MINISTRY OF TOURISM AND ENVIRONMENTAL AFFAIRS

MODIFIED FOREST REFERENCE EMISSION LEVEL KINGDOM OF ESWATINI JULY 2026



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ACKNOWLEDGEMENT

This document was created with the assistance of the Coalition for Rainforest Nations and under the auspices of the Ministry of Tourism and Environmental Affairs. We extend our heartfelt thanks to the Coalition for Rainforest Nations for providing their technical and financial support towards the capacity-building process of the Eswatini technical group. We would also like to express our gratitude to the Climate Change Unit under the Department of Meteorology in the Ministry of Tourism and Environmental Affairs for their logistic support and technical input during the development of this document.

We are grateful to the UNESWA team led by Dr. Wisdom Dlamini, Dr. Sizwe Mabaso, and Dr. Samkele Tfwala for their technical guidance during the production of this report. We also want to extend our appreciation to the report drafting team led by Eloise Guidi from CfRN. The members of the drafting team included Dr. Wisdom Dlamini, Dr. Samkele Tfwala, Dr. Sizwe Mabaso, Sandile Gumedze, Wilfred Nxumalo, Nkosinathi Jele, Vumelani Dlamini, Sipho Shiba, Sikhumbuzo Maseko, and Patrick Dlamini.

We would like to thank the Eswatini Technical team for participating in the training program and for collecting the data that was analysed to come up with this report. We also extend our thanks to the CfRN team, which included Eloise Guidi, Milena Nino, Alphonse Bizimana, Marcia Arias and other team members, for conducting the training lessons. Finally, our appreciation is extended to the Eswatini National Focal Point to the UNFCCC, Ms Khangeziwe Mabuza for the support during the training and production of the report.

LIST OF ACRONYMS

AFOLU	Agriculture, Forestry, and Other Land Use
BUR	Biennial Update Report
BTR	Biennial Transparency Report
CfRN LUA App	Coalition for Rainforest Nations Land Use Assessment Application
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties
ETF	Enhanced Transparency Framework
FAO	Food and Agriculture Organization (of the United Nations)
FOLU	Forest and Other Land Use
FRL/FREL	Forest Reference Level / Forest Reference Emissions Level
Gg	Gigagrams
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GPG	Good Practice(s) Guidance
GWP	Global Warming Potential
Ha	Hectare
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LULUCF	Land Use, Land Use Change and Forestry
LDC	Least Developed Countries
m^3	Cubic metre
MPG	Modalities Procedures and Gridlines
MRV	Monitoring, reporting, and Verification
N_2O	Nitrous oxide

NFI	National Forest Inventory
NIR	National Inventory Report
NAP	National Adaptation Plan
NDC	National Determined Contribution
NDVI	Normalised Difference Vegetation Index
PA	Protected Areas
SoER	State of the Environment Report
TNC	Third National Communication
TOA	Top of Atmosphere
UNESWA	University of Eswatini

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Summary

Table 1: summary

Date of submission	July 2026
REDD+ Activities Included	-Reducing emissions from deforestation -Reducing emissions from forest degradation
Scale	National
Historical reference period	2016-2020
Results period	2021-2025
FRL value per year of results period	1 077 435 t CO2e / year

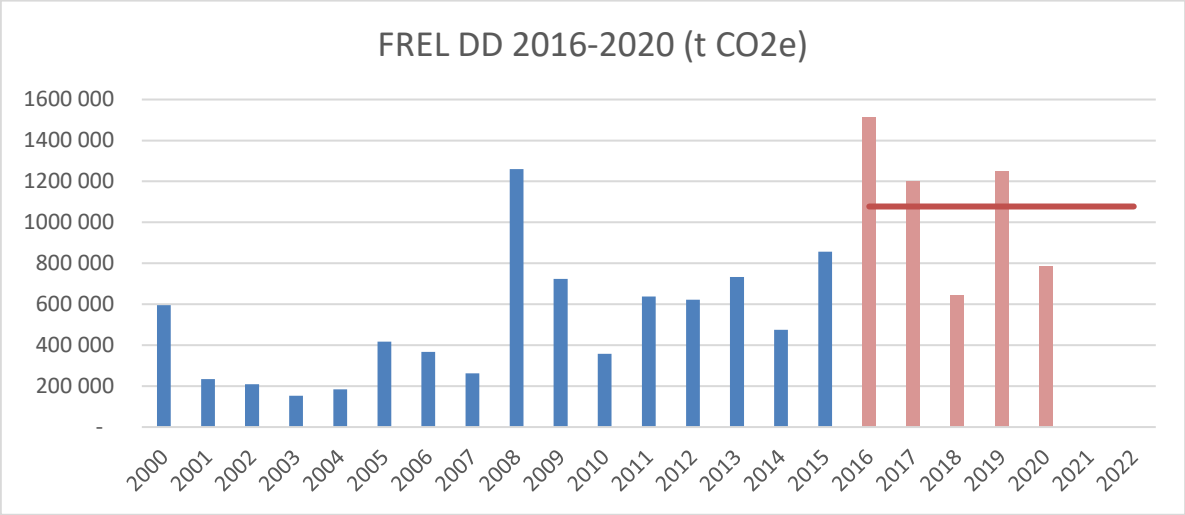


Figure 1: Eswatini's Modified Forest Reference emission level

Table 2:Annual emissions from forest degradation and deforestation (uncertainty %)

Unit: t CO2e	TOTAL forest-related emissions	Forest Reference level (historical average 2016-2020 forest related emissions)
2016	1 513 947 *(21.63%)*	
2017	1 199 123 *(24.91%)*	
2018	641 394 *(32.67%)*	
2019	1 246 487 *(21.80%)*	
2020	786 221 *(27.99%)*	
2021		1 077 435 *(15%)*
2022		1 077 435 *(15%)*
2023		1 077 435 *(15%)*
2024		1 077 435 *(15%)*
2025		1 077 435 *(15%)*

1. Introduction

Eswatini is presenting its first Forest Reference Emission Level (FREL) to the United Nations Framework Convention on Climate change (UNFCCC) with a view of accessing results-based payments for the reduction of emissions from deforestation andforest degradation (REDD. The country is also considering generating post-2021 REDD+ ITMOs following the requirements of article 6 of the Paris Agreement.

This submission is voluntary and for the purpose of obtaining and receiving result-based payments for REDD+ activities. The country has made its best effort to present the information in a transparent, accurate, consistent and complete manner following the principles of the 2006 Intergovernmental Panel of experts on Climate Change (IPCC) guidelines and decisions 13/CP.19 paragraph 2 and 14/CP.19 paragraphs 7 and 8. Eswatini is applying the step wise approach and is planning to improve over time by including national values instead of tier 1 default emission factors.

This submission is Eswatini's first national Forest Reference Emission Level. This Modified FREL is national, covering all the forests in the country. The FREL serves as the benchmark for two REDD+ activities as defined in paragraph 70 of decision 1/CP.16. The present national FREL submitted by Eswatini is based on the net Greenhouse gas (GHG) emissions for the Forest remaining Forest land losses, and forest converted to other land use categories and country specific land use subcategories. The selected FREL has a value of 1 077 434 t CO2e based on the historical average of years 2016-2020 with the results based period would cover the years 2021-2025..

1.1 Forest Reference Emission level according to Decision 12/CP.17

The table below explains how the FREL approach fully aligns with COP decisions for REDD+ reference levels, particularly decision 12/CP.17:

Table 3: Modalities for FREL

Modalities for submission of FREL/FRL (12/CP.17)	Elements for justification
7. Agrees that, in accordance with decision 1/CP.16, paragraph 71(b), forest reference emission levels and/or forest reference levels expressed in tonnes of carbon dioxide equivalent per year are benchmarks for assessing each country's performance in implementing the activities referred to in decision 1/CP.16, paragraph 70;	· Eswatini's FREL is expressed in tonnes of CO_2 equivalent per year. The benchmark used for the current FREL is based on the historical average of the years 2016-2020. · By setting this historical average, Eswatini expresses its intention to get recognition for emissions reductions against the FREL

8. Decides that forest reference emission levels and/or forest reference levels, in accordance with decision 1/CP.16, paragraph 71(b), shall be established taking into account decision 4/CP.15, paragraph 7, and maintaining consistency with anthropogenic forest- related greenhouse gas emissions by sources and removals by sinks as contained in each country's greenhouse gas inventories;	· Eswatini's FREL is based on the estimation of emissions during a historical reference period 20016-2020, noting that this 5 year historical reference period is part of 20 years time-series going back to year 2000. · Updated methods, data, assumptions, and results will be consistent with (and will serve as the basis for) in the national GHG inventory included in the second BTR.
9. Invites Parties to submit information and rationale on the development of their forest reference emission levels and/or forest reference levels, including details of national circumstances and if adjusted include details on how the national circumstances were considered, in accordance with the guidelines contained in the annex to this decision and any future decision by the Conference of the Parties;	· Through this submission, Eswatini is providing information and a rational on national circumstances affecting the FREL. · This approach does not include an adjustment.
10. Agrees that a step-wise approach to national forest reference emission level and/or forest reference level development may be useful, enabling Parties to improve the forest reference emission level and/or forest reference level by incorporating better data, improved methodologies and, where appropriate, additional pools, noting the importance of adequate and predictable support as referenced by decision 1/CP.16, paragraph 71;	- The FREL is national scale. - Eswatini will use the step-wise approach to improve the estimation of emissions that underlie the FREL approach, following IPCC guidance and guidelines, and as methods, data and knowledge improves.

11. Acknowledges that subnational forest reference emission levels and/or forest reference levels may be elaborated as an interim measure, while transitioning to a national forest reference emission level and/or forest reference level, and that interim forest reference emission levels and/or forest reference levels of a Party may cover less than its entire national territory of forest area;	· The FREL approach applies to national scale, as it attempts to recognize national-level efforts in conserving national-level emissions from forest.
12. Agrees that a developing country Party should update a forest reference emission level and/or forest reference level periodically as appropriate, taking into account new knowledge, new trends and any modification of scope and methodologies;	· See above, on paragraph 10.
(a) Information that was used by Parties in constructing a forest reference emission level and/or forest reference level, including historical data, in a comprehensive and transparent way;	Before applying the historical average, Eswatini first estimated emissions following IPCC guidance and guidelines for the period 2000-2020. The 5 years historical reference period was selected as it reflects the most current trend in forest-related emissions.
(b) Transparent, complete, consistent and accurate information, including methodological information, used at the time of construction of forest reference emission levels and/or forest reference levels, including, inter alia, as appropriate, a description of data sets, approaches, methods, models, if applicable and assumptions used, descriptions of relevant policies and plans, and descriptions of changes from previously submitted information;	· The FREL is based on transparent, complete, consistent, and accurate information. · All descriptions of methods, data and assumptions are provided in this report.

(c) Pools and gases, and activities listed in decision 1/CP.16, paragraph 70, which have been included in forest reference emission levels and/or forest reference levels and the reasons for omitting a pool and/or activity from the construction of forest reference emission levels and/or forest reference levels, noting that significant pools and/or activities should not be excluded;	Two REDD+ activities, emission reductions from deforestation and emission reduction from forest degradation are taken into account in this national FREL effectively covering all forest-related emissions. All carbon pools and GHGs have been taken into account in relation to these two activities. Other activities may be significant, however, Eswatini lacks sufficient data for their inclusion in the present FREL.
(d) The definition of forest used in the construction of forest reference emission levels and/or forest reference levels and, if appropriate, in case there is a difference with the definition of forest used in the national greenhouse gas inventory or in reporting to other international organisations, an explanation of why and how the definition used in the construction of forest reference emission levels and/or forest reference levels was chosen.	· The forest definition used in this FREL will be consistent with the national GHG inventory; any differences between definitions and with other definitions used in reporting to other international organisations would be explained.

1.2 Importance of Removals for Eswatini

Eswatini is in a unique situation as a **net carbon sink country**, meaning that its carbon removals exceed its emissions, according to the latest data for the 2000–2020 period developed in parallel with this FREL/FRL (Figure 2). This places Eswatini in a distinctive position to lead climate action, particularly through strengthened governance and increased financial resources that enable its forests to continue removing carbon from the atmosphere. This would help maintain—or even increase—net removals at the national level, thereby enhancing the country's contribution to reducing global atmospheric CO_2 concentrations.

According to Eswatini's latest national greenhouse gas (GHG) inventory, submitted in 2025 as part of its first Biennial Transparency Report (BTR) to the UNFCCC, the energy, industrial processes and product use (IPPU), Agriculture and waste sectors emitted a total of 2213.94 kt of CO2 eq in 2022 (without LULUCF). The country becomes a net remover when adding the LULUCF sector with – 1922.2 kt CO2 eq in 2022 (Kingdom of Eswatini, 2025).

Eswatini has therefore already achieved the balance between emissions and removals—commonly referred to as net zero—that the Paris Agreement requires countries to reach by the second half of the century (Article 4, paragraph 1 of the Paris Agreement).

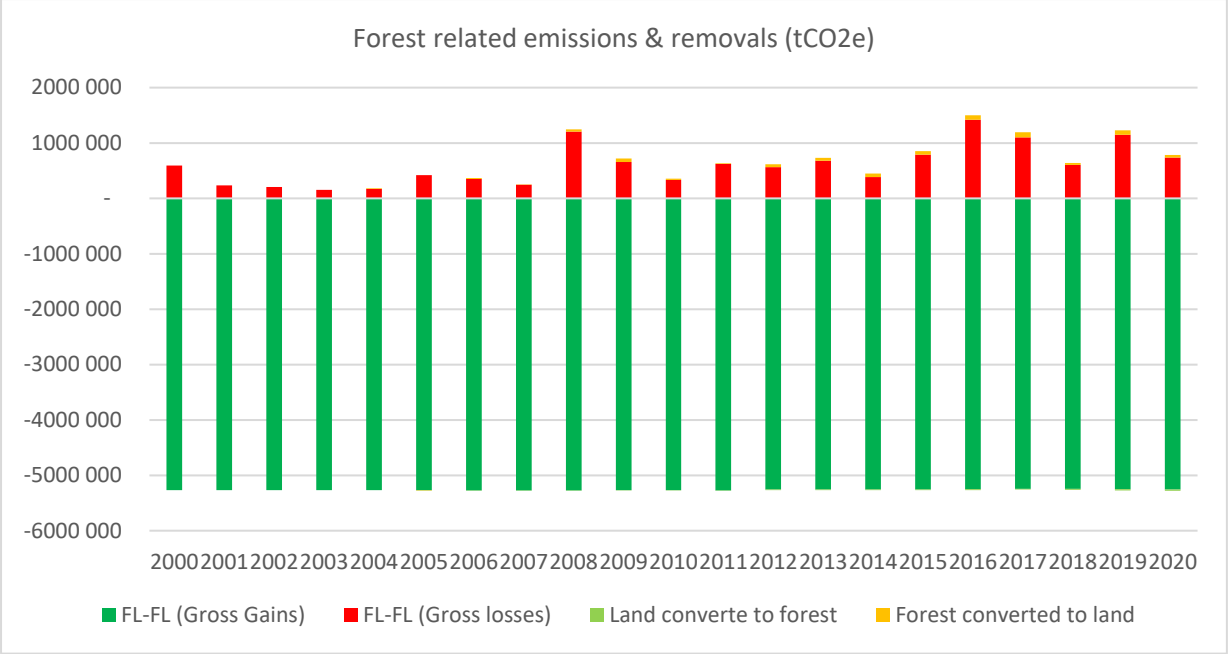


Figure 2: emissions and removals from 2000-2020 Forest sector (as indicative information)

Table 4: Emissions and removals for the forest sector in Eswatini (as indicative information)

Unit : tCO2e	FL-FL (Gross Gains)	FL-FL (Gross losses)	Land converted to forest	Forest converted to land	Net emission/removals
2000	-5 269 797	592 654	-	-	-4 677 143
2001	-5 269 797	234 416	-	-	-5 035 381
2002	-5 269 797	208 193	-	-	-5 061 604
2003	-5 269 797	152 295	-	-	-5 117 502
2004	-5 269 363	173 265	-	10 318	-5 085 780
2005	-5 268 496	416 679	-3 361	-2 727	-4 857 905
2006	-5 273 365	351 378	-3 561	14 038	-4 911 509
2007	-5 273 798	247 765	-1 854	3 720	-5 024 168
2008	-5 272 064	1 205 970	-3 157	42 377	-4 026 874
2009	-5 266 328	657 993	-3 157	62 937	-4 548 555
2010	-5 265 895	334 442	-5 331	23 745	-4 913 038
2011	-5 271 197	619 201	-3 938	14 680	-4 641 253
2012	-5 256 591	565 274	-10 045	48 595	-4 652 767
2013	-5 258 325	680 307	-9 780	49 209	-4 538 588
2014	-5 257 458	386 252	-10 791	60 353	-4 821 644
2015	-5 256 157	788 017	-10 387	63 196	-4 415 332
2016	-5 253 556	1 418 090	-13 109	82 282	-3 766 293
2017	-5 243 818	1 102 176	-15 051	91 378	-4 065 315
2018	-5 245 119	600 842	-19 746	33 933	-4 630 091
2019	-5 253 122	1 149 655	-20 594	81 655	-4 042 406
2020	-5 257 124	736 447	-22 786	42 682	-4 500 780

The Role of Net Sink Countries under the Paris Agreement

Net zero is a benchmark approach firmly rooted in the ultimate objective and level of climate ambition of the Paris Agreement, as set out in Article 4, paragraph 1:
In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with the best available science, so as to achieve a balance between anthropogenic emissions by sources and anthropogenic removals by sinks of greenhouse gases in the second half of this century, on the basis of equity and in the context of sustainable development and efforts to eradicate poverty.
Based on the latest national GHG inventory submitted by Eswatini under the Paris Agreement and the UNFCCC, the country has already achieved this balance between emissions and removals and, beyond that, exhibits significant net forest removals (as reported in the BTR). This situation positions Eswatini as a global reference example in terms of atmospheric CO_2 removal and should be supported by the international community.

The IPCC's Call for Net-Zero Emissions Economies
According to the IPCC Special Report on Global Warming of 1.5°C, "maintaining decarbonization rates consistent with limiting warming to 1.5°C would be unprecedented and impossible without rapid transformations toward a global net-zero emissions economy by the middle or second half of the century." The IPCC also emphasizes that "this requires, in the short term, more transformative public policy frameworks that enable pathways toward deep decarbonization and a net-zero emissions energy system during the period 2040–2060."

The IPCC further indicated that enhanced action to achieve the goals of the Paris Agreement "would require reaching net-zero CO_2 emissions in less than 15 years." The report concludes that "limiting warming to 1.5°C implies achieving global net-zero CO_2 emissions around 2050."
As a sovereign State and Party to the Paris Agreement, Eswatini is implementing measures aimed at preserving its status as a net-zero emissions economy, thereby helping to pave the way toward a carbon-neutral global economy during the second half of the century.
The FREL/FRL presented here will enable the country to continue reducing emissions from deforestation and forest degradation. It represents an important step toward this long-term vision by promoting the conservation of critical forest ecosystems through the mobilization of financial support aimed at maintaining Eswatini's role as a carbon sink for the benefit of humanity.

2. General context

The kingdom of Eswatini is a landlocked country covering an area of 17.364km^2 in Southern Africa, lying between South Africa and Mozambique. Economically, the country relies on the exportation of agricultural products such as sugar, beef, citrus, forestry products and textiles (Ministry of Tourism and Environmental Affairs, 2016). Agriculture is the primary economic sector with maize production for commercial and subsistence purposes and is the staple crop for the citizens. The national landscape is quite hilly with a mosaic of agricultural areas with high mountain grasslands for pasture, forest plantation for commercial and domestic wood production, indigenous forests, and wetlands forms and types (rivers, ponds, marshes, dams, and peatlands). Notably, the country has four physiographic regions, Highveld, Middleveld, Lowveld and Lubombo plateau, representing the different reliefs from west to east, see image below (Ministry of Tourism and Environmental Affairs, 2016) as shown in Figure 2. The total population in 2017 was estimated to be around 1.093.238 citizens with 76,2% of the population living in rural areas (Ministry of Tourism and Environmental Affairs, 2021). The climate is tropical to temperate with a summer rainy season (October to April) and a dry winter season (May to August).

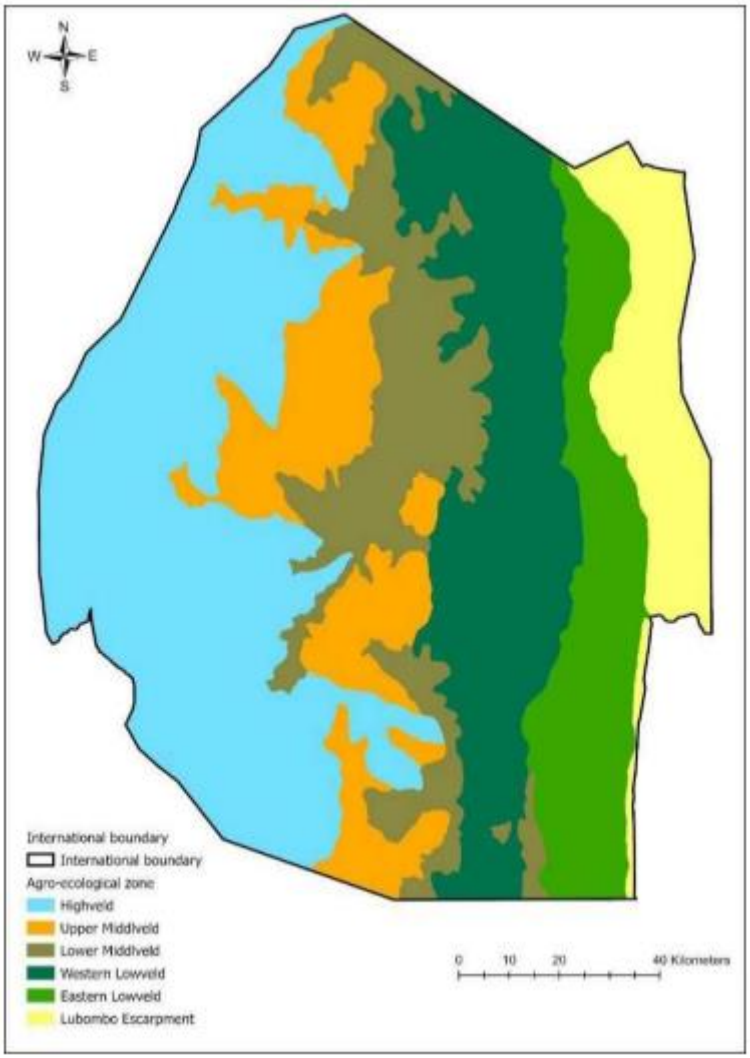


Figure 3: Map showing the Agro-ecological Zones in Eswatini. (Source: SoER, 2022)

Rainfall also impacts the regions differently from the west to the east. Northern Highveld is the moister area with an annual average rainfall of 1500mm during the rainy season. However, rainfalls have highly decreased between 2000-2010 according to Eswatini's Third National Communication. Mean annual temperatures vary from 17°C in the Highveld to 22°C in the Lowveld. The Lowveld region on the border with Mozambique registers the highest temperatures.

Croplands covered 23% of the country in 2020 (CfRN LUA Assessment, October 2023). Sugar cane represented 74% of the total agriculture output in 2015. This cash crop represented 13% of Eswatini GDP in 2015 (Third National Communication, 2016). Other cash crops are citrus and bananas. On the other hand, Maize is the national staple crop requiring 118.000 metric tonnes annually. The country has been able to produce on average only 100 '000 metric tonnes annually, which implies large imports to cover local demand. Commercial agricultural land is found mainly on Title Deed Land, which is one type of land use management in the country. In Eswatini, the land is managed under Title Deed Land (31%) or Swazi Nation Land (69%). This system ensures that all the population has access to land ownership to build their homes and grow some crops, even the poorest part of the population. Grazing can be found on the Swazi Nation Land. It is estimated that only 20% of the country area is arable land, increasing pressure on this natural resource due to human population growth.

The forestry sector involves mainly pine and eucalyptus plantations and wattle forest to provide wood timber, saw logs, pulp and biofuel, mining timber and other products from timber. In 2020, plantations, wattle forest and woodlots represented 11% of the total country area (CfRN LUA Assessment, October 2023). The establishment of plantations occurred prior to the year 2000. It is important to note that within our analysis for the period from 2000 to 2020, no natural forests were converted into plantations. Minor expansions of some plantations into areas previously designated as croplands and grasslands were assessed during the data collection.

Increase in fires and floods have fragilized the sector. First commercial production started in 1949 and the area of plantation has since expanded (National Forest Policy, 2002). Plantations of pine and eucalyptus have a high degree of management as compared to wattle forests where the scale has always been much smaller, and the management has greatly deteriorated over the years. The wattle forests today have spread uncontrollably around the Highveld and upper Middleveld regions. The commercial forestry and related processing industry form a very important part of the economy of Eswatini, contributing approximately 15 % to GDP, mainly through exports. The forestry sector, including the secondary processing sector, provides employment to approximately 8. 000 people, which is 8 % of total formal employment in Eswatini. Commercial forestry in Eswatini is entirely run by private companies, of which Sappi-Usutu now trading as Montigny Investments, Mondi Forest now trading as TWK Peak Timbers and Shiselweni Forestry Company are the largest. These three companies, together with some smaller ones, manage a total area of about 130.000 ha covered by forest plantations. Of this total area, about 25.000 ha (20 %) is unplanted and used for infrastructure and for the protection of biodiversity and ecosystems (National Forest Policy, 2002). Further works will be undertaken by the country to adjust these areas with the observed areas of plantation forests from remote sensing to ensure full monitoring over the years.

