INITIATIVE ON Low-Emission Food Systems

Kenya's Perspectives Across Climate, Conservation, and Clima + Conservation scenarios using Global Forest Model (G4M)

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List of Abbreviation and Acronym

AFOLU	Agriculture, Forestry, and Other Land Use
BAU	Business-As-Usual
BTR	Biennial Transparency Report
CO2	Carbon Dioxide
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics Database
FM	Forest Management
FRA	Forest Resources Assessment
FRL	Forest Reference Level
G4M	Global Forest Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas(es)
GLOBIOM	Global Biosphere Management Model
HA	Hectares
IPCC	Intergovernmental Panel on Climate Change
LEAP	Long-range Energy Alternatives Planning System
LTS	Long-Term Strategy
LULUCF	Land Use, Land-Use Change, and Forestry
MtCO2e	Mega Tons of Carbon Dioxide Equivalent
NCCAP	National Climate Change Action Plan
NDC	Nationally Determined Contribution
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SSP2	Shared Socioeconomic Pathway 2
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

1. Introduction

Kenya is highly vulnerable to climate change due to a combination of political, geographical, and social factors (Ide et al., 2014). Nevertheless, the country has demonstrated a strong commitment to mitigating and adapting to climate change, as well as to biodiversity conservation. To this end, it has developed various legislative instruments and public policies that will enable the country to achieve these objectives. Additionally, Kenya is a signatory to multiple international agreements related to these issues such as the Paris Agreement and the Convention on Biological Biodiversity (CBD) among others.

Beyond these efforts, it is essential to have tools that support decision-making and provide quantitative estimates of potential future scenarios for the achievement of such commitments. These tools should facilitate the identification of challenges and opportunities for designing measures that contribute to the achievement of different national objectives. Additionally, the main objective of Kenya's national policies related to climate change is to support adaptation and mitigation efforts, strengthen the country's capacity to prepare for and respond to natural disasters, and enhance resilience to climate change. However, aligning these policies with conservation needs to preserve biodiversity is essential. This report presents the findings from the application of the Global Forest Model (G4M), to evaluate the impact of selected Policy and Mitigation Measures (PaMs) on Kenya's commitment under its National Determined Contributions (NDC) and The Global Biodiversity Framework's "30x30" Target and their long-term vision outlined in diverse strategies and policies such as the National Climate Change Action Plan, Long term low emissions development strategy (LTS) among others.

The Model developed four scenarios: a baseline and three thematic scenarios. These include the Climate Scenario, aligned with the objectives of the Paris Agreement; the Conservation Scenario, aligned with the Kunming-Montreal Global Biodiversity Framework; and the Combined Climate and Conservation Scenario, which integrates the objectives of both frameworks. These scenarios enabled an evaluation of emissions, deforestation, afforestation, and land cover changes in Kenya under defined assumptions. The analysis not only identified points of convergence between climate measures and biodiversity conservation but also promotes the identification of strategic actions that enable the simultaneous achievement of both objectives. Furthermore, it highlights critical areas requiring prioritized attention to foster conservation. The performance of Kenya's deforestation and afforestation measures was also analyzed in relation to the actions needed to meet international objectives, providing insights into the country's progress and areas for improvement. This holistic approach aims to support the long-term vision established key policies, strategies and commitments.

2. Kenya's Commitments to Climate-related Multilateral Agreements

The medium- and long-term commitments analyzed in this report are derived from Kenya's 2020 Nationally Determined Contribution (NDC) and the draft Long-Term Low Emission Development Strategy (LT-LEDS). In its 2020-2030 NDC, Kenya commits to reducing greenhouse gas (GHG) emissions by 32% relative to the Business-As-Usual (BAU) scenario, aligning this target with the country's broader sustainable development agenda, which includes milestone goals extending to 2050 (Republic of Kenya, 2020). Furthermore, under the LT-LEDS, Kenya aims to achieve net-zero emissions by 2050, demonstrating its commitment to long-term climate resilience and sustainable development (Government of Kenya, 2022).

Achieving these ambitious mitigation targets will require Kenya to both reduce emissions and enhance carbon absorption. The mitigation strategy primarily emphasizes on reducing emissions in the energy and transport sectors, preventing land use changes and deforestation, and increasing carbon sinks. Transitioning to net-zero emissions by 2050 will depend on adopting new technologies, the implementing more ambitious mitigation policies, and significantly enhancing carbon sequestration, particularly through the forestry sector. National estimates indicate that reversing current deforestation trends and achieve over 15% forest cover by 2050, Kenya, would make substantial progress towards net-zero emissions targets (Government of Kenya, 2022).

2.1. National Determined Contribution (NDC)

Kenya submitted its first NDC to the United Nations Framework Climate Change Convention (UNFCCC) in December 2016, committing to a 30% reduction in emissions relative to the Business as Usual (BAU) scenario of 143 $MtCO_2e$ (Government of Kenya, 2020). Four years later, Kenya increased its ambition, updating the NDC to a 32% reduction target. The implementation of both mitigation and adaptation actions outlined in the NDC will be guided by the National Climate Change Action Plans (NCCAPs) as mandated by the Climate Change Act, and the most Recent NCCAP is 2023-2027.

The expected emission reductions from Kenya are around 46 $MtCO_2e$. Most of the planned reduction in emissions will be from the energy sector, which is expected to decrease overall emissions by 24 $MtCO_2e$ by 2030. Additionally, Land Use, Land Use Change, and Forestry (LULUCF) will also contribute to the overall reduction of up to 12 $MtCO_2e$ by 2030. (Government of Kenya, 2022) as it is shown in the Table 1.

Table 1. Summary of Sectorial Potential Mitigation Reductions of the Actions Prioritized for the Updated NDC ($MtCO_2e$)

Sector	Action up to 2022	Action up to 2025	Action up to 2030
Energy	11.6	16.5	24.1
Transport	1.0	1.5	2.4
LULUCF	**5.9**	**8.2**	**11.9**
Agriculture	1.6	3.2	5.8
IPPU	0.5	0.8	1.4
Waste	0.4	0.4	0.5
Total	21.0	30.6	46.0

Source: (Government of Kenya, 2022)

The forestry sector is the second most critical sector after energy for achieving Kenya's mitigation targets, with the potential to contribute approximately 23% of the expected emissions reductions. The cumulative mitigation potential from the four priority actions in the forestry sector is estimated at 11.9 MtCO2e per year by 2030, compared to net emissions of 52.2 MtCO2e per year in the absence of interventions (Government of Kenya, 2020). The main mitigation actions for the sector as outlined in the NDC include the following;

- Achieving a tree cover of at least 10% of the land area of Kenya
- Make efforts towards achieving land degradation naturality
- Enhancement of REDD+ activities

The mitigation targets outlined in Kenya’s 2020-2030 NDC are unlikely to be sufficient to achieve net-zero emissions by 2050. The estimated mitigation potential in the forestry sector, based on four priority mitigation actions, is approximately 20.8 MtCO2e by 2030, as shown in Table 2. This is significantly lower than the current net emissions of 52.2 MtCO2e annually, as reported in the 2016 National Communication (Republic of Kenya, 2015).

Table 2. Summary of discount mitigation potential from the NDC in the forestry sector ($MtCO_2e$)

Prioritized mitigation actions (MtCO2e)	2022	2025	2030
Reduce deforestation and forest degradation by protecting of additional 100,000 ha of natural forests (including mangroves) by 2022	2	2	2
Afforestation/reforestation/agroforestry of an additional 100,000 ha of land by 2022	2	3.1	4.8
Restoration of 200,000 ha of forest on degraded landscapes (ASALs, rangelands) by 2022	5.4	8.3	13
Increase area under private sector-based commercial and industrial plantation from 71,000 ha to at least 121,000 ha	1	1	1
Total	10.4	14.4	20.8

Source: (Government of Kenya, 2022)

2.2. Long Term Climate Related Commitments

The draft Long-Term Low Emission Development Strategy (LTS) outlines Kenya's vision, objectives, and priority interventions required to achieve a net-zero economy by 2050. This goal will largely depend on carbon sequestration efforts between 2022 and 2050, with the forestry sector playing a central role. Reversing current deforestation trends and increasing forest cover to 15% by 2050 are critical steps toward making net-zero emissions achievable.

The pathway to 2050 was quantified by developing two scenarios: a BAU scenario - consistent with the NDC BAU scenario- and an LTS scenario - corresponding to the mitigation scenario. Emission projections were modeled using the Low Emission Analysis Platform (LEAP), based on macroeconomic projections, while the forestry sector was modeled separately and later integrated into LEAP. The forestry model utilized land use inventories and international emissions factors for various land use categories to estimate current baseline emissions.

The LTS assumes a 50% reduction in deforestation by 2030 and a 65% reduction by 2050, relative to the 2002-2018 average. Under these assumptions, the forest cover will be increased by 2050. If this increase reaches 15% by 2050, the LULUCF sector could become a carbon sink, being neat to achieve the net zero emission target.

The targeted interventions proposed by the LTS were;

- Increase tree and forest cover by increasing afforestation to 580,000 ha per year by 2030 and sustain afforestation efforts to 2050
- Reverse forest degradation by reducing deforestation to 120,000 ha per year, a 65% decrease relative to the 2002-2018 level.

Targeted interventions could achieve 41 $MtCO_2e$/year in negative emissions by 2050, effectively acting as a carbon sink. Reducing deforestation by 50% by 2030 and by 65% by 2050, compared to the 2002-2018 average, would decrease deforestation-related emissions to 18 $MtCO_2e$ by 2050. While converting grasslands to forests may result in some emissions, since grasslands also sequester carbon, these emissions are expected to be under 3 $MtCO_2e$ in 2050. Continued afforestation efforts from 2022 onward are projected to sequester 60.5 $MtCO_2e$/year by 2050.

2.3. Kenya's Commitments to Biodiversity Global Frameworks

Kenya has made significant efforts in biodiversity conservation and management through the development and implementation of different policies, legislation, and national strategies. The country's commitment to biodiversity conservation aligns with the global 30x30 initiative, which aims to protect 30% of the world's land and marine ecosystems by 2030. Kenya's policy framework reflects this ambition, underpinned by key national instruments such as the National Wildlife Strategy 2030, National Wildlife Policy 2020, Wildlife Conservation and Management Act 2013, Wetlands Conservation and Management Policy 2015, Environment and Management Coordination Act 1999, and the Forest Conservation and Management Act 2016 (Anyonge, 2023). These policies collectively aim to address biodiversity loss, ecosystem degradation, and the sustainable use of natural resources. For instance;

The Wildlife Conservation and Management Act 2013 (Government of Kenya, 2013) provides a legal foundation for wildlife protection, establishing the Kenya Wildlife Service as the primary agency responsible for conservation efforts. The National Wildlife Policy 2020 builds on this framework by prioritizing community engagement and the integration of conservancies, recognizing that local communities play a vital role in wildlife management (Government of Kenya, 2020). The Forest Conservation and Management Act 2016 is essential for safeguarding critical ecosystems such as wetlands and forests. Kenya's commitment is exemplified by the reservation of 676,806.63 hectares of forest between 2015 and 2019. This action was bolstered by the Kenya Forest Service's engagement with local NGOs to manage and protect forests, ensuring that benefits from forest resources and tourism flow to local communities (Government of Kenya, 2016).

