestation such as promoting natural regeneration is likely to be less risky to farmers than higher cost methods such as plantation establishment. This is because where the costs of forest establishment are high, farmers risk losing more if their trees are destroyed by adverse weather events or if the market prices for forest products falls significantly. Similarly, fast growing species are usually more attractive than slow growing species, because financial returns occur sooner and risks caused by adverse weather events are reduced due to shorter rotations. Financial incentives or subsidies such as low interest rate loans can reduce risks to local people involved in reforestation projects and improve participation (Rietbergen-McCracken et al., 2007).

5.3.4. Unique characteristics of reforestation

Besides the biophysical, technical, socioeconomic, institutional and political environment surrounding reforestation projects, characteristics of the projects themselves have been found to influence success (Belassi and Tukel, 1996). These include project objectives and goals, size, location, funding, project implementer, and project life cycle.

Reforestation experiences from the Philippines showed that projects with economic production objectives provided strong incentives for long term management, while pure conservation projects had little chance of success (Chokkalingam et al., 2006a). This suggests that producing timber is important for ensuring the long term sustainability of reforestation projects by meeting industrial and household demand for forest products, generating income for impoverished communities, and providing environmental services in the process (Chokkalingam et al., 2006a). It is important not to consider reforestation in isolation from other conservation and development projects, but rather as an integral part of joint efforts to achieve sustainable ecosystems and landscapes. This implies better integration of reforestation projects with other plans and development projects, such as protected area selection, species conservation, water conservation and climate change mitigation.

Project location and accessibility of sites: The distance between a field and the farmer's house is negatively related to tree growing. Trees are preferably grown close to the house where farmers can more easily inspect them and prevent damage or losses by fire, animals and theft (Schuren and Snelder, 2008). Nawir et al. (2007) suggested reforestation success is higher on land close to human settlements as opposed to remote areas because the former is highly accessible, enabling continuous monitoring. Degraded sites that are difficult to access will be expensive to reforest and it may be too costly to do anything about such sites apart from using low cost assisted natural regeneration (Rietbergen-McCracken et al., 2007).

Project implementers: The type of organization or actors implementing a reforestation project can have a large influence on success. Whether reforestation occurs on public or private land can strongly influence the reforestation objectives, the size of reforestation projects, and the relative importance of success drivers. Most projects undertaken on public land are larger projects which have community livelihood and environmental benefits as key objectives, and therefore success is dependent on community support and external funding. However, a substantial area of reforestation in the tropics is implemented by farmers on private smallholdings of less than five hectares. In 2001 for example, farm forestry accounted for 43% of the total forest plantation area in Indonesia, with 3.43 million households involved in managing 4.2 million hectares (FAO, 2001). In Viet Nam, 80,000 hectares have been reforested annually through farm forestry since 1998 (FAO, 2006a). On a global scale, small scale farm forestry plantations (50 million hectares) nearly matched the area planted by state forestry agencies (77.3 million hectares), and are almost double the area of plantations established by corporate groups (27.2 million hectares) (FAO, 2006b). Trees are often planted by farmers on private land for financial benefit, and this represents a conscious investment for which other options have been forfeited. Such plantations are generally restricted to the number of trees that can be maintained and the available land, labour and other resources allocated according to the farmer's objectives. Smallholder tree plantations generally benefit from intensive management over small areas and vested self-interest (Roshetko et al., 2008). However, not all smallholder tree plantations are successful. Experience from the Philippines indicated that where smallholders do not have access to good quality seedlings and lack the basic knowledge of site-species matching and silvicultural techniques, they perform poorly or fail (Baynes et al., 2011).

Project funding: Most externally funded reforestation projects are not commercial ventures and are planted for environmental and local community benefits. These projects are reliant on government and NGO funding rather than private investment. Access to government funding and the longevity of the funding can therefore be important drivers of project success. For projects that are not externally funded, such as plantations on smallholder farms, the availability of funding is also important to support extension and education services that influence the plantation management and their eventual success.

6. Successful reforestation experiences

Terraces of a Teff field, Ethiopia. Photo by ©Bernd - stock.adobe.com

There are positive experiences in reforestation and ecological restoration from around the world. Most developed countries lost most of their original native vegetation and woodlands in the past. However, USA, Canada, Australia and European countries, at some point in their history, have made critical policy and investment measures to restore their declining forest resources. An example of a model for large scale reforestation experience comes from South Korea, which suffered significant loss of its native forests in the 1950s due to the wars. But by making reforestation top national priority (Lamb and Gilmour, 2003), major achievements have been recorded. South Korea's forest cover increased from approximately 3.5 million hectares in the mid-1950s to 6.5 million hectares in about 40 years. Due to the reforestation measures taken, South Korean people are proud of increasing the forest cover from 35% to 64% of its territory, while the country's population doubled and the economy grew 300-fold (Bae et al., 2012; Buckingham and Hanson, 2015). There are also exemplary reforestation success stories from developing countries in Asia and Africa. Experiences and lessons from Nepal, Kenya, Tanzania and South Korea are presented in this chapter, with a special focus on Nepal.

6.1. Nepal

6.1.1. Community forestry initiatives and cases in Nepal[3]

Nepal is a good example of forest landscape restoration achieved by sustained support for community forestry with much progress in its spread and contribution to restoration efforts in the past 40 years. According to satellite data, despite a high population growth rate of 2.3% annually from 1990 to 2010, forest area has been restored at a rate of about 2% per year (Niraula et al., 2013). In a national forest inventory carried out in the early 1990s (FAO, 2007), forests and shrubs covered approximately 5.83 million hectares – about 40% of the nation's land area. From this, community forestry alone occupies nearly 23% of total national forest area (over 1.2 million hectares), supporting more than 1.6 million households throughout the country (MSFC, 2012a).

As early as 1975, forest loss was recognized as accelerating soil erosion, contributing to landslides, flooding, and increasing runoff and sediment transfer onto the plains (Pandit and Bevilacqua, 2011). Population growth, agricultural expansion and demand for wood products and fuelwood caused large scale deforestation of Nepal's forests from the1950s to 1990s (LFP, 2013). Between 1978 and 1994, forest area decreased by 1.7% per annum (FAO, 2010). Already in the 1970s, landscapes were severely degraded and the government of Nepal began watershed conservation. In the transformation process, who later took the move of including people's participation into the efforts, leading to a new approach – community forestry – emerged in the late 1970s. The aim was to motivate and engage the rural population in protecting, utilizing, rehabilitating and managing forests (Taylor, 1993). Initiated by the government in the 1970s with help from donors, policy changes decentralized forest management by shifting responsibility from the central to local governments, and Nepal's community forestry program now manages around a quarter of the country's forest resources. The Forest Act 1993 allowed for the formation of autonomous groups, resulting ultimately in the formation of some 18,000 community forest user groups (CFUGs), among others (Rutt and Lund, 2014). The program bestows rights of access, use, exclusion, and management of national forestland to local user groups (Thoms, 2008a).