The types of forest are distributed according to varied elevation and rainfall. On the western Highveld, the high elevation is favourable to dense montane and highland forest, the rainfall is also very good for commercial growing. This is where most of the plantations are located (National Forest Policy, 2002). The open grasslands on the top of Highveld hills are where livestock is brought for pasture. This region is also where most of the commercial plantations of eucalyptus and pine have been established as the climate favours fast growth. In the lower altitudes in the Highveld, some acacia/wattle can be found. The Middleveld region is also split between upper and lower, the upper section has some of the wattle forest, while the lower part is covered by the open bushlands and the open mixed woodland.
In the Lowveld, the forest goes from west to east, from acacia woodland to dry acacia woodland.
The eastern part of the country at the border with Mozambique, which is called the Lubombo Region, is covered mainly by the mixed woodland and the dry acacia woodland. Figure 3 shows the general distribution of the forest cover types.

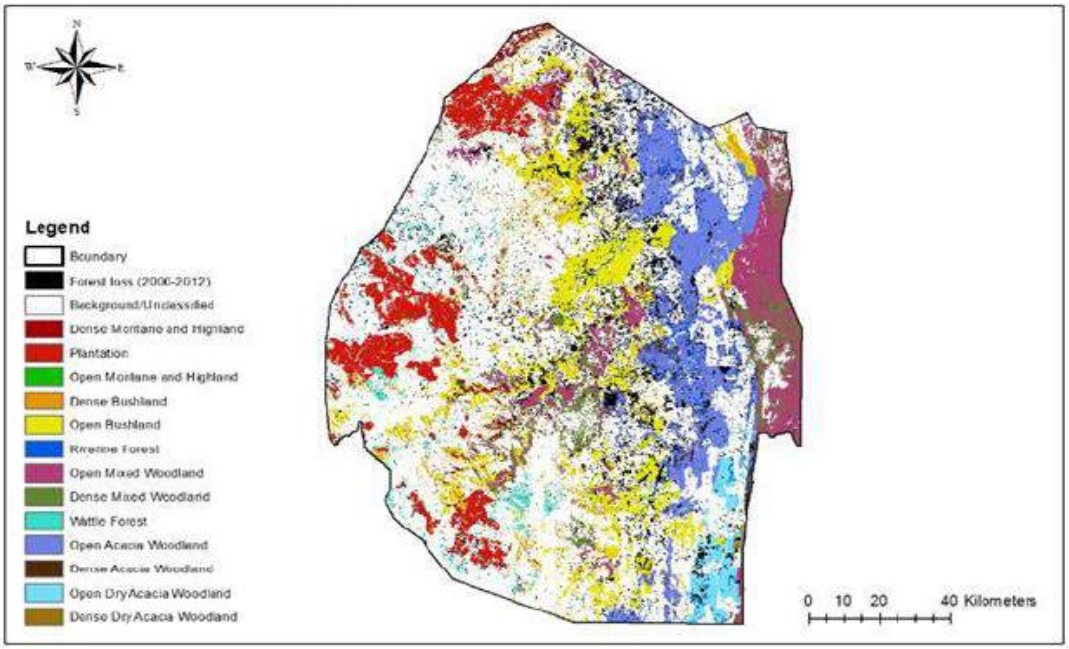


Figure 4: Map showing forest cover in Eswatini (Source: TNC, 2016)

The forest inventory done in 1999 by the national authorities showed that forests covered 45% of the land of which 2,2% were natural forest, 22% natural woodlands, 13.4% natural bushlands, 1,4% wattle forest and 6,4% plantations. Based on the latest assessment done in 2023, in the year 2020, the forest area covers around 46% of the country, followed by grasslands 24%, croplands 23%, settlements 4%, wetlands 2% and other land 1%. The 46% of forest comprises 24% plantations, wattle forest and woodlots, and the rest is natural forest. Deforestation rate for the historical period 2000-2020 has been estimated at 811.61 ha of forest lost per year, which is a rate of 0,1% (CfRN LUA App assessment, October 2023).

Table 5: Proportion of forest and other land uses in 2020

Area per land use in 2020		Ha	Proportion by national classes %	Proportion by IPCC classes %
Forestland	Dryer acacia savannah forest	401.297	23,11%	46%
	Moister acacia savannah forest	97.619	5,62%	
	Montane and highland	48.471	2,79%	
	Plantations	125.575	7,23%	
	Riparian	64.253	3,70%	
	Wattle forest	40.581	2,34%	
	Woodlots	23.221	1,34%	
Cropland	*Annual crop*	390.250	22,47%	23%
	Perennial crop	9.018	0,52%	
	Agroforestry	6.763	0,39%	
Grassland	Bushveld	215.303	12,40%	24%
	High mountain grasslands	206.736	11,91%	
Wetland	Natural water bodies	18.938	1,09%	2%
	Artificial water bodies	8.792	0,51%	
Settlement	Settlements	45.766	2,64%	4%
	Woody settlements	19.163	1,10%	
Otherland	Other	13.978	0,80%	1%
	Mining	676	0,04%	
Total		**1.736.400**	**100 %**	100%

The drivers of deforestation and degradation include the increased demand for settlements and agricultural land which is mainly due to the increase in population and the extension of sugar cane fields and other commercial crops especially in the Middleveld and Lowveld regions, respectively. There is also over-exploitation of indigenous forests which is exacerbated by the high demand for firewood for fuel and other forest products for livelihoods and domestic usage in the Middleveld where a high rate of urbanisation is observed. Drivers of land degradation in Eswatini have been listed in the Land

Degradation Neutrality Target Setting programme (Dlamini T., 2018). In Eswatini, degradation can either be classified on non-forest land or forest, the former occurs across all land use sectors and is mainly characterised by soil erosion that is witnessed through the formations of gullies and dongas whereas the latter is whereby the flora species richness and distribution is greatly reduced and may even result in loss of biodiversity in a forestland remaining forestland. Natural causes that have been intensifying due to climate change are loss of biodiversity, pests, floods and droughts and uncontrolled fires.. In the 2002 National Forest Policy it was underlined that forest degradation was indirectly caused by poverty, hunger, access to land and unemployment and that these problems will have to be solved in parallel to the policy making in order to ensure efficiency of the forest policies (National Forest Policy, 2002).
Based on the assessment for the FREL historical period the main drivers of forest degradation monitored are by order of amplitude: infrastructure, agriculture and grazing (CfRN LUA APP assessment, October 2023).

Traditionally, forestry has largely focused on industrial production, but today its impact on social and environmental matters is fully recognized. The proper use and management of forest and woodland resources is essential to sustain the livelihoods of rural communities. Forestry today is an integral part of most land use systems; hence it must be considered in national planning as a priority in resource allocation. Cross-sectoral working relationships and integrated approaches in forest planning are key elements in today's holistic development strategies.

These development trends are also clearly occurring in Eswatini, and they consequently enhance the importance and relevance of forestry, such as in the following areas of interest:

- The essential contribution to GDP and national accounts, not only from the formal plantation sector, but also the informal sector, such as from non-timber forest products.
- Relevance of forestry in biodiversity conservation, an obligation of Eswatini to the Convention on Biological Diversity (CBD).
- Utilisation of forestry in combating desertification, an obligation of Eswatini to the Convention to Combat Desertification (CCD).
- Importance of forestry in providing essential sources of energy.
- Relevance of forestry to tourism development, in particular eco-tourism.
- The role of urban and peri-urban forestry, to improve quality of life.
- Cooperation and partnership between the industrial forestry sector, Government, rural communities and other relevant stakeholders.

2.1 Policies and plans

The Kingdom of Eswatini ratified the United Nations Framework Convention on Climate change (UNFCCC) in 1996. This was followed by the adoption of the Kyoto Protocol in 1997, recognizing the complex effects of climate change on the evolution of humankind. Eswatini ratified the Paris Agreement in 2016. As a party to the convention, Eswatini is committed to pursue coordinated actions to reduce greenhouse gas (GHG) emissions and climate change impacts while continuing to advance sustainable economic development.

Eswatini is not a major contributor to the global Greenhouse Gas (GHG) emissions. Although the impacts of climate change are largely linked to the historical and contemporary industrial development of other

nations, like most countries in the Global South, the country is disproportionately impacted by the changing climate. Under these circumstances Eswatini presented its enhanced Nationally Determined Contribution (NDC) in October 2021, acknowledging that despite their contribution to climate change emissions being miniscule, the country is committed to climate action. The country intends to communicate that climate resilient, sustainable, and equitable development are its priorities (Ministry of Tourism and Environmental Affairs, October 2021).

The Eswatini's updated NDC contains contributions planned in the adaptation sectors of Agriculture, Water, Health, Ecosystems and Biodiversity and Infrastructure; mitigation sectors of Energy and Transport, Waste, Industrial Processes and Product Use (IPPU) and Agriculture, Forestry and Other Land Use (AFOLU) and cross cutting areas of Gender, Youth and Disaster Risk Reduction (DRR). These include 33 outcomes, 96 outputs and 270 key performance (NDC Implementation Plan Narrative, April 2023). The forest sector is included in the section of Ecosystems and biodiversity adaptation contribution with the goal to:

- **Strategically plan and manage** ecological infrastructure including grasslands, rivers, wetlands, woodlands, and **forests** including updating and implementing the National Biodiversity Strategy and Action Plan (NBSAP) and ensuring that vulnerable ecosystems are addressed in national adaptation programmes.
- **Reduce pressures driving biodiversity loss** (e.g., **deforestation**, human settlements) to improve carbon sinks and promote eco-tourism
- **Conduct research, innovation, and knowledge sharing** for income generation through use of **tree resources and non-timber forest products**.

In the AFOLU sector, Eswatini commits to move from Tier 1 to Tier 2 GHG inventory and improve data collection and institutional arrangements by 2030. Furthermore, the country commits to reducing land degradation (including in mountain ecosystems) through restoration including tree planting and improving livelihoods through better livestock management. The country aims to plant 10 million trees (Ministry of Tourism and Environmental Affairs, 2021).
The agricultural sector represents opportunities for mitigation measures, particularly those related to conservation agriculture, manure management and changing practices associated with sugar cane production, the restoration and management of grasslands, afforestation, reforestation and forest conservation, among others. The forestry sector is vulnerable to the effects of climate change impacts, specifically drought, increased fire risks, floods and pests. The protection of this sector is critical not only due to its status as a national industry (and source of employment) and its GHG removal potential, but also due to the forestry sector being a source of energy in both rural and industrial contexts (Ministry of Tourism and Environmental Affairs, 2021).

2.1.1 National Policy Documents addressing Climate Change Issues

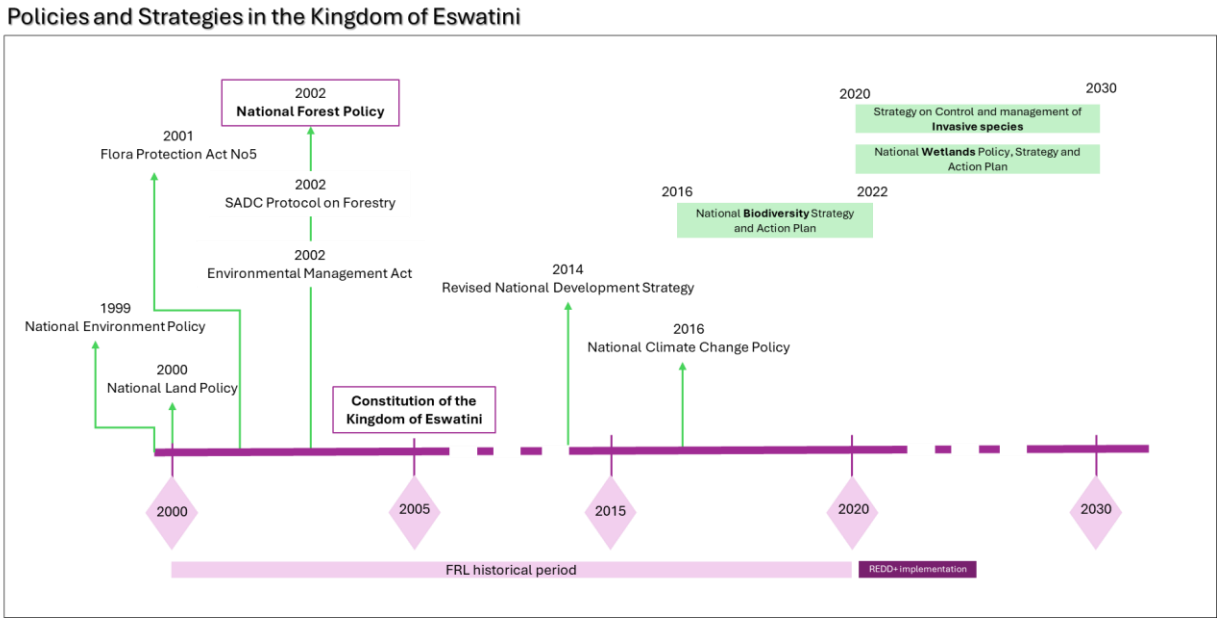


Figure 5: Eswatini's Policies and measures covering forestland

The Government of the Kingdom of Eswatini has embarked on several initiatives and planning frameworks in pursuit of sustainable development of her people. Eswatini also has a set of policies and strategies more general to incorporate land use management in regard of adaptation to climate change, notably:

The Constitution of the Kingdom of Eswatini Act (No. 1/ 2005) – emphasises through Government; protection and rational/ sustainable use of its land, mineral and water resources as well as its fauna and flora. Section 216 (1) requires that every person shall promote the protection of the environment for the present and future generations (King and the Parliament of Swaziland, 2005).

National Climate Change Policy (2016), which supports the priorities outlined in the National Development Plan. The aim of the policy is to provide the enabling framework that will guide Eswatini in addressing the challenges posed by climate change, per relevant sectors in the country. The policy options are specifically aligned with the commitments (Ministry of Tourism and Environmental Affairs, 2016).

The National Development Strategy (NDS), formulated in 1997 and reviewed in 2014, is the overarching framework that provides a platform for the achievement of sustainable development in the country. It seeks to balance the needs of the Swazi people with the environment's capacity (Ministry of Economic Planning and Development, Government of Swaziland, 2014).

The National Land Policy (NLP) (2000) translates the vision of the NDS into a land-related context. The NLP addresses nation-wide issues under six headings, namely Human Rights Issues and Policies, Cultural Issues and Policies, Land Tenure Issues and Policies, Land Use and Land Management Issues and Policies, Land Market Issues and Policies and Land Administration Issues and Policies.

The draft National Environment Policy (NEP) (1999) is intended to be the national policy to protect and conserve the environment and to attain sustainable development in Eswatini. The most direct reference to forestry, which is an integral part of the environment affected by the policy, is the 'user-pays' principle, which is explained as follows. Many natural resources including land, indigenous forestry, and water are free or under-priced, which leads to over-use and degradation or depletion. The costs and benefits of resource use should be internalised through the use of clearly defined property rights, providing 'green' subsidies to encourage environmentally beneficial behaviour and 'brown' taxes and charges to increase the cost of activities which pollute or otherwise degrade the environment.

The National Biodiversity Strategy and Action Plan (NBSAP) (2016 – 2022) recognises that the biodiversity in Eswatini is unusual for a country so small; six physiographic zones are normally spread over a much wider area. As is to be expected with the importance of forestry in the biosphere, references to forestry also pervade this document. It makes reference to forestry's importance in social value systems, both in the formal economic and traditional senses. It recognizes uncontrolled cutting of wood as one of the six serious threats to the habitat; the loss of indigenous trees is also the loss of shelter for birds, animals, etc (Ministry of Tourism, Environment and Communications, 2016).

Draft National Wetlands Policy (2020), Strategy and Action Plan (2020 - 2030), through these instruments it is anticipated that wetlands would be able to make a greater contribution to the sustainable development of the Kingdom of Eswatini through enhanced wetlands management, utilisation and conservation.

2.1.2 Policies & measures in the context of Forest

Eswatini has established a series of policies and measures covering all the forest on the national territory. These policies and measures can be listed as summarised in Table 5 below.

Table 6: Policies of the Kingdom of Eswatini on forests[1]

Policy	Description	FL-FL	L>FL	FL>L
National Forest Policy (2002)	which addresses the rapid population growth in relation to a complex of related issues, including changing health conditions and care, worsening unemployment, increased consumption needs and gender equity. The environment is recognized as an important factor in population matters. The draft Policy notes with concern the **increasing environmental degradation,** with **increased population pressure** as one of its main underlying causes. The draft Policy recommends promoting community **forests and land reclamation programmes**, as well as review of cultural practices that have a negative influence on the environment. High incidence of poverty and malnutrition are related to high levels of food insecurity. Agriculture and forestry are recognized as important sectors with respect to income and employment. The draft Policy recommends intensification and diversification of production to improve food security and nutrition levels (Ministry of Agriculture and Cooperatives, 2002).			
Environment Management Act of 2002	This is an Act to provide for and promote the enhancement, protection and conservation of the environment and ensure there is sustainable management of natural resources. One of its fundamental principles is to ensure renewable resources and ecosystems are used in a manner that is sustainable and does not prejudice their availability and integrity. Section 12 (1) of the Act states clearly the roles of the Environment Authority under this Act in order to provide for and promote the protection, conservation and enhancement of the environment and the sustainable management of natural resources including forests. To ensure compliance and enforcement of the Act, Section 60 (1) gives authority to the Board to appoint any public officer or any officer of the local			

[1] The full policies can be accessed on the supporting document link: https://drive.google.com/file/d/1ZQ_RNCm0akllX8FnuD8BcKL29aSyC-2I/view?usp=sharing

Policy	Description	FL-FL	L>FL	FL>L
	authority including community members to become inspectors who will ensure that all people comply with the requirements of the Act.			
Flora Protection Act No5 (2001)	This act seeks to ensure that there is conservation and sustainable utilisation of indigenous forest resources in the country.			
Eswatini National Strategy for the control and management of the Invasive Alien Plant Species (2020-2030)	This is a country strategy that was developed to control the negative impacts caused by Invasive Alien Plant Species (IAPS) to the country's biodiversity including forests. Bush encroachment and invasion by IAPS had been reported to be one of the major threats in Grasslands, Savanna, Forest and Aquatic ecosystems in Eswatini (NBSAP, 2014) which has resulted in loss of the country's biodiversity. This strategy also helps to guide the control of IAPS by the different stakeholders including communities, municipalities, private landowners and private sector forest companies as they implement their IAPS planning and management efforts on their land holdings. This is in line with **Sustainable Development Goal 15** which seeks to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss			
SADC Protocol on Forestry (2002)	This is a regional instrument which seeks to encourage member countries including Eswatini to implement and enforce national and administrative measures to promote sustainable forest management based on clear policies, objectives and forest management plans. It also seeks to protect ecologically visible forests that are representative or unique examples of their forest types as well as forests that have cultural, spiritual, historical values and also to protect endangered forest species.			

The objectives of the National Forest Policy, National Development Strategy, the National Land Policy, the National Environmental Policy and the National Biodiversity Strategy are:

a. **To improve the access to land** for the utilisation and development of forest resources, and secure the tenure of forest and trees.
b. **To promote the rational and sustainable use of land**, and achieve a sustainable balance between forestry and other uses of the land and water resources.
c. **To improve the forest productivity**, and ensure sustainable supply of multiple forest products and services by maintaining the forest areas.
d. **To improve income and living conditions**, and alleviate poverty.
e. **To conserve the biodiversity** of the forest resources, encourage its sustainable use and ensure that benefits accrued are shared equitably.
f. To promote the **integration of forestry into urban development**.
g. To enhance the national capacity to manage and develop the forestry sector in collaboration with other stakeholders.

Table 7: National measures and programmes on forests in Eswatini

Measure	Description	FL-FL	L>FL	FL>L
Implementation of the National Tree Planting Programme (2020)[2]	The Government of the Kingdom of Eswatini launched a National Tree Planting campaign on 24 September 2020 with a target of planting 10 million trees in 5 years up to 2025. The campaign encouraged all Swazis to engage in tree planting to increase the forest cover, reduce the impacts of climate change, soil erosion, and improve community livelihoods. Cabinet Ministers also participated in tree planting in different areas of the country, providing the campaign with massive support. The Programme also received support from private sector companies, including banks, who donated seedlings to communities for the establishment of woodlots and planting in degraded areas. This national initiative was meant to fast track the implementation of the **afforestation and reforestation programme** under the Department of Forestry as enshrined in the National Forest Policy.			
Memorandum of Understanding between the Kingdom of Eswatini and the Republic of South Africa to cooperate in the management of cross-border wildfires and other forestry development issues (2021).	The Memorandum of Understanding (MoU) was signed in 2011 and it acknowledged that both Parties encountered similar challenges in regards to managing cross-border wildfires and other forestry issues. These incidents pose a threat to the sustainable development of forests and ecosystems in both countries. This agreement ensures that the two countries cooperate with each other to safeguard forest resources from wildfires. The two countries are in the process of reviewing the MoU which is at the stage where the countries' Heads of States will sign it.			
Integrated Fire Management Programme (2012)	The Department of Forestry is implementing a program to educate communities on fire prevention, suppression, and control which began in 2012. Within each community, a certain number of members are chosen to form a team of Fire Brigades. These teams undergo intensive training on how to control fires in the community. Additionally, the communities are provided with firefighting equipment to use in case of a fire outbreak.			
Project on Restoration of the Mbuluzi Ecosystem (2024 - 2028)	The Ministry of Tourism and Environmental Affairs, through the Eswatini National Trust Commission, is implementing a project aimed at restoring the Mbuluzi Ecosystem which will run for a period of 4 years. The primary objective of the project is to **enhance the biodiversity** within the Mbuluzi River Basin. To achieve this, the project involves upgrading government nurseries and establishing community nurseries to increase the availability of tree seedlings for **restoration** works within the ecosystem. Additionally, the project seeks to control Invasive Alien Plant Species both within the ecosystem and in the **protected areas** along the Mbuluzi River. The project also seeks to implement afforestation and reforestation activities within the ecosystem.			
Restoration of the Riverine areas to enhance biodiversity	There is also a project that is being developed by the Department of Water Affairs with the technical assistant of			

[2] Many newspaper articles covered this activity such as ZWANE S. (2020), Eswatini Environment Authority (2021), Africa Press (February 9th 2023), Africa Press (February 8th 2023)

and improvement of water quality and quantity.	United National Development Programme (UNDP) whose aim is to **enhance biodiversity** along the riverine to improve water quality and quantity. The project also has a component on **control** of Invasive Alien Plant Species which will be implemented by the Department of Forestry. The date of inception of this project is yet to be determined upon finalisation of the concept note implementation plan and period.			
Promotion of establishment of individual, community and private nurseries to support restoration activities in the country whilst improving community livelihoods (2020)	The Department of Forestry, under the Ministry of Tourism and Environmental Affairs, is encouraging individuals and communities to set up their own private **tree nurseries**. The aim is to produce tree seedlings that are in high demand within their respective communities. This initiative will help to meet the high demand for tree seedlings which the government nurseries are unable to meet. Furthermore, the establishment of these tree nurseries will also provide an opportunity for communities to improve their livelihoods by selling the seedlings. This initiative has been part of the department's mandate since its inception but it was then upscaled in 2020 upon realisation of the high demand arising from the campaign to plant 10 million trees in 5 years.			
Promotion and adoption of Agroforestry by farmers which will highlight forest based enterprises e.g. beekeeping and mushroom production as a way of addressing the underlying drivers of deforestation (2020)	Farmers are encouraged to adopt agroforestry practices, which involves **integrating trees in their fields**. This promotes forest-based enterprises such as beekeeping and mushroom production, and **helps address the underlying causes of deforestation**. The Ministry of Tourism and Environmental Affairs has an extension program to assist farmers in integrating trees with their crops, which helps improve soil fertility and increase overall crop yield. This program was also upscaled in 2020 as a way to create incentives for forest ecosystems conservation and restoration activities to reduce deforestation and forest degradation as the need for land for agricultural purposes and human settlements increases as well as livelihood improvement.			
To promote conservation of Indigenous Forests and their sustainable management, implemented programmes and projects that will ensure co-benefits and benefit sharing mechanisms (2019-2023) **& Strengthening the National Protected Area System of Swaziland (2015-2020).**	The Department of Forestry promotes sustainable management of indigenous forests with programs that address their challenges. Our initiatives aim to preserve forests and ensure benefits are shared by stakeholders. The Department of Forestry working in collaboration with the Eswatini Environment Authority and the Energy Department under the Ministry of Natural Resources and Energy also support **sustainable forestry practices**, alternative livelihoods for communities, and public education. Through the collaboration by the different stakeholders, communities and schools are promoted to use alternative energy sources rather than to rely on firewood for energy which contributes to global efforts to protect forests and their vital ecosystem services. A project called Smoke-free kitchens was implemented between 2019 and 2023.			

	There was also the Strengthening the National Protected Area System of Swaziland (SNPAS) project implemented between 2015 and 2020, which covered the following activities: (i) Knowledge-Based Platform: This was operationalized at the national, regional, and community levels to address current and emerging threats to Protected Areas (PAs) and biodiversity conservation. (ii) Expansion of PA Network: The project aimed at developing, expanding, and effectively managing the capacities of Eswatini's Protected Areas (PAs) network in order to adequately protect biodiversity . (iii) Strengthening PA Functioning: This involved improved conservation management and operational support for existing and new PAs, including both formal and informal. PAs were established and managed in critical biodiversity areas as clusters, integrating different sites that are managed by the Government of Eswatini (GoS), the private sector, and local communities. (iv) Species Inventory Exercise: The SNPAS team undertook a species inventory exercise at a wetland in Vikizijula that had been fenced with support from the project. (v) Invasive Alien Plant Species Management: The SNPAS Project collaborated with Motigny to capacitate Luzelweni Chiefdom with tools and knowledge to successfully cut down black wattle (Umtfolo), an invasive alien plant species, from their grazing areas, waterways, and sites of cultural significance. (vi) Tree Planting: The project also involved tree planting activities in several communities (Global Environmental Facility, 2018 & Pelum,2020)			

2.2 National institutional arrangements

Eswatini's National MRV System for the GHG inventory, including REDD+, is still under development. The roles, responsibilities and legal framework (organisation mandates) supporting the reporting of the GHG inventory and REDD+ will be further formalised through upcoming support programmes including the United National Development Programme (UNDP) Climate Promise Initiative, the NDC Partnership Climate Action Enhancement Package (CAEP) and the Capacity Building Initiative for Transparency (CBIT) programmes of work.