Kenya's BIODEV2030 initiative reflects a proactive approach to biodiversity conservation by integrating biodiversity considerations into key economic sectors. This initiative aims to mainstream biodiversity into sectors such as agriculture, fisheries, and infrastructure development, which are essential for Kenya's economic growth. By embedding biodiversity conservation into economic planning, Kenya seeks to mitigate sectoral pressures on natural ecosystems, thereby supporting the 30x30 initiative's objectives. Kenya's alignment with the global

30x30 strategy requires targeted interventions to protect 30% of its land and marine areas by 2030. To achieve this goal, it is imperative to augment existing policies, particularly those related to agriculture and land use, by incorporating biodiversity conservation measures that reduce conflicts between farming activities and conservation efforts

3. Methodology

The model selected for this analysis was the Global Forest Model (G4M), which was calibrated using available national data.

3.1. Data Sources

The data required for running the model included land use area data, Greenhouse Gases Emission Historical Data, and GHG Emission Projections. The sources of this information are described below.

3.1.1. Land Use Area

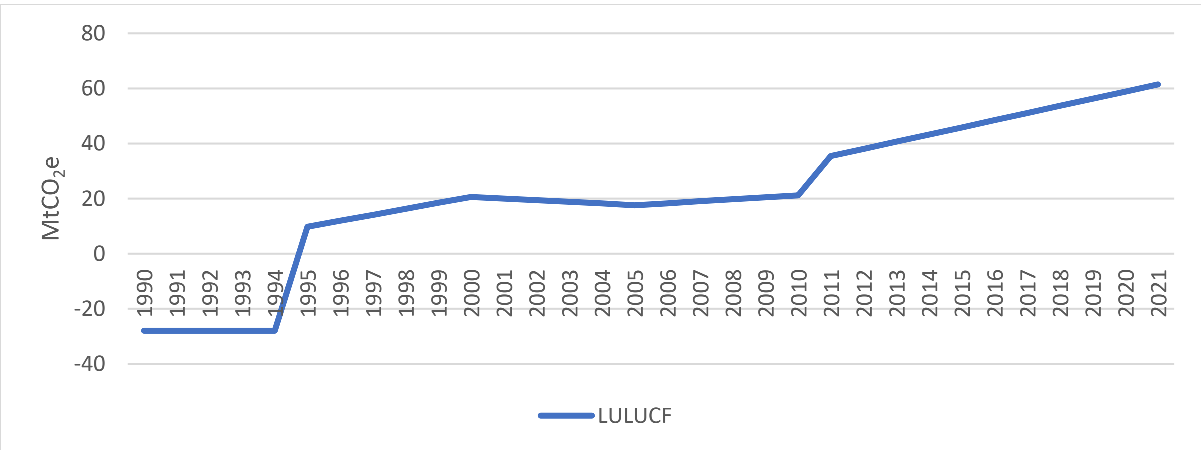
Land use data access from FAOSTAT (https://www.fao.org/faostat/en/#data/RL). The information extracted included: forestland, Cropland, Permanent meadows and pastures, other land, and land area in 1000 ha for the period between 1990 to 2022. This data is consistent with the Forest Assessment Report (FRA) 2015, and was in the Kenya's Second National Communication. The FRA 2015 data was utilized as it was the best available at the time the inventory work was conducted (Republic of Kenya, 2015) . Although the FRA 2020 is available, it was not used in any of the country estimations

3.1.2. Greenhouse Gases Emission Historical Data

The GHG historical information extracted from the Second National Communication published in December 2015[1]. Kenya's total GHG emissions have increased by 82% since 1995, driven mainly by agriculture (40%) and forestry (33%) emissions (Republic of Kenya, 2015).

The LULUCF sector has become a net emitter since 1994, amounting to 52.2 $MtCO_2e$/year between 2002 and 2018 (Government of Kenya, 2023). The total emissions from the sector reach 61.7 $MtCO_2e$/year due to deforestation, averaging 48.2 $MtCO_2e$ annually, followed by forest degradation with an additional 10.9 $MtCO_2e$/year, and management of plantation forests contributed with 2.7 $MtCO_2e$/year, efforts in afforestation and forest enhancement have offset some of these emissions, capturing 9.5 $MtCO_2e$ bringing total net emissions from the forestry sector to 52.2 $MtCO_2e$ per year.

Figure 1. Historical GHG emissions of the LULUCF sector in MtCO2e



Source: (Republic of Kenya, 2015) and lineal projections from 2015

[1] https://unfccc.int/documents/109628

The inventory considers all forests in Kenya as managed forests. Forest management is defined as the process of planning and implementing practices for stewardship and use of the forest aimed at fulfilling relevant ecological, economic, and social functions of the forest. The carbon pools represented in the model are consistent with IPCC Guidelines and include above-ground biomass, below-ground biomass, soil organic matter, and the atmosphere. The predominant gas in this sector is CO_2, but there are also emissions of other GHGs such as CH_4 and N_2O from the imperfect burning of wood left in the field, in case of forest conversion to other uses. The GHG emissions data for the LULUCF sector are reported in $MtCO_2e$. The data set includes data from 1990 to 2021, based on Kenya's Second National Communication, to complete the time-series linear extrapolation.

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3.1.3. GHG Emission Projections

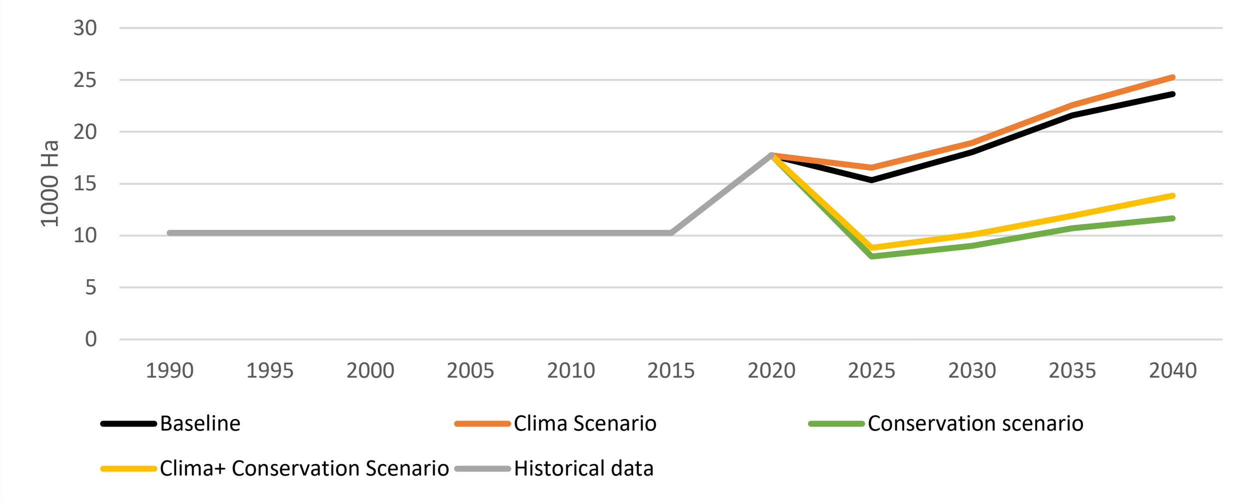
For the international commitments under the UNFCCC, Kenya has estimated two different types of projections: the BAU scenario and the potential GHG emission reductions through mitigation. Under the BAU scenario, Kenya's GHG emission will be 143 $MtCO_2e$ in 2030, mainly composed of electricity generation (29%), transport (15%), agriculture (27%), and LULUCF (15%), energy demand (7%), industrial processes (6%) and waste (3%) (Government of Kenya, 2023), and was reported in the NCCAP 2023-2027 (Table 3). As shown in Figure 2, emissions in all sectors increase until 2030 except forestry, where emissions have their peak in 2015 due to the historical implementation of actions to reduce deforestation and the increase of tree planting policies.

Table 3. BAU emission projections to 2030 in $MtCO_2e$

Sector	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Forestry (LULUCF)	**10**	**21**	**18**	**21**	**26**	**25**	**23**	**22**
Energy	8	10	10	14	17	32	49	72
Agriculture	24	23	26	30	32	34	36	39
Industrial process	1	1	1	2	3	4	5	6
Waste	1	1	2	2	2	3	3	4
Total	44	56	57	69	80	98	116	143

Source: (Government of Kenya, 2023)

Figure 2. Grouped BAU projections to 2030[2]



The Potential GHG emission reduction through mitigation scenario is a group of scenarios produced by the country that reflect the different mitigation commitments and estimations. However, most are consistent with the long-term targets defined in the LTS, looking for zero emissions by 2050 (Table 4).