The key feature of this decentralized forest management and restoration approach is empowering local people to make decisions about forest management and restoration the benefit them. The establishment of community forest user groups as independent, autonomous and self-governing institutions allowed for clear leadership and responsibility for sustainable land use and management at the local level. Community forest user groups were largely inclusive, with more equal representation of men and women (33% of leadership positions were reserved for women) (www.ndc-cluster.net/gpd/community-forest-restoration-nepal). Development of a Federation of Community Forest User Groups supported policy reform, advocated for community groups and organized training among peers. International and NGO partnerships provided long term financial support and technical assistance for restoration planning and implementation, and coordination among these partners facilitated positive outcomes.

Nepal's experience demonstrates the relevance of community forestry as a proven approach for forest landscape restoration in some contexts, with a number of notable environmental, economic and social benefits. From an environmental perspective, forests managed by communities have experienced fewer forest fires and less illegal felling. Across Swiss-funded sites, the number of trees increased from 1,648 per hectare in 1994 to 2,126 per hectare in 2008, a 29% increase (SADC, 2009). Increased availability of grass and fodder from community forests encouraged the practice of stallfeeding, reducing

3 The Nepalese Community Forestry Initiative experience (sections 6.1.1 and 6.1.2) is based on WRI's case study report: The Restoration Diagnostic – Case Example – Nepal community forestry (https://files.wri.org/s3fs-public/WRI_Restoration_Diagnostic_Case_Example_Nepal.pdf). Note that the references listed in the WRI report are included in the References section of this review for further reading.

grazing pressure and saving cattle herding time. In addition, the number of freshwater springs and the volume of water increased. Soil nutrition and moisture conditions in agricultural land during the dry season have also improved (Pokharel et al., 2005).

Economically, the revenue generated by community forest groups is US$12.4 million per year, which is greater than the total budget of the Department of Forests, and greater than the revenue the department generates from the rest of Nepal's forests (SADC, 2009). This approach has also impacted on democratization and social equity. Community forestry in Nepal supports inclusive democracy by aiming for more equal representation of women and men in groups. Community forest user groups also provide land to poor families and scholarships for children from disadvantaged families. Moreover, the improvements in forest conditions have had a significant impact on the time management of rural women and girls who now require less time to collect firewood, fodder and other resources because of their greater availability. This in turn leaves more time for other activities such as attending school and childcare (SADC, 2009).

The Nepalese experience can be demonstrated by examples in certain landscapes and approaches. A typical success story comes from Phewa Lake region where villages dot the landscape among fields of tea and coffee. Some 500,000 tourists visit this area in Nepal just south of Pokhara annually, using it as a base to conquer the nearby 2,508 m peak of Panchase, as a gateway to the Annapurna Circuit, or simply as a place of quiet contemplation. The Phewa Lake region is wasn't always this way. Some 40 years ago, the emerald hillsides - steep, with average slopes of 40% - were barren and eroded, and the midnight-blue waters of the lake were laden with sediment. Nearby fields and villages were prone to flash floods and mudslides. But after restoration efforts over four decades, trees and shrubs now blanket the ridges and run down to the water, and beyond,

The restoration process in Phewa did not come without challenges, however. Some arose in the communities themselves, stemming especially from the divide between those who lived upstream and downstream. While those who lived downstream benefitted directly from the sources of water, communities who lived upstream were largely responsible for the health of water sources and often received limited economic benefits for their efforts. In Phewa, those who lived by the lake enjoyed a booming tourism economy, while those who lived higher up by the tributaries were far removed from this source of income. Then a scheme was planned that fairly and equitably shared the costs and benefits to both sets of communities. At first, downstream people were only interested in their businesses during early discussions held with communities involved. There was conflict because they blamed upstream communities for clearing forests. But after a series of meeting, downstream communities understood that upstream communities had a different economy. It took time to resolve, but eventually, downstream communities showed interest in supporting upstream communities with 'payment for environmental services'. With time, neighbourly awareness grew, with an understanding of how they depend on one another and the benefits each deserves, which is crucial to watershed management.

Another instance from Nepal that demonstrates how interest of people can become a driver for change is in Badase village in the Middle Hills, northeast of Kathmandu. Three indigenous forest management systems were identified during an investigation of local responses to forest loss and degradation (Gilmour and Fisher, 1991). One of these systems related to two patches of natural forest covering the slopes on both sides of a valley, managed by a local committee from 1981 to 1986. Although the user groups for the two forests were not exactly the same, there was considerable overlap and the same committee managed both forests. The land was legally under the management control of the Forest Department, but the local community had exercised de facto management control for several decades as common property resources. Local informants indicated that a shortage of forest products in the early 1980s led them to hire a local forest guard, paying for the service with proceeds of a collection of one or two rupees from each user household. A committee was formed to manage the forests. Thus, this local system had two formal organizational elements: a local forest guard and a management committee, and that allowed a degraded forest to regenerate by protecting it.

Management practices were clearly developed with this objective in mind. The main silviculture elements were that users could collect dry branches, grass and fodder, with approval from the village leader (who was a member of the user group) to cut trees for timber. Cutting grass was not permitted in the monsoon period since this is the crucial period for regeneration of grasses and tree seedlings, and children were not allowed to cut grass at any time, because children were considered as inexperienced and might cut tree seedlings as well as grass. Rules were simple, and provided a sound formula for allowing the degraded forest to regenerate. They allowed a type and intensity of utilization that would not interfere with regeneration. The existence of healthy broadleaved forests on both slopes of the valley, replacing what was once low shrubland, attests to the effectiveness of these controls.