The Ministry of Tourism and Environmental Affairs (MTEA) is the designated National Entity and hosts the UNFCCC Focal Point / REDD+ Focal point. MTEA has overall responsibility for the outputs of the MRV system including the GHG inventory, NIR, BURs and NCs. MTEA provides a key link between the domestic MRV system with the outside world and international community. MTEA coordinates the activities needed to ensure that outputs are prepared, and of sufficient quality, to meet Eswatini's commitments. The Department of Forestry and Department of Agriculture have legal mandates to coordinate data collection processes, otherwise there are no pre-existing data agreements.

The National Climate Change Committee (NCCC) is a steering committee made up of representatives from national ministries, private sector and non-government organisations. Although non-functional, the NCCC was designed to provide a focal point for collaboration around the GHG inventory and climate action and the monitoring of MRV system outputs, trends and challenges. The NCCC is inactive and is dependent on the budget available through project funding.

The FREL was compiled by team constituted of members from MTEA (Department of Forestry and Climate Change Unit), Ministry of Agriculture, University of Eswatini (UNESWA), and Eswatini National Trust Commission (ENTC). These experts have a good understanding of national activities within the forest and land use sector either through previous involvement with the national MRV system or through related projects. The national experts were responsible for collecting the data, compiling the FREL estimates using the compilation tools and templates, and IPCC 2006 Guidelines, assessing completeness of the compiled inventory, undertaking QA/QC activities on the data, identifying improvements, and providing input into the FREL report.

3. Data, methodologies and procedures

3.1 Information used by the Party to construct the FREL

Table 8: Data used for the construction of the FREL

IPCC guidelines used	2006 IPCC guidelines for Greenhouse gas inventories
Time-series	Annual information in tonnes CO_2e for the years 2016 to 2020
Data sources for representing land	**CfRN LUA assessment, October 2023.** Land use and land use change areas have been calculated based on a systematic sampling assessment undertaken on the CfRN LUA App. The whole country was covered by a systematic grid of 2,5 -2,5km which represents 7702 plots assessed. All six IPCC land use classes were observed with a subdivision of 18 national land categories. The assessment was done between June and October 2023, by a team of 15 experts from the Ministry of Tourism and Environmental Affairs, Ministry of Agriculture, ENTC and UNESWA. The method for the estimation of area is presented in section Annex I : Area of land and land use change.
Data sources for activity data of roundwood- fuelwood	**CfRN LUA assessment, October 2023** Area of wood extracted from forestland was extracted from the CfRN LUA app assessment of October 2023. Thanks to the high resolution images and the indexes, it was possible to monitor the areas that have experienced wood extraction. At this point it was not possible to differentiate the proportion of roundwood and proportion of fuelwood. The country is currently collecting information of wood extraction from plantations companies to have a second set of data for comparison.

Data sources for activity data area under degradation/ fire	**CfRN LUA assessment, October 2023** Forest area affected by degradation activities including infrastructure, agriculture, grazing, firebreaks, mining, pest, floods/storms was monitored through the high-resolution images on the CfRN LUA App. Areas affected by fire were also detected during the assessment.
Data source for estimating carbon stocks	**Ministry of Tourism and Environmental Affairs, October 2020 & Department of Environment Affairs, 2015** Eswatini does not have national data on carbon stocks. Information used was the same one included in the GHGI 2020, which is in majority coming for a South African study 2015. Some default values from IPCC guidelines were also used to complement (see tables 14 & 15).
Eswatini Calculation sheet	To produce the estimates of emissions for the historical period Eswatini developed an excel based calculation sheet. This calculation sheet can be accessed here: ADD THE LINK TO EXCEL The calculation sheet is composed of the following tabs: - **Introduction:** explanation of each sheet - **Database 241023**: plot assessment from CfRN LUA - **Land representation**: Presentation of land use categories used for the FREL and definition - **Land AD**: Matrix of land use and land use change - **Land_AD**_RandomError: Analysis of the random error for the activity data - AD_**Disturbance**: activity data for forest types under disturbance and/or logging - **Land_EF-RF**: Presentation of the carbon stocks value used and the conversion of these values into emission factors - **FL_ΔCL**: Estimation sof losses on forest land remaining forest land - **Land_ΔCO2**: estimations of gains on forest land remaining forest land and carbon stock change for land converted to/from forest - **Reporting table**: Total estimations for the forest sector including removals - FREL DD: estimations of the historical average for the FREL for two REDD+ activities, deforestation and degradation - **Completeness**: tables of carbon pools and gases included To ease the review process, tables included in this report have referenced to the calculation sheets.

3.2 Pools, gases and activities included in FREL

3.2.1 Scale

This is a national forest reference level covering the whole kingdom of Eswatini, which is 17.364km^2. All land is considered managed land following IPCC definition of managed land. IPCC states that managed land is land where human interventions and practices have been applied to perform production, ecological or social functions. In the case of Eswatini as presented in the section 1 of this report policies and measures presented in the FREL apply to all the forest lands, making it managed land (refer to Tables 5 and 6 above).

The forest area was 801.918 ha in 2020 which represents 46,2% of the national territory. By definition, all forest areas have been included in the FREL.

Table 9: Area of forest for the period 2016-2020

Unit: Ha	Dryer Acacia Savannah Forest	Moister Savannah Forest	Montane and Highland	Plantations	Riparian	Wattle Forest	Woodlots	TOTAL	% national territory
2016	401.974	98.070	48.922	125.124	64.253	40.806	22.770	**801.918**	46,2%
2017	402.199	98.070	48.922	125.349	64.253	40.355	22.770	**801.918**	46,2%
2018	402.875	98.070	48.922	125.349	64.253	40.355	22.770	**802.595**	46,2%
2019	401.974	98.070	48.922	125.349	64.253	40.355	23.221	**802.144**	46,2%
2020	401.974	97.844	48.697	125.575	64.253	40.355	23.221	**801.918**	46,2%

Source: CfRN LUA App assessment 2023

The main forest is dryer acacia savannah on the east side of the country followed by the plantation area in the Highveld on the west of the country.

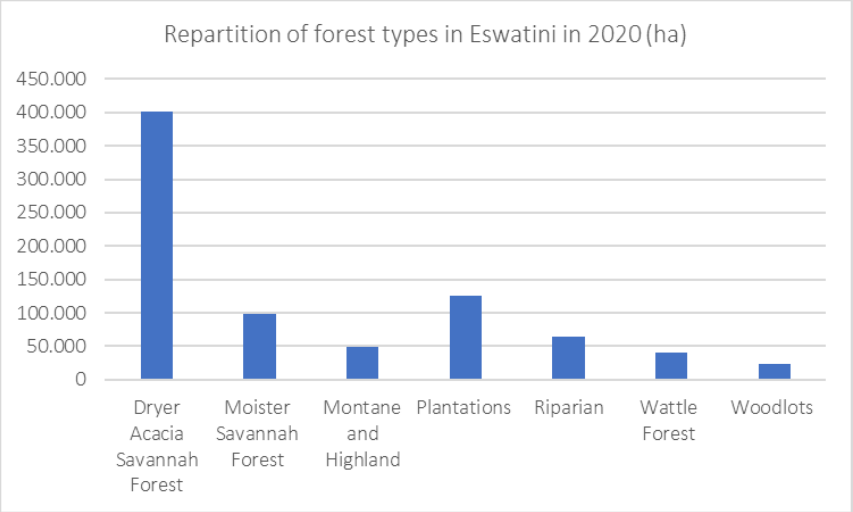


Figure 6: Proportion of forest types in Eswatini. Source: CfRN LUA App assessment, 2023

3.2.2 Pools and gases included

Table 10: ***Pools included in the FREL***

Land-based carbon stock changes		Biomass	Dead organic matter	Soils	
Land-use category	Land-use subcategory			Mineral	Organic
Forest land (FL)	FL remaining FL (losses only)	Yes	Yes	Yes	NE
	Land converted to FL	Not applicable in this FREL			
Cropland (CL)	Forest converted to CL	Yes	Yes	Yes	NE
Grassland (GL)	Forest converted to GL	Yes	Yes	Yes	NE
Wetland (WL)	Forest converted to WL	Yes	Yes	Yes	NE
Settlement (SL)	Forest converted to SL	Yes	Yes	Yes	NE
Other land (OL)	Forest converted to OL	Yes	Yes	Yes	NE

Table 11: ***Gases included in the FREL***

Land-use category	**Land-use subcategory**	**CO_2**	**Non-CO_2 emissions**
Forest land (FL)	FL remaining FL (losses only)	Yes	Yes
	Forest converted to FL	Not applicable in this FREL	
Cropland	Forest converted to CL	Yes	NA
Grassland	Forest converted to GL	Yes	NE
Wetland	Forest converted to WL	Yes	NE
Settlement	Forest converted to SL	Yes	NA
Other land	Forest converted to OL	Yes	NA

*All forest fires were included under FL remaining FL

3.2.3 REDD+ activities included

TwoREDD+ activities have been included in this FREL which includes all forest-related emissions. The land based approach was used to estimate emissions following IPCC guidance and guidelines, specifically the 2006 IPCC Guidelines for National GHG Inventories.

The table below provides an illustration, in the form of a land use and land use change matrix, where REDD+ activities have a mitigation impact with respect to forest-related emissions. By adopting the land-based approach, Eswatini takes responsibility for all emissions by sources affecting national forests.

Table 12: REDD+ activities by land uses

REDD+ activity	Land use category
Degradation	FL remaining FL (Carbon Losses) - Wood removals - Firewood - Disturbances
	Biomass Burning in FL
Deforestation	Forest land converted to CL
	Forest land converted to GL
	Forest land converted to WL
	Forest land converted to SL
	Forest land converted to OL

Deforestation: Deforestation represents the net source of emissions resulting from the conversion of forests to another land use. The post-deforestation carbon stock is taken into account in this estimate by calculating the difference between the carbon stock before conversion and the carbon stock after conversion. Details of the methodological approach are presented in Chapter 4.
Degradation of forests: This refers to the gross source of emissions arising from timber extraction in forests, as well as disturbances occurring on forest lands, including small-scale agriculture and grazing, infrastructure and mining, storms and flooding, pest and fire. Post-degradation removals (carbon sequestration) are not included in this FREL.

3.3 Methodologies information, including description of data sets, approaches and methods

3.3.1 Methods for land representation

In order to have a full data set all six IPCC categories were assessed during the data collection and all possible land use changes were observed. For the purpose of this FREL, only information for forest is presented.

3.3.1.I Definition of forest

Following FAO's definition of forest, this land use category refers to all land with woody vegetation. Compared to the GHGI FOLU from 2020, where Forest land was disaggregated into two forest types, plantation and indigenous forests, this current FREL has divided the forest in 7 classes: Montane and Highland, Dryer Acacia Savannah Forest, Moister Acacia Savannah Forest, Riparian, Plantations, Wattle forest and Woodlots.
Forest land category in Eswatini as follows:

- Minimum Mapping Unit (MMU) is 0,5 ha
- Minimum tree cover is 10 %
- Potential to reach minimum height at maturity (in situ) as 5 m

(Ministry of Tourism and Environmental Affairs, October 2020)

To remain consistent with the National GHGI, the seven classes have been subdivided into plantations and indigenous forest as follow:

Table 13: ***Comparison between GHGI classes and FREL classes***

GHGI FOLU 2020	FREL 2026
Plantation forests refer to the woody vegetation that at maturity is predominantly composed of trees established through planting and/or deliberate seeding. These are typically intensively managed forests that at maturity are composed of one or two species, with uniform age classes, and have regular tree spacing.	• **Plantations** • **Wattle** • **Woodlots**
Indigenous forests include all savannah woodlands and bushlands. It also includes systems with a vegetation structure that currently fall below, but in situ and could potentially reach the proposed national values used to define the forest land category in Eswatini - 0.5ha, 10% cover, potential to reach 5m.	• **Montane and Highland** • **Dryer Acacia Savannah Forest** • **Moister Acacia Savannah Forest** • **Riparian**
Source: Ministry of Tourism and Environmental Affairs, October 2020	Source: CfRN LUA Assessment, October 2023

The definitions of each land use classes presented in this FREL are included in the table below:

*Table 14: :****Land Use classes definition in Eswatini's FREL 2024***[3]

Land Use Category Level 1	Sub-Land Use category Level 2	Elevation	Description	Location
Forest	Montane and Highland	These ecosystems are found in the highest elevations of Eswatini, hosting unique plant and animal species adapted to cooler temperatures. They are crucial for maintaining the hydrological balance within the region.		
		>800m	Afromontane and mixed woodland, Indigenous forest.	Highveld Upper Middleveld
	Wattle Forest	Introduced species like *Acacia mearnsii* are cultivated in wattle plantations, used for timber and tannin extraction, playing a significant role in Eswatini's forestry industry.		
		>800m	*A. mearnsii* dominated forests. Man-made Forest. Clear felling – planned logging	Highveld
	Plantations		Man-made Forest. Plantations of pines and eucalypts	Mainly Highveld

[3] A case study by Professor Cliff S. Dlamini conducted in 2007 has further forest classification definitions titled PhD Forestry-Cliff S. Dlamini-Stellenbosch, page 188 can be accessed through the shared folder link: https://drive.google.com/file/d/1ZQ_RNCm0akllX8FnuD8BcKL29aSyC-2I/view?usp=sharing

Land Use Category Level 1	Sub-Land Use category Level 2	Elevation	Description	Location
	Moister Savannah Forest	This forest type is characterized by a mix of grasslands and acacia-dominated woodlands, which receive more rainfall than their drier counterparts. They support a diverse array of flora and fauna.		
		400-800m	Mainly broadleaved, mixed woodland. Indigenous forest.	Middleveld Lubombo range.
	Dryer Acacia Savannah Forest	Located primarily in the lowveld regions of Eswatini, these savannahs are adapted to less frequent rainfall and are dominated by species such as *Acacia tortilis* and *Acacia nigrescens.*		
		200-400m	Acacia dominated woodland, Indigenous forest. Precipitation <600mm.	(East) Lowveld
	Riparian	These forests occur along rivers and streams and are vital for protecting water quality, preventing erosion, and supporting a diverse range of species.		
		All physiographic zones	Mixed woodland. Indigenous forest.	Occurring along rivers
	Woodlots	These are smaller areas of planted or naturally regenerated forests, often established for the purpose of providing a sustainable supply of wood for local use. In Eswatini, woodlots may be established by communities with government assistance and some have become invasive.		
		>600m	Different ages for allowing regeneration. Mostly for domestic use (fuelwood).	Found next to urban/rural areas. Common in the Middleveld and Highveld
Cropland	Annual Crops	Cotton	Harvest around wintertime. Annual. Some crop lands abandoned	
		Sugar Cane	Some crop lands are abandoned (Farmer's communal lands / electricity). Harvest time (April to November)	
		Maize	Harvest time March-May.	Throughout the country

Land Use Category Level 1	Sub-Land Use category Level 2	Elevation	Description	Location
		Other annual crops		
	Perennial Crops	Citrus		Mostly Lowveld. Also, in the Highveld
		Banana		Mostly Lowveld and Middleveld
		Macadamia		Mostly Highveld and Middleveld
		Pineapple		Mostly Middleveld
		Other Perennial Crops		
	Agroforestry		<10% canopy cover. Fruit trees intercropped with annual/legumes crop	
Grassland	Bushveld	200-800m	<5m canopy height Bush/thicket communities Natural	Lowveld to Middleveld
	High Mountain grasslands	>800m	<5m canopy height. Mostly Open grasslands	Highveld
Wetland	Natural water bodies		Lakes and rivers	
	Artificial Water bodies		Dams (irrigation / animals), off streams.	
Settlement	Settlements		Urban/ rural areas (housing, industry)	
	Woody Settlements		Urban/ rural areas combined with trees - homestead forestry	
Other lands	Other lands		Bare rock	
	Mining		Coal	

3.3.1.II Land assessment using remote sensing

The Activity data for all the land use classes was derived from remote sensing products generated by Eswatini Ministry of Tourism and Environmental Affairs team, Ministry of Agriculture, University of Eswatini and Eswatini National Trust Commission team members.

The data was collected between June and October 2023 following the systematic sampling approach as recommended by the 2006 IPCC guidelines for an Approach 3 for Land Representation. The CfRN Land Use Assessment Application (CfRN LUA) was used to access and analyse the images through time.

This approach was favoured:

- To produce a consistent and complete database of land use and land use change for a long period of time,
- To ensure the six land use categories recommended by IPCC were taken into account,
- To allow for rapid and efficient estimations of the forested area at national level and the changes through time,
- To build more specific maps and land use assessments in the future,
- As this approach is consistent with IPCC guidelines and will be used for REDD+ and GHGI reporting, ensuring consistency between the reports.

3.3.1.III Methodological approach

Eswatini applied the systematic sampling approach covering the whole country. The assessment was executed by national experts within a period of 4 months in 2023 with the use of the CfRN LUA App[4].

CfRN LUA App is a land Use assessment application derived from the Collect Earth Online application developed by SERVIR (joint USAID and NASA program) and FAO, and was adapted to ensure full consistency with the format needed for the GHG Inventories and REDD+ under the UNFCCC. The CfRN LUA gives access to different satellite imagery of different resolution such as Planet NCFI, Sentinel2, Landsat 5-7-8, Bingload, MODIS and Google Earth Pro as well as indices of NDFI, NDVI, NDWI that help interpreters assess the land use and the land use changes/disturbances through time.

The information collected with this land assessment application was then imported into an Excel spreadsheet to apply 2006/2019 IPCC Guidelines estimations of emissions (see chapter 4); in addition, showing information by IPCC land use classes (Forest land, Grasslands, etc.).

CfRN LUA uses the IPCC Land representation approach 3 meaning that information is spatially explicit. It is based on a sampling approach, where a systematic grid is superimposed over the national territory. In each plot the land use is assessed by national experts on any land usage or disturbance such as fires, agriculture, grazing, etc.

The land use assessment grid has plots every 2,5km with a total of 7702 plots. Each plot represents an area of 0,5 ha to represent the national forest definition. Each of the plots contains 49 samples to help with the visual interpretation. The period cover is the land use and land use changes that occurred between 2000 and 2022. The period starts in 2000 as no high-resolution images are available prior to 2000. Figure 5 below shows how the grid and the plots are seen on the CfRN LUA.

This methodology involves a human assessment, analysing the land use within a 0.5ha plot. The dimension of this plot was selected to align with the forest definition, thereby facilitating the assessment process. The findings from this individual plot analysis are then projected to represent a larger area, which in the context of Eswatini corresponds to 225ha.

[4] https://lua.rainforestcoalition.org/

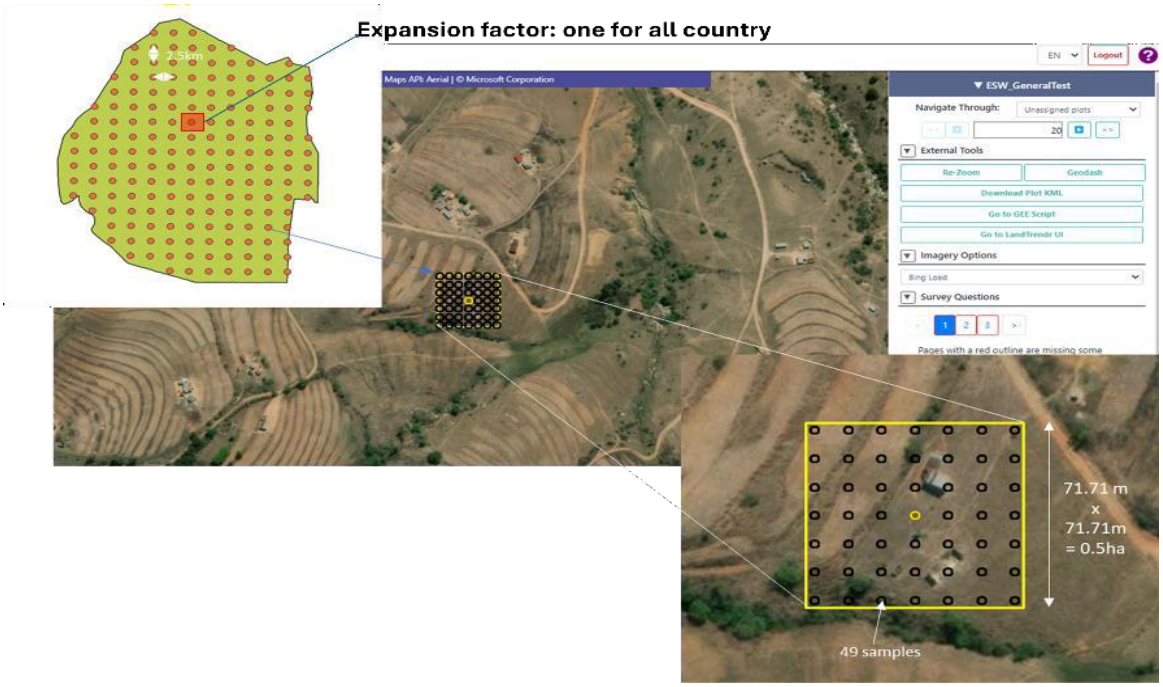


Figure 7: ***Grid and plot structure***

The protocol for the land use assessments included; hierarchy of land classes, matrix of impossible and possible land use conversions, roles and tasks for data collection, interpretation keys as well as disturbances.

Disturbances on forest lands that have been considered in this FREL to be activities or punctual events that affect the carbon stock in the forest area but thresholds of forest definition (10% canopy cover for 0,5ha) would remain visible:

- Agriculture: land where cultivation is visible inside forest areas but the overall area is still under canopy cover. Crop area remains less than 0,5ha.
- Infrastructure: Constructions of roads or houses of less than 0,5ha.
- Firebreak: Around and through the plantation. The land is cleared of trees to avoid fires spreading uncontrollably. The land-use is still forestland.
- Grazing: Forestland used a pasture.
- Storm: naturally occurring storms causing disruption on the forestland
- Pest: damage caused by insects or small animal on plantations
- Mine: small extraction of mineral of less than 0,5ha happening in forestland

The full protocol for data collection is available in Annex II : Protocol for the Land Use assessment

3.3.2 Methods for estimating activity data

Each plot assessed has a story of land use and land use change and disturbance that may have occurred, such as fire. Each plot represents an area of the country. The sum of all the plots represents the country area. To calculate the area of each plot, the plot is multiplied by an expansion factor.

The proportion of each assignment category (pi), also known as the expansion factor, is obtained by dividing the number of points in the given category (ni), by the total number of points available for collection (n).

$$p_i = \frac{ni}{n}$$

The area is calculated by multiplying the proportion of each category (expansion factor) by the total area inventoried.

$$A_i = A\ x\ p_i$$

The confidence interval is derived from the calculation of the standard error of area estimation (described in Appendix 3.A.3.5 of Volume 4 – 2006 IPCC GL) obtained by the following equation:

$$SD_i = A\ x \sqrt{\frac{p_i\ x\ (1 - p_i)}{n - 1}}$$

"Pi is the proportion of points in the particular land use category, A is the total known area, and n is the total number of sample points." Ultimately, the 95 percent confidence interval is obtained by multiplying the standard error by the independent coefficient for the confidence level, i.e. 1.96.

Country area (km²)	750	75000
Expansion factor	46,73	
STEP 2 - AREA ESTIMATION (Plot count * Exp. Factor)		
	3210	150000
Row Labels	Count of Transition Coding	Area
CC/CANNUAL/_	130	6074,8
CC/CPER/_	84	3925,2
CF/CANNUAL>FRAIN_2013/Hurricane_2017	1	46,7
CG/CANNUAL>GGRASS_2014/_	1	46,7
CG/CPER>GGRASS_2014/_	1	46,7
CG/CPER>GGRASS_2018/_	1	46,7
CG/CPER>GWGRASS_2017/_	1	46,7
CS/CANNUAL>SSET_2016/_	1	46,7
CS/CPER>SSET_2014/_	1	46,7
FC/FCLOUD>CANNUAL_2011/_	1	46,7
FC/FDEC>CANNUAL_2005/_	1	46,7
FC/FDSCRUB>CANNUAL_2011/_	1	46,7
FC/FEVER>CANNUAL_2017/_	1	46,7
FC/FEVER>CANNUAL_2018/_	1	46,7

Figure 8: Example of the calculation of the areas of the plot groups

All activity data used in this FREL comes from CfRN LUA Assessment, October 2023 and is composed of:

Table 15: ***Method for estimating activity data***

Data included	**Final format of the Activity data**
Area of land and land use change	
- Forest remaining forest - Forest converted to land *Other data Not included or not relevant for REDD+* - Land converted to forest - *Non-forest land remaining* - *Non forest Land conversion to other non-forest land*	Annual matrices of land use and land use change (see full tables in Annex I : Area of land and land use change) 1. **Matrix I:** Total area in hectares split by land use remaining and land converted in that year 2. **Matrix II:** For land in transition in hectares. These matrices represent the land that has been converted to a new land use but that needs 20 years for its carbon stocks to reach new stability. For example: Grassland is converted to Forestland in 2005, the Dead Organic matter and the Soil will need 20 years to reach new stability: year of conversion 2005 + transition **19** = new stability reached **2024**. Calculation sheets on tab **LAND_AD**

Area where logging was monitored	
- Logging on plantations, wattle forest and woodlots where the management practice is to expect some wood extraction through time - Logging on natural forest such as Dryer Acacia Savannah forest, Moister Acacia Savannah forest, Montane and Highland forest, Riparian, where extraction of wood is illegal and not planned.	Annual area of forest that is logged by forest types. Average of proportion of the area that is affected by the logging (fd) Calculation sheets on tab **FL_ΔCL**
Area where disturbances were monitored	
Different types of disturbances can be monitored on the forestland. Natural and uncontrolled disturbances included in this assessment are **pests**. The anthropogenic degradation monitored during this assessment are **agriculture, infrastructure, grazing, firebreaks and mining**. Areas affected by **fires** have been included and are estimated separately to other disturbances.	Annual area of forest that is disturbed by Infrastructure, agriculture, grazing, firebreaks, pest and mining Average of proportion of the area that is affected by disturbance (fd) Annual area of forest affected by fire Average of proportion of area affected by the fire (fd) Calculation sheets on tab **FL_ΔCL**

NB: Due to lack of data before 2000, the changes occurring before the historical period are not included in the estimations. The land in transition for 20 years is only accounted for from 2000 onwards. Eswatini tried to be transparent about this issue in the Annex I.2 Matrix II presenting the years included in the matrix for land in transition. Estimations will improve over time as Eswatini continues to monitor on a yearly basis the land use and land use change. As of estimations of the year 2021, all land in transition will be included in the estimations (this will be presented in the countries REDD+ technical Analysis).