Table 4. Emission reduction potential reported by Kenya

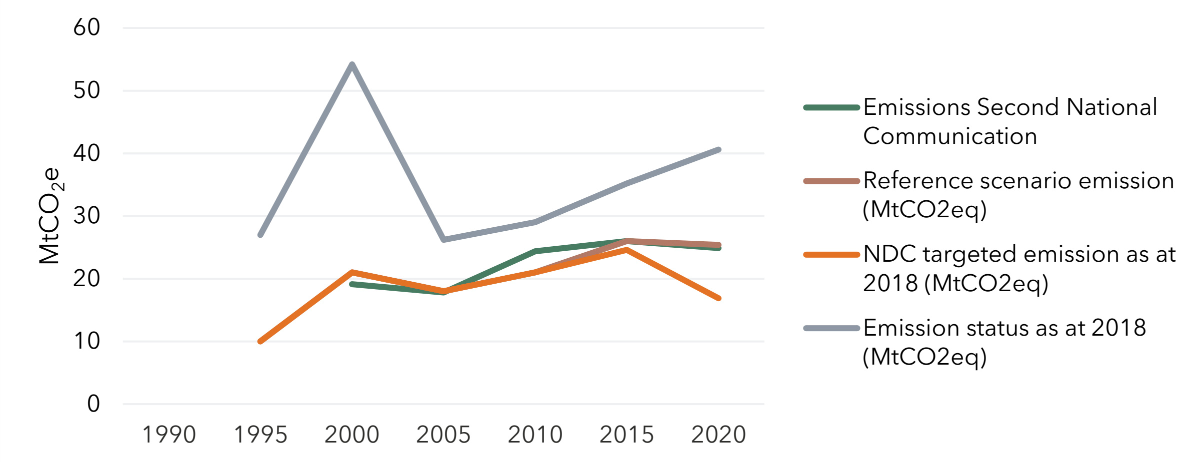
Mitigation potential	Scenario	Forestry (abatement)	Forestry (Sink)	Total $MtCO_2e$
NDC Sector analysis	2030 BAU Emissions projection	22		143
	2030 Emission reduction commitment	20.1		42.91
NCCAP I & II Targets	2015 emission reduction potential	2.71		8.21
	2022 emission reduction potential	10.4		32.02
Updated NDC Targets Potentials	2022 emission reduction potential	10.4		38.92
	2025 emission reduction potential	14.3		59.2
	2030 emission reduction potential	20.8		86.5
LTS targets	2050 BAU emission projection	52.2		304.2
	2050 abatement/ sink potential	52.2	-41.1	212.4

Source: (Government of Kenya, 2023)

Additional GHG emission information is reported by the country also in the 2021 National Forest Resources Assessment where is stated that Kenya had exceeded its constitutional obligation to maintain national tree cover at 10% of the total land area, reaching a tree cover of 12.13% of the total land area in 2021 and a total national forest cover of 8.83% in the same year, an increase of 2.93% compared to 2015 data (the initial forest cover area was 5.9%). Beyond the positive progress in afforestation, restoration of degraded lands, and agroforestry; the results of these actions will take time to reflect their impact on GHG emission reductions, maintaining the GHG trend. In 2022, the forestry sector demonstrated high GHG emissions of 52.3 $MtCO_2e$ against the NDC target of 13.4 $MtCO_2e$.

[2] Grey sectors include electricity generation, energy demand, transportation, industrial processes, and waste.

Figure 3. Comparison between current emissions, NDC, and BAU scenarios



As shown in Figure 3, the actual historical emissions estimated for 2018 exceed the reference scenario projections for 2020 by 40% and are 23.7 $MtCO_2e$ above what was anticipated in the NDC scenario for 2030. This discrepancy in national estimates is due to improvements in the country's estimation methodology, which now relies on more and better-quality information. While this progress has led to higher reported values, it has also resulted in more accurate and realistic estimates.

However, since disaggregated information for the 2018 inventory is not available, the estimates used in the model presented later are based on the 2015 GHG inventory. This has significant implications for the projections, introducing some uncertainty into the results.

3.2. Selected Climate Related Policy and Mitigation Measures

In Kenya, the main policy instrument guiding the implementation of mitigation actions in the country is the NCCAP 2023-2027. It outlines four main objectives consisting of various activities to reduce emissions in the forestry sector. Some of the mitigation actions included in the NCCAP 2023-2027 are part of the NDCs and/or the LTS, but not all. Table 5 presents the list of mitigation measures.

Table 5. Main policies included in the NCCAP 2023-2027

Main objective	Activity	Action	Total Hectares	Yearly hectares	End year	Reference Document (NDC /LTS)
Reduce emissions from deforestation and forest degradation	Reduce deforestation by rehabilitation and protecting an additional 100,000 hectares of natural forests (including mangroves) by 2028.	Reduce deforestation	100,000	12,500	2028	NDC and LTS
	Restoration of 35,000 ha of degraded public forests.	Restoration	35,000	7,000	2025	NDC
	Establishment of 5,000 ha of public forest plantations.	Plantations	5,000	5,000	2025	-
Reduce emissions from land degradation outside forests	Restoration of up to 1,000,000 hectares of forest on degraded landscapes (ASALs, rangelands).	Restoration	1,000,000	125,000	2028	NDC

	1,000 ha of bamboo commercial forest established.	Plantations (Bamboo)	1,000	1,000	2026	-
	300,000 ha of commercial forest plantation established.	Plantations	300,000	60,000	2028	-
	1,000,000 ha agroforestry established on farmlands.	Agroforestry	1,000,000	200,000	2028	-
	75,000 ha of private commercial forest plantations were established.	Plantations	75,000	15,000	2028	NDC
Enhance the resilience of wildlife, their habitats, and their ecosystems	Increase tree cover in 30,000 ha of protected areas to enhance the resilience of the wildlife habitat.	Forest management	30,000	30,000	2028	
Enhance the contribution of youth to forestry and wildlife	1,000 ha degraded mangrove forest sites restored through youth-led programs	Restoration	1,000	1,000	2027	NDC

Source: (Government of Kenya, 2023)

3.3. Modelling Framework - G4M

G4M was used to model the impact of the mitigation policies in the forestry sector, this model is a spatially explicit (0.5 x 0.5 deg.) model of land use change and forestry. G4M distinguishes two land use types: forest land and non-forest land. It simulates afforestation (including natural forest expansion on abandoned land), deforestation, and forest management and estimates consequent CO_2 emissions and removals.

Land use change decisions (afforestation or deforestation) in each spatial unit are modeled by comparing the net present value of agriculture and forestry in the same place. Forest management (FM) decisions (change of rotation time, thinning, abandonment of managed forest or start harvesting previously unmanaged forest) in each spatial unit are modeled by comparing the net present values of forestry under current forest management and new forest management and directed to satisfy wood demand on a regional scale or country scale.

A set of forest parameters was initialized to calibrate the model iteratively using country data. At the country level, grid cells containing forest were selected until the sum of the forest area in the collected grid cells matches the managed forest area for that country as presented in (Grassi, et al., 2021). The rate of afforestation is a function of GDP and agriculture suitability. In this case, GDP represents a capacity of planting or restoring forests and the agriculture suitability indicates the quality of soil and accessibility of land. We assume that the biomass emissions are released at the time of deforestation, while the litter and soil follow a decay curve depending on the annual air temperature and precipitation. In the case of afforestation, G4M considers carbon accumulation in tree biomass, litter, and soil leading to negative CO_2 emissions (or CO_2 sink).

The afforestation and deforestation rates were averaged for the periods 1991-2000, 2001-2010, 2011-2015, and 2016-2020 as the data are presented in FAO FRA 2020. The harvest intensity of forests used for wood production is adjusted to match exogenous wood demand for Kenya.

Runs of G4M as applied for this project assume a constant climate. This implies that the model does not account for changes in climate over time or impacts thereof. However, projected climate change scenarios do not differ much by 2030 (WB, 2021[3]).

For consistency with the countries' GHG reports to the UNFCCC, we report the land use change and forestry emissions only for managed forest land and not for unmanaged forest. This is done following the IPCC definitions of managed and unmanaged forest land as of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) and using a spatially explicit layer in the G4M model for filtering out the UNFCCC-managed forests considering their geographical locations. G4M can convert the UNFCCC unmanaged forest land to the UNFCCC managed forest land in the projections if the wood demand is high. After being converted to the UNFCCC managed the forest land is reported as managed by the end of modelling. Only non-protected forest land can be converted to managed.

Within the scope of this project, historical GHG emissions and removals are being reported for the years 1990, 2000, 2005, 2010, 2015, and 2020. GHG projections can be used to assess the feasibility of countries meeting domestic (such as the NCCAP III 2023-2027) and international climate commitments, such as those reflected in Nationally Determined Contributions (NDCs) under the Paris Agreement. While doing so, it is vital to note that the reporting for these periods is a combination of modeling results that have been harmonized with historical data sources, but which may differ from the historical values that countries are applying themselves when calculating fulfilling their commitments.

3.3.1. Mitigation Actions Considered in G4M

G4M also considers CO_2 mitigation options in land use change and forestry which includes reducing deforestation, increasing afforestation, and alteration of forest management. The driver of the mitigation in G4M is the price of carbon that affects the anthropogenic emissions by sources and removals by sinks as covered by the G4M model.

Mitigation options as considered for the different sources of emissions related to the land use change and forestry sector include the following:

- **CO2 emissions from Afforestation**
  - Afforestation: Removals of CO_2 (i.e., sink) due to carbon accumulation in biomass, litter, and soil of the forest planted through payments for the carbon accumulated in tree biomass. The mitigation effect is measured by comparison with a reference afforestation occurring under zero carbon price.
- **CO2 emissions from Deforestation**
  - Deforestation: Avoidance of anthropogenic CO_2 emissions from forest biomass, dead organic matter, and soil. Change in the different carbon pools reflects the outcome of a carbon price. The mitigation effect is measured by comparison with reference deforestation occurring under zero carbon price.
- **CO2 emissions from |Forest Management**
  - Forest Management: CO_2 emissions due to alteration of forest management e.g., forest rotation time. The mitigation effect is measured by comparison with reference forest management emissions occurring under zero carbon price.

Considering the mitigation options that can be modeled in G4M, it was considered to consider for the analysis the policies related to deforestation (100,000 ha) and afforestation which will represent and group the three mitigation measures that are focused on forest plantations, giving a total of 380,000 ha afforested (Table 6).

Table 6. Potential policies to be evaluated.

Activity	Action
Reduce deforestation by rehabilitation and protecting an additional 100,000 hectares of natural forests (including mangroves) by 2030.	Reduce deforestation

[3] https://climateknowledgeportal.worldbank.org/country/kenya/climate-data-projections

Establishment of 5,000 ha of public forest plantations.	Plantations
300,000 ha of commercial forest plantation established.	Plantations
75,000 ha of private commercial forest plantations were established.	Plantations

3.4. Development Scenarios

This section provides a detailed description of how the scenarios were developed and the key assumptions applied within the G4M modeling frameworks.

It is important to note that all scenarios used the same historical baseline data for calibration between 1990 and 2000. In this case, the data reported in the FRA 2015 was used. The section corresponding to the baseline scenario will provide a more detailed description of the variables used and their implications.

3.4.1. Baseline Scenario

A common socioeconomic assumption for Kenya and other world regions is applied for all scenarios simulated in this study, including the Baseline scenario. The socioeconomic assumption follows the Shared Socioeconomic Pathway 2 (SSP2) scenario (Fricko, et al., 2016), which is a "Middle of the Road" scenario that assumes global population, economic, societal, and technological development follows a BAU -usual trend.