A further example is assisted natural regeneration for conservation and development. This is a simple, low cost forest restoration method that can effectively convert deforested land and degraded vegetation into more productive forests. The method aims to accelerate rather than replace natural successional processes by removing or reducing barriers to natural forest regeneration, such as soil degradation, competition with weeds, and recurring disturbances (e.g. fire, grazing and wood harvesting). Compared to conventional reforestation involving planting of tree seedlings, is assisted natural regeneration offers significant cost advantages because it reduces or eliminates the costs associated with propagating, raising and planting seedlings. It is most effectively utilized at the landscape level in restoring the protective functions of forests such as watershed protection and soil conservation, and is most suitable for restoring areas where some level of natural succession is in progress. Techniques are flexible and allow for the integration of various values such as timber production, biodiversity recovery, and cultivation of crops, fruit trees, and non-timber forest products in the restored forest.

One of the most successful plantation species in the middle hills of Nepal is the indigenous chir pine (*Pinus roxburghii*). It is a hardy pioneer species that occurs naturally at elevations of around 1,300 m. Many sites with potential for restoration are heavily grazed eroding grasslands with shallow stony soils, and chir pine is one of the few species that can survive and grow on these sites. It is also easy to handle in low technology nurseries, making it well suited for small village nurseries. Attempts to grow more desirable broadleaved species in large scale plantations on such sites have largely failed (Gilmour and Fisher, 1991). This is particularly the case in drier locations, although some success has been achieved in some moister areas with species such as utis (Alnus nepalensis). If a plantation area is protected from grazing, a range of tree and shrub species often invades soon after establishment, particularly on moister north facing sites. Invading species dramatically increase the biodiversity and add to the productive potential for village forest users. Chir pine acts as a pioneer species, returning the site to forest which can then be manipulated silviculturally to provide goods and services that people need.

Three waves of regeneration followed planting with chir pine (Gilmour et al., 1990). The first developed as coppice from stumps which were remnants of the original forest. Protection from regular cutting and grazing which accompanied planting allowed coppice shoots to survive, and these became an early component of the stand along with the pines. Most coppice shoots were of Schima wallichii, a widespread broadleaved tree which produces high value firewood, construction material and leaves for animal bedding. The second wave consisted of seedling regeneration which germinated about five years after plantation establishment. As in the first wave, the dominant species was Schima wallichii, with small seeds spread by birds.

Although plantations would not have had a closed canopy after five years, the site had improved enough to provide a suitable habitat for Schima. A dramatic change in species composition then began after about 12 years when the canopy closed. The third wave of regeneration occurred at this time, and included a large number of useful fuel and fodder species, the most notable being Litsea polyantha, which is highly valued for its leaf fodder. It regenerated at high densities and 14 years after planting the density was about 1,600 trees per hectare. Other valuable species which appeared at the same time included *Fraxinus floribunda, Cedrela toona, Castanopsis indica, Prunus cerasoides* and *Michelia champaca*. Future silvicultural practices, as well as the actions of forest users, will determine whether these valuable species become dominant components of the stand. This story of assisted natural regeration demonstrates that for some difficult sites, hardy trees could be planted at the beginning as nurse species for the regenerating native species. The main lesson is that restoration can often start with low technology and low cost options, relying on natural ecological process to provide added biological diversity over time, with social controls over cutting and grazing being essential to obtain a diverse species mix.

Nepal's community forestry activities have resulted in the restoration of 1.2 million hectares of forests, the formation of 18,000 community user groups, who now generate an annual US$12.4 million in income from these forests, with fewer forest fires and illegal felling as a result of community involvement, a reduction in downstream flooding, and increased supply of fuelwood.

6.1.2. Success factors for Nepalese restoration

Several countries may take the successful Nepalese restoration story as a benchmark for adoption in their restoration efforts. As such, this subsection is devoted to describe the factors that have led to this transformation of the country's landscapes and rural livelihoods. Several factors are responsible for the successful outcomes of community forestry initiatives, categorized as motivational, enabling and implementation. Motivational factors include crisis, awareness and expectations for benefits.

Crisis events: These were leveraged as a motivating factor for forest landscape restoration in Nepal. From 1950 to 1980, about half a million hectares of forests were cleared in Nepal (Pokharel et al., 2005). In the late 1970s, serious flooding downstream in Bangladesh focused the Nepalese government's attention on the rapid depletion and degradation of forest resources in upstream Nepal. The disaster in Bangladesh highlighted the risk of erosion, landslides, sedimentation and localized flooding (SADC, 2009).

Awareness: The benefits of restoration were adequately communicated. For example, the Livelihoods and Forestry Program (LFP) included some 12,000 community forest user group members in awareness raising campaigns, focusing on forestry, and more recently on climate change. LFP developed guidelines, training materials and tools, and demonstration plots for active forest management. They addressed issues such as natural resource governance, poverty and inequity which raised awareness and stimulated participation in restoration activities (LFP, 2013).

Benefits: Governments and people in the region started to pursue forest landscape restoration with the expectation that it would yield economic, social and environmental benefits. Benefits included the reduction in downstream flooding and increased supply of fuelwood (Gautam et al., 2002).

There are also several enabling conditions that occurred to facilitate restoration in Nepal that include ecological, policy and social conditions.

Ecological conditions: Soil and water (rainfall) availability in Nepal are conducive to the rapid growth of planted trees and to the regeneration of managed forests. Where source populations did not exist, nurseries were established, with for example, financial and technical support from Australia between 1966 and 2006. Initially, restoration efforts concentrated on plantations of exotic tree species. Non-native Pinus roxburghii and Pinus patula were the focus for international aid agencies, although technical designs were later modified to stress the importance of better forest management and to include different native species (Gautam et al., 2002).

Policy conditions: Over several decades, the government of Nepal created policy conditions conducive to restoration through the establishment of a supportive policy framework for community forestry. In 1956, all forests were nationalized for "their protection, conservation and sustainable management through enactment of the Forest Nationalization Act, 1957" (FAO, 1999). Combined with weaknesses in the capacity of the government to protect and manage forests, this nationalization laid the grounds for a period of high rates of deforestation and forest degradation. The government moved toward the adoption of decentralized community forestry in 1978 by enacting legislation that allowed the transfer of forest management responsibility from the government to local panchayats (the smallest political and administrative unit), as panchayat forest and panchayat protected forest (Pokharel, 2012). However, this was not formalized until the Master Plan for the Forestry Sector in 1988. In 1989, this plan identified 3.5 million hectares of Nepal's forest area (61% of forests) as suitable for community forest user groups (MFSC, 1989). In the 1990s, there was the emergence of democratic government and an active civil society which created new dynamics for forest management and use at the local level. These new dynamics were reflected in the Forest Bill of 1992, with the renaming of the panchayat forests and panchayat protected forests to community plantations and community forests, respectively (Taylor, 1993). The Forest Act of 1993 legitimized community forest user groups as independent, autonomous and self-governing institutions responsible for protecting, managing and using demarcated areas of national forest. Similarly, Forest Regulations and Community Forestry Operational Guidelines were prepared in 1995 to facilitate the smooth implementation of the community forestry program (Ojha et al., 2014).