3.3.2.I Land Use classes and changes through time

All six land use IPCC categories as well as subnational categories were assessed during the data collection. In 2020, the country is covered at 46% of forestland, 24 % of grassland, 23% of cropland, 3% of settlement, the rest between wetland and other land as presented in the table below. The land is quite stable through the years. The conversion from and to forest is minimal and presented in matrix in annex I of this report. The main conversion is forest to cropland (27% of conversions). However, there is also a high number of new forests being created through the years (30% of conversions).

3.3.3 Methods for estimating carbon stocks and carbon stock changes

The information on Emission Factors (EF) was obtained in part from default values of the 2006 IPCC Guidelines, that have been also used for the Eswatini National Greenhouse Gas Inventory: Agriculture, Forestry and Land Use (AFOLU) Sector Report from October 2020. The other part of the values used in this report come from the South African study prepared by the Department of Environmental Affairs in 2015 (Department of Environment Affairs, 2015).

Eswatini currently lacks the financial resources to carry out an independent carbon assessment. This activity is earmarked as a key area for future improvement. After internal deliberations, it was noted that the agro-ecological conditions in South Africa are highly similar to those in Eswatini, given that South Africa encircles Eswatini on the north, west, south, and southeast. This similarity extends to forest management practices, largely because many of the plantations in Eswatini are managed by companies based in South Africa. Furthermore, as part of the South African National Terrestrial Carbon Sinks

Assessment, South Africa included Eswatini within their study's scope. This inclusion was based on the premise that the land in Eswatini could be considered part of the average values reported in the study. However, it's important to note that while biomass and litter data for Eswatini were incorporated into the South African study, soil organic matter was not. Based on these considerations, it was assumed that the carbon stock values derived from South African data would be more representative of the conditions in Eswatini than those provided by the IPCC default values.

South Africa study - National Terrestrial Carbon Sinks Assessment 2015 (Tier 1)

In 2015, South Africa published their National Terrestrial Carbon Sinks Assessment. This report was prepared to allow the country to report on their Nationally Determined Contributions and Enhanced Transparency framework. It provides information on the carbon stocks, their dynamics, drivers and climate change mitigation and adaptation opportunities. South Africa also worked on the Carbon Sink Atlas (CSA), whose results are also included in the previous mentioned report. The CSA provides spatial distribution data on carbon stocks and fluxes across the country.

The methodology assesses the carbon stocks and fluxes with a wall-to-wall mapping of land areas of the whole country in combination with geostatistical methods, models and remote sensing to extrapolate the large set of field measurements.

Carbon stocks of the different pools, namely biomass and dead organic matter, were estimated using remotely sensed tree height from ICESAT-GLAS and canopy cover (MODIS) and published data from IPCC guidelines. Soils carbon pools are from the Africa Soil Property map which was created based on 3000 soil profiles in South Africa and 6000 elsewhere on the African continent. This information is reported into the National Land Cover studies 1990-2014 and 2018. It is expected that it will be produced at two-year intervals in the future.

For their 4th National Communications, Eswatini used emissions factors from the South African studies to estimate emissions from the land sectors. In a view to maintain as much consistency as possible with the latest GHGI, this Forest Reference level used most of these same emissions factors as described in the following chapter.

The link between South African classes and Eswatini classes are as followed:

Table 16: ***Land use classes between the different reports to extract emission factors***

IPCC land use classes	South African classes 2015	Eswatini GHGI 2020	Eswatini FREL 2026
Forestlands	Woodland- Thickets	Indigenous forest	**Montane and Highland Forest**
			Moist Acacia Savanna Forest
			Dry Acacia Savanna Forest
			Riparian Forest

IPCC land use classes	South African classes 2015	Eswatini GHGI 2020	Eswatini FREL 2026
	Plantations	Plantation	**Plantations**
			Wattle forest
			Woodlot
Croplands	Annual Crop	Croplands irrigated	**NA**
		Cropland rainfed	**Annual Croplands**
			Agroforestry
	NA	NA	**Perennial Cropland**
Grasslands	Grasslands	Grasslands	**Bushveld**
			High mountain grassland
Wetlands	Wetland	Wetland	**Natural Water body**
			Artificial Water body
Settlements	Settlements	Settlement	**Settlement**
			Woody settlement
Other lands	Other land	Other land	**Other land**
			Mines

The carbon pools included with the related values are presented in the two tables below.

Table 17: ***Tier used and reference by carbon pools***

Completeness	***AGB***	***BGB***	***DOM***	***SOC***
Dryer Acacia Savannah Forest	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Moister Savannah Forest	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Montane and Highland	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Plantations	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Riparian	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Wattle Forest	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Woodlots	Tier 1, SA	Tier 1, SA	Tier 1, SA	Tier 1, DE
Annual Crops	Tier 1, SA	Tier 1, DE	Tier 1, DE	Tier 1, DE
Perennial Crops	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Agroforestry	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Bushveld - Before	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Bushveld - after	Tier 1, SA	Tier 1, DE	Tier 1, DE	Tier 1, DE
High Mountain grasslands - Before	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
High Mountain grasslands - after	Tier 1, SA	Tier 1, DE	Tier 1, DE	Tier 1, DE
Natural Water Body	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Artificial Water Body	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Settlement	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Woody Settlement	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Other Lands	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE
Mine	Tier 1, SA	Tier 1, DE	Tier 1, SA	Tier 1, DE

AGB: above-ground biomass, **BGB**: below-ground biomass, **DOM**: Dead organic matter (deadwood & litter), **SOC**: soil organic carbon.

CS = country specific, **SA** = National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa, **DE** = IPCC default value

Source: Calculation spreadsheet, tab Land_EF-RF

3.3.4 Methods for estimating uncertainties

This FREL submission provides a description of the uncertainty related to the data used. The Monte Carlo simulation was implemented (see Annex II). The methodology used is the IPCC Approach 2, known as the Monte Carlo simulation (Volume 1, Chapter 3, IPCC 2006).

4. Estimation of the emissions for FREL

4.1 IPCC Methodologies applied

For the estimation of GHG emissions, Eswatini has followed the 2006 IPCC guidelines. It includes the analysis for Land remaining in a land-use category and lands converted to a new land-use category. The estimation of the emissions used a combination of: (a) country-specific data; (b) emissions factors from the regions and default values from IPCC and (c) IPCC methodologies Tier 1 were applied. All definitions, methods and assumptions are described.

Good practice: To ensure high quality in the GHG inventories, IPCC guidelines provide a set of good practice that Eswatini implemented in the following manner:

- Transparency: All background information used to produce Eswatini's FREL is openly available. National reports and documentation are made available through an online shared folder. This folder contains the Calculation tool of Eswatini which presents all the details of the activity data, the random error estimation for the activity data and the estimations for emissions, ADD LINK TO EXCEL
- Accuracy: The data included in this report is the most accurate data available at this time in Eswatini. The activity data covers the whole country and all the land use changes dynamic for a period of twenty years. This data also provides information about the area of forest land that is affected by logging, fire and other disturbances such as agriculture, grazing, etc.
- Consistency: The methodology applied for the estimation is annual and consistent through the whole period from 2016 to 2020. The information produced for this FREL will be used for future GHGI submissions for this sector to increase consistency between the reports.

Table 18: ***Method applied for the estimations of emissions on Forest land***

Carbon pool	Land category	
	Forest land remaining forest land	**Forest converted to land**
REDD+ activity	**Degradation (gross emissions)**	**Deforestation (net emissions)**
Biomass	**Gain-loss method** Gains: NOT APPLICABLE FOR THIS FREL Losses: equations 2.11 - *Details of estimation included in calculation sheet Land_ΔCL*	**Carbon stock change** difference following 2006 IPCC GL equation 2.15 - section 4.1.5 of this report - *Details of estimation included in calculation sheet Land_ΔCO2 using Matrix type I*

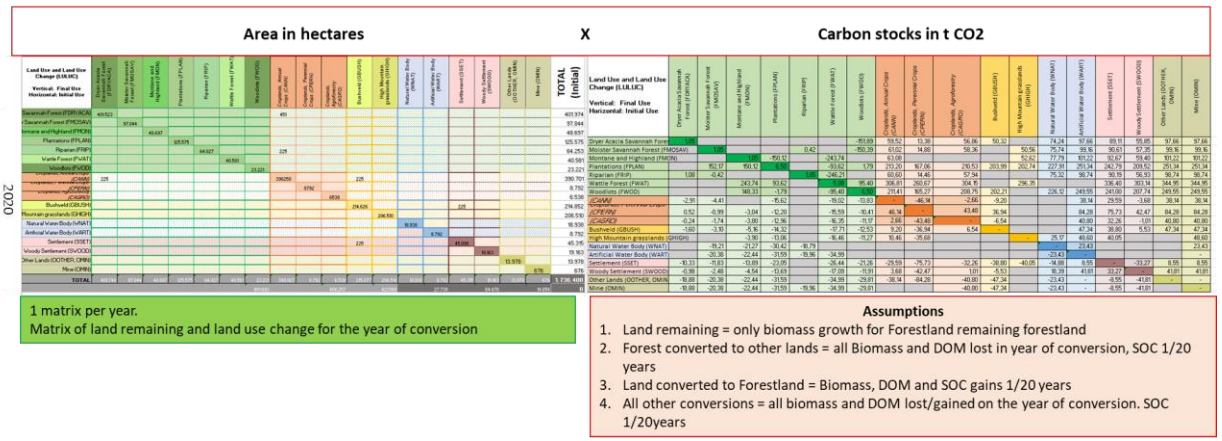
Carbon pool	Land category	
	Forest land remaining forest land	**Forest converted to land**
Dead organic matter	The Tier 1 assumption - zero changes - section 4.1.3 of this report	**Carbon stock change** following 2006 IPCC GL equation 2.23 - section 4.1.6 of this report - *Details of estimation included in calculation sheet Land_ΔCO2 using Matrix type I and II*
Soil	The Tier 1 assumption - zero changes - section 4.1.3 of this report	**Carbon stock change** following 2006 IPCC GL equation 2.25 - section 4.1.7 of this report - *Details of estimation included in calculation sheet Land_ΔCO2 using Matrix type I and II*
Fire	**Non CO2** - 2006 IPCC GL equation 2.27 - section 4.1.8 of this report - *Details of estimation included in calculation sheet Land_ΔCL*	All fires are assumed in forest land remaining forest land

The equations were applied to each of the land use dynamics included in the matrix of land use and land use change. However only the estimations related to forest are presented in this report following IPCC methods.

To ensure that the land in transition is estimated (following IPCC assumption the land converted is under transition for 20 years), two types of matrices are applied as presented in the figure below. On the left the matrices for the area of land and use change and on the right the matrices with carbon stock changes for carbon pools of biomass, DOM and SOC. What are called Matrix type 1 are the matrices with land use remaining and land use converted on that year. What are called Matrices type 2 represent the addition of the land in transition for the 19 years following the conversion.

Matrix I and Matrix II - **Gains** on forest land remaining + **Carbon stock change** on land converted to/from forest land

Matrix type I



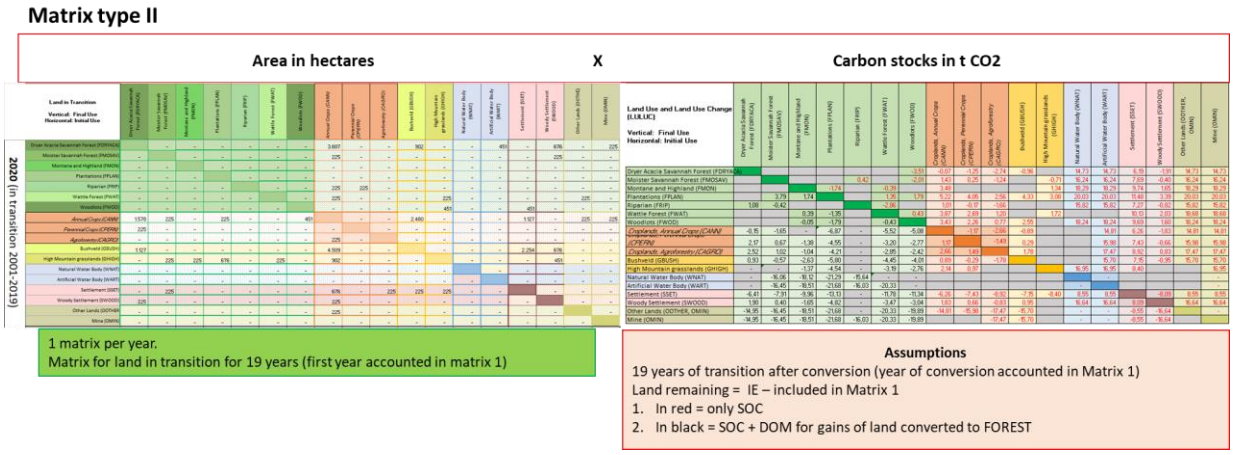


Figure 9: Two types of matrices for land use and land in transition

4.1.1 Annual carbon stock changes for a stratum of a land-use category as a sum of changes in all pools (IPCC Equation 2.3, Ch2, V4)

$$\Delta CLUi = \Delta CAB + \Delta CBB + \Delta CDW + \Delta CLi + \Delta CSOC + \Delta CHWP$$

Where:

ΔCLU$_i$ = carbon stock changes for a stratum of a land-use category. subscripts denote the following carbon pools:

AB = above-ground biomass
BB = below-ground biomass
DW = deadwood
LI = litter
SOC = soils
HWP = harvested wood products

*Table 19: **Carbon pools included***

	Included
ΔC_{AB}	Yes
ΔC_{BB}	Yes
ΔC_{DOM}	Yes
ΔC_{SOC}	Yes
ΔC_{HWP}	No

Clarification Notes

Data on HWP was not available.

4.1.2 Loss in biomass carbon stocks (above-ground biomass and below-ground biomass) in forest lands remaining in the same category

Annual decrease in carbon stocks due to biomass losses in forest land remaining in the same land-use category (IPCC Equation 2.11, Ch2, V4)

$$\Delta CL = \Delta Lwood - removals + \Delta Lfuelwood + \Delta Ldisturbance$$

Where:

ΔCL= annual decrease in carbon stocks due to biomass loss in land remaining in the same land-use category, tonnes C yr_{-1}

Lwood-removals = annual carbon loss due to wood removals, tonnes C yr_{-1} (See Equation 2.12)

Lfuelwood = annual biomass carbon loss due to fuelwood removals, tonnes C yr_{-1} (See Equation 2.13)

Ldisturbance = annual biomass carbon losses due to disturbances, tonnes C yr_{-1} (See Equation 2.14)

Annual carbon loss in biomass of wood removals (modified equation of I PCC Equation 2.12, Ch2, V4)

$$Lwood - removals = \{ Alogged \bullet C \bullet (44/12) \}$$

Where:

Lwood-removals = annual carbon loss due to biomass removals, tonnes CO2 yr_{-1}

Alogged = Area of forest that is affected by planned and unplanned logging, ha

C = Carbon stock available in each forest types for logging, included aboveground and belowground biomass, tonne C $(ha)_{-1}$

(44/12) = conversion of t C to t CO2

Eswatini considered areas affected by logging under two different conditions. one as planned logging and the second as unplanned logging:

Unplanned logging refers to the wood that is extracted on the natural forest such as Dryer Acacia Savannah Forest, Moister Acacia Savannah Forest, Montane and Highland Forest, Riparian forest where wood extraction is not allowed or managed. Local communities collect some wood for their personal use. The extraction is smaller and less consistent. The planned logging is for the forest types that have a management practice that plan for logging extraction such as plantations, Wattle and Woodlots. The quantity of wood extracted is bigger and consistent through time. The uncertainty attached to the areas of land under logging is 18% for the interpretation error. The random error ranges between 236%-35%.

Table 20: ***Area of forest under logging***

Area = Area of forest affected by logging (ha), uncertainty (%)							
Year	**Dryer Acacia Savannah Forest**	**Moister Savannah Forest**	**Montane and Highland**	**Plantations**	**Riparian**	**Wattle forest**	**Woodlot**
2016	0	0	0	9506 *(33%)*	0	0	225 *(137%)*
2017	0	34 *(237%)*	0	15489 *(39%)*	0	135 *(237%)*	113 *(237%)*
2018	0	0	0	8372 *(53%)*	0	90 *(237%)*	0
2019	0	0	0	6338	0	135	361

				(40%)		*(167%)*	*(167%)*
2020	0	0	0	4828 *(45%)*	0	451 *(167%)*	0
source	CfRN LUA Assessment, 2023 available in calculation sheet tab FL_ΔCL						

NO = Not occuring

Table 21: ***Biomass available for logging tonnes C ha-1 yr-1***

Above-ground & Below-groudG biomass: Biomass available for logging tonnes C ha-1 yr-1, uncertainty (%)					
LU	**Category**	**Type**	**Value**	**TIER**	**Source**
F	**Dryer Acacia Savannah Forest**	Indigenous	11,6 **(16,6%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Moister Savannah Forest	Indigenous	11,6 **(16,6%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Montane and Highland	Indigenous	11,6 **(16,6%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Plantations	plantation	31,28 **(16,2%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Riparian	Indigenous	11,6 **(16,6%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Wattle forest	plantation	31,28 **(16,2%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8
	Woodlot	plantation	31,28 **(16,2%)**	TIER 1	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8

Clarification Notes

Currently data on cubic metres of wood extracted from plantations is not available. Once this data will become available Eswatini will be able to compare with the area affected by logging.

Annual carbon loss in biomass of fuelwood removal

Fuelwood extraction is included in the roundwood section as this was extracted from the remote sensing data that see all types of wood extractions for every forest type. In the case of Eswatini, fuelwood is a very common practice in the country. For example, it is expected that local communities will use the Wattle Forest and the woodlots to extract fuelwood. Further studies will be implemented to be able to extract a more precise value. At this point the only data available was FAOSTAT but this would have

included a double count of part of the estimations because of the extraction captured by remote sensing. Small extraction of branches and small trees are most likely not captured by remote sensing. However, a good part of the bigger extraction of big trees will be captured by remote sensing and included in the roundwood estimations above.

Annual carbon losses in biomass due to disturbances (IPCC Equation 2.14, Ch2, V4)

$$Ldisturbance = Adisturbance \bullet BW \bullet (1 + R) \bullet CF \bullet fd$$

Where:

Ldisturbances = annual other losses of carbon, tonnes C yr^{-1}

Adisturbance = area affected by disturbances, ha yr^{-1}

BW = average above-ground biomass of land areas affected by disturbances, tonnes d.m. ha^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$.

CF = carbon fraction of dry matter, tonne C (tonnesd.m.)$^{-1}$

fd = fraction of biomass lost in disturbance

Table 22: ***Area disturbed in forest land (uncertainty %)***

Forest class	Disturbance	2016	2017	2018	2019	2020	Fd	Bw	(1+R)	CF
		hectares					dimensionless	t d.m. ha-1	t d.m. BGB (t d.m. AGB)$_{-1}$	t C (t d.m.)-1
Dryer Acacia Savannah Forest	Agriculture	NO	225,45 *(196%)*	NO	NO	NO	1	20 *(20%)*	1,24 *(16%)*	0,47 *(5%)*
	Infrastructure	NO	NO	NO	101,45	NO	1		1,24 *(16%)*	
	Grazing	90,18 *(196%)*	157,81 *(139%)*	NO	338,17 *(98%)*	NO	0,5		NA	
	Storm/flood	90,18 *(196%)*	NO	NO	NO	90,18 *(196%)*	0,5		NA	
	Fire	2572,36 *(51%)*	704,52 *(88%)*	721,43 *(98%)*	3922,79 *(42%)*	541,08 *(113%)*	0,74 *(37%)*		NA	
Moister Savannah Forest	Agriculture	135,27 *(196%)*	NO	NO	NO	NO	1	20 *(20%)*	1,24 *(16%)*	
	Infrastructure	NO	NO	45,09 *(19%)*	NO	45,09 *(196%)*	1		1,24 *(16%)*	
	Fire	631,25 *(113%)*	541,08 *(113%)*	90,18 *(196%)*	1239,96 *(62%)*	NO	0,74 *(37%)*		NA	
Montane and Highland	Agriculture	NO	NO	NO	NO	NO	1	20 *(20%)*	1,24 *(16%)*	
	Fire	845,43 *(88%)*	901,79 *(98%)*	293,08 *(139%)*	901,79 *(98%)*	225,45 *(196%)*	0,74 *(37%)*		NA	
Plantations	Fire-break	225,45 *(196%)*	518,53 *(98%)*	NO	608,71 *(98%)*	270,54 *(113%)*	1	52 *(20%)*	1,28 *(19%)*	
	Fire	1375,23 *(74%)*	180,36 *(196%)*	450,9 *(139%)*	1127,24 *(88%)*	225,45 *(196%)*	0,74 *(37%)*		NA	
Riparian	Agriculture	202,9 *(139%)*	112,72 *(196%)*	NO	NO	NO	1	20 *(20%)*	1,24 *(16%)*	
	Grazing	NO	NO	NO	112,72	NO	1		NA	
	Fire	67,63 *(196%)*	428,35 *(139%)*	225,45 *(196%)*	608,71 *(98%)*	225,45 *(196%)*	0,74 *(37%)*		NA	
Wattle forest	Infrastructure	NO	22,54 *(196%)*	225,45 *(196%)*	NO	NO	1	52 *(20%)*	1,28 *(19%)*	
	Fire	293,08 *(113%)*	405,81 *(113%)*	90,18 *(196%)*	518,53 *(113%)*	405,81 *(113%)*	0,74 *(37%)*		NA	
Woodlot	Agriculture	112,72 *(196%)*	NO	NO	NO	NO	1	52 *(20%)*	1,28 *(19%)*	
	Fire	450,9 *(139%)*	2,25 *(196%)*	220,94 *(196%)*	67,63 *(196%)*	450,9 *(139%)*	0,74 *(37%)*		NA	
Source	CfRN LUA Assessment 241023						Expert judgment Fire – IPCC 2006, V4, Ch.2, table 2.6	National Terrestrial Carbon Sinks Assessment:	Ministry of Tourism and Environmental	IPCC 2006 Table 4.3

		All savanna woodlands (mid/late dry season burns)	Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa -- Woodland/thickets values	affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	

Clarification Notes

The disturbance fraction (fd) is based on an expert judgment assessing if whole or only part of the biomass present on the area disturbed is lost during the disturbance. For the disturbances type Infrastructure, mining, agriculture, grazing and firebreak it is assumed that whole the biomass is lost due to the disturbance. Whereas for fires, pest, storm/floods only part of the biomass is lost during the disturbance and it is assumed that only above-ground is affected in these cases.

4.1.3 Change in dead organic matter carbon stock in forest land remaining in the same category

The Tier 1 assumption for both dead wood and litter pools for all forest land sub-categories is that their stocks are not changing over time if the land remains within the same land-use category. Thus, the carbon in biomass killed during a disturbance or management event (less removal of harvested wood products) is assumed to be released entirely to the atmosphere in the year of the event.

4.1.4 Change in soil organic carbon stock in forest land remaining in the same category

The assumption in Tier 1 is that the SOC carbon stocks in all Forest land Remaining Forest land are insignificant or are not changing and therefore no emission factors and activity data are needed.

4.1.5 Change in biomass carbon stocks (above-ground biomass and below-ground biomass) in land converted to a new land-use category

Annual change in biomass carbon stocks on Forest converted to other land-use category (IPCC Equation 2.15, Ch2, V4)

$$\Delta CB = \Delta CG + \Delta CCONVERSION - \Delta CL$$

Where:

ΔC_B= annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G= annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L = annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C yr^{-1}

Table 23: ***Sources of area of land converted to a land-use category***

A: area of land converted to a land-use category			
LU	**Sub-Category**	**Source**	**Notes**
F>C	Forest lands > Croplands	Ministry of Tourism and Environmental Affairs	CfRN LUA App – Annual time series 2000-2022
F>G	Forest lands > Grasslands	Ministry of Tourism and Environmental Affairs	CfRN LUA App – Annual time series 2000-2022
F>W	Forest lands > Wetlands	Ministry of Tourism and Environmental Affairs	CfRN LUA App – Annual time series 2000-2022
F>S	Forest lands > Settlements	Ministry of Tourism and Environmental Affairs	CfRN LUA App – Annual time series 2000-2022
F>O	Forest lands > Other lands	Ministry of Tourism and Environmental Affairs	CfRN LUA App – Annual time series 2000-2022

Annual increase in biomass carbon stocks on land converted to other land-use category (IPCC Equation 2.9, Ch2, V4)

Annual increase in carbon stocks in biomass due to land converted to another land-use category is estimated to be 0 on the year of conversion following IPCC assumption.