Under the SSP2 assumption, the world population is projected to increase by 25% from around 7.7 billion people in 2020 to 9.6 billion people by 2050. Global GDP is projected to double by 2050 compared to 2020 and increase from 130 to 320 trillion USD. The remaining drivers (e.g., change in dietary preferences, technological change) for the agricultural sectors are consistent with the SSP2 Future diets follow the consumption patterns projected by FAO at the horizon of 2050 (Alexandratos & Bruinsma, 2012). For technological change in the crop sector, yield response functions to GDP per capita were estimated for 18 crops using a fixed effects model with panel data. The response to GDP per capita was differentiated over four income groups oriented at the World Bank's income classification system (<1.500, 1.500-4.000, 4.000-10.000, >10.000 USD GDP per capita) to estimate region- and crop-specific productivity changes. This implies that productivity changes are crop and region-specific for Kenya the region corresponds to East Africa. Regional wood demand is projected based on per-capita income growth trends under the SSP socioeconomic pathway and income elasticities that differ across income groups.

Beyond the common socioeconomic setup, the Baseline scenario is characterized by the continuation of current trends (business as usual). No climate stabilization target is considered for the Baseline scenario, which is translated into zero CO_2 prices and relatively stable biomass demand projections for future periods in G4M modeling. There are also no additional biodiversity conservation actions beyond existing protected areas. This indicates no land conversion restrictions or forest management restrictions in biodiversity-rich locations, which are applied only in the biodiversity protection scenario (the "Conservation scenario", to be introduced in section 3.4.3).

The afforestation and deforestation rates are calibrated to the observed values in 1990-2020 based on historical data from FAOSTAT, FRA 2015, and FRA 2020. The forest state in the regions is initialized using historic wood production and observed forest management emissions. Besides the G4M internal drivers, the baseline projection is driven by the agriculture land rent, wood price, wood demand, and agriculture land use obtained from the GLOBIOM setup for the baseline run.

3.4.1.1 Harmonization of Projections

The harmonization approach used ensured that projections are consistent with historical data and that the GHG emission reduction targets based on historical values can be accurately assessed based on the data sources provided by the project team. Thus, the harmonization approach applied, especially the ex-post scaling approach, allowed for a direct comparison of scenario projections to the official target emission levels reported by the government of Kenya. In other words, the projections to the data sources provided by the country and the National Inventory Submissions to the UNFCCC were harmonized and the main harmonization points of G4M were:

- Afforestation and deforestation rates (ha) adjusted for the 1990-2019 period to FAO FRA 2020.

- Forest management emissions and removals ($MtCO_2$) are scaled to 2010-2020 net forest living biomass change from FAO FRA 2020.

To assess whether Kenya's mitigation measures are aligned with its international commitments, such as the Paris Agreement and the Biodiversity Conventions, three additional scenarios were developed for comparison against the baseline. These scenarios are as follows:

- Climate Scenario ("Clima"), which aims to achieve the goal of net-zero emissions.
- Biodiversity Scenario ("Conservation"), which seeks to meet the 30x30 biodiversity protection and restoration targets set under the Kunming-Montreal Global Biodiversity Framework (GBF).
- Combined Scenario, which aims to simultaneously fulfill the objectives of both the Climate and Biodiversity goals.

These scenarios provided a comprehensive framework for evaluating Kenya's capacity to meet its international obligations while balancing climate action and biodiversity conservation.

3.4.2. Clima Scenario

Under the Clima scenario, climate mitigation efforts are aligned with the 1.5-degree Celsius target. The socioeconomic driving forces in this scenario mirror those in the Baseline scenario. Specifically, the Shared Socioeconomic Pathway 2 (SSP2) framework is adopted for consistency across both scenarios.

In this study, the Clima scenario is implemented by setting a carbon budget trajectory consistent with the 1.5-degree target. The carbon budget follows the "EN_NPi2020_600f" trajectory from the ENGAGE database (IIASA, 2021). This trajectory assumes a global cumulative CO_2 emission limit of 600 $GtCO_2$ between 2020 and 2100, corresponding to the "End-of-century budget" scenario (Riahi, et al., 2021). This carbon budget trajectory is translated into increased bioenergy demand and GHG emission pricing in the Clima scenario, which further affects total wood demand, wood price, and agricultural land prices as G4M inputs.

Apart from the above-mentioned mitigation target, there is no additional interventions in this scenario. This indicates that the Clima scenario does not incorporate any additional conservation actions beyond the mitigation measures.

3.4.3. Conservation Scenario

The Conservation scenario assumes a strong commitment to biodiversity protection through achieving the Global Biodiversity Framework and ensuring that 30% of the planet's land surface is under protection by 2030. Areas are classified as highly biodiverse ("biodiversity hotspots") when at least three biodiversity priority schemes overlap, including Conservation International's Hotspots (Conservation International , 2024), WWF Global 200 terrestrial and freshwater ecoregions (World Wildlife Fund, 2024), BirdLife International Endemic Bird Areas (Bird Life International, 2024), IUCN Centres of Plant Diversity (UNEP-WCMC, 2024), and Amphibian Diversity Areas.

The Conservation scenario is focused on biodiversity conservation without climate stabilization or any additional interventions. This scenario is modeled similarly to the "C Scenario" from the Bending-the-Curve study (Leclere, et al., 2020). The implementation consists of two main elements:

1. Increased Land Protection: From 2030 onward, strict land-use change restrictions will be applied in biodiversity hotspots. Land-use changes flows that will have negative impact on biodiversity (e.g., agriculture expansion into natural land), and any forest-related land-use change or management scheme changes (including conversion from unmanaged to managed forest, afforestation, and deforestation) are prohibited in the model.
2. Increased Land Conservation: This involves introducing a new land-use class—restored land—and implementing economic instruments such as subsidies and taxes to influence biodiversity-related land-use changes. Restored Land is created by restoring agricultural production lands (e.g., cropland, pasture, or short-rotation plantation land) to prioritize biodiversity.

The scenario assumes restoration targets derived from the GBF "restoration" target 2, which aims to restore 30% of degraded land by 2030. Global estimates suggest degraded land constitutes 20–40% of total land (2,700–5,400 Mha), of which 810–1,620 Mha could be restored by 2030. Considering that restoring managed land to natural land (the focus of this scenario) should represent 33–50% of this total, a plausible target is set at

540 Mha by 2030, with a doubling to 1,080 Mha by 2070. This approach ensures a comprehensive alignment of the Conservation scenario with ambitious biodiversity conservation goals while maintaining methodological consistency with global restoration benchmarks.

3.4.4. Combined Clima and Conservation Scenario

This scenario combines a 1.5-degree climate stabilization target with biodiversity conservation actions. It integrates the features of both the Clima and the Conservation scenarios, implementing these frameworks simultaneously. This scenario represents a comprehensive approach to achieving both climate and biodiversity goals.

4. Results

4.1. Baseline Scenario results

This section presents the results for the Baseline scenario.

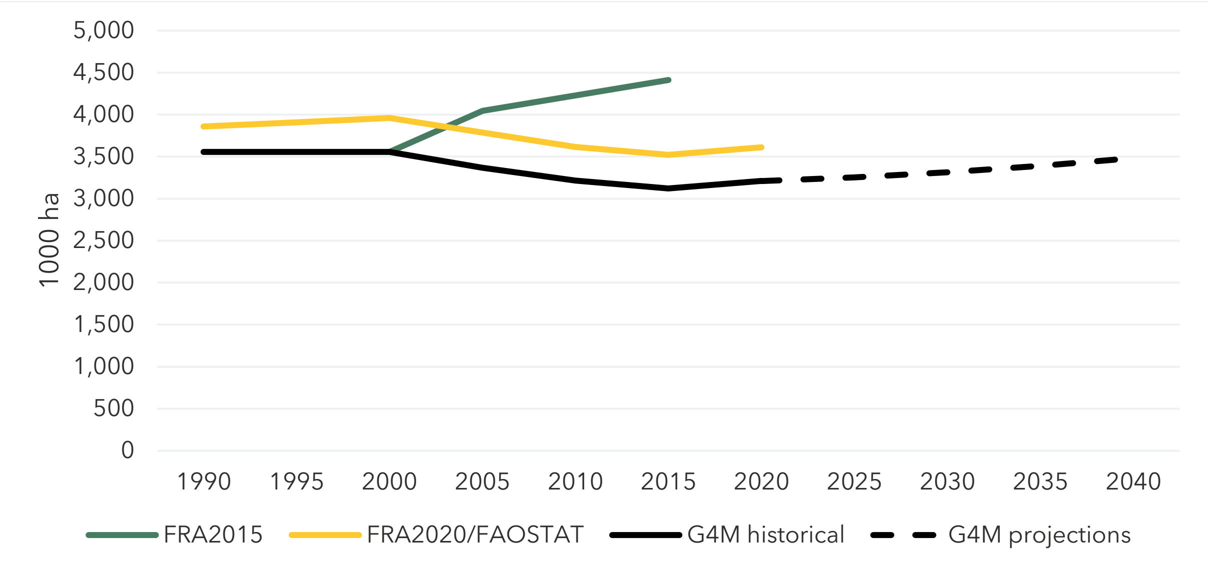
4.1.1. Forest Area

The forest area used as the baseline, was based on the FRA 2015 (FAO, 2015) for the historical period from 1990 to 2000. According to this FRA, Kenya's forest area in the year 2000 was 3,557,000 hectares. Since no data was provided for 1995, the same value was assumed for the entire historical series to maintain consistency within the model.

For the period from 2000 to 2020, the calibration was updated using deforestation and afforestation rates reported in the FRA 2020 (FAO, 2020). This adjustment was necessary because the earlier FRA report did not include these rates. This approach ensures that the historical data aligns consistently with the modeling framework for future projections.

Figure 4 presents a comparison of the data from various reports and the model's historical results, illustrating the consistency with FRA 2015 for the historical period. Furthermore, the trend from 2000 to 2020 aligns with the patterns reported in FRA 2020, demonstrating the integration of updated data in the modeling process.

Figure 4. Historical forest area 1990-2000



For the baseline scenario covering the period 2020 to 2040, it is assumed that historical trends in deforestation and afforestation remain consistent with past patterns. Specifically, a deforestation rate of 6,010 hectares per year and an afforestation rate of 19,650 hectares per year are projected after 2020. Deforestation in G4M is defined as the loss of existing forest area after 2000, and afforestation is the new forest area after 2000. Under this scenario, the lowest forest area, recorded in 2015 at 3,122,260 hectares, is projected to recover, reaching 3,483,020 hectares by 2040.

This is consistent with the trends presented in the baseline scenario of the NCCAP 2023-2027 (Government of Kenya, 2023), where is stated that deforestation begins to decline after 2020 due to an increase in the number and size of trees as a result of tree planting programs, reduced projected wood harvesting and other new forestry-related policies and programs.