Social conditions: Local people were empowered to make decisions and were able to benefit from improved forest management and forest restoration. In response to rapid deforestation in the late 1970s, the government initiated a community forestry program that encouraged people's participation in the protection, management, and utilization of forests, with community forest user groups forming the foundation (Uprety, 2006).

Institutional conditions: Roles and responsibilities for restoration are somewhat defined, particularly those of community forest user groups . Shortly after the formation of the guidelines for these groups, the national Federation of Community Forestry Users, Nepal (FECOFUN) was founded. FECOFUN emerged since 1996 as one of the nation's most powerful civil society organizations, representing and advocating for thousands of groups throughout the country and as a prominent actor in policy making processes (Timsina, 2003).

Market conditions: Value chains for products from restored landscapes were established, including for fuelwood, fodder, construction materials, composting materials, supplementary food, and raw materials for direct sale or processing (SADC and DFID, 2012). In Nepal, household energy and forestry are closely linked, with more than 80% of the country's energy derived from fuelwood which is used mostly at the household level (Thoms, 2008). While there are markets in some areas, in the foothills of the Himalayas many community forests are managed by community forest user groups for domestic use. The forests they manage are generally used to meet basic needs such as fuelwood and leaf litter for mulch, fodder, and bedding. Some construction materials can be sold, but most ban tree cutting unless approved and used for local needs.

The implementation capacity and resources also emerged as critical factors in Nepal's restoration success. Leadership, technical design and knowledge and financial incentives played key roles.

Leadership: Leadership existed at both national and local levels to drive restoration, and FECOFUN provided a pioneering platform for local leadership to arise to support community-based forest protection and management. The main objective of FECOFUN is to raise the awareness of community rights of access and the importance of devolution of forest management responsibilities to communities (Timsina, 2003). Apart from FECOFUN leadership, sustained commitment to restoration existed from donors and NGOs through continuation in funding. Good donor coordination reduced duplication, as each donor project focused on different districts. Donors also made long term commitments to Nepalese forest restoration, with partnerships lasting as long as 40 years.

Knowledge: Restoration 'know-how' relevant to the landscape existed and was transferred via peers through community group training (awareness), demonstrated through the accumulated experience in restoration from FECOFUN, NGOs, and donor coordination.

Technical design: Restoration was technically grounded. Early emphasis was on classical aspects of forestry – nurseries, seedlings and tree planting – before tree planting was questioned as a solution. The key to restoration in Nepal was better management, not just tree planting alone, so the restoration approach was modified to include agroforestry and the use of multiple species other than pines (Taylor, 1993). Different projects focused on various priorities. For example, Swiss-funded projects established methods for afforestation, infrastructure development, and promotion of community forestry through training, forest demarcation and seedling distribution (SADC, 2009). Others such as The Western Terai Landscape Complex Project (WTLCP) focused on connecting fragmented forest patches and demarcating boundaries for wildlife grazing. The WTLCP project planted 747 hectares of corridors and buffer zones and constructed a 20 km trench with biofencing, safeguarding 675 hectares of community forest from grazing and encroachment (WTLCP, 2010).

Finance and incentives: Funds were accessible to create incentives for restoration. In 1984, the Nepalese government and major development assistance agencies met to review ongoing and planned programs, such as the Comprehensive Forestry Sector Master Plan. The Asian Development Bank took the lead in preparing the proposal and finding funding. The master plan was developed into six 'primary development' programs and six supportive development programs which were instrumental in revolutionizing forestry in the country (Taylor, 1993). Donor support was instrumental in driving government support for community forestry and FECOFUN schemes (Timsina, 2003). Australian funding supported two districts with US$40 million over 40 years (1966-2006) (AusAID, 2006). Funding from Switzerland supported three districts with investment of over US$2.2 million over 20 years (1989-2011) (SADC, 2009). DFID (UK) supported 15 districts with US$43.67 million over 10 years (2001-2011), creating 2.8 million person-days of employment a year within project areas, leading to an annual income in the forestry sector of US$4.3 million (LFP, 2013). WTLCP had an investment of US$13.1 million over eight years from United Nations Development Programme, with a three-year plan for piloting payments for environmental services (PES) in western Terai with the goal of providing scientific evidence to government officials to develop appropriate national policies on PES. Most community forest user groups in WTLCP sites developed saving funds generated from forest revenue that provided credit at a fair rate of around 12% per year to members who would otherwise have to depend on money lenders who charge rates of at least 24-36% per year (WTLCP, 2010).

6.2. Kenya

Kenya provides an example of an increasing population helping to reforest rural areas, in contrast to the widely held view that higher human populations inevitably lead to deforestation. The situation is often more complicated than this. Kenya has a limited area of natural forests and good agricultural land. In the early 1990s its population grew at the rate of over 3% per year. Statistics suggested that forest degradation would be widespread and Kenya did lose 0.5% (93,000 ha) of forest cover annually between 1990 and 2000. This notwithstanding, aerial and ground surveys in areas with high agricultural potential found a strong correlation between rural population density and the number of planted trees, with much more woody biomass in areas with high population densities (Bradley et al., 1985; Holmgren et al., 1994). The rate of planting exceeded the rate of population growth while the extent of native vegetation remained constant over a six-year period ending in 1991. At a national level, the number of planted trees in farmland was greater than in industrial plantations under government control, and the amount of woody biomass was greater than that in natural forests.

There appear to be several reasons for this apparent contradiction. Forest products such as fuelwood and poles were not available to farmers outside their farmed area, so the best way to acquire these products was to grow them on their own land. But perhaps more importantly, farmers have well established tenure over their land. They have the security of knowing that they will benefit from any reforestation activity they undertake. However, much of this reforestation was with exotic species such as fast growing eucalypts, meaning there was not a direct contribution to national biodiversity conservation (Holmgren et al., 1994). In other cases, on-farm hedgerows may have a considerable diversity of indigenous species (Backes, 2001). These forms of reforestation undoubtedly reduced pressure on remaining natural forests, which were therefore able to contribute ecological services. The main lesson from this case is that reforestation can occur in areas with high rural population densities, provided farmers have security of tenure.