Initial change in biomass carbon stocks on land converted to another land category (IPCC Equation 2.16, Ch2, V4)

$$\Delta CCONVERSION = \sum_{i} \{(BAFTER - BBEFORE) \bullet \Delta ATO_OTHERS\} \bullet C$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

$BAFTER_i$ = biomass stocks on land type i immediately after the conversion, tonnes d.m. ha^{-1}

$BBEFORE_i$ = biomass stocks on land type i before the conversion, tonnes d.m. ha^{-1}

ΔATO_OTHERS_i = area of land use i converted to another land-use category in a certain year, ha yr^{-1}

CF = carbon fraction of dry matter, tonnes C (tonnes d.m.)$^{-1}$

i = type of land use converted to another land-use category

Table 24: ***Biomass available before or after conversion tonnes C. ha-1 yr-1***

B_Before or B_After : Biomass stocks tonnes C. ha-1 yr-1, uncertainty (%)					
LU	**Category**	**AGB**	**BGB**	**Source**	**Comments and assumptions**
F	**Dryer Acacia Savannah Forest**	9,4 *(20%)*	2.,26 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Moister Savannah Forest	9,4 *(20%)*	2,26 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Montane and Highland	9,4 *(20%)*	2,26 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Plantations	24,44 *(20%)*	6,84 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Riparian	9,4 *(20%)*	2,26 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Wattle forest	24,44 *(20%)*	6,84 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Woodlot	24,44 *(20%)*	6,84 *(20%)*	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
C	**Annual Crops**	1,88 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Perennial Crops	25,38 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Agroforestry	1,88 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
G	**Bushveld**	Bafter: 2,26 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	For after conversion only herbaceous biomass is accounted.

B_Before or B_After : Biomass stocks tonnes C. ha-1 yr-1, uncertainty (%)					
LU	**Category**	**AGB**	**BGB**	**Source**	**Comments and assumptions**
	High Mountain grasslands	Bafter: 2,26 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	For after conversion only herbaceous biomass is accounted.
W	**Natural Water Body**	2 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
	Artificial Water Body	0	0	Assumption	
S	**Settlements**	0	0	Assumption	
	Woody Settlements	1,97 *(20%)*	0	Ministry of Tourism and Environmental affairs, 2020, Eswatini National GHGI: AFOLU sector report, Table 8	
O	**Other Lands**	0	0	Assumption	
	Mining	0	0	Assumption	

Clarification Notes

It is assumed that all the biomass is lost during the year of conversion when we have a forest converted to another land.

Annual decrease in carbon stocks in biomass due to losses, ΔCL (IPCC Equation 2.11-2.14, Ch2, V4)

Assumed to be 0 for the year of conversion following TIER 1 of IPCC Guidelines.

4.1.6 Change in dead organic matter in Carbon stock in land converted to a new land category

Land converted to another land-use category (IPCC Equation 2.23, Ch2, V4)

$$\Delta CDOM = \frac{(Cn - Co) * Aon}{Ton}$$

Where:

ΔC_{DOM} = annual change in carbon stocks in dead wood or litter, tonnes C yr-1

C_o = dead wood/litter stock, under the old land-use category, tonnes C ha-1

C_n = dead wood/litter stock, under the new land-use category, tonnes C ha-1

A_{on} = area undergoing conversion from old to new land-use category, ha

T_{on} = time period of the transition from old to new land-use category, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses.

Table 25: ***Dead wood/litter stock values***

DOM = Dead wood/litter stock tonnes C ha-1 , Uncertainty (%)				
LU	**Category**	**DOM**	**Source**	**Comments and assumptions**
F	**Dryer Acacia Savannah Forest**	1,19 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Moister Savannah Forest	1,19 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Montane and Highland	1,19 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Plantations	9,00 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Riparian	1,19 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Wattle forest	9,00 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Woodlot	9,00 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
C	**Annual Crops**	0	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Perennial Crops	6,23 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	GHGI TEAM 4th NAT COM
	Agroforestry	0	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
G	**Bushveld**	1,01 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	

DOM = Dead wood/litter stock tonnes C ha-1 , Uncertainty (%)				
LU	**Category**	**DOM**	**Source**	**Comments and assumptions**
	High Mountain grasslands	1,01 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
W	**Natural Water Body**	2,14 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
	Artificial Water Body	0	Assumption	
S	**Settlements**	0	Assumption	
	Woody Settlements	1,17 *(20%)*	National Terrestrial Carbon Sinks Assessment: Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa	
O	**Other Lands**	0	Assumption	
	Mining	0	Assumption	

4.1.7 Change in Carbon stock in soils in land converted to a new land category

Annual change in carbon stocks in mineral soils, tonnes C yr-1 (IPCC Equation 2.25, Ch2, V4)

$$\Delta CMineral = \frac{(SOCo - SOC_{o-t})}{D}$$

$$\Delta SOC = \sum_{c,s,i} \{(SOC_{REF} * F_{LU} * F_{MG} * F_I * A)\}$$

Where,

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC0 = soil organic carbon stock in the last year of an inventory time period, tonnes C

SOC(0-T) = soil organic carbon stock at the beginning of the inventory time period, tonnes C

T = number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr.

c **=** represents the climate zones, *s* the soil types, and *i* the set of management systems that are present in a country.

SOCREF = the reference carbon stock, tonnes C ha^{-1}

FLU = stockchangefactorforland-usesystemsorsub-systemforaparticularland-use, dimensionless

FMG = stock change factor for management regime, dimensionless

FI = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha.

Table 26: ***Soil organic carbon by land use sub-category [tC ha]***

SOC_ref in tonnes C. ha-1 yr-1					
LU	**Category**	**SOC ref**	**Error**	**Source**	**Comments and assumptions**
F	**Dryer Acacia Savannah Forest**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Moister Savannah Forest	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Montane and Highland	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Plantations	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Riparian	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Wattle forest	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Woodlot	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
C	**Annual Crops**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Perennial Crops	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Agroforestry	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
G	**Bushveld**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	High Mountain grasslands	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
W	**Natural Water Body**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Artificial Water Body	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
S	**Settlements**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Woody Settlements	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
O	**Other Lands**	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral
	Mining	88	90%	IPCC 2006, Volume 4, Chapter 2, table 2.3	High Activity Clay Mineral

Table 27: ***FLU, FMG and FI Values for values by Land use and sub-categories of land use***

	Notation	*FLU*	*FMG*	*FI*		
LU	**Category**	**Factor land use systems**	**Factor management regime**	**Factor input organic matter**	**error**	**Source**
		Dimensionless	**Dimensionless**	**Dimensionless**		
F	**Dryer Acacia Savannah Forest**	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Moister Savannah Forest	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Montane and Highland	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Plantations	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Riparian	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Wattle forest	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
	Woodlot	1	1	1	20%	IPCC 2006, Vol 4, Ch 4, pg 4.40
C	**Annual Crops**	0,69	1	0,95	12%, *20%, 13%*	IPCC 2019 RF, Ch 5, Table 5.5,
	Perennial Crops	0,69	1,006	0,96	12%,20%,13%	IPCC 2019 RF, Ch 5, Table 5.5,
	Agroforestry	0.69	1	0,95	12%,20%,13%	same system as forest plantation, IPCC 2006, Vol 4, Ch 4, pg 4.40
G	**Bushveld**	1	0,939	**1**	20%, 11%,20%	IPCC 2019 RF, Ch 6, Table 6.2
	High Mountain grasslands	1	0,939	**1**	20%, 11%,20%	IPCC 2019 RF, Ch 6, Table 6.2
W	**Natural Water Body**	0	0	0	NA	Assumption TIER 1
	Artificial Water Body	0	0	0	NA	Assumption TIER 1
S	**Settlements**	0,831	1	1	20%	IPCC 2006, Vol 4, Ch 8, section 8.3.3.2
	Woody Settlements	1	1	1	20%	IPCC 2006, Vol 4, Ch 8, section 8.3.3.2
O	**Other Lands**	0	0	0	NA	TIER 1 - The reference C stock at the end of the 20 years default transition period is assumed to be zero.
	Mining	0	0	0	NA	TIER 1 - The reference C stock at the end of the 20years default transition period is assumed to be zero.

Clarification Note

Matrix type I: For Forest lands converted to other lands, D=20, until new land is considered stable, then change to SOC= 0.

Matrix type II: To estimate the remaining 19 years after the year of conversion, the same equation is applied but multiplied by the area in Matrix II (see Calculation tool tab Land_EF-RF).

The SOC reference is a default value from IPCC that is used for the whole country. More detailed information about soil types in the country will be developed in future submissions.

4.1.8 Non-CO2 Emissions

Management of forest fires: The use of fire in Eswatini is recognized as an efficient tool in the management of natural forests and rangelands. Most of the burning that takes place in the natural woodlands is intended to improve grazing conditions. However, there is evidence that uncontrolled and random fires result in the destruction of natural forest resources and loss of biodiversity. There is no full understanding of the effects of the fire regimes occurring in Eswatini. Fires tend to favour certain species to the detriment of others and reduce overall diversity. Uncontrolled fires caused by strained social relations between forest companies and neighbouring communities also affect industrial forestry (Minister of Agriculture and Cooperatives, 2002).

Estimation of Greenhouse Gas Emissions from fires (IPCC Equation 2.27, Ch2, V4)

$$Lfire = A \bullet MB \bullet Cf \bullet Gef \bullet 10{-}3$$

Where:

Lfire = amount of greenhouse gas emissions from fire, tonnes of each GHG (CH4, N2O).

A = area burnt, ha

MB = mass of fuel available for combustion, tonnes ha^{-1}.

Cf = combustion factor, dimensionless

Gef = emission factor, g kg-1 dry matter burnt

Table 28: ***Forest area burnt & Emission factors (uncertainty %)***

Forest class	Disturbance	2016	2017	2018	2019	2020	Cf	Mb	Gef CH4	Gef N2O
		hectares					dimensionless	t d.m. ha-1	g/kg dry matter burnt	g/kg dry matter burnt
Dryer Acacia Savannah Forest	Fire	2572,36 *(51%)*	704,52 *(88%)*	721,43 *(98%)*	3922,79 *(42%)*	541,08 *(113%)*	0,74 *(37%)*	10,59 *(18%)*	3,5 *(157%)*	0,24 *(192%)*
Moister Savannah Forest	Fire	631,25 *(113%)*	541,08 *(113%)*	90,18 *(196%)*	1239,96 *(62%)*	NO	0,74 *(37%)*	10,59 *(18%)*		
Montane and Highland	Fire	845,43 *(88%)*	901,79 *(98%)*	293,08 *(139%)*	901,79 *(98%)*	225,45 *(196%)*	0,74 *(37%)*	10,59 *(18%)*		
Plantations	Fire	1375,23 *(74%)*	180,36 *(196%)*	450,9 *(139%)*	1127,24 *(88%)*	225,45 *(196%)*	0,74 *(37%)*	33,44 *(16%)*		
Riparian	Fire	67,63 *(196%)*	428,35 *(139%)*	225,45 *(196%)*	608,71 *(98%)*	225,45 *(196%)*	0,74 *(37%)*	10,59 *(18%)*		
Wattle forest	Fire	293,08 *(113%)*	405,81 *(113%)*	90,18 *(196%)*	518,53 *(113%)*	405,81 *(113%)*	0,74 *(37%)*	33,44 *(16%)*		
Woodlot	Fire	450,9 *(139%)*	2,25 *(196%)*	220,94 *(196%)*	67,63 *(196%)*	450,9 *(139%)*	0,74 *(37%)*	33,44 *(16%)*		

Source	CfRN LUA Assessment 241023	Fire – IPCC 2006, V4, Ch.2, table 2.6 All savanna woodlands (mid/late dry season burns)	Above-ground biomass and Dead organic matter National Terrestrial Carbon Sinks Assessment : Technical Report (2020), Department of Environment, Forestry and Fisheries, Pretoria, South Africa -- Woodland/thickets values	IPCC 2006, Table 2.5 average of extra tropical forest - Savanna and Grassland	IPCC 2006, Table 2.5 average of extra tropical forest - Savanna and Grassland

4.2 Areas of Land use and land use change

Table 29: Areas of land use

2020	Matrix type 1 : stable land and land converted in 2020 Unit: ha	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	Annual Crops (CANN)	Perennial Crops (CPERN)	Agroforestry (CAGRO)	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHE)	Mine (OMIN)	TOTAL (January)	
	Dryer Acacia Savannah Forest (FDRYACA)	401 523								225										401 748	
	Moister Savannah Forest (FMOSAV)		97 619						225											97 844	
	Montane and Highland (FMON)			48 697									225							48 922	
	Plantations (FPLAN)				125 349															125 349	
	Riparian (FRIP)					64 253														64 253	
	Wattle Forest (FWAT)						40 355													40 355	
	Woodlots (FWOD)							23 221												23 221	
	Annual Crops (CANN)						225		388898											389 123	
	Perennial Crops (CPERN)									8792										8 792	
	Agroforestry (CAGRO)										6763									6 763	
	Bushveld (GBUSH)											215 077								215 077	
	High Mountain grasslands (GHIGH)								225				206 510							206 736	
	Natural Water Body (WNAT)													18 938						18 938	
	Artificial Water Body (WART)														8 792					8 792	
	Settlement (SSET)								451							45 991				46 442	
	Woody Settlement (SWOOD)								225								19 163			19 389	
	Other Lands (OOTHER																	13 978		13 978	
	Mine (OMIN)																		676	676	
	Decembre 2020 - TOTAL	**401 523**	**97 619**	**48 697**	**125 349**	**64 253**	**40 581**	**23 221**	**390 025**	**9 018**	**6 763**	**215 077**	**206 736**	**18 938**	**8 792**	**45 991**	**19 163**	**13 978**	**676**	**1 736 400**	Country area
	Matrix type II : land in transition for previous 19 years																				
	Dryer Acacia Savannah Forest (FDRYACA)		-	-	-	-	-	-	3 607	225	-	1 127	-	-	451	-	676	-	225		
	Moister Savannah Forest (FMOSAV)	-		-	-	-	-	-	225	-	-	-	-	-	-	-	225	-	-		
	Montane and Highland (FMON)	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	Plantations (FPLAN)	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	Riparian (FRIP)	-	-	-	-		-	-	225	225	-	-	-	-	-	-	-	-	-		
	Wattle Forest (FWAT)	-	-	-	-	-		-	225	-	-	-	225	-	-	-	-	225	-		
	Woodlots (FWOD)	-	-	-	-	-	-		-	-	-	-	451	-	-	451	-	-	-		
	Annual Crops (CANN)	1 578	225	-	225	-	-	451		-	451	2 480	-	-	-	1 127	-	225	225		
	Perennial Crops (CPERN)	225	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-		
	Agroforestry (CAGRO)	-	-	-	-	-	-	-	225	-		-	-	-	-	-	-	-	-		
	Bushveld (GBUSH)	1 127	-	-	-	-	-	-	4 284	-	-		-	-	-	2 254	676	-	-		
	High Mountain grasslands (GHIGH)	-	225	225	451	-	225	-	902	-	-	-		-	-	-	451	-	-		
	Natural Water Body (WNAT)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-		
	Artificial Water Body (WART)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-		
	Settlement (SSET)	-	-	-	-	-	-	-	676	-	-	-	225	-	-		-	-	-		
	Woody Settlement (SWOOD)	225	-	-	-	-	-	-	225	-	-	-	-	-	-	-		-	-		
	Other Lands (OOTHER	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-	-		-		
	Mine (OMIN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			

2019

Matrix type 1 : stable land and land converted in 2019 Unit: ha	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	Annual Crops (CANN)	Perennial Crops (CPERN)	Agroforestry (CAGRO)	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHE)	Mine (OMIN)	TOTAL (January)	
Dryer Acacia Savannah Forest (FDRYACA)	401 523							451			225					225			402 425	
Moister Savannah Forest (FMOSAV)		97 844						225											98 070	
Montane and Highland (FMON)			48 922																48 922	
Plantations (FPLAN)				125 124															125 124	
Riparian (FRIP)					64 253														64 253	
Wattle Forest (FWAT)						40 355													40 355	
Woodlots (FWOD)							23 221												23 221	
Annual Crops (CANN)				225				388221			451								388 898	
Perennial Crops (CPERN)	225								8792										9 018	
Agroforestry (CAGRO)										6763									6 763	
Bushveld (GBUSH)								225			214 401								214 626	
High Mountain grasslands (GHIGH)												206 736							206 736	
Natural Water Body (WNAT)													18 938						18 938	
Artificial Water Body (WART)														8 792					8 792	
Settlement (SSET)															46 442				46 442	
Woody Settlement (SWOOD)																19 163			19 163	
Other Lands (OOTHER																	13 978		13 978	
Mine (OMIN)																		676	676	
Decembre 2020 - TOTAL	401 748	97 844	48 922	125 349	64 253	40 355	23 221	389 123	8 792	6 763	215 077	206 736	18 938	8 792	46 442	19 389	13 978	676	**1 736 400**	Country area

Matrix type II : land in transition for previous 19 years

Dryer Acacia Savannah Forest (FDRYACA)		-	-	-	-	-	-	3 156	225	-	902	-	-	451	-	451	-	225	
Moister Savannah Forest (FMOSAV)	-		-	-	-	-	-	-	-	-	-	-	-	-	-	225	-	-	
Montane and Highland (FMON)	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Plantations (FPLAN)	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Riparian (FRIP)	-	-	-	-		-	-	225	225	-	-	-	-	-	-	-	-	-	
Wattle Forest (FWAT)	-	-	-	-	-		-	225	-	-	-	225	-	-	-	-	225	-	
Woodlots (FWOD)	-	-	-	-	-	-		-	-	-	-	451	-	-	451	-	-	-	
Annual Crops (CANN)	1 578	225	-	-	-	-	451		-	451	2 029	-	-	-	1 127	-	225	225	
Perennial Crops (CPERN)	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Agroforestry (CAGRO)	-	-	-	-	-	-	-	225	-		-	-	-	-	-	-	-	-	
Bushveld (GBUSH)	1 127	-	-	-	-	-	-	4 058	-	-		-	-	-	2 254	676	-	-	
High Mountain grasslands (GHIGH)	-	225	225	451	-	225	-	902	-	-	-		-	-	-	451	-	-	
Natural Water Body (WNAT)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	
Artificial Water Body (WART)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	
Settlement (SSET)	-	-	-	-	-	-	-	676	-	-	-	225	-	-		-	-	-	
Woody Settlement (SWOOD)	225	-	-	-	-	-	-	225	-	-	-	-	-	-	-		-	-	
Other Lands (OOTHER	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-	-		-	
Mine (OMIN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

2018

Matrix type 1 : stable land and land converted in 2018 Unit: ha	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	Annual Crops (CANN)	Perennial Crops (CPERN)	Agroforestry (CAGRO)	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHE)	Mine (OMIN)	TOTAL (January)	
Dryer Acacia Savannah Forest (FDRYACA)	402 425																		402 425	
Moister Savannah Forest (FMOSAV)		97 844																	97 844	
Montane and Highland (FMON)			48 922																48 922	
Plantations (FPLAN)				125 124															125 124	
Riparian (FRIP)					64 253														64 253	
Wattle Forest (FWAT)						40 355													40 355	
Woodlots (FWOD)							22 770												22 770	
Annual Crops (CANN)							451	388221		225	451						225		389 574	
Perennial Crops (CPERN)									9018										9 018	
Agroforestry (CAGRO)								225		6538									6 763	
Bushveld (GBUSH)								451			214 176				225				214 852	
High Mountain grasslands (GHIGH)		225										206 736							206 961	
Natural Water Body (WNAT)													18 938						18 938	
Artificial Water Body (WART)														8 792					8 792	
Settlement (SSET)															46 217				46 217	
Woody Settlement (SWOOD)																19 163			19 163	
Other Lands (OOTHER																	13 752		13 752	
Mine (OMIN)																		676	676	
Decembre 2020 - TOTAL	402 425	98 070	48 922	125 124	64 253	40 355	23 221	388 898	9 018	6 763	214 626	206 736	18 938	8 792	46 442	19 163	13 978	676	**1 736 400**	Country area

Matrix type II : land in transition for previous 19 years

Dryer Acacia Savannah Forest (FDRYACA)		-	-	-	-	-	-	3 156	225	-	902	-	-	451	-	451	-	225	
Moister Savannah Forest (FMOSAV)	-		-	-	-	-	-	-	-	-	-	-	-	-	-	225	-	-	
Montane and Highland (FMON)	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Plantations (FPLAN)	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Riparian (FRIP)	-	-	-	-		-	-	225	225	-	-	-	-	-	-	-	-	-	
Wattle Forest (FWAT)	-	-	-	-	-		-	225	-	-	-	225	-	-	-	-	225	-	
Woodlots (FWOD)	-	-	-	-	-	-		-	-	-	-	451	-	-	451	-	-	-	
Annual Crops (CANN)	1 578	225	-	-	-	-	-		-	225	1 578	-	-	-	1 127	-	-	225	
Perennial Crops (CPERN)	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Agroforestry (CAGRO)	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	
Bushveld (GBUSH)	1 127	-	-	-	-	-	-	3 607	-	-		-	-	-	2 029	676	-	-	
High Mountain grasslands (GHIGH)	-	-	225	451	-	225	-	902	-	-	-		-	-	-	451	-	-	
Natural Water Body (WNAT)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	
Artificial Water Body (WART)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	
Settlement (SSET)	-	-	-	-	-	-	-	676	-	-	-	225	-	-		-	-	-	
Woody Settlement (SWOOD)	225	-	-	-	-	-	-	225	-	-	-	-	-	-	-		-	-	
Other Lands (OOTHER	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-	-		-	
Mine (OMIN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

2017

Matrix type 1 : stable land and land converted in 2017 Unit: ha	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	Annual Crops (CANN)	Perennial Crops (CPERN)	Agroforestry (CAGRO)	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHE)	Mine (OMIN)	TOTAL (January)
Dryer Acacia Savannah Forest (FDRYACA)	401 748							225	225										402 199
Moister Savannah Forest (FMOSAV)		97 844																	97 844
Montane and Highland (FMON)			48 922																48 922
Plantations (FPLAN)				125 124															125 124
Riparian (FRIP)					64 253														64 253
Wattle Forest (FWAT)						40 355						225					225		40 806
Woodlots (FWOD)							22 770												22 770
Annual Crops (CANN)	225							388898			225				451			225	390 025
Perennial Crops (CPERN)									8792										8 792
Agroforestry (CAGRO)										6763									6 763
Bushveld (GBUSH)	451							225			214 626				676				215 979
High Mountain grasslands (GHIGH)								225				206 736							206 961
Natural Water Body (WNAT)													18 938						18 938
Artificial Water Body (WART)														8 792					8 792
Settlement (SSET)															45 090				45 090
Woody Settlement (SWOOD)																19 163			19 163
Other Lands (OOTHER																	13 527		13 527
Mine (OMIN)																		451	451
Decembre 2020 - TOTAL	402 425	97 844	48 922	125 124	64 253	40 355	22 770	389 574	9 018	6 763	214 852	206 961	18 938	8 792	46 217	19 163	13 752	676	**1 736 400**

Country area

Matrix type II : land in transition for previous 19 years

Dryer Acacia Savannah Forest (FDRYACA)		-	-	-	-	-	-	2 931	-	-	902	-	-	451	-	451	-	225	
Moister Savannah Forest (FMOSAV)	-		-	-	-	-	-	-	-	-	-	-	-	-	-	225	-	-	
Montane and Highland (FMON)	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Plantations (FPLAN)	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Riparian (FRIP)	-	-	-	-		-	-	225	225	-	-	-	-	-	-	-	-	-	
Wattle Forest (FWAT)	-	-	-	-	-		-	225	-	-	-	-	-	-	-	-	-	-	
Woodlots (FWOD)	-	-	-	-	-	-		-	-	-	-	451	-	-	451	-	-	-	
Annual Crops (CANN)	1 353	225	-	-	-	-	-		-	225	1 353	-	-	-	676	-	-	-	
Perennial Crops (CPERN)	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Agroforestry (CAGRO)	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	
Bushveld (GBUSH)	676	-	-	-	-	-	-	3 382	-	-		-	-	-	1 353	676	-	-	
High Mountain grasslands (GHIGH)	-	-	225	451	-	225	-	676	-	-	-		-	-	-	451	-	-	
Natural Water Body (WNAT)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	
Artificial Water Body (WART)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	
Settlement (SSET)	-	-	-	-	-	-	-	676	-	-	-	225	-	-		-	-	-	
Woody Settlement (SWOOD)	225	-	-	-	-	-	-	225	-	-	-	-	-	-	-		-	-	
Other Lands (OOTHER	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-	-		-	
Mine (OMIN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

2016

Matrix type 1 : stable land and land converted in 2016 Unit: ha	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	Annual Crops (CANN)	Perennial Crops (CPERN)	Agroforestry (CAGRO)	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHE)	Mine (OMIN)	TOTAL (January)	
Dryer Acacia Savannah Forest (FDRYACA)	401 748							676			451					225			403 101	
Moister Savannah Forest (FMOSAV)		97 844																	97 844	
Montane and Highland (FMON)			48 922																48 922	
Plantations (FPLAN)				125 124															125 124	
Riparian (FRIP)					64 253														64 253	
Wattle Forest (FWAT)						40 806													40 806	
Woodlots (FWOD)							22 770												22 770	
Annual Crops (CANN)	225							387996			451				225				388 898	
Perennial Crops (CPERN)									8792										8 792	
Agroforestry (CAGRO)										6763									6 763	
Bushveld (GBUSH)								902			215 077				451	451			216 881	
High Mountain grasslands (GHIGH)								225				206 961				225			207 412	
Natural Water Body (WNAT)													18 938						18 938	
Artificial Water Body (WART)														8 792					8 792	
Settlement (SSET)								225							44 413				44 639	
Woody Settlement (SWOOD)	225															18 261			18 487	
Other Lands (OOTHER																	13 527		13 527	
Mine (OMIN)																		451	451	
Decembre 2020 - TOTAL	402 199	97 844	48 922	125 124	64 253	40 806	22 770	390 025	8 792	6 763	215 979	206 961	18 938	8 792	45 090	19 163	13 527	451	**1 736 400**	Country area

Matrix type II : land in transition for previous 19 years

Dryer Acacia Savannah Forest (FDRYACA)		-	-	-	-	-	-	2 254	-	-	451	-	-	451	-	225	-	225	
Moister Savannah Forest (FMOSAV)	-		-	-	-	-	-	-	-	-	-	-	-	-	-	225	-	-	
Montane and Highland (FMON)	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Plantations (FPLAN)	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Riparian (FRIP)	-	-	-	-		-	-	225	225	-	-	-	-	-	-	-	-	-	
Wattle Forest (FWAT)	-	-	-	-	-		-	225	-	-	-	-	-	-	-	-	-	-	
Woodlots (FWOD)	-	-	-	-	-	-		-	-	-	-	451	-	-	451	-	-	-	
Annual Crops (CANN)	1 127	225	-	-	-	-	-		-	225	902	-	-	-	451	-	-	-	
Perennial Crops (CPERN)	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Agroforestry (CAGRO)	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	
Bushveld (GBUSH)	676	-	-	-	-	-	-	2 480	-	-		-	-	-	902	225	-	-	
High Mountain grasslands (GHIGH)	-	-	225	451	-	225	-	451	-	-	-		-	-	-	225	-	-	
Natural Water Body (WNAT)	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	
Artificial Water Body (WART)	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	
Settlement (SSET)	-	-	-	-	-	-	-	451	-	-	-	225	-	-		-	-	-	
Woody Settlement (SWOOD)	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-		-	-	
Other Lands (OOTHER	-	-	-	-	-	-	-	225	-	-	-	-	-	-	-	-		-	
Mine (OMIN)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

4.3 Estimations of total emissions and the Modified Forest Reference Emission Level

The table below presents the tonnes of CO_2 equivalent emitted for the historical period from 2016 to 2020 which is the basis to estimate the historical average for this FREL.