4.1.2. GHG Emissions

The most recent GHG emissions inventory published by Kenya is the 2024 Biennial Transparency Report (BTR). However, this study focused on the Second National Communication (SNC) from 2015, as the BTR had not been released at the time of preparing this report. Kenya has also conducted additional estimates of baseline emissions and projected emissions for the forestry sector. These estimates are documented in the country's 2019 Forest Reference Level (FRL) (Ministry of Environment and Forestry, 2019) and the National Climate Change Action Plans (NCCAPs). The most recent of these is the Third NCCAP (2023-2027), which serves as the primary source of data for the present analysis (Government of Kenya, 2023). The methodologies employed in these reports differ significantly.

The GHG inventory for the Second National Communication was developed using the 2003 IPCC Good Practice Guidelines (IPCC, 2003). Under this approach, GHG estimates account for both emissions and removals from land uses that remain within the same land-use category. This includes changes in carbon stocks within a specific land-use type (e.g., increases in carbon stocks in secondary vegetation or primary vegetation within managed areas). In addition, the methodology addressed land-use conversions between the six IPCC-defined land-use categories: Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Land (Table 7).

Table 7. Total LULUCF emissions reported in the Second National Communication (MtCO2e).

	1995	2000	2005	2010
Sub-Total for Forest Land	6,346	13,437	13,202	16,821
Sub-Total for Cropland Land	3,204	6,910	4,084	4,175
Sub-Total for Grassland Land	205	242	250	179
Sub-Total for Wetland Land	0	0	0	0
Sub-Total for Settlements Land	-49	-15	-12	-85
Sub-Total for Other Land	0	0	0	0

Source: (Republic of Kenya, 2015)

Kenya's Forest Reference Level (FRL) for REDD+ is set at 52,204,059 tCO_2/year, based on a combination of Approach 3 mapping and the use of both local and IPCC default values. It reflects the average annual historical emissions from key forest-related activities, namely deforestation, forest degradation, sustainable forest management, and enhancement of forest carbon stocks, for 2002-2018. The calculation includes four years of data for each of these activities.

The breakdown of annual emissions by activity is as follows (Ministry of Environment and Forestry, 2019): Deforestation: 48,166.94 $MtCO_2$; Forest Degradation: 10,885.95 $MtCO_2$; Sustainable Management of Forests: 2,681.43 $MtCO_2$; and Enhancement of Carbon Stocks: 9,530.26 $MtCO_2$.

A significant factor contributing to the differences in emission values reported by Kenya lies in the definition of "forest". While the Second National Communication (SNC) to the UNFCCC used the FAO definition of forest to calculate forest cover and related emissions, the FRL adopted a different forest definition. The differences in these definitions influence which areas are classified as forests, thereby affecting the estimation of emissions from deforestation, forest degradation, and other related activities.

It is also important to recognize that the objectives of a Greenhouse Gas Inventory (GHGI) and a Forest Reference Level (FRL) are fundamentally different. While the GHGI seeks to provide a comprehensive accounting of emissions and removals from all relevant sources and sinks in a given year, the FRL serves as a benchmark for measuring performance under REDD+. For this reason, the comparisons of emissions in this report are made exclusively with Kenya's GHGI.

Another critical difference lies in the scope of land-use categories included in Kenya's FREL, its Second National Communication, and the Global Forest Model (G4M). Not all land-use categories reported by Kenya under the FREL or the SNC are explicitly included in G4M. For instance, G4M focuses primarily on forest-related processes such as deforestation, afforestation, and, in some cases, forest management. However, it does not comprehensively account for all land-use transitions (e.g., forest to settlement or wetland to cropland) reported under IPCC guidelines.

A comparative analysis of the emission sources covered by the IPCC methodologies and those included in G4M is presented in Table 8. This differentiation is critical for understanding how Kenya's emission estimates from its GHGI, FREL, and G4M may differ and why care must be taken when interpreting and comparing these results.

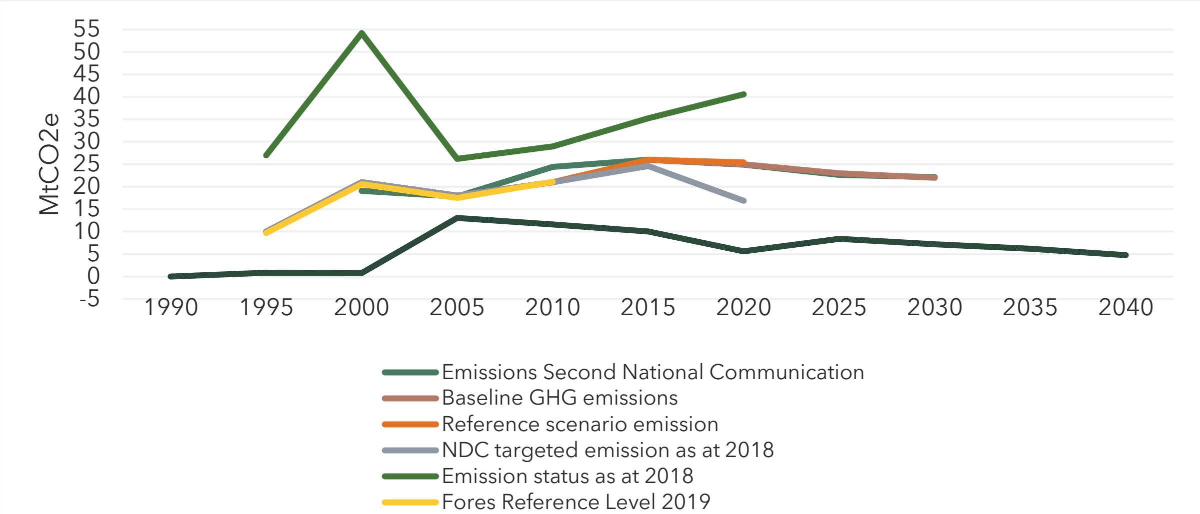
Table 8. Land Use categories under IPCC 2003 and G4M

Land-Use Category	IPCC Emission Categories (1996, 2003, 2006, 2019)	FREL 2019 Kenya	G4M Emission Categories	Notes / Key Differences
Forest Land	- **Emissions from forest degradation** (e.g., selective logging, wildfires, pests)	- **Emissions from forest degradation** (e.g., selective logging, wildfires, pests)	**Forest degradation is** treated as decline in forest biomass	G4M focuses primarily on deforestation, afforestation and development of forest biomass and does not include structural degradation as a separate process unless explicitly defined.
	- **Carbon stock changes in managed forests** (biomass, deadwood, litter, and soil organic carbon)	**Not explicitly included**	**Partially included**	
	- **Emissions from biomass burning** (CO_2, CH_4, and N_2O from forest fires)	**Not explicitly included**	**Partially included**	
Cropland	- **Emissions from conversion of forest to cropland (Emissions from deforestation)** (CO_2 from biomass and soil carbon loss)	- **Emissions from deforestation** (CO_2 from biomass and soils)	- **Emissions from deforestation** (carbon loss from deforestation events)	G4M does not model cropland emissions directly. Instead, it focuses on forest-related processes. Land converted to cropland is accounted for as "deforestation."
	- **Soil organic carbon loss from cropland management** (tillage, crop rotation, etc.)	**Not explicitly included**	**Not explicitly included**	
	- **Burning of agricultural residues** (CO_2, CH_4, N_2O)	**Not explicitly included**	**Not explicitly included**	
Grassland	- **Emissions from conversion of forest to grassland** (carbon emissions from biomass and soil)	- **Emissions from deforestation** (CO_2 from biomass and soils)	- **Emissions from deforestation** (carbon loss from deforestation events)	G4M primarily tracks deforestation, so if forest is converted to grassland, this is counted as deforestation, but ongoing emissions/removals from managed grassland are not modelled.
	- **Loss of soil carbon due to overgrazing**	**Not explicitly included**	**Not explicitly included**	
	- **Grassland fires** (CO_2, CH_4, and N_2O)	**Not explicitly included**	**Not explicitly included**	
Wetlands	- **Emissions from drainage of peatlands** (CO_2, CH_4 from oxidation of peat)	**Not explicitly included**	**Not explicitly included**	Wetlands are not explicitly modelled in G4M. Conversion of forested wetlands may be treated as deforestation, but specific wetland processes (e.g., CH_4 emissions from peat) are not included.
	- **Emissions from wetland conversion** (e.g., to agriculture, settlements)	**Not explicitly included**	**Not explicitly included**	
	- **Peat fires** (CO_2, CH_4, N_2O)	**Not explicitly included**	**Not explicitly included**	
Settlements	- **Emissions from land conversion to settlements** (CO_2 emissions from biomass loss and soil carbon loss)	-Partially included, only for **Emissions from deforestation** (CO_2 from biomass and soils)	-Partially included, only for **Emissions from deforestation**	G4M does not model urbanization or settlement growth. If forest land is converted to a settlement, it is classified as deforestation. Emissions from construction or

			(CO_2 from biomass and soils)	infrastructure development are not modelled.
	- **Soil disturbances** (e.g., construction)	**Not explicitly included**	**Not explicitly included**	
Other Land	- **Emissions from land degradation** (CO_2 from soil erosion and loss of vegetation cover)	**Not explicitly included**	**Not explicitly included**	G4M focuses on forested landscapes, so changes on "other land" are not directly modelled. If forest becomes "degraded land," it is accounted for as deforestation or degradation, depending on the case.
	- **Changes in carbon stocks on degraded or abandoned lands**	**Not explicitly included**	**Not explicitly included**	
Harvested Wood Products (HWP)	- **Emissions from oxidation of harvested wood products** (HWP pool decay, CO_2 emissions from short-lived products)	**Not explicitly included**	**Partially included** (only deforestation-driven emissions)	G4M accounts for emissions from harvesting but does not track long-term storage of carbon in wood products.
	- **Carbon storage in wood products** (long-term storage in construction materials, furniture)	**Not explicitly included**	**Partially included** (only deforestation-driven emissions)	
Soil Carbon Changes	- **Soil carbon losses from land-use change** (conversion of forest to cropland, grassland, settlements, etc.)	**Not explicitly included**	**Partially included** (only linked to deforestation)	G4M accounts for the loss of soil carbon following deforestation, but ongoing soil carbon dynamics (e.g., changes in managed forest soils) are not modelled.
	- **Soil carbon gains from improved land management** (e.g., agroforestry, forest regrowth)	**Not explicitly included**	**Partially included** (only linked to deforestation)	
Biomass Burning (Fires)	- **Emissions from forest fires** (CO_2, CH_4, and N_2O)	**Not explicitly included**	**Partially included** (forest fires linked to deforestation)	G4M includes emissions from biomass burning only in the context of deforestation (e.g., slash-and-burn clearing of forest), but ongoing wildfires in managed forests are not fully modelled.
	- **Emissions from fires in grasslands, wetlands, and croplands**	**Not explicitly included**	**Partially included** (forest fires linked to deforestation)	

As shown in Table 8, there are significant differences in the LULUCF sector emissions reported in Kenya's various national reports and the baseline of the G4M model. These discrepancies are primarily attributed to two key factors. First, as highlighted in the previous table, the differences in the reporting categories are included. Second, the variations in the activity data and emission factors used for the estimations. These methodological differences have a direct impact on the magnitude and comparability of the reported emissions.