6.3. Tanzania

Two cases are considered from Tanzania – one on reforestation and another on traditional conservation system in pastoral areas.

The Kwimba Reforestation project beginning in 1990 was a multinational and multi-organizational effort to reforest land in 40 villages. Tanzania along with many East African countries, suffers from widespread deforestation, the vast majority of which results from the use of wood as a fuel for cooking. More efficient use of wood for fuel, as well as overall economic development, drove efforts, including the planting of exotic and fast growing eucalyptus trees that served the needs of affected communities well. The project also focused on the establishment of community and school nurseries, and the design of cleaner, more efficient cookstoves by the women who lived in the region. Organizations and governmental agencies from both Australia and Africa contributed to this effort. During the project's nine-year period, over 6.4 million trees were planted. One of the most unique aspects was ensuring responsibility for those trees, with tree ownership certificates that gave the owner titles to trees, regardless of who owned the land on which they were planted.

Another best practice is from semi-arid Shinyanga region in northwestern Tanzania with 600-800 mm annual rainfall, although it varies greatly from year to year. This part of Tanzania is occupied by forests and miombo woodlands. High population densities (up to 42 persons per sq. km) exert significant pressure on land and resources. The Sukuma people who live there are pastoralists, and many communities have traditional enclosures (known as ngitili) reserved for dry season grazing and browsing. This widespread practice encourages vegetation to regenerate and provides browse and fodder later in the dry season when they are scarce. Despite the enclosures, however, much of the original woodland in the region was lost because of overgrazing and firewood harvesting. Tree clearance accelerated between 1920 and 1940 when forests in the region were also cleared to eradicate tsetse fly, a practice that continued until the early 1980s and established a basis for much agricultural expansion, including cash crops such as cotton and tobacco.

Traditionally, ngitili were located near home compounds, and fodder collected from them was used to support calves, old animals and oxen which could not follow the rest of the herd. Ownership, management and tenure rights of ngitilis were governed by customary law. At independence in 1961, almost every family in the region had a ngitili, but the system broke down when the Villagization (Ujamaa) Act was introduced in 1975. This act relocated farmers from traditional villages to newly created settlements, and their main household assets, including houses, farms and ngitilis, were abandoned. This concentration of large numbers of people and livestock in small areas increased the pressure on farmland and grazing lands.

While the new village structure was easier to administer, it disrupted traditional mechanisms for adapting to local ecological conditions such as droughts, and led to breakdowns in traditional soil conservation practices. With the gradual decline of the villagization program after the 1980s and the emphasis on in-situ conservation practices by a government soil conservation program, previously owned ngitilis were re-established or restored, along with new communally managed enclosures. More than 18,000 enclosures covering some 88,000 hectares were established between 1980 and 2001 that have allowed a significant increase in forest regenerating throughout the region. Many of the shrubs and trees are native miombo woodland species, although some exotics have been planted in reserves and on farmland. In some area there is a high diversity of native species from regrowth, with up to 23 tree species in less than 0.5 hectare. This regrowth is important both for the resulting fodder and timber trees and because many ngitilis are now the source of important traditional medicinal plant species. A variety of mechanisms and management practices have been used in different communities to establish new enclosures. In many communities grazing is prevented for up to five years to ensure that restoration begins, with a range of methods used to manage regrowth, with for example, some community-managed ngitilis having controls to regulate pruning or tree harvesting.

There are several reasons why this program has been a success. One is that people regained ownership and control over their land and resources. Another is that the reservation system was once part of the community's traditional land management practices. This made it comparatively easy to reinstate, once the government had put in place an enabling and supporting policy and a legal framework. It was also strongly helped by the reintroduction of many traditional and customary legal mechanisms that previously operated at village level. Rules have been developed to meet community needs, rather than being imposed by higher levels of government. The main lesson is that farmers and villagers can restore significant areas, with appropriate incentives are a support traditional and institutional legal framework.

6.4. South Korea

The extensive forests that existed in the Korean peninsula in the 1800s were severely degraded by overharvesting during Japanese occupation between 1910 and 1945, when average stand volume declined from 100 to 10.6 cubic metres per hectare. Deforestation was so extensive that reforestation became a national priority, with reforestation commencing in 1959 and expanded with a series of national Forest Development Plans. The first was undertaken between 1973 and 1978 and was a turning point in Korean forestry, reforesting one million hectares in only six years. The land used for reforestation belonged to a variety of land owners including national and provincial governments, industrial companies and private owners. The plan had several elements. First was a strict program of protection that was established for remaining forests, particularly those in mountain areas. Second, a number of zones were identified in which to carry out intensive forest development, with reforestation to increase conservation benefits and improve rural incomes and an emphasis on ensuring that rural communities had access to sufficient fuelwood for their needs. Third, fast growing species such as hybrid poplars, black locust, alders and Lespedeza were used, so that benefits would be received as quickly as possible. Finally, the national government sought wide participation and community involvement and provided financial subsidies to encourage this. A slight change of emphasis took place in each of the three subsequent plans.

The Second Forest Development Plan (1979-1987) continued the protection activities of the first plan but gave greater emphasis to reforestation for larger scale commercial purposes. The Third Forest Development Plan (1988-1997) focused on rational land use and the creation of superior timber resources. Efforts were also made to distribute forest products. The Fourth Forest Development Plan (1998-2007) concentrated on achieving sustainable forest management. It marked the end of government-led reforestation, followed by more self-regulation with less government involvement. In the early stages of the program the emphasis was on conserving remaining forests and developing forests for timber production. This emphasis has changed over time and the current proportion is now around 50% for timber production, 30% for protection and conservation purposes, and 20% for other purposes such as agriculture or building.

This large scale effort supported with long term and continuous planning resulted in dramatic landscape transformation in South Korea (Buckingham and Hanson, 2015). Between 1961 and 1995, stocked forest land increased from 4 million to 6.3 million hectares. Total timber production rose from 30.8 million cubic metres in 1954 to over 164.4 million cubic metres in 1984. By 2008, 11 billion trees had been planted, and about two thirds of South Korea is now covered with forests. There are no denuded areas, with land either under forests or cultivated, producing a variety of crops, with trees also growing in urban areas, villages, on farmlands, and along roads, rivers, streams and ditches. The planting of trees has become a national tradition, and in spring and autumn on specially designated days, schools and citizens participate in voluntary tree planting, mainly in urban and farm areas. However, this is not like reforestation efforts of the past when thousands of people terraced the mountainsides and carried soil in buckets for every seedling planted in shallow soil and rocks. Reforestation activity today is limited to areas where forests have been destroyed by either fire, pests, or has been harvested – there is no other land left to be planted. Planting crews are organized by the Forest Service. The reforestation of South Korea has been successful and through their involvement in planting, people became aware of the need for trees and of the role of forests in saving the land and improving the environment.