Table 30: Modified Forest Reference level of Eswatini related emissions

Year	Degradation	Deforestation	TOTAL emissions	Historical average
	Forest land remaining Forest land (Gross losses) & Biomass burning on Forest	Forest converted to land		
	Unit: t CO2e *(Uncertainty %)*			
2016	1 431 665 *(22.88%)*	82 282 *(66.35%)*	1 513 947 *(21.63%)*	1 077 435 *(15%)*
2017	1 107 745 *(27.2%)*	91 378 *(62.4%)*	1 199 123 *(24.91%)*	1 077 435 *(15%)*
2018	607 462 *(34.55%)*	33 933 *(94.43%)*	641 394 *(32.67%)*	1 077 435 *(15%)*
2019	1 164 833 *(23.29%)*	81 655 *(62.5%)*	1 246 487 *(21.8%)*	1 077 435 *(15%)*
2020	743 539 *(29.44%)*	42 682 *(83.64%)*	786 221 *(27.99%)*	1 077 435 *(15%)*

The figure below presents the values in graphical format.

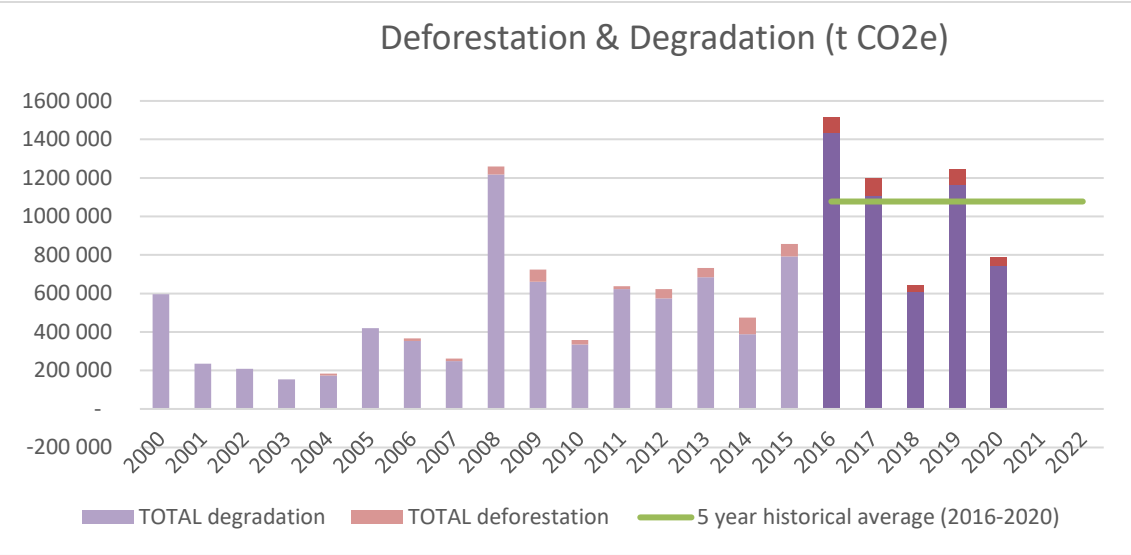


Figure 10: Modified Forest reference level 2016-2020

5. Assessment of Uncertainties

The table below presents a qualitative uncertainty assessment for the data used in this FREL.

*Table 31: **Summary of Uncertainty by data used***

Data	Related uncertainty
Area of land use, Area of land use change Area logged Area under a disturbance/fire from CfRN LUA Assessment, October 2023	**Systematic error** **Interpretation error 18%** The uncertainty of data collection was calculated on the following basis: **10% of the plots interpreted by national assignment classes** will be interpreted a second time by an external GIS expert. The result of this assessment shows that 82% of the plot double checks result in the same interpretation. **The error of interpretation is 18%** which is very good results for a first assessment. This represents the uncertainty related to the land use assessment and the possibility that a plot has been wrongly interpreted. Another systematic error comes from the **land in transition**: for each conversion, IPCC recommends to estimate 20 years of land in transition before this land is in a new remaining category. To follow IPCC recommendation, Eswatini estimated the land in transition in order to apply the carbon stock changes through time for 20 years. This is the reason why two types of Matrices are presented in this report. However, activity data available was only for the period 2000-2022. Which means that for many years, we do not have the full picture of the land in transition before the year 2000. For example, for year 2010 - the land of transition which should be included in matrix II - 2010 should represent the years 1990-2009 however we only have information from 2000-2009. Other related uncertainty not quantified above: - Lack of images available - Difference of resolution through the years - 2000 to 2015 Landsat and Google earth pro, after also Sentinel 2, Planet NICFI, etc. - Missing disturbance or logging because the area affected is very small **Random error** Random error is the variation above and below a mean value following the equation: 1,96if ni>30 or 2,365 if ni<30*s_AD/ADi*100 where: AD = area ADi = Standard deviation of area ni = number of plots The smaller the sampling the higher the uncertainty is. It was calculated for the activity data to provide the precision of this activity data. **The Uncertainty related to Forestland is calculated at 2% (see table below)** - the detail of the estimation is included in the Calculation sheet tab Land_AD-RandomError

Table 32: ***Random error of the activity data for Forest land (%)***

Random Error unit : %	**Forestland**	Dryer Acacia Savannah Forest	Moister Acacia Savannah Forest	Montane and Highland	Plantations	Riparian	Wattle Forest	Woodlots	*Forest to cropland*	Forest to grassland	Forest to Wetland	Forest to Settlement	Forest to otherland
2016	2	4	9	13	8	11	14	19	137	167	-	236	-
2017	2	4	9	13	8	11	14	19	167	236	-	-	236
2018	2	4	9	13	8	11	14	19	-	-	-	-	-
2019	2	4	9	13	8	11	14	19	137	236	-	236	-
2020	2	4	9	13	8	11	14	19	167	236	-	-	-
Average	2	4	9	13	8	11	14	19	111	72	23	73	23

Emission/removal factors from Ministry of Tourism and Environmental Affairs, 2020 & IPCC, 2006	IPCC 2006 provides SD, error or mean for the default values. The details are included in the tables included in the previous section. For the Values extracted from the GHGI 2020, that come from the 2015 South African study, no information is provided on the uncertainty of these values. As these values are not country specific, the uncertainty related to them is very high. Also considering that the classes were not exactly the same between South Africa and Eswatini's FREL (see section 3.3.3), this increases the error.
MONTE CARLO	IPCC Approach 2, known as the Monte Carlo simulation (Volume 1, Chapter 3, IPCC 2006), performed in Microsoft Excel using the Argo add-in is presented in the Annex II of this report. The uncertainty for the FREL historical Average is **15%.**

REDD+ activity	Land use category	IPCC equations	2016	2017	2018	2019	2020
Degradation	FL remaining FL (Carbon Losses) [t CO2e]	eq. 2.11 gross	1 418 090	1 102 176	602 769	1 149 655	738 001
	Uncertainty [%]		*23,13*	*27,37*	*34,92*	*23,64*	*29,74*
	Biomass Burning in FL [t CO2e]	eq. 2.27 gross	13 576	5 569	4 693	15 177	5 538
	Uncertainty [%]		*73,30*	*75,65*	*78,96*	*72,09*	*78,59*
	TOTAL degradation [t CO2e]		1 431 665	1 107 745	607 462	1 164 833	743 539
	Uncertainty [%]		*22,86*	*27,20*	*34,55*	*23,29*	*29,44*
Deforestation	Forest land converted to CL [t CO2e]	eq. 2.16 net	47 204	16 029	22 475	53 429	22 255
	Uncertainty [%]		*53,38*	*111,98*	*84,49*	*49,92*	*94,70*
	Forest land converted to GL [t CO2e]	eq. 2.16 net	16 710	31 702	1 109	9 243	9 465
	Uncertainty [%]		*70,68*	*66,35*	*129,06*	*71,97*	*73,85*
	Forest land converted to WL [t CO2e]	eq. 2.16 net	7 274	7 274	7 274	7 274	7 274
	Uncertainty [%]		*163,01*	*163,85*	*164,80*	*162,93*	*163,74*
	Forest land converted to SL [t CO2e]	eq. 2.16 net	11 094	3 073	3 073	11 708	3 688
	Uncertainty [%]		*70,48*	*71,19*	*70,88*	*67,66*	*71,65*
	Forest land converted to OL [t CO2e]	eq. 2.16 net	0	33 300	0	0	0
	Uncertainty [%]			*74,96*			
	TOTAL deforestation [t CO2e]		82 282	91 378	33 933	81 655	42 682
	Uncertainty [%]		*66,35*	*62,40*	*94,43*	*62,50*	*83,64*
	TOTAL DD [t CO2e]		1 513 947	1 199 123	641 394	1 246 487	786 221
	Uncertainty [%]		*21,63*	*24,91*	*32,67*	*21,80*	*27,99*
	5-year historical average (2016-2020) [t CO2e]				1 077 435		
	Uncertainty [%]				*15,00*		

6. Consistency with the National GHG inventory

The FREL was developed following the guidance provided in Decision 12/CP.17, decision 4/CP.15, paragraph 7, and seeks to maintain consistency with the anthropogenic forest-related

greenhouse gas emissions by sources to be included in the next update of the national greenhouse gas (GHG) inventory. Specific activity data was collected for the development of this FREL. Due to improvements in the data used in this FREL compared to the 2016 GHGI included as part of the Third National Communication, the consistency was not maintained with previous GHGI. Furthermore, ongoing work for the next GHGI to be included in the first Biennial Update Report was not coordinated with the FREL. This means that information in the BUR to be submitted in 2024 will not be consistent with the FREL either. It was estimated that the dataset used for the FREL was the most accurate at this time as it provides details of the different forest types and the disturbance occurring of forest land as well as area of logging. The dataset used in the FREL was developed by the national team inside the Ministry of Tourism and Environmental Affairs. The country will work on streamlining the process to ensure that only one dataset is produced and used in the future submissions.

The work undertaken for the development of this Forest Reference level was well integrated inside the Ministry and the team involved will be responsible to develop future GHGI and REDD+ reports which will ensure full consistency in the next report to be submitted to the UNFCCC.

Consistency will be possible in the future between the FREL and the GHGI, as this FREL follows 2006 IPCC guidelines and provides a transparent explanation of the estimations and assumptions taken.

7. Improvement plan

Following REDD+ decisions of the stepwise approach, the country has decided to present this submission using the best available data at that time. Eswatini is aware that some improvements are needed to provide more accurate information on the Forestland sector. The national team has already taken into consideration the following elements to be improved for the future submissions:

- **Activity data** – Eswatini provided newly collected data on land use and land use change covering the entire country and looking at all the six IPCC land use categories. This tremendous work allows Eswatini to have a full time series of areas of land use and land use change which is completely new to the country. Previous submissions used extrapolations from FAO data. This great improvement has allowed Eswatini to present this FREL. However, the country is aware that improvements are still needed in terms of assessment.
    - **Disturbances**: In particular, for the areas that are under disturbances and specific management practice. It is well known in the country that agriculture and grazing affects forest areas, more research will need to be done to ensure that fully affected areas are recorded through time.
    - **Fire**: Fire is also present in the country; some studies have shown that big areas of land are affected by fires. For this assessment Fire is included using the remote sensing data available in CfRN LUA App. Parallel studies will need to be undertaken to make sure the areas affected by fire have been captured accurately.
    - **Logging**: The country has an important production of Timber. The West side of the country is covered by big timber companies extracting roundwood from plantations. The country is currently contacting all the timber companies to get more details on the amount of wood they extract on a yearly basis, this information will be compared to the data collected with remote sensing to make sure current estimates are accurate. Although it was very clear on the high-resolution images when wood extraction occurred on plantations, it was a bit more difficult to see the extraction of wood from other types of forest where local communities use the wood for their day-to-day use. This information is

more difficult to get on the ground as this is part of the informal economy. Other studies will need to be undertaken to provide better quality of the local practice on wood extraction.

- **Emission Factors** – All values used in the FREL are TIER default values from IPCC guidelines and from a South African study. The country is looking for funding to execute a National Forest Inventory to collect carbon stock data directly from the national forests. This work will tremendously improve estimations. The priority should be given to plantation forests as these are the areas with the highest uncertainty at the moment.
- **Uncertainty** – For this submission the country provided a qualitative assessment of the related uncertainty of emission factors. The random and systematic error of the activity data provides some estimations of the uncertainty related to the activity data. As the data used is all tier 1, error is expected to be high. In the future, the country would like to include a quantitative estimation of the uncertainty using the propagation of error. propagation of error following IPCC guidelines.
- **HWP** - not included in this submission due to lack of data. The country will work on including this information in future submissions.

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Access to **additional** documents:
https://drive.google.com/file/d/1ZQ_RNCm0akllX8FnuD8BcKL29aSyC-2I/view?usp=sharing

Annex I: Protocol for the Land Use assessment

The Activity data for all the land use classes was derived from remote sensing products generated by the Eswatini Ministry of Tourism and Environmental Affairs team.
The data was collected between June and October 2023 following the systematic sampling approach as recommended by the 2006 IPCC guidelines. The CfRN Land Use Assessment Application (CfRN LUA) was used to access and analyse the images through time.

The land use assessment grid has plots every 2,5km with a total of 7700 plots. Each plot represents an area of 0,5 ha to represent the national forest definition. Each of the plots contains 49 samples to help with the visual interpretation. The period cover is the land use and land use changes that occurred between 2000 and 2022.

Annex I.1 Hierarchy of land use classes

In some cases, the plot covers different land use classes. In the case of this assessment, only one land use category can be given to each plot. With some sub information of the composition of the plot, as for example, proportion covered by trees, by infrastructure, etc. To classify the plot into one land use class a hierarchy of priority classes have been established by the national team. The hierarchy is presented in the figure below and an example is provided in Figure 12.

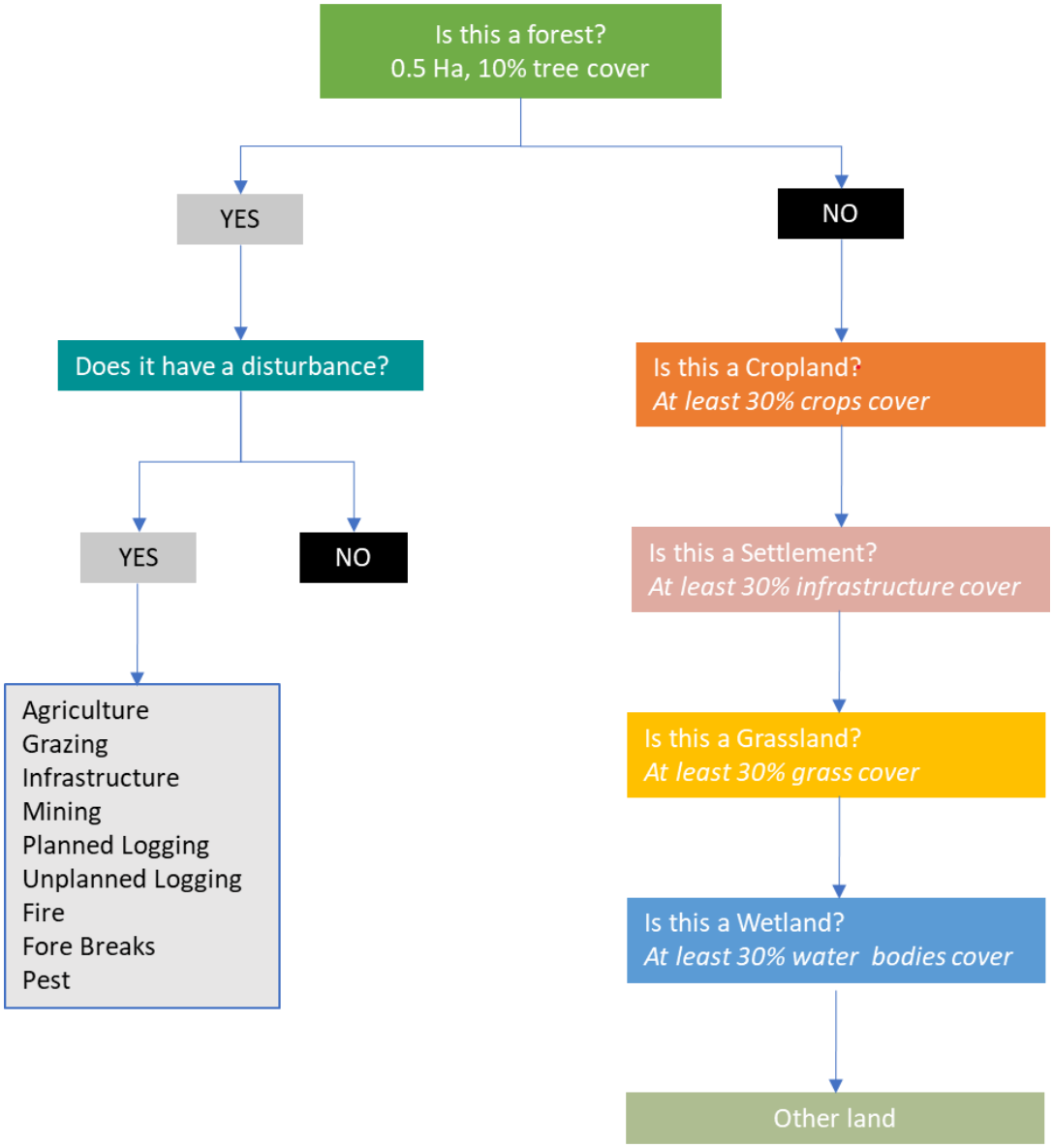


Figure 11: ***Decision tree for the plot hierarchy***



Figure 12: ***Example on how to assess the plot class when multiple land use classes can be observed inside the plot***

Annex I.2 Matrix of impossible and possible land use conversions

To limit errors during the land use assessment, experts have determined which land use classes cannot be converted into a different land use. Some land use conversions are physically impossible, because the classes are located at different altitudes or areas of the country. For example, it is impossible to see a Montane and Highland forest which is always located above 800m from sea level, converted into Acacia Savannah Forests which are located between 200-400m above sea level. In the same understanding some disturbances are not visible on some forest types.

Impossible conversions related to Forest	Dryer Acacia Savannah Forest (FDRYACA)	Moister Savannah Forest (FMOSAV)	Montane and Highland (FMON)	Plantations (FPLAN)	Riparian (FRIP)	Wattle Forest (FWAT)	Woodlots (FWOD)	*Croplands, Annual Crops (CANN)*	*Croplands, Perennial Crops (CPERN)*	*Croplands, Agroforestry (CAGRO)*	Bushveld (GBUSH)	High Mountain grasslands (GHIGH)	Natural Water Body (WNAT)	Artificial Water Body (WART)	Settlement (SSET)	Woody Settlement (SWOOD)	Other Lands (OOTHER, OMIN)	Mine (OMIN)
Dryer Acacia Savannah Forest (FDRYACA)																		
Moister Savannah Forest (FMOSAV)																		
Montane and Highland (FMON)																		
Plantations (FPLAN)																		
Riparian (FRIP)																		
Wattle Forest (FWAT)																		
Woodlots (FWOD)																		
Croplands, Annual Crops (CANN)																		
Croplands, Perennial Crops (CPERN)																		
Croplands, Agroforestry (CAGRO)																		
Bushveld (GBUSH)																		
High Mountain grasslands (GHIGH)																		
Natural Water Body (WNAT)																		
Artificial Water Body (WART)																		
Settlement (SSET)																		
Woody Settlement (SWOOD)																		
Other Lands (OOTHER, OMIN)																		
Mine (OMIN)																		

Impossible conversion

Annex I.3 Roles and tasks for data collection

Training on UNFCCC decisions and REDD+ concept	March to June 2023 Online training held by CfRN for the Ministry of Tourism and Environmental Affairs.
Data collection and protocol	June to October 2023 Team of 15 experts from the Ministry of Tourism and Environmental Affairs
Workshop finalisation of data collection	October 2023 Ministry of Tourism and Environmental Affairs - guided by CfRN
QA of the data collection	November 2023 10% of plots checks by GIS CfRN expert = 18% interpretation error
Preparation of estimations	November 2023 Ministry of Tourism and Environmental Affairs with CfRN support
Preparation of Report	December 2023 Ministry of Tourism and Environmental Affairs with CfRN support

Annex I.4 Interpretation keys

The identification of the classes is based on the observation of four (4) visual characteristics: **colour, shape, size and texture** that allow better analysis and interpretation of objects on the

satellite image. The **context** plays a big role as well and will influence the final interpretation of land use.

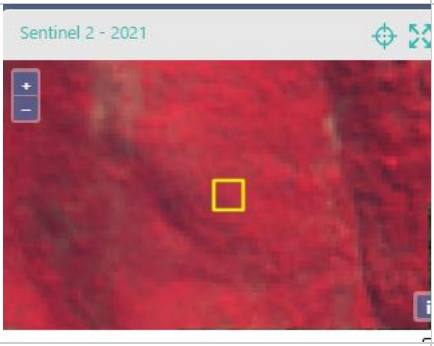
Characteristics	Definition
Colour	Association of a colour channel; primary colours red, green, blue to spectral bands; this is called: coloured composition. In the context of the visual interpretation of images we say that colour or hue refers to the **relative clarity of objects on an image.**
Shape	The shape refers to the **general appearance, structure or outline of individual objects**. Shapes with **straight edges** are usually found in urban areas (settlement) or constitute cultivated land, while natural structures, such as forest edges, are generally more **irregular**, except in places where man has built a road.
Size	A quick assessment of the approximate area of an object often facilitates interpretation. Thus, in an image where one would have to distinguish between small-scale and large-scale crop areas, the dimension provides clarification. At the time of interpretation, it will therefore **be necessary to zoom out** to be interested in this characteristic
Texture	Texture refers to the **arrangement and frequency of hue variations** in particular regions of an image. **Rough** textures and **smooth** textures are mainly distinguished. Rough textures are generally referred to as when there are many tonal variations in a small region of the image, whereas smooth textures would have little or no tonal variations. Uniform surfaces such as fields will be associated with smooth textures while targets such as forests are associated with rough textures
Context	Context refers to the **entire environment around the object being observed**. The interpreter will need to take this environment into account when interpreting, especially in the absence of a very high-resolution image. Gaps in the canopy at the edge of a mosaic of occupation, often indicate a fragmentation of the forest; The building is mainly observed in urban areas, and a green and uniform surface will suggest that you are in the middle of the natural forest, without observed losses. These indications may seem obvious at first, but they allow the interpreter to analyse more quickly the land cover he observes.