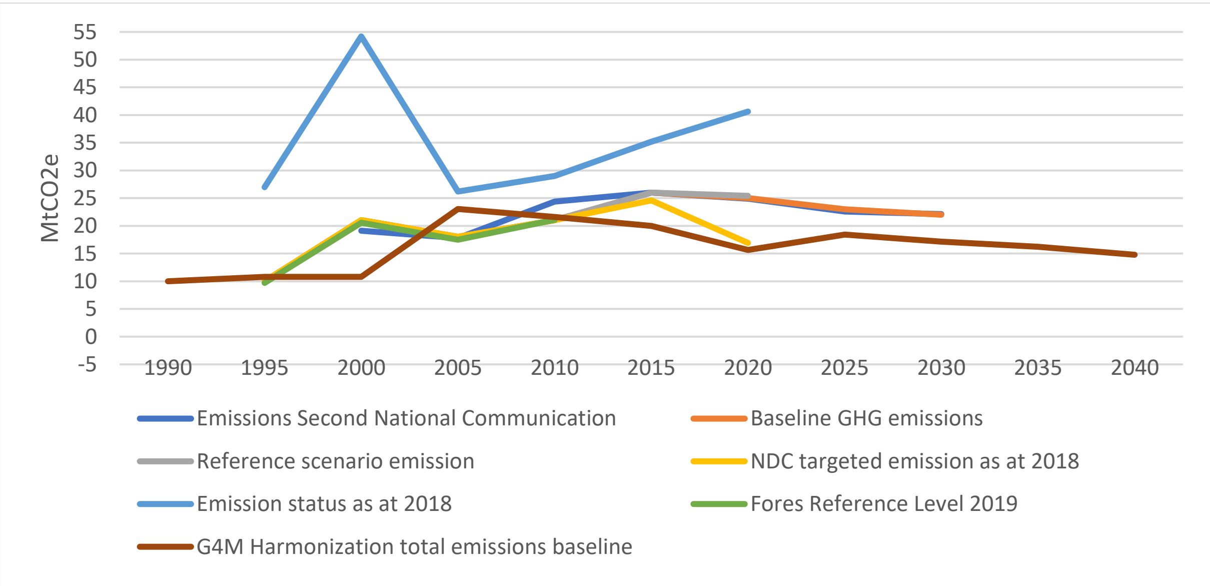
Figure 5. GHG emissions comparison of the LULUCF sector between the different country reports and the G4M baseline.



These methodological differences have a direct impact on the magnitude and comparability of the reported emissions. While the baseline estimated by G4M shows significant discrepancies, these are primarily attributed to differences in the categories included, the definition of forest used, and the activity data, which differ substantially. One of the most notable differences is the deforestation rate, which, under the G4M model, is estimated at 21,780 ha/year, compared to the 338,863 ha/year reported in the Forest Reference Level (FRL) (Figure 5).

Although it is possible to harmonize the country's emissions data with those produced by the model (Figure 6), a more methodologically sound approach would be to assess policies and model data comparing between the different scenarios, avoiding comparison with projections done outside the model. To clarify the analysis done in this report will focus on the trends observed across the different scenarios, comparing between them.

Figure 6. Comparison of the GHG LULUCF country data and G4M harmonization results



4.2. Comparison to the Baseline Scenario

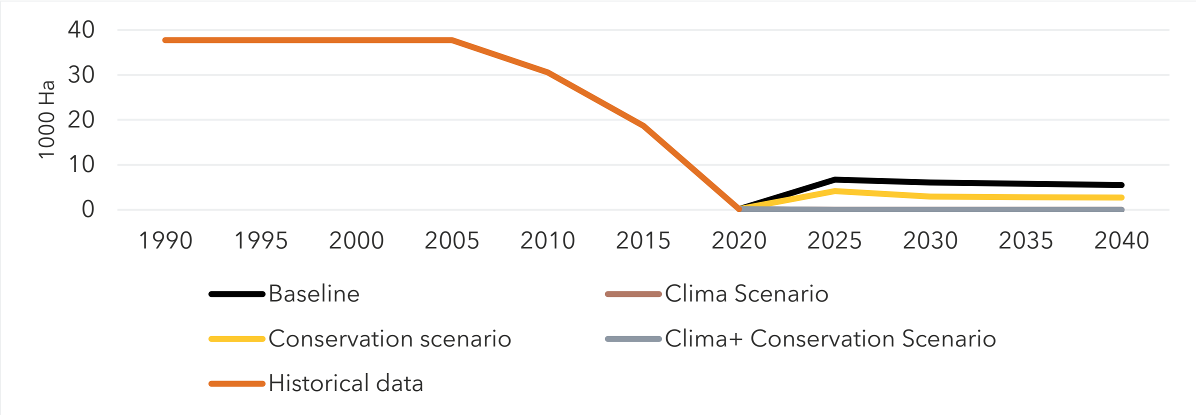
The analysis of the different scenarios will be focused on Kenya's policies: deforestation -to reduce 100,000 ha of deforestation by 2030 -and forest plantation (understood as afforestation) -to afforest 380,000 ha by 2030-; forest area, GHG emissions, and harvesting, considering that biomass is fundamental for the current energy security of the country.

4.2.1. Deforestation

The historical deforestation data reported in the FRA 2020 serves as the starting point for Kenya's baseline deforestation trajectory. According to this data, deforestation rates reached approximately 38,000 hectares per year until 2005, marking the peak of deforestation activity. From this point onward, a declining trend is observed, reaching its lowest point in 2020. However, the baseline scenario in the G4M model projects that annual deforestation will resume an upward trend, peaking at 6,000 hectares in 2030, before gradually declining to approximately 5,500 hectares by 2040 (Figure 7).

Deforestation is the primary contributor to Kenya's GHG emissions, as highlighted in the National Climate Change Action Plan (NCCAP) III (2023-2027). The mitigation measures outlined in Kenya's climate strategy aim to reduce and ultimately eliminate deforestation in the long term. To meet its commitment under the Paris Agreement – specifically, achieving net-zero emissions – Kenya needs to reduce deforestation to zero (Clima Scenario in figures). While the FRL 2019 aligns with this goal in the medium term, achieving a deforestation rate of zero requires more ambitious and sustained efforts. This shift is particularly challenging due to Kenya's reliance on biomass energy, which contributes significantly to deforestation rates. Therefore, in addition to halting deforestation, the country must also transition towards a cleaner, more diversified energy mix.

Figure 7. Deforestation across the different scenarios



If conservation becomes the primary objective, the projected deforestation extent will be smaller than the baseline, but some level of deforestation can continue. In this scenario, deforestation follows a downward trend since 2025, and it is projected to be 20% lower than the baseline by 2025 and nearly 50% lower by 2040. While this scenario ultimately aims for a deforestation rate of zero in the long term, it allows for some degree of deforestation in the interim. Importantly, unlike in climate-focused strategies, the emphasis in conservation scenarios is not on the rate of deforestation itself but on the location and protection of conservation areas. This means that under the Conversation scenario, mitigating land-use-related emissions is not the primary target; rather, it is the spatial designation of conservation areas that takes precedence.

To achieve its biodiversity targets, Kenya must reduce deforestation by at least 50% compared to the baseline scenario by 2040, which would position the country to meet its conservation objectives. While this approach may put Kenya on track to meet its biodiversity goals, the slower reduction pace implies that it may achieve its climate objectives later than originally expected.

Notably, while the Climate Scenario aims for zero deforestation, the Conservation Scenario allows for ongoing deforestation, although at a reduced rate. This difference results in an estimated additional 1 $MtCO_2e$ of emissions in the Conservation Scenario compared to the Climate Scenario (see section GHG emissions).

Kenya faces a significant challenge in aligning its climate and biodiversity goals. Under a combined scenario that aims to achieve both objectives, deforestation must be reduced to zero. Given Kenya's specific context, a zero-deforestation strategy is the only viable approach to meeting both its climate and biodiversity commitments. As can be seen in Figure 7, the Climate Scenario (orange line) reaches zero deforestation ahead of the Combined Climate + Conservation Scenario (yellow line).

Kenya's climate policy includes a commitment to reduce deforestation by a cumulative value of 100,000 hectares by 2030, compared to a 2020 baseline. This goal set by Kenya is a challenging objective. Using the baseline scenario as a point of comparison, the country would not be able to achieve this target of hectares without deforestation under any of the scenarios evaluated for 2030. The climate scenario, which is the most ambitious, presents a cumulative avoided deforestation of approximately 63,000 hectares by 2030 and nearly 93,000 hectares by 2040 (Table 9). These same values are projected for the combined climate + conservation scenario. Under these two scenarios, zero deforestation is assumed. It is important to note that this only considers the values obtained from the scenarios, and the deforestation rates produced by the model are lower than those reported by the country.

Table 9. Cumulative avoided deforestation for the different periods compared between the scenarios and the baseline (Ha).

Comparison between the scenarios and the baseline	2025	2030	2035	2040
Base- Clima	33,586.4	63,895.25	92,745.3	120,190.15
Base- Conservation	12,749.4	28,377.1	4,3181.5	57,076.25
Base- Clima+ Conservation	33,586.4	63,895.25	92,745.3	120,190.15

This discrepancy highlights a key challenge: the historical data used to develop the deforestation reduction target is based on older, higher estimates, while more recent data reflects lower deforestation rates. As a result, the country's 100,000-hectare reduction goal is significantly more ambitious than the trajectories produced by both the Climate and Conservation Scenarios.

The analysis reveals that Kenya's current deforestation mitigation policies, particularly the goal of reducing deforestation by 100,000 hectares by 2030, are more ambitious than the scenarios produced by G4M. Achieving a zero-deforestation rate is essential for meeting Kenya's climate and biodiversity commitments. While the Climate Scenario achieves this goal earlier, the Conservation Scenario allows for a slower reduction, with deforestation rates reaching zero at a later stage.

For Kenya to meet its commitments under the Paris Agreement and biodiversity conventions, it must pursue a combined strategy that not only reduces deforestation but also shifts its energy demand away from biomass dependence. This combined approach offers the best chance of achieving both climate and biodiversity goals simultaneously.