This experience serves as the model for reforestation. National and local government efforts have turned bare mountains into forested land. The main lesson from South Korea is that large scale reforestation is possible if national governments, science, industry and communities make a commitment to it. Success depends on thorough planning, long term funding and community support and involvement.

7. Conclusions

Fields and village of the tribe Derashe in Ethiopia. Photo by ©volk1945 - stock.adobe.com

Several international organizations such as IUCN, WRI, CIFOR and many more, are promoting restoration of degraded lands as part of the solution to climate change and improved supply of ecosystems services. Many countries are responding positively and are integrating forest restoration as part of their NDCs. Given the technical, legal, socioeconomic and institutional challenges associated with forest restoration, developing countries that have made bold policy measures in the forest restoration as part of their NDCs need to strengthen their national capacities.

The review begins with background information on the climate policy of Ethiopia and includes a detailed description of its exemplary forest-based NDCs. Ethiopia has demonstrated its continued and enhanced commitments to the international community and the Paris Agreement by presenting a bold and ambitious new and updated NDC. This NDC aspires to reduce national emissions by 68.8% as compared to business as usual by 2030, to be largely accomplished through reforestation and forest restoration, and primarily implemented in the drylands of the country. Land use and forestry (LUCF) policy measures suggested for enhancing carbon sequestration in soil or vegetation include large scale afforestation, reforestation and revegetation, sustainable forest management, and reduced deforestation and forest degradation through the existing national REDD+ program. However, given afforestation and reforestation efforts are costly and technically challenging, the realization of LUCF targets set in the updated NDC is conditional on commitments of the international community for providing access to enhanced financial resources and other support.

The review has thus made a detailed analysis of conditions for successful forest restoration projects by adopting a comprehensive framework. It has identified common mistakes and assumptions made by some reforestation projects that leads to failure, and identified the gaps that must be addressed depending on the country context. For example, many reforestation projects in Ethiopia fail because the need for careful planning of technical and biophysical details are overlooked, limited attention is paid to the participation of local communities and empowering and engaging grassroots institutions, and most often, there is inadequate attention given to the long term nature of reforestation projects that requires equally long term legal, institutional and funding support. The experiences in South Korea and Nepal clearly underline the need for empowering local communities, strengthening popular participation in decentralized approach and the importance of long-term vision and support leading to successful national reforestation programs.

In addition, the review outlines the most common indicators of reforestation success at various stages of forest development, to help focus on specific factors that must be checked and addressed at each stage. In summary, the major stages are (1) forest establishment that refers to a 3-5 year period from when seed or seedlings are planted to when young trees have 'captured' the site, forming a relatively closed canopy that suppresses weeds, (2) forest growth (building phase) where the focus of success is on tree growth, stand density, stem form (in the case of timber trees) and the production of non-timber forest products (such as fruit and resins), and (3) whether or not the forests created are providing the targeted services or products.

The analysis on reforestation success factors and challenges is backed with positive experiences from other countries that show key factors for success and lessons learned. The experiences of South Korea show the national leadership and the population working hand in hand, while also gaining technological and knowledge support from its scientists (e.g. tree improvement such as breeding of species imported from North America for adaptation to local conditions) is a good example. The Korean reforestation success is a prototype that is being promoted globally, and being pursued by many in the green growth movement. The commitment and enthusiasm of the government and people of Ethiopia appear to be in parallel with that seen in South Korea in the 1950s. By making immediate adjustments on enablers – policy, institutional and legislative – and on technical readiness and adequate incentives, Ethiopia can make fundamental landscape and livelihoods transformation through successful reforestation and forest restoration in the coming decades, like Nepal and South Korea. Currently, the prime minister provides leadership on the Green Legacy Initiative (GLI) that aims to plant 20 billion seedlings in just four years (2019-2022), with strong support from the population.

Nepal's community forestry initiative since 1970s has resulted in the restoration of 1.2 million hectares of forest land, the formation of 18,000 community user groups and who now generate an annual US$12.4 million income from their restoration efforts. Community forests have fewer forest fires and illegal felling as a result of community involvement. The initiative has also resulted in a reduction in downstream flooding, and increased supply of fuelwood. Most of the drivers of success for reforestation in Nepal such as decentralized policy, increased technical capabilities, good governance, incentives, long term plans with adequate funding support, secure tree and land tenure, market prospects, etc., are all relevant for Ethiopia and many other developing countries.

The large scale restoration aspired to in Ethiopia certainly requires high dedication and transformation in forestry development approaches. However, fragmented reforestation approaches that are common in many developing countries may not be adequate to achieving large scale reforestation goals in short timeframes. Assessing and addressing the challenges will ensure the readiness of the country for successful implementation of such a large scale reforestation program as stipulated in Ethiopia's NDCs. Furthermore, in Ethiopia that is largely a dryland country, the significance of drylands for NDC policy interventions in the LUCF and livestock sectors is key. But the historic lack of policy attention and inadequate institutional arrangement for the development of pastoral areas might be an additional challenge for the implementation of planned forest restoration programs in these areas. Supporting communities, capacity development, and revitalization of traditional conservation practices such as in Tanzania are some of the measures that could be made in dryland pastoralist areas.

Under the umbrella of the Paris Agreement, countries are responding to the climate change challenges according to their national circumstances and capabilities. Developing countries in particular have an opportunity to act on climate change mitigation and adaptation by integrating forest restoration programs in their NDCs. The report begins with policy and measures Ethiopia has expressed in its NDC as the background, followed by detailed analysis on factors of reforestation success. Particular effort has been made to enhance the knowledge base on forest restoration with a view to helping Ethiopia's ambitious reforestation plans to be successful. This report is thus an important addition to the analysis of forest landscape restoration in Ethiopia and especially in dryland areas, and adds to the global body of knowledge on the topic. With support from the international community, as highlighted, Ethiopia can achieve its ambitious goals for reducing its CO2 emissions and meet its targets under the Paris Agreement, while also improving the environment and social wellbeing, with forest landscape restoration as key.