Source: Collect Earth Online Manual

Land Use Category Level 1: Forest

Land Use Sub- Category Level 2: Montane and Highland

Colour	True colours: dark green with some brown for the ground during dry season Not uniformed colour as there is a mix of vegetation
Shape	Irregular canopy is not too dense with small and big trees.
Size	Big areas of forest
Texture	Rough
Context	Above 800m altitude. Can be found in the Highveld, Upper and Middleveld. Afromontane and mixed woodland. Indigenous forest

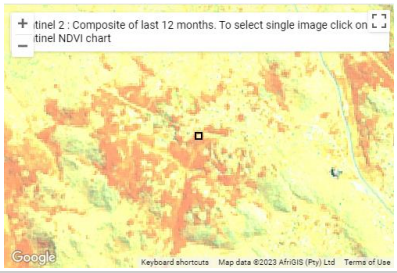
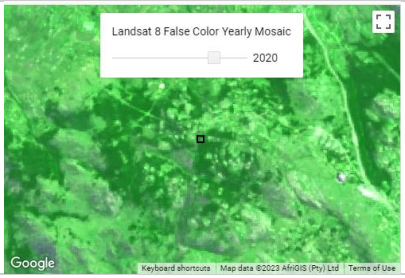
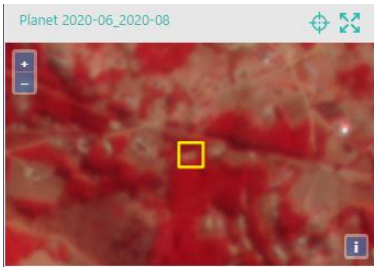
Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2021	2021	2014

Land Use Sub- Category Level 2: Wattle Forest

These forests are used as woodlots for fuelwood, pulpwood, mining timber, charcoal and tannin. They were originally planted and are today unmanaged forests although still exploited by local communities. The species are invasive species that could be a threat to indigenous biodiversity.

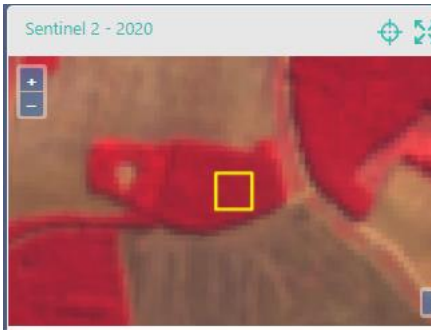
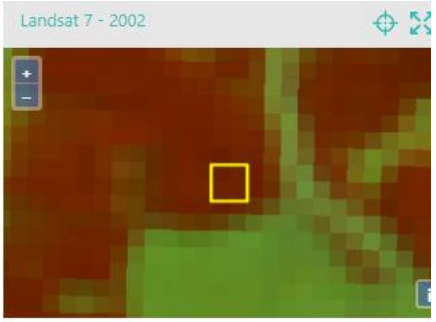
The area wattle seems to have decreased over the years, but some sections are still encroaching on other vegetation such as croplands, grazing and valley floors (National Forest Policy, 2002, p.28).

Colour	True colours: dark green, brown ground visible after logging and fire False colours: red-orange colour, white when bare ground, black when fire
Shape	Regular canopy as this is only one type of trees
Texture	rough
Context	Above 800m altitude in Highveld, human made forest, clear felling - planned logging. In the Swazi National Land. *Acacia mearnsii* dominated forests, Invasive species. The canopy is closed, except when logging activities can create holes in the canopy

Google Earth pro	**Sentinel 2 or Planet NICFI**	**Landsat**
		
2022	2021	2014
		
fire in 2019	Fire in 2019 – Planet NICFI	Logging in 2020 – Planet NICFI

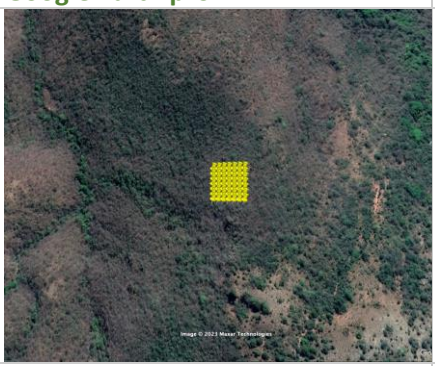
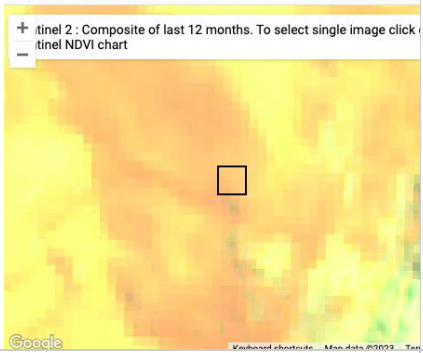
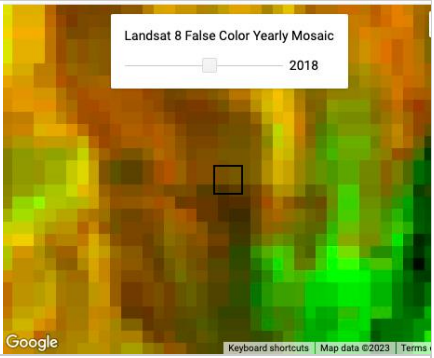
Land Use Sub- Category Level 2: Plantations

Shape	Straight well-defined lines
Size	Depends
Texture	Smooth
Context	Man-made Forest. Plantations of pines and eucalypts. Mainly Highveld, regular logging

Google Earth pro	**Sentinel 2 or Planet NICFI**	**Landsat**
		
2013	2020	2002

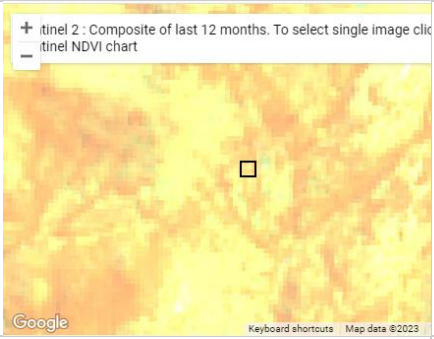
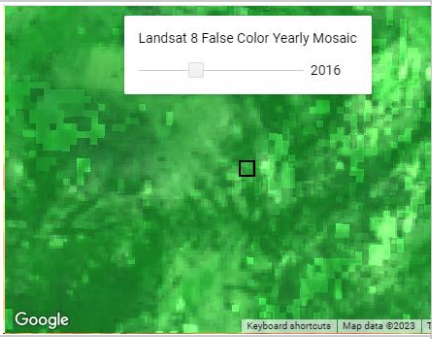
Land Use Sub- Category Level 2: Moister Acacia Savannah Forest

Context	Between 400-800m altitude mainly broadleaved mixed woodland, Indigenous Forest in the Middleveld Lubombo range

Google Earth pro	**Sentinel 2 or Planet NICFI**	**Landsat**
		
2018	Last 12 months	2018

Land Use Sub- Category Level 2: Dryer Acacia Savannah Forest

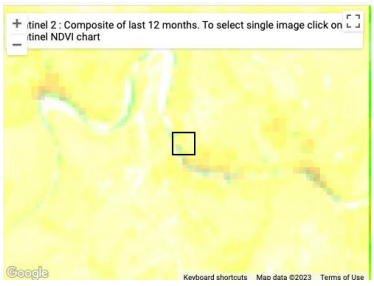
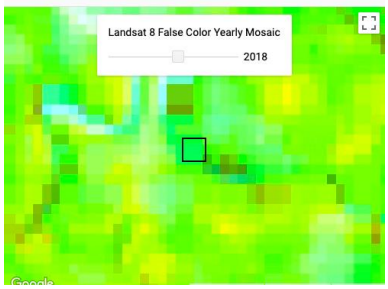
Colour	True colours: mix of green and brown False colours: mix of yellow, light orange, red
Shape	Natural irregular structure, with patches of vegetation and herbaceous soil/
Texture	Rough texture, with different tons or colours and texture
Context	Between 200-400m altitude. Acacia dominated woodland, Indigenous forest in the Lowveld (east) The scrubby nature of the vegetation. During dry season May to August (winter) – only a few evergreen trees are visible, rest of vegetation is dry Located in the same region where there are Sugar Cane plantations. This includes also the shrubland, which contains smaller trees and more grass. It was not possible to differentiate these classes on the images and therefore they are included together.

Google Earth pro	**Sentinel 2 or Planet NICFI**	**Landsat**
		
2016	Last 12 months	2016

Land Use Sub- Category Level 2: Riparian

Colour	True colours: dark green False colours: dark red, with very dark red in the middle where the water is
Shape	Irregular on the outside and but with a clear perception of the river bed in the middle
Size	Will extend from a few meters to XXX meters from the river bed.

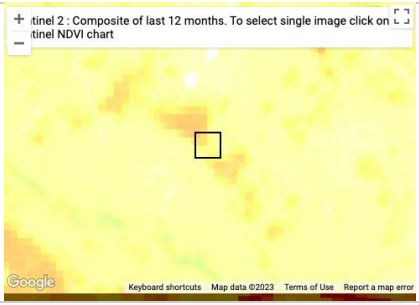
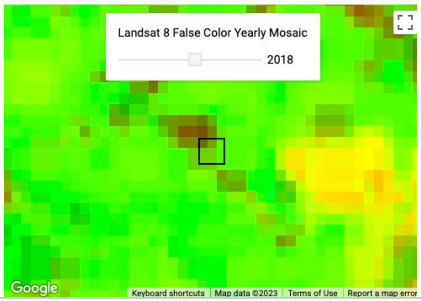
Texture	Round shapes
Context	All physiographic zones but along a river. Mixed woodland and Indigenous Forest

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2018	Last 12 months	2018

Land Use Sub- Category Level 2: Woodlots

Originally human-made, community-based woods to provide fuelwood and timer to communities in addition to wattle and natural forests. The main species planted was eucalyptus (gum.) (National Forest Policy, 2022, p.28).

Colour	True colours: patch of dark green False colours: patch of dark red
Shape	Irregular patches
Size	0.5ha – 5ha
Texture	Round shapes of the canopy
Context	Above 600m, next to urban/rural areas. Common in the Middleveld and Highveld. Different ages for allowing regeneration. Mostly for domestic use (fuelwood).

Bing Load	Sentinel 2 or Planet NICFI	Landsat
		
2018	Last 12 months	2018

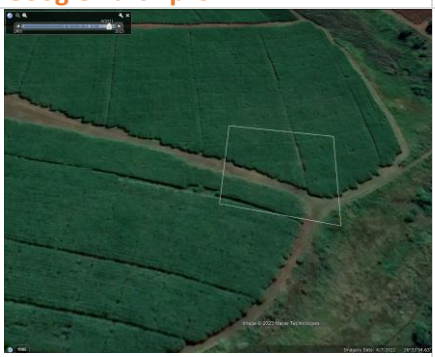
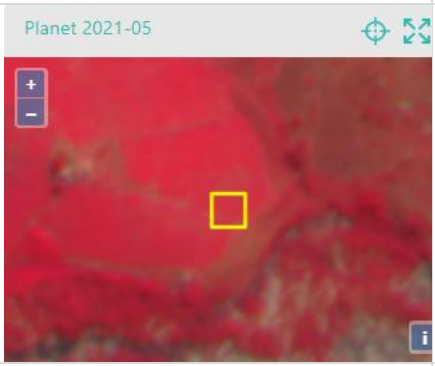
Land Use Category Level 1: Cropland

Land Use Category Level 2: Annual Crops

Land Use Category Level 3: Sugar Cane

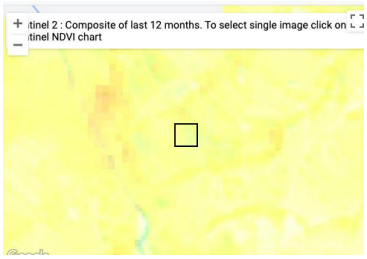
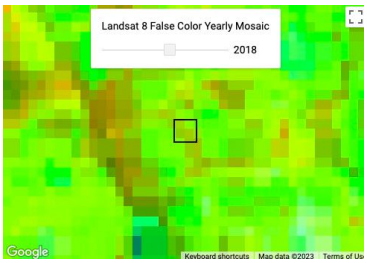
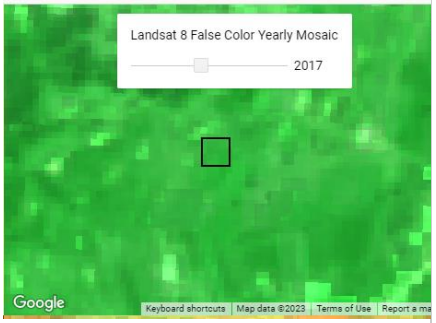
Colour	True colours: Dense green False colours: dense red when the plant is green, orange after the harvest
Shape	Varying shapes
Size	Vary
Texture	Dense structure

Context	The fields are very densely populated by dark green grass with clear lines for the machines to go through. Majority of the sugar cane fields are visible on the east of the country. Some crop lands are abandoned (Farmer's communal lands / electricity). Harvest time (April to November)

Google Earth pro	**Sentinel 2 or Planet NICFI**	**Landsat**
		
2021	2021	2010

Land Use Category Level 3: Maize

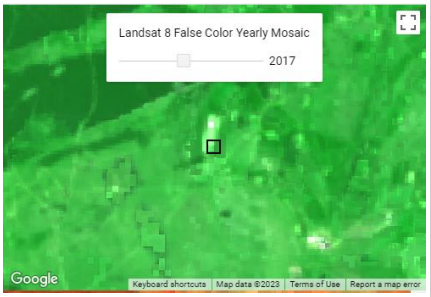
Shape	Rectangular fields
Texture	Before the harvest the texture is very rough
Context	The rectangular fields are split by high grass. During harvest it is possible to see piles of crop residues (white circle) left on the fields. Harvest March-May.

Bing load	**Sentinel 2 or Planet NICFI**	**Landsat**
		
	Last 12 months	2018
		
2017		


harvested maize

Land Use Category Level 3: Other annual crops

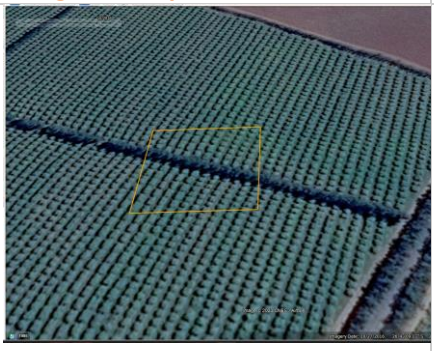
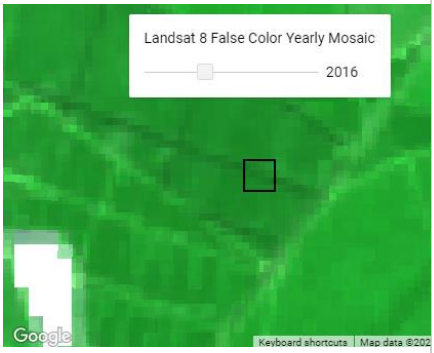
Shape	Straight lines of crop planted
Texture	Smooth
Context	Other annual crops regroup all other crops such as cotton, legumes, vegetables, etc. For cotton, the land is usually abandoned during the winter time. Roads, urban areas in the nearby, clear lines of the crops, can see the harvest period

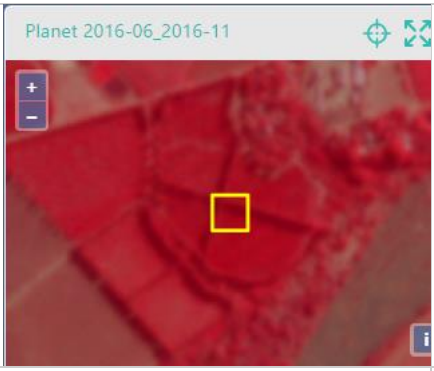
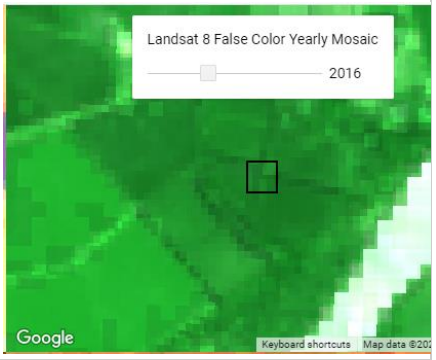
Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2017	Last 12 months	2018

Land Use Category Level 2: Perennial Crops

Land Use Category Level 3: Citrus or Macadamia

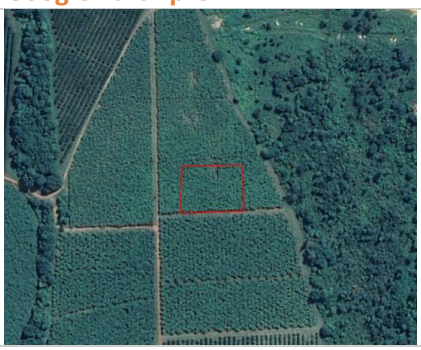
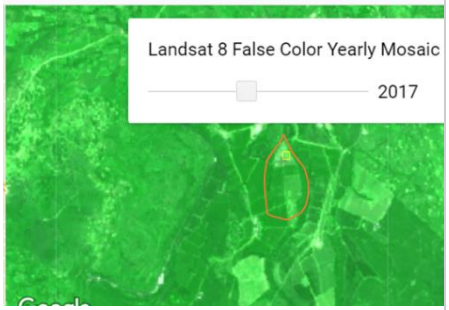
Colour	False colour: dark red True colours: dark green
Shape	Round shapes in straight lines
Size	
Texture	Smooth
Context	Clear round shapes of the canopies of the trees in line with paths for machines to go through. Mostly Highveld and Middleveld. Can be surrounded by trees to limit the field.

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2016	2017	2016

		
2016	2016	2018

Land Use Category Level 3: Banana

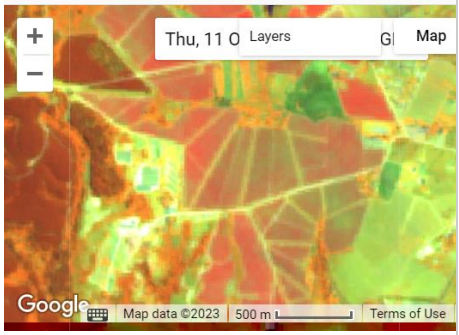
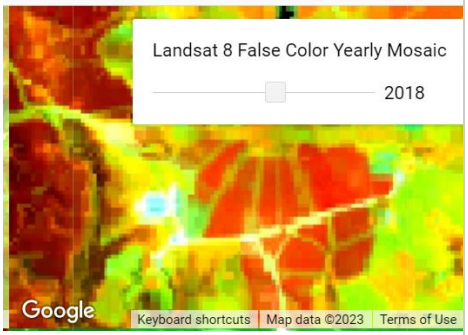
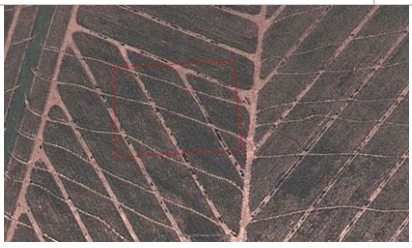
Colour	True colour: Lighter green than for citrus and macadamia and pineapple
Shape	
Size	
Texture	Smooth but straight lines are less clear than for Macadamia and citrus
Context	The palms of the banana trees are lighter in colours. The palms can be seen in some images. The trees are smaller than other

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2019 (Ngonini)	Last 12 months	2017

Land Use Category Level 3: Pineapple

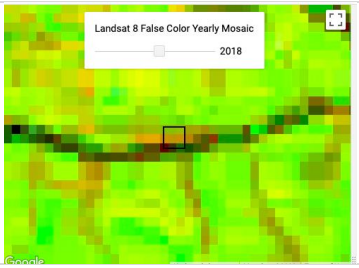
Colour	False colours: bright pink True colours: dark green
Shape	
Size	
Texture	Smooth with straight lines
Context	Intensive agriculture with clear access paths and crop lines. There are also small paths through the crops that are clearly visible when the field is getting prepared for planting. The crop is intense dark green.

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat

		
2018	2018	2018
 visible access path through the crop		

Land Use Category Level 2: Agroforestry

Mixed land uses with trees, crops and livestock. The trees provide a micro-climate that improves the crop development and stabilises the soil with nutrients and stability (roots). This practice is not well developed for the moment and new practices need to be further developed. (National Forest Policy, 2002, p. 28)

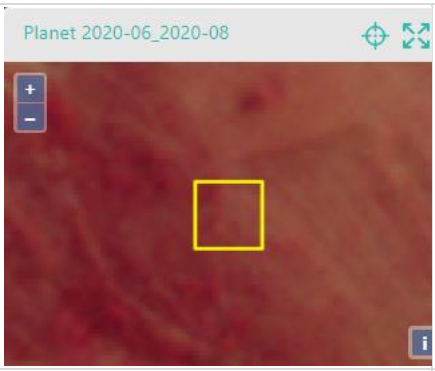
Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2018	Last 12 months	2018

Land Use Category Level 1: Grassland

Land Use Category Level 2: Bushveld

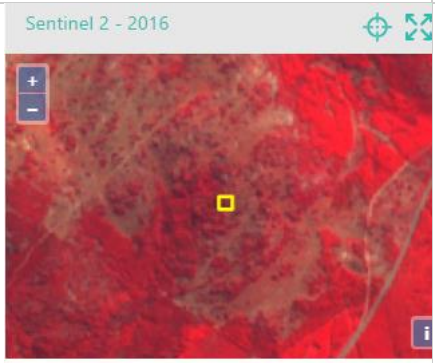
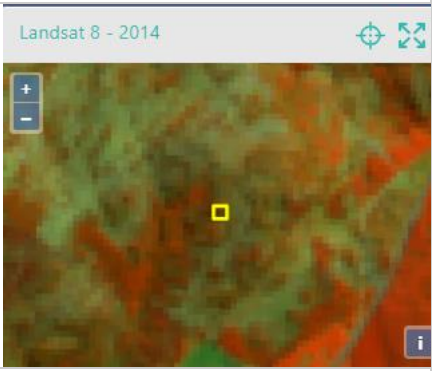
Colour	False colour: mix of brown-red and green
Texture	Rough, mix of small trees and bushes with grass
Context	Elevation between 200-800m. <5 canopy height with bush/thicket communities, natural ecosystem close to human settlement.

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat

		
2020	2020	2018

Land Use Category Level 2: High Mountain grasslands

Colour	False colours: orange-red with some green-grey visible
Shape	Not uniform (patch of trees) with some areas that are more uniform (open grass)
Size	
Texture	Lots of tonal variation
Context	Elevation is more 800m Small trees with <5m canopy height with mostly open grasslands and some rocks in the Highveld region. Areas where pasture and path can be observed

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2013	2016	2014

Land Use Category Level 1: Wetland

Land Use Category Level 2: Natural water bodies

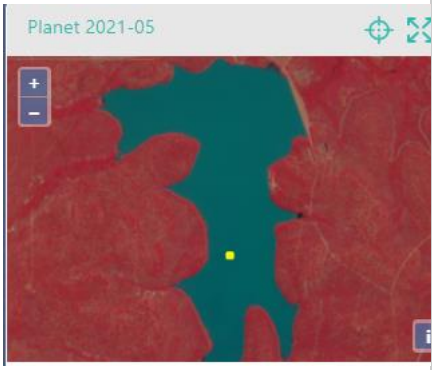
Context	Lakes, rivers, this includes all the flooded grass that surrounds the rivers, where no agriculture is possible because the soil is too damp.

Google Earth pro


2018

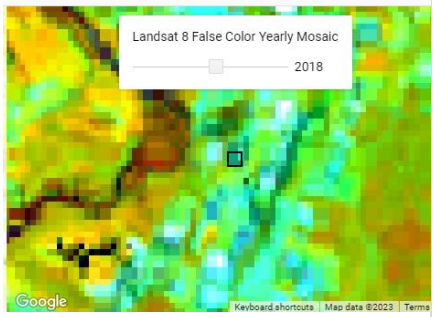
Land Use Category Level 2: Artificial Water bodies

Colour	False colour: dark blue-green. True colour: white
Shape	At least one side is straight line – where we can see that is is human-made The other side of the reservoir can have smoother lines.
Size	Example below –> 3km top-down
Texture	Smooth
Context	Dams and reservoir for irrigation/animals, off streams. Human-made

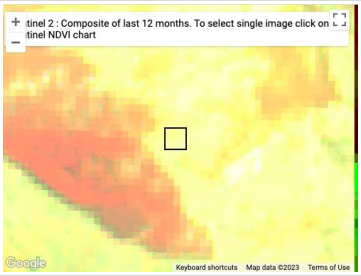
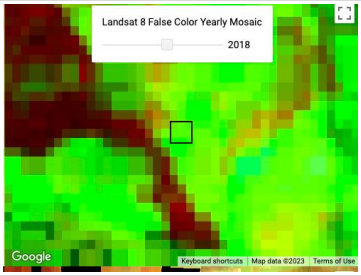
Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2021	2021	2018

Land Use Category Level 1: Settlement

Land Use Category Level 2: Settlements

Google Earth pro	Sentinel 2 or Planet NICFI	Landsat
		
2018	2018	2018

Land Use Category Level 1: Other lands

Bing load	Sentinel 2 or Planet NICFI	Landsat
		
	Last 12 months	2018

Annex I.5 Disturbances

Disturbances are punctual events that affect the land, in particular some of the carbon pools present on these lands. According to the IPCC, there are two types of disturbances; 1. Natural disturbances that happen without any human intervention, for example hurricanes or storms, 2. Anthropogenic disturbances that are created by some specific management practices can be controlled or not, for example fires. This also includes what is called degradation under REDD+, activities that will degrade the stock of carbon in a specific land use. This event can be punctual (fire) or permanent (infrastructure).

In Eswatini the following disturbances have been identified, these disturbances can be observed on forestland as presented in the table below:

Disturbances		Anthropogenic							Anthropogenic/Natural	Natural	
		Agriculture	Grazing	Infrastructure	Planned Logging (SFM)	Unplanned Logging	Mining	Fire Breaks	Fire	Stormflood	Pest
Forest	Montane and Highland	Yes	Yes	Yes		Yes	Yes		Yes	Yes	
	Wattle Forest	Yes	Yes	Yes	Yes			Yes	Yes	Yes	
	Plantations	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Moister Savannah Forest	Yes	Yes	Yes		Yes			Yes	Yes	
	Drier Acacia Savannah Forest	Yes	Yes	Yes		Yes			Yes	Yes	
	Riparian	Yes	Yes	Yes		Yes	Yes		Yes	Yes	
	Woodlots	Yes	Yes	Yes	Yes				Yes	Yes	
Croplands									Yes	Yes	
Grasslands									Yes	Yes	
Wetlands									Yes	Yes	
Settlements									Yes	Yes	
Otherlands									Yes	Yes	

Agriculture on Forestland

Some trees are cut down to leave space for the crops but at least 10% of the plot is still covered by trees. The croplands can be seen extending (NB: if the cropland is already there at the beginning of the period and doesn't move this is NOT a disturbance, this is a multi-use plot where priority is given to forestland). The vegetation disappears clearly on Landsat and Sentinel 2 images.