4.2.2. Afforestation

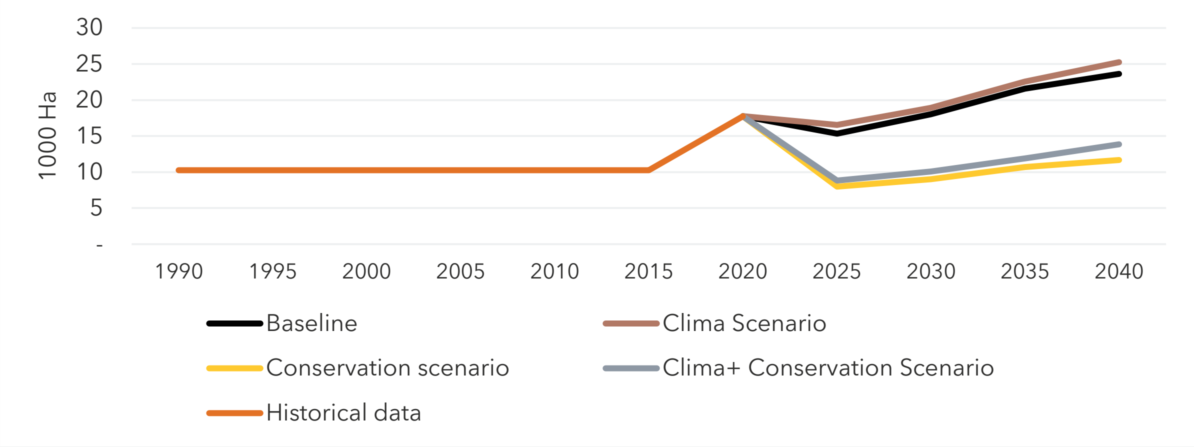
Afforestation presents a significant opportunity for Kenya to increase its carbon sinks, yielding both short- and long-term benefits. Historical data indicate an upward trend in afforestation rates, with the highest values recorded in 2020. However, under the baseline scenario (BAU), afforestation rates are projected to decline until 2025, reaching a low point before gradually recovering.

The scenario with the highest afforestation requirement is the Climate Scenario, which aims to increase carbon sinks while simultaneously reducing deforestation. Under this scenario, Kenya would need to afforest, on average, 1,000 hectares more per year than under the BAU scenario (Figure 8). This effort would result in an average annual afforestation rate of approximately 21,000 hectares from 2021 to 2040. By 2030, the cumulative afforested area under this scenario would reach approximately 82,000 hectares. This afforestation effort is critical for achieving the country's net-zero emissions goal.

If Kenya were to focus only on its biodiversity conservation commitments, the afforestation strategy would differ significantly. Under this scenario, afforestation rates are projected to be the lowest among all scenarios, averaging 9,000 hectares per year, which is about 50% lower than the Climate Scenario. This is because certain areas with potential for afforestation hold intrinsic biodiversity value if maintained as non-forest natural vegetation[4], thereby limiting the available area for afforestation. Priority is given to zones previously designated s protected areas, where no additional activities, including afforestation, are allowed.

[4] The reduced afforestation area in the Conservation scenario (compared to the Baseline or Clima scenario) is due to reduced afforestation from other natural vegetation (the available land for afforestation considered in G4M) instead of less afforestation from cropland/pasture.

Figure 8. Annual afforestation across the different scenarios (1000Ha)



A combined approach that integrates climate and biodiversity objectives produces an intermediate afforestation outcome. Under this scenario, annual afforestation rates increase by an additional 2,000 hectares per year compared to the Conservation Scenario. However, the afforestation rate remains approximately 40% lower than the Climate Scenario. From 2025 to 2035, the afforestation rate in the combined scenario follows a growth trajectory like the Climate Scenario, with an average annual growth rate of 14% (Table 10). By 2040, however, this rate will increase to 16%, 4 percentage points higher than the Climate Scenario.

These findings suggest that over the long term, the afforestation trajectory under the combined scenario may eventually converge with that of the Climate Scenario, although the cumulative area afforested would differ significantly. This underscores the need for long-term scenario analysis to better understand the potential differences in total afforestation under each strategy.

Kenya's climate policy aims to afforest 380,000 hectares by 2030. If achieved, this target would exceed the afforestation required to meet the long-term net-zero goal. However, meeting this ambitious target requires careful planning. Based on current projections, Kenya would only reach this cumulative target under the BAU scenario by 2039. If Kenya follows the Climate Scenario, it could achieve this goal by 2037, but only with sustained increases in afforestation efforts.

To accelerate progress, it is recommended that Kenya implements field-based actions and increases afforestation rates in the short term. Without this intervention, the country may struggle to meet its 2030 target. Moreover, under the combined Climate + Biodiversity Scenario, afforestation rates would be significantly lower, making it even more challenging to achieve the 380,000-hectare target, under this scenario the country needs to redefine the areas that will be considered for afforestation. This means that under the conservation scenario, not all the available land for afforestation should be considered for this activity, the prioritization will be focused on the areas not relevant for conservation.

Table 10. Cumulative afforestation under different scenarios (1,000 Ha)

	2025	**2030**	**2035**	**2040**
Baseline	76.6945	166.90	274.87	393.05
Clima Scenario	82.737	177.35	290.18	416.47
Conservation scenario	39.9264	85.02	138.56	196.94
Clima+ Conservation Scenario	44.1498	94.54	154.06	223.26

Given Kenya's specific context and the high priority placed on biodiversity conservation, it may be necessary to reassess and revise afforestation policies and strategies. Relying solely on afforestation as a pathway to achieve climate and biodiversity goals may not be the most effective approach. Instead, Kenya could consider diversifying its mitigation policies within the LULUCF sector, focusing on measures that contribute to both climate action and biodiversity conservation. For example, instead of prioritizing large-scale afforestation, forest landscape restoration or agroforestry systems could provide more integrated solutions that support biodiversity, increase carbon sequestration, and maintain livelihoods.

By doing so, Kenya can create a more synergistic approach to its climate and biodiversity commitments, ensuring that trade-offs are minimized and that the country is better positioned to meet its Paris Agreement and biodiversity conservation targets simultaneously.

4.2.3. Forest area

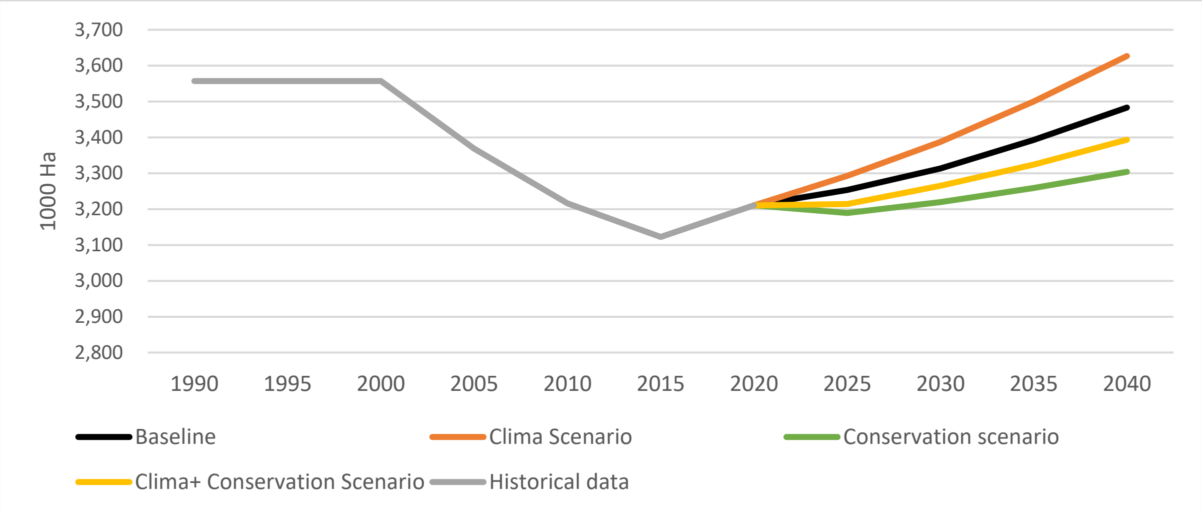
The evolution of Kenya's forest area is primarily driven by historical forest cover and the rates of afforestation and deforestation under each scenario. Historically, the lowest level of deforestation was recorded in 2015, as discussed in previous sections, followed by a recovery in forest cover by 2020. Across all scenarios, the projected forest area shows a general upward trend under a BAU trajectory.

The Climate Scenario projects the largest forest area among all the evaluated scenarios. This outcome is driven by the objective of achieving net-zero emissions in the long term, which requires larger forest areas to increase carbon sequestration capacity. By 2040, the total forest area is projected to reach approximately 3.36 million hectares, representing an increase of 150,000 hectares compared to the forest area in 2020. This growth is achieved through sustained efforts to both reduce deforestation and promote afforestation, resulting in a steady net increase in total forest area.

The Conservation Scenario projects the smallest forest area among all scenarios, reaching approximately 3.3 million hectares by 2040, an increase of only 90,000 hectares relative to 2020. During the period 2020 to 2025, the scenario experiences a slight decline of 21,000 hectares, representing a 1% decrease in forest area relative to the 2020 baseline. This decline is later offset by gradual recovery, but the rate of forest growth remains low, averaging only 1% per five-year period. This limited growth is attributed to the strict conservation measures implemented under this scenario, which restrict land-use transitions. Unlike the Climate Scenario, the Conservation Scenario prioritizes the protection of existing natural landscapes, preventing the conversion of non-forest land into forest. As a result, there is limited potential for large-scale afforestation or reforestation efforts.

A more balanced approach is presented in the Combined Climate and Conservation Scenario (represented by the yellow line in Figure 9). This scenario seeks to harmonize climate and biodiversity objectives, leading to intermediate outcomes. The projected forest area in this scenario is lower than the BAU scenario but higher than the Conservation Scenario. This intermediate position results from the dual constraints of maintaining existing non-forest lands in biodiversity hotspots while still promoting afforestation as a climate mitigation strategy.

Figure 9. Total forest area across the different scenarios



Unlike the Conservation Scenario, the Combined Scenario allows for selective land-use transitions to forest, which enables efforts in forest recovery and reforestation. However, unlike the Climate Scenario, this approach limits large-scale land conversion for afforestation, prioritizing areas with high biodiversity value. This compromise between the two goals results in a gradual increase in forest area, albeit at a slower pace than the Climate Scenario.