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Annex 1: Ethiopia's prioritized adaptation actions

Notes

1 There is a need to refine definitions of climate indicators vs development indicators in the next 5 years for clearer distinction of climate and development actions.

2 Quintal = a unit of weight equal to 100 kg.

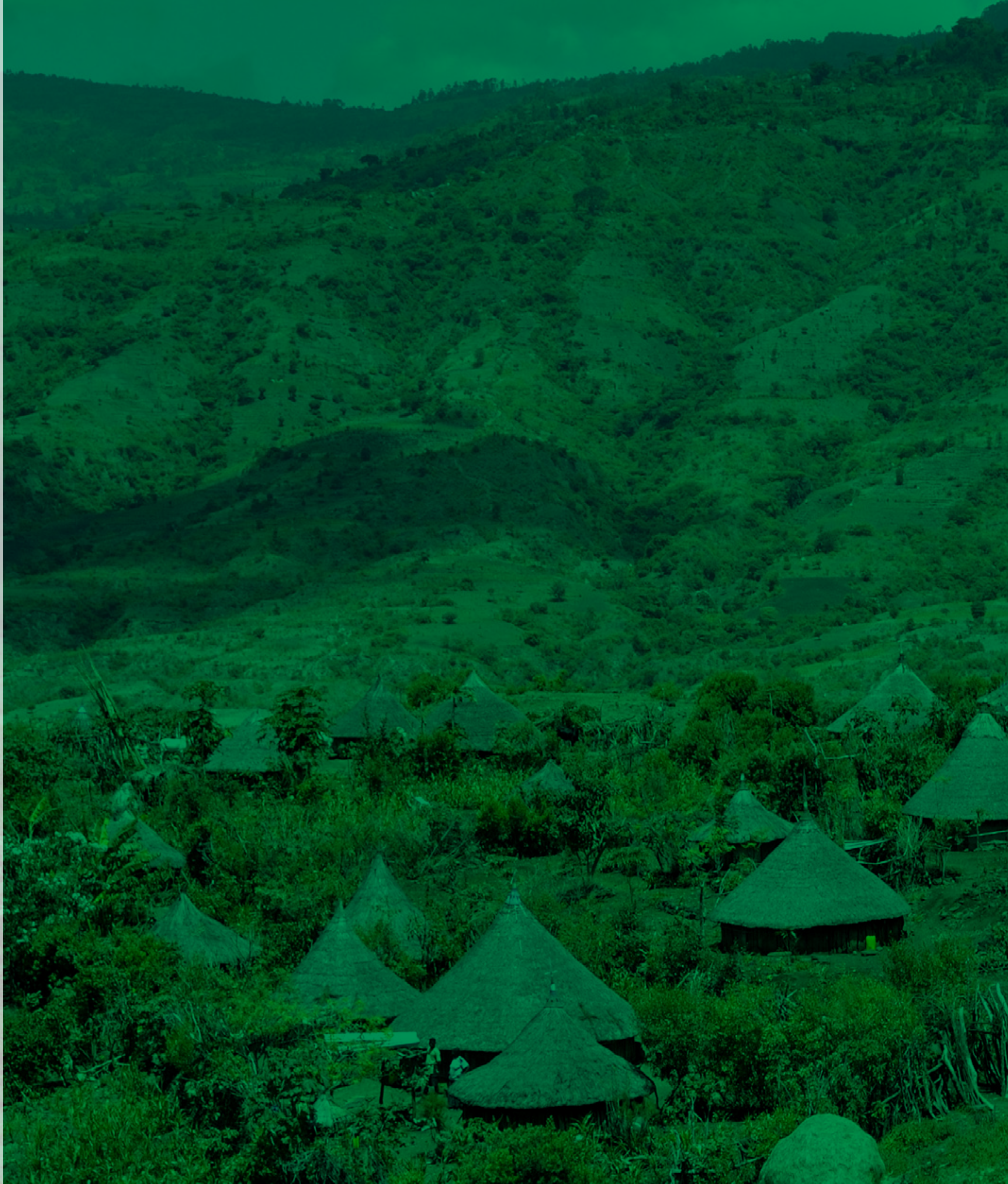
3 Represents indicator, baseline (2020) and target (2030) figures obtained from Ethiopia's 10YDP; other targets and baseline are from sectors.

Adaptation intervention (Commitment)	Indicator(s)[2]	Baseline (2018)	2030 Target
SECTOR: AGRICULTURE			
Enhance food security by improving agricultural productivity in a climate-smart manner (promote yield increasing techniques)	Productivity of rain fed crop land (based on average for teff, wheat, barley and corn)	28.9 quintals[3]/ha	45.9 quintals/ha
	Area under irrigation (based on corn, wheat, tomatoes and onions)*[4]	62,050 ha*	225,913 ha*
	Crop production through irrigation*	8 million quintals*	38 million quintals*
Diversify livestock and animal mix, including promotion of poultry and small ruminants	Productivity of poultry and small ruminants (Tons)	Specialized poultry commercial – 33,100 t Household – 13,200 t	Specialized poultry commercial – 80,900 t Household – 16,200 t
		Sheep – 66,000 t Goat – 44,000 t	Sheep – 324,000 t Goat – 282,000 t
	Percentage of improved livestock number (dairy)	Dairy – 2.7%*	Dairy 17%*
Enhanced climate resilience in livestock	Percentage of coverage of animal health services	Dairy – 11% Beef – 7%, Small ruminants – 7%	Dairy – 42% Beef – 28% Small ruminants – 28%
Prevent and control the spread of climate-driven vector-borne diseases	Percentage reduction of crop and animal disease cases	To be established	30% reduction from 2022/2023 baseline (to be established)
Improve rangeland and pasture-land management diversification, including selection of drought resistant animal breeds	Percentage of improved content in dry feed	Local dairy – 77% Cross-breed – 41% Exotic – 33%	Local Dairy – 100% Cross-breed – 100% Exotic – 100%
Expand the use of improved crop varieties with climate resilient characteristics	Improved seed coverage (Ha)	Teff – 31,000 ha Barley – 70,000 ha Wheat – 413,000 ha Corn – 438,000 ha	Teff – 100,000 ha Barley – 193,000 ha Wheat – 673,000 ha Corn – 823,000 ha
Strengthen crop disease and pest monitoring systems in vulnerable areas	Vulnerable districts covered by such monitoring systems	Indeterminate	All districts nationally
Strengthen drought and crop insurance mechanisms for climate risk management	Number of farmers (gender disaggregated) covered by drought and crop insurance	Indeterminate	30% increase from 2022/2023 baseline (to be established)
SECTOR: FORESTRY			
Restoration and reforestation through tree planting	Hectares reforested/ restored (Ha)	2.6 million ha	9 million ha
Increase national forest coverage	Percentage of National forest coverage	15.5%	25-30%
Enhance sustainable forest management	Area of natural forest under sustainable forest management	2 million ha	4 million ha