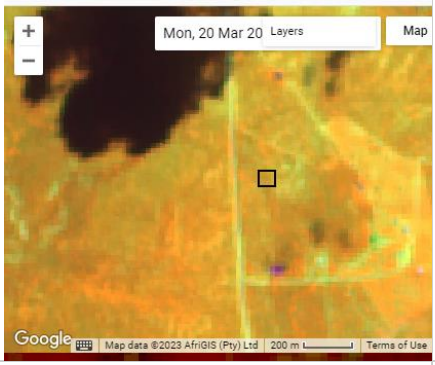
Google earth pro



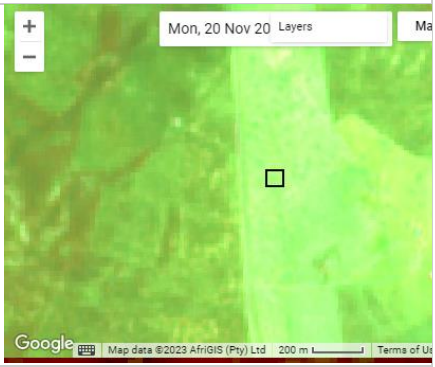
2009



2019



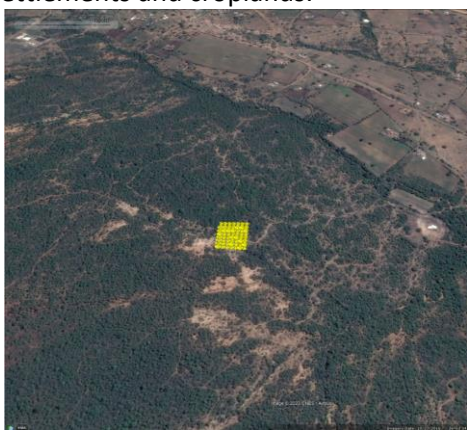
March 2017



Nov 2017

Grazing on Forestland

In Eswatini, livestock are left to pasture on open grassland at high and low altitudes. Sometimes we can find livestock on forestlands. This can be seen in rural areas close to settlements and croplands.



Infrastructure on Forestland: Expansion of the urban areas or construction of roads are the main elements that can be seen degrading the forests. These disturbances most likely will expand even more in the future and produce a land use change from forestland to settlement.



2019 – before disturbance



2021 – after disturbance

logging: in practice this is not a disturbance but a management practice, however for the exercise, logging was assessed the same way that other disturbances. In this case there was a distinction between planned and unplanned logging. Unplanned logging makes a reference to the wood that is extracted on the natural forest such as Dryer Acacia Savannah forest, Moister Acacia Savannah Forest, Montane and Highland forest, Riparian forest. The planned logging is for the forest types that have a management practice that plans for logging extraction such as plantations, Wattle and Woodlots. This is clearly visible on managed forest such as Plantations, Wattle forest, Woodlots.

The **firebreaks** are also part of the planned logging and are clearly visible on Plantations. The land is left bare soil with a bit of grass for a few years before we can see the new plantation growing.

Google earth pro **Sentinel 2 or Planet NICFI** **Landsat 5-7-8**

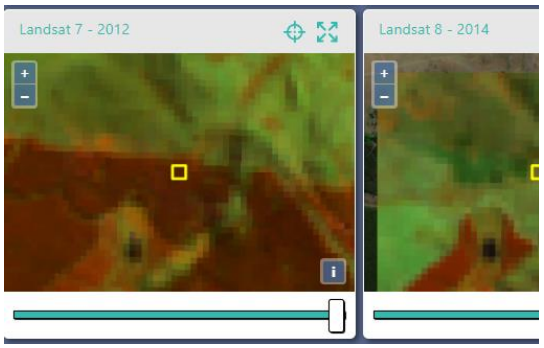
PLANNED LOGGING ON PLANTATION



2011



2013

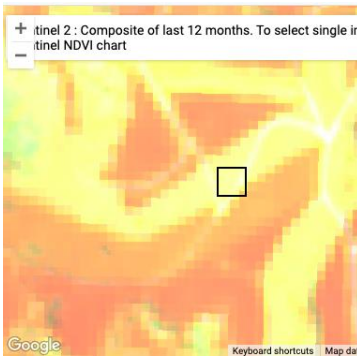


2012 vs 2013

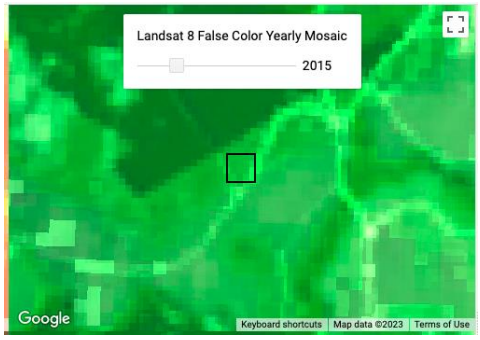
FIREBREAK



2011



Last 12 months



2015

Mining on forest land: extraction of mineral is a common practice in Eswatini.



Before disturbance 2021



After disturbance 2023

Fire: The use of fire in Eswatini is recognized as an efficient tool in the management of natural forests and rangelands. Most of the burning that takes place in the natural woodlands is intended to improve grazing conditions. However, there is evidence that uncontrolled and random fires result in the destruction of natural forest resources and loss of biodiversity. There is no full understanding of the effects of the fire regimes occurring in Swaziland. Fires tend to favour certain species to the detriment of others and reduce overall diversity. Uncontrolled fires caused by strained social relations between forest companies and neighbouring communities also affect industrial forestry (Minister of Agriculture and Cooperatives, 2001).



Before fire 2018



After fire 2019

Annex II: Uncertainty Assessment following Monte Carlo simulation

Preamble

This document provides an uncertainty assessment of the Forest Reference Emissions Level of Eswatini. The Forest Reference Emissions Level is determined by the average emissions from deforestation and forest degradation during the 2016–2020 reference period. The methodology used is the IPCC Approach 2, known as the Monte Carlo simulation (Volume 1, Chapter 3, IPCC 2006), performed in Microsoft Excel using the Argo add-in (https://github.com/boozallen/argo/wiki).

The content of this document is presented as follows:
Section 1: Presentation of the inputs.
Section 2: Presentation of the methodology used to estimate the uncertainties.
Section 3: Presentation of the results.

Section 1. Presentation of the inputs

1.1. Introduction

Estimating the Forest Reference Emissions Level (FREL) requires the use of annual emissions (E). These values are calculated by multiplying activity data (AD) by their respective emission factors (EF). The process is explained by the following generic model:

Equation 1. Emissions: $E = AD \times EF$.

1.2. Data used and Associated uncertainties

The data and uncertainties presented in the table below were used to define the parameters of the probability density functions (PDFs) that were employed to generate random samples using the Monte Carlo simulation. Section 2 provides details of this methodology.

A summary of the data used is presented in the table below.

Table 33: Data used and their uncertainties.

Data description	**Tab in the Analysis tool**
Annual area of land use and land use change in hectare estimated based on the CfRN LUA App assessment.	Land_AD
Estimation of uncertainty of the activity data coming from the CfRN LUA App applying the random error estimation.	Land_AD_Uncertainties
Emission factors selected to estimate stock changes in the different carbon pools.	Land_EF-RF
Estimations of the uncertainties for the carbon stocks values used in the FREL following 2006 IPCC, Volume 1, Chapter 3, Equations 3.1 and 3.2 for propagation of error.	Land_EF-RF_Uncertainties
Emissions from biomass loss in forest land remaining forest land (IPCC 2006, Volume 4, Chapter 2, Equations 2.12, 2.13, 2.14, and 2.27).	FL_ΔCL
Estimations of the uncertainties for loss of biomass and fires on forest land remaining, (IPCC 2006, Volume 1, Chapter 3, Equations 3.1 and 3.2).	FL_ΔCL_Uncertainties

Data description	Tab in the Analysis tool
Emissions on land by carbon pools: Biomass, Dead organic matter, Soil organic carbon (IPCC 2006, Volume 4, Chapter 2, Equations 2.9, 2.16, 2.23 and 2.25).	Land_ΔCO2
Total of the estimations of emissions/removals for the FOLU sector.	Reporting Table
Results of total emissions due to deforestation and forest degradation, as well as the estimate of the 5-year historical average (2016-2020) for calculating the FREL.	FREL_DD

Section 2. Methodology for estimating uncertainties

2.1. Simulation tool

The simulations were performed using Argo, an add-in for Microsoft Excel developed by Booz Allen Hamilton (https://github.com/boozallen/argo/wiki) and designed to conduct Monte Carlo simulations directly within spreadsheets (a step-by-step installation guide is available in the shared folder). Fully integrated into the Excel environment through the addition of an "Argo" tab to the main ribbon, this tool provides enhanced accessibility and ease of use.

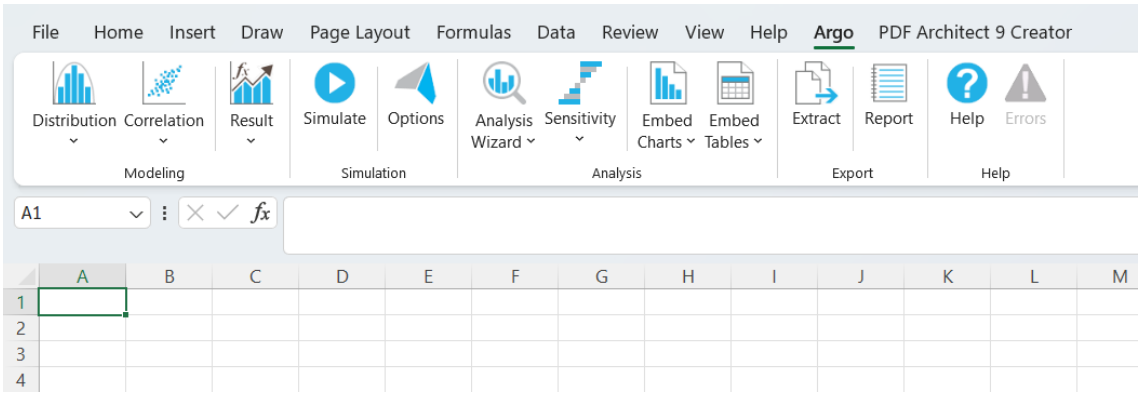


Figure 13: General view of Argo in the menu bar.

2.2. Probability density function

The generation of random samples for both activity data and emission factors was carried out using Monte Carlo simulation, following a parametric bootstrap procedure.

The "parametric bootstrap" resampling method is a statistical technique used to estimate the sampling distribution of a statistic (such as the mean, median, or variance) or to construct confidence intervals, especially when the underlying population distribution is known or assumed to follow a specific parametric model.

A triangular distribution was selected for the resampling of variables. This choice was driven by the information available (values and associated uncertainties) for both activity data and emission factors.

The triangular distribution is a continuous probability distribution defined by a minimum value, a maximum value, and a most probable value (mode). The minimum value, the maximum value and the mode are referred to as the parameters of the Triangular distribution. Characterized by

a triangular-shaped probability density function, this distribution is particularly useful for representing variables for which only limited data are available.

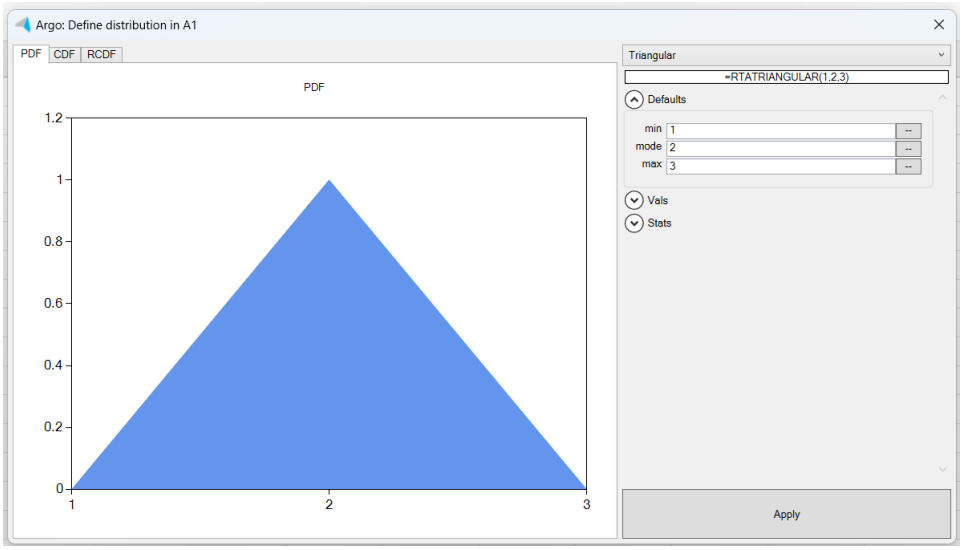


Figure 14: Triangular distribution as represented within the tool.

The methodology used to determine the parameters is explained in the table below.

Table 34: Parameters of the Triangular distribution.

	Activity data (area)	***Emission / removal factors and other variables***
Lower bound (***min***)	$\max\left\{0, AD - AD \times \frac{U_{AD}}{100}\right\}$ [1]	$\max\left\{0, EF - EF \times \frac{U_{EF}}{100}\right\}$ (for emission factor)
		$EF + EF \times \frac{U_{EF}}{100}$ (for removal factor)
		$\max\left\{0, EF - EF \times \frac{U_{EF}}{100}\right\}$ (for fractions)
Most frequent value (***mode***)	AD	EF
Upper bound (***max***)	$AD + AD \times \frac{U_{AD}}{100}$	$EF + EF \times \frac{U_{EF}}{100}$ (for emission factor)
		$\min\left\{0, EF - EF \times \frac{U_{EF}}{100}\right\}$ (for removal factor)
		$\min\left\{1, EF + EF \times \frac{U_{EF}}{100}\right\}$ (for fractions)

- AD and U_{AD} represent the Activity data value and the associated uncertainty for the relevant category,

[5] To maintain the consistency of the simulated values and the nature of the variables, 'min' and 'max' functions were introduced when determining the parameters of the probability density functions. This prevents values from falling outside acceptable limits when uncertainty is high.

- EF and U_{EF} represent the Emission/removal factor and the associated uncertainty for the relevant category.

2.3. Data processing

This phase consists of implementing the methodology detailed in Section 2.2. A triangular distribution is assigned to each input variable, with its parameters determined in accordance with the process described in the table above.
The table below lists the location of the data within the Excel analysis tool following the data processing phase.

Table 35: Data from the processing phase.

Data description	Tab in the Analysis tool
Determination of probability density function parameters for the Monte Carlo simulation of activity data.	Land_AD_DataProcessing
Determination of probability density function parameters for the Monte Carlo simulation of emission factors.	Land_EF-RF_DataProcessing
Determination of probability density function parameters for the Monte Carlo simulation of variables involved in estimating emissions related to biomass loss (IPCC 2006, Volume 4, Chapter 2, Equations 2.11 and 2.27).	FL_ΔCL_DataProcessing

The figure below shows an example of data processing. See the [Land_AD_DataProcessing] tab for details.

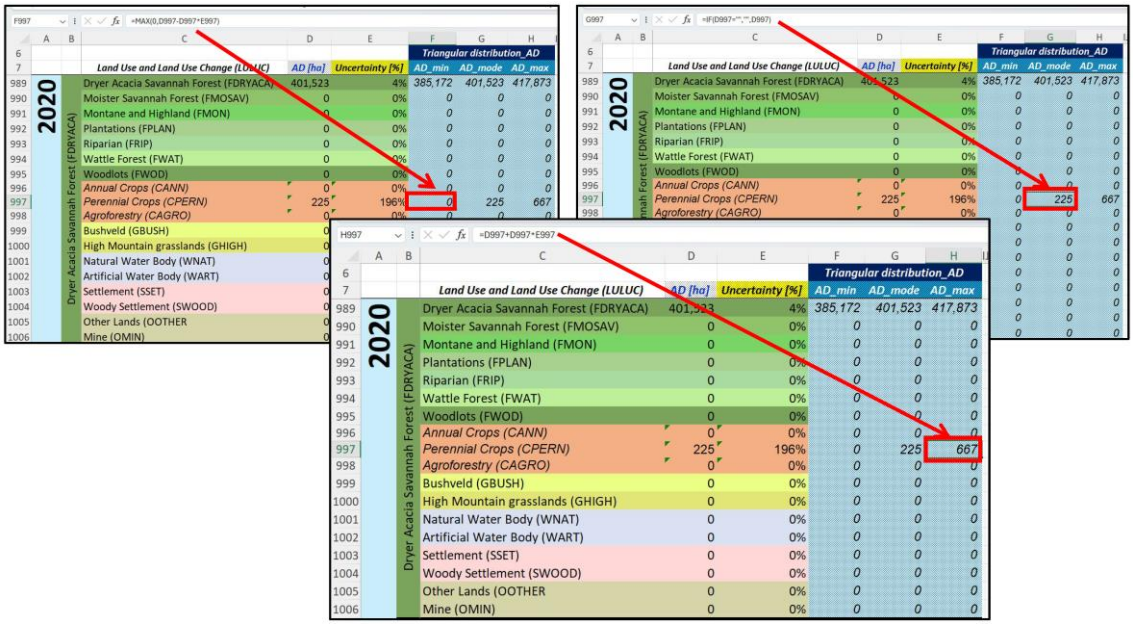


Figure 15: Illustration of the data processing phase.

2.4. Resampling process and Estimation of uncertainties

The resampling process was performed by generating random samples from the input data. Thus, for each input variable associated with a category, samples of size were generated by applying a triangular distribution.

This sample size is sufficient to ensure the convergence of the output variable, which, in the context of this work, represents the emissions or removals associated with each category.

The Blocking Random Seed[6] was set to "100". This parameter ensures the reproducibility of the results when running simulations at different times or on different computers.

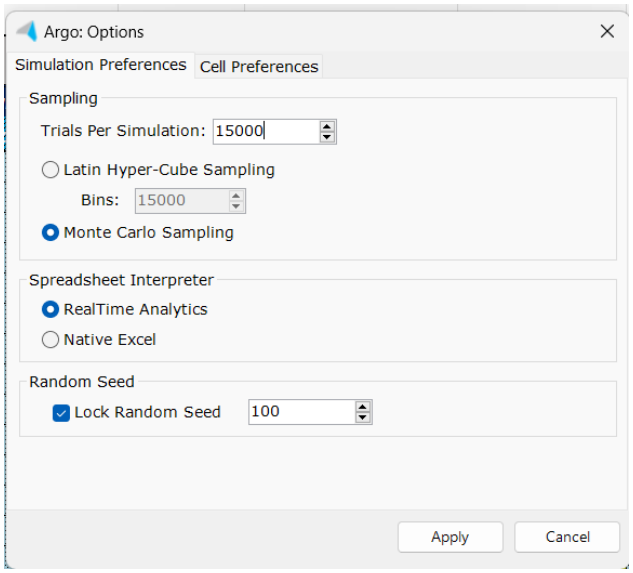


Figure 16: Simulation configuration used.

The following table presents the location of the data in the analysis tool after resampling and uncertainty estimation.

Table 36: Data after resampling and uncertainty estimation.

Description des données	**Onglet dans l'outil d'analyse**
Uncertainty propagation by approach 2 (Monte Carlo simulation) for emissions from land during biomass loss in forest remaining forest (IPCC 2006, Volume 1, Equations 2.12, 2.13, 2.14 and 2.27).	FL_ΔCL_MC
Propagation of uncertainties using Approach 2 (Monte Carlo simulation) for biomass emissions/removals.	Land_ΔCO2_BIOMASS_MC
Propagation of uncertainties using Approach 2 (Monte Carlo simulation) applied to emissions and removals from dead organic matter.	Land_ΔCO2_DOM_MC
Propagation of uncertainties using Approach 2 (Monte Carlo simulation) applied to emissions and removals from soil organic carbon.	Land_ΔCO2_SOC_MC

[6] It should be noted that even with the random seed fixed and the option enabled, the inherent volatility of Microsoft Excel is still highly likely to manifest. This volatility is a characteristic that leads to minor variations in results when simulations using random functions are executed at different times. Increasing the number of simulations and enabling the blocking random seed help control this volatility.

2.4.1. Resampling process for input data

The input data consist of individual variables, including activity data, emission/removal factors, and various complementary parameters. The input data resampling was performed by applying the @RtaTRIANGULAR function from the Argo tool. A set of 15,000 iterations is generated for each cell associated with a category; a single value, randomly drawn from this sample, is then displayed in the cell.

To explain the input variable resampling process, three examples are detailed below.

Example 1:
The figure below illustrates the resampling process for the area of Dryer Acacia Savannah Forest (FDRYACA) that is converted to Perennial Crops (CPERN) during the year 2020. See the [Land_ΔCO2_BIOMASS_MC] tab.

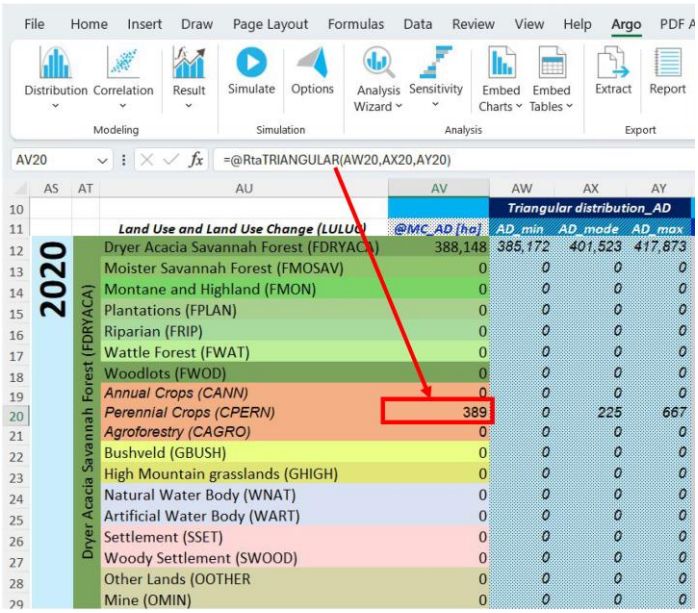


Figure 17: Illustration of activity data resampling.

Example 2:
The following illustration details the resampling process for the annual decrease in biomass carbon stocks of Dryer Acacia Savannah Forest (FDRYACA) that is converted to Annual Crops (CANN). See the [Land_ΔCO2_BIOMASS_MC] tab.

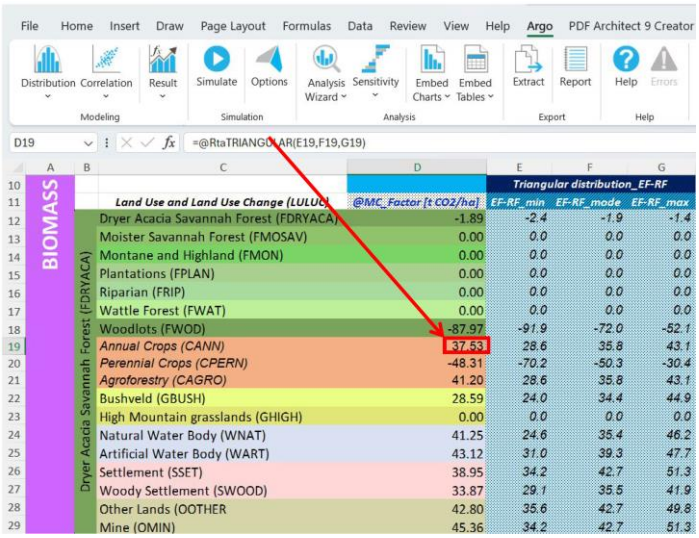


Figure 18: Illustration of emission factor resampling.

Example 3:
The figure below illustrates an example of the resampling process applied to the carbon fraction. See the [FL_ΔCL_MC] tab.

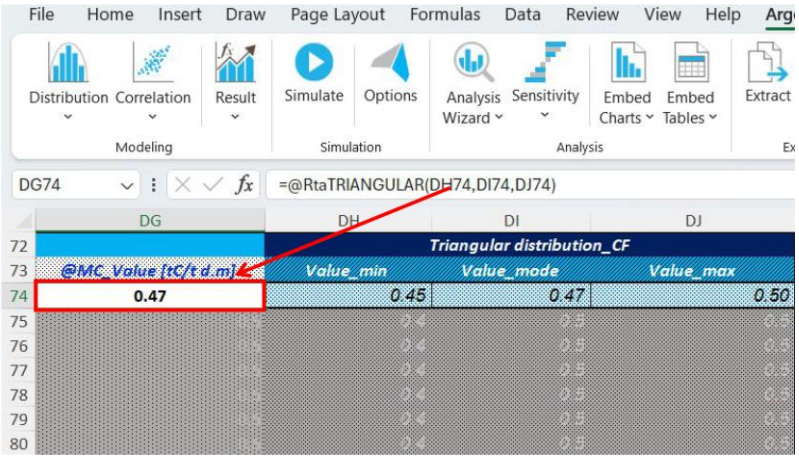


Figure 19: Illustration of carbon fraction resampling.

2.4.2. Resampling process for output data

The output data result from the integration of the input data through basic arithmetic operations and the application of statistical operators, such as the calculation of the mean or standard deviation.

In the context of this report, the output data correspond primarily to emissions