The projected forest area under each scenario reflects Kenya's policy priorities and strategic choices. The Climate Scenario emphasizes maximum afforestation and forest recovery to meet net-zero commitments, leading to the largest increase in forest area. In contrast, the Conservation Scenario prioritizes the protection of existing ecosystems, limiting land-use change and afforestation opportunities. The Combined Scenario attempts to balance both goals, producing moderate increases in forest area that reflect Kenya's ambition to align its climate and biodiversity commitments.

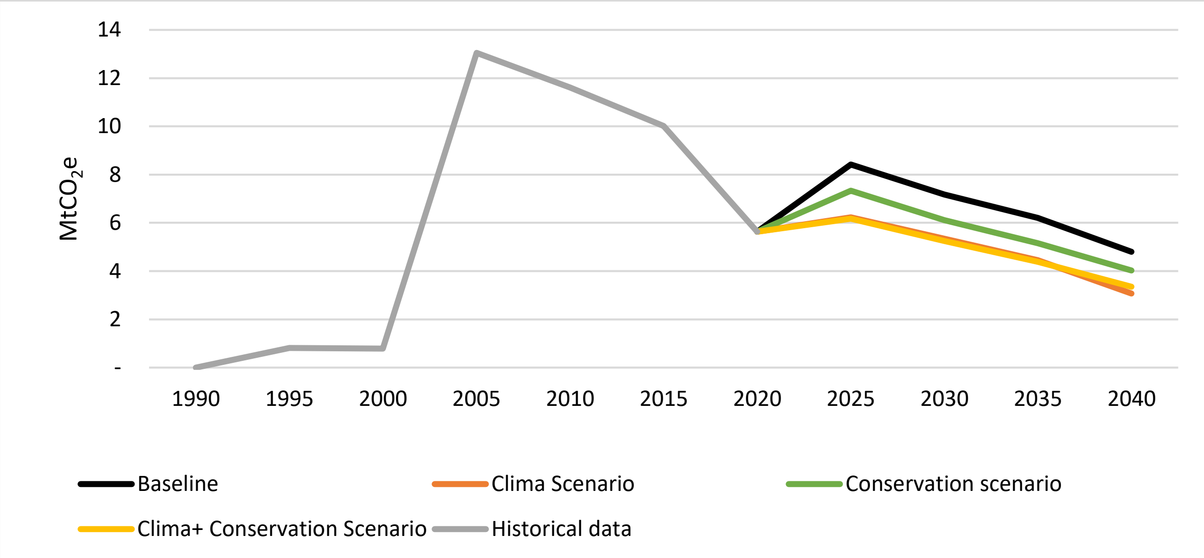
These findings highlight the trade-offs and synergies between climate mitigation and biodiversity conservation strategies. While pursuing climate goals requires more significant afforestation efforts, conservation-oriented strategies emphasize the preservation of natural landscapes and restricted land-use transitions. The results underscore the need for a coherent policy framework that addresses these dual objectives, with special attention to the balance between forest expansion and landscape preservation.

4.2.4. GHG emissions

As described in the Baseline Scenario section, the emission categories reported in G4M are not directly comparable to the emissions reported by Kenya in its national reports. Therefore, this section focuses solely on the comparison of emissions across the different modeled scenarios, excluding direct comparisons with the country's official reference values.

The historical emissions trajectory of Kenya's LULUCF sector shows that the highest peak in emissions occurred in 2005, followed by a steady downward trend that reached its lowest point in 2020. The development of future scenarios begins from this point. In general, all scenarios exhibit a similar pattern, with a peak in emissions in 2025, followed by a declining trend thereafter, which is consistent with the increase in the afforestation rates (Figure 10).

Figure 10. GHG emissions across the different scenarios



The primary goal of the Climate Scenario is to achieve net-zero emissions by 2050. While emissions increase between 2020 and 2025, reaching a peak of 6.23 $MtCO_2e$, the scenario demonstrates one of the steepest emission reduction trajectories. By the end of the period, emissions are reduced to 4.77 $MtCO_2e$, making this the scenario with the lowest emissions by 2040. This substantial reduction is driven by the implementation of strong mitigation measures, including efforts to reduce deforestation and promote afforestation.

The Conservation Scenario results in higher emissions than the Climate Scenario but lower emissions than the BAU scenario. By 2025, emissions peak at 7.33 $MtCO_2e$, and by 2040, they decline to 5.66 $MtCO_2e$. This outcome reflects the focus on biodiversity conservation. While deforestation is allowed in some areas, specific zones are designated as protected or conservation areas, which restricts land-use transitions. This approach explains the more moderate emissions reduction, as the strategy emphasizes landscape conservation rather than a full transition to forest cover.

The Combined Climate and Biodiversity Scenario follows a trajectory very similar to the Climate Scenario, especially during the period 2020 to 2035. During this phase, emissions in the combined scenario remain only slightly lower than those in the Climate Scenario, with differences of less than one percentage point as shown in Figure 10. After 2035, the Climate Scenario demonstrates a faster decline in emissions, resulting in slightly lower final emissions than the combined scenario. By 2040, emissions in the Combined Scenario reach approximately 4.79 $MtCO_2e$, which is only 0.02 $MtCO_2e$ higher than emissions in the Climate Scenario.

The results of the Combined Scenario demonstrate that it is possible to simultaneously meet Climate and Biodiversity objectives, but this requires careful planning. Such planning should not be limited to identifying specific mitigation activities, such as afforestation or deforestation avoidance, but should also include spatially explicit planning. This means determining precisely where these activities should take place to optimize the dual goals of emissions reductions and biodiversity conservation.

An essential factor to consider is the role of biomass energy in Kenya's energy matrix. Given the country's dependence on biomass for electricity generation, a reduction in biomass consumption would significantly contribute to emissions reductions. A combined approach involving spatially explicit land-use planning and a transition to cleaner energy sources could position Kenya to achieve its climate and biodiversity objectives. This strategy would not only ensure compliance with international commitments like the Paris Agreement but also support long-term conservation goals.

5. Conclusion

Kenya's commitment to achieving the climate goals of the Paris Agreement and the biodiversity goals of the Kunming-Montreal Global Biodiversity Framework requires an integrated and strategic approach to the design of mitigation measures. This approach must balance emissions reduction, biodiversity conservation, and sustainable land use, ensuring that efforts are not isolated. In this way, the implementation of measures will have cross-cutting benefits and enable the simultaneous achievement of multiple objectives.

Scenario analysis reveals that climate and biodiversity goals are not mutually exclusive. The similarity in emissions reductions between the Climate Scenario and the Combined Climate and Biodiversity Scenario demonstrates this compatibility. However, achieving both goals requires better land-use planning, an energy transition, and changes in policies related to afforestation and deforestation.

The Combined Climate and Biodiversity Scenario follows a trajectory very similar to the Climate Scenario, especially from 2020 to 2035, with only slightly higher emissions. By 2040, the difference between these two scenarios is 0.02 $MtCO_2e$, indicating that the joint climate and biodiversity goals are achievable with proper planning.

The analysis also shows that Kenya's forest area is projected to increase under all scenarios, consistent with national commitments. Under the Climate Scenario, forest cover reaches 3.36 million hectares by 2040, which is 150,000 hectares more than 2020 levels. In contrast, the Conservation Scenario results in a smaller increase, reaching 3.3 million hectares by 2040, just 90,000 hectares more than in 2020. This difference reflects the emphasis on protected areas and biodiversity conservation in the Conservation Scenario, which restricts certain types of land-use transitions.

Afforestation efforts play a fundamental role in achieving climate goals. Historical data shows an upward trend in reforestation rates, with a peak in 2020, after which rates decline slightly but then recover. The Climate Scenario projects an average annual reforestation rate of 21,000 hectares per year between 2021 and 2040, significantly higher than the 9,000 hectares per year under the Conservation Scenario. This reflects the need for integrated approaches that balance reforestation efforts with biodiversity protection.

Kenya has set a target to reduce deforestation by 100,000 hectares by 2030. However, model results suggest that the reduction achieved under the Climate Scenario would only reach 64,000 hectares, highlighting the challenge of meeting national policy goals and the need for greater short-term action. The main driver of deforestation in Kenya is the use of biomass for energy, making a transition to a cleaner energy matrix crucial for the country\u2019s success.

Kenya’s energy sector relies heavily on biomass, which is a major driver of deforestation. Reducing biomass consumption while ensuring access to affordable energy presents a significant challenge. Without clean energy alternatives, it will be difficult for Kenya to meet its climate commitments and reduce deforestation. Therefore, a just energy transition is a fundamental component of Kenya’s strategy to achieve net-zero emissions.

The Conservation Scenario allows for controlled deforestation in certain areas to maintain biodiversity, contrasting with the need to completely avoid deforestation in the Climate Scenario. This commitment highlights the challenge of achieving dual objectives under the Kunming-Montreal Framework and the Paris Agreement. While it is possible to simultaneously pursue climate and biodiversity goals, careful spatial planning is required to identify areas for protection, areas for afforestation, and areas for sustainable development.

Achieving the objectives of the 30x30 strategy will require continuous efforts to strengthen existing policies, resolve land-use conflicts, and promote sustainable agricultural practices. Conservation areas will play a vital role in this endeavor, especially in promoting community-driven conservation. By maintaining a balance between regulatory oversight and community empowerment, Kenya can ensure that biodiversity conservation and sustainable development mutually reinforce each other.

Significant differences exist in the emissions reported by the G4M model, the Second National Communication, the NCCAP, and the FRL. This divergence is due to differences in forest definitions, data sources, and reporting categories. The G4M model and national reports use different approaches to define and classify forests, resulting in discrepancies in deforestation rates and associated emissions. Harmonizing definitions and methodologies is essential to align national inventories with international reporting frameworks. Furthermore, the results highlight the need to improve the data used by consolidating it with official data that is consistent across different reports, which will enhance transparency and strengthen consistency between national reports.

5.1. Future Improvements

Some potential improvements that could be implemented to enhance the results obtained in this analysis are:

- Update of FRA data: Upgrade from the 2015 and 2020 versions to the 2025 version, which will also be consistent with the country's new reports.
- Recalibration of estimates: Once Kenya publishes its new GHG inventory as part of the Biennial Transparency Report or a new National Communication, the estimates can be recalibrated so that the model results are comparable with the country's estimates.
- More detailed analysis of harvested wood products (HWP): A more in-depth analysis of harvested wood products can be included, allowing for an evaluation of biomass use as an energy source. This will also require a review of energy policies as a complementary measure.
- Collaboration with relevant stakeholders: Engage with key stakeholders so that the results of this analysis can be considered for national reports, such as the Biennial Transparency Report or the progress report on Nationally Determined Contributions (NDCs).

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