Adaptation intervention (Commitment)	Indicator(s)[2]	Baseline (2018)	2030 Target
Improve sustainable utilisation of forest resources	Number of green jobs created	0.2 million	5 million
	Export earnings from sustainable forest products	US$41.4 million	US$221 million
Implement forest protection and health enhancement measures in natural forest ecosystems	Area of forest protected from diseases, pests and fire	-	17.2 million ha
	Proportion of federal and regional institutions' improved capacity for forest protection	To be established	To be established
SECTOR: LAND USE, AND NATURAL RESOURCES MANAGEMENT			
Enhance climate resilient livelihoods of wildlife resource dependent communities in protected areas	Number of dependent communities benefiting from climate resilient wildlife resources	30,000 people	1.5 million people
Enhance sustainable natural resources development, management, and watershed protection	Number of PFM associations vested with legal personality*	-	To cover 10,000 catchment areas*
SECTOR: WATER			
Integrated watershed development in million Ha	Area under integrated watershed development	2.24 million ha	10 million ha
Improve access to potable water to strengthen community climate resilience	Potable water supply per capita	19.36 litres/capita/day	Rural – 25 litres/capita/day by 2025/ within 1 km. Urban – 50-100 litres/capita/day by 2025
	Proportion in decreasing non-functionality rate of water schemes	19%	7%
	Percentage of decreasing water waste	39%	20%
	Water Supply for humans and animals in 100 isolated and drought affected woredas	Indeterminate	100 woredas
	Number of residents using fluoride contaminated water	3.5 million people	0*
Expand the construction of medium and largescale irrigation systems to enhance food security	Number of ha under medium and largescale irrigation schemes	0.49 million Ha	1.2 million ha
	Percentage of improved irrigation technologies for medium and largescale irrigation	2%	20%
	Percentage of water use efficiency in medium and large-scale irrigations	30%	50%
	Number of gender balanced Irrigation Water User Associations (IWUAS)	none	35.5
	Number of jobs created through expansion of irrigation network	-	930,000*

Adaptation intervention (Commitment)	Indicator(s)[2]	Baseline (2018)	2030 Target
	Number of persons acquired skills through tailored capacity building activities	To be established	To be established
	Proportion of women shared development and management role in irrigation system	To be established	To be established
SECTOR: ENERGY			
Increasing number of households using renewable off-grid energy sources for lighting	Percentage of households using renewable off-grid energy sources for lighting (i.e. those not served by the grid)	39.91%	100%
	Percentage of population with stable access to electricity from alternative off-grid renewable energy (RE) technologies	11%	35%
	Number of unstable and unreliable diesel-based standalone generator systems	36 systems	0
	Percentage of increased renewable energy contribution	9%	27%
	Percentage of reduced total electricity waste in transmission and distribution systems	19.60%	12.50%
	Percentage improvement in private sector contribution in energy generation and distribution	none	36.10%
	Number of green jobs created in the Energy sector	To be established	To be established
	Number of capacity building interventions for actors across renewable energy value chain	To be established	To be established
	Percentage increase in women and youth participation in RE development and utilisation	To be established	To be established
SECTOR: TRANSPORT			
Build sustainable transport systems for resilience through enhanced access to mobility	Length of non-motorised transport infrastructure constructed	26.5 km	506 km
	Number of cities/ towns (above 50k residents) with dedicated non-motorised transport lanes (for bicycles)	2	69
Increase climate resilient designs and safety standards for transport systems	Number of major transport infrastructures that take climate change into consideration	1	9
SECTOR: URBAN			
Construct new sanitary landfill sites in cities/ towns in climate resilient locations	Number of constructed landfill sites in climate resilient locations	6 constructed sanitary landfills	200 sanitary landfills
Increase the climate resilience of urban systems	Area of land covered by green infrastructure and recreational areas (Ha)	159,263.16 ha	30% of the land in 200 cities/towns, equal to 5,308,772 ha

Adaptation intervention (Commitment)	Indicator(s)[2]	Baseline (2018)	2030 Target
Improve provision and condition of housing for enhanced human safety against climatic stressors	Percentage of urban dwellers residing in safe and adequate housing* (gender disaggregated)	Indeterminate	70%
Enhance urban greenery for improved climate resilience	Urban green area per capita in m2	0.41 m2 per urban inhabitant	Indeterminate
Undertake climateadaptive urban planning	Area of land covered by green infrastructure and recreational areas (Ha)	159,263.16 Ha	-
	Number of land use plans	Not available	4,000
SECTOR: CLIMATE SERVICES AND DISASTER RISK REDUCTION			
Number of climate and early warning data produced and disseminated/year	Number of climate and early warning data analysed and disseminated/year	15	59
Number of modern weather condition monitoring stations	Number of modern weather condition monitoring stations	325	806
Enhancing climate service data reliability	Proportion of increase in climate service data reliability	0.75	0.85
Number of Eco-Hydrology Demonstration Sites in all basins	Number of Eco-Hydrology Demonstration Sites in all basins*	10*	55*
Modernise and update the basin information system coverage	Modernise and update the basin information system coverage	16.66	99.7
Surface water resource assessment coverage	Percentage of surface water resource assessment coverage	78%	100%
Ground water resource assessment coverage	Percentage of ground water resource assessment coverage	17.95%	35%
Enhancing water quality monitoring coverage	Percentage of increase in water quality monitoring coverage	Indeterminate	80%
SECTOR: HEALTH			
Reduce Malaria case incidence	Percentage reduction of Malaria case incidence	26/1,000 in 2020	8/1,000
Reduce cholera case incidence	Percentage reduction in Cholera case incidence	Baseline in 2020	0
Increase proportion of households with improved toilet	Percentage of households with improved toilets	20% in 2020	60%
Increase proportion of households with safe water supply	Proportion of households with safe water supply	70% in 2020	100%
Increase proportion of health care facilities safely managing health care waste	Percentage of health care facilities with safe waste management	16% in 2020	50%
Increase proportion of health facilities with safe energy sources (electricity, solar)	Proportion of health facilities with safe energy sources	76% in 2020	100%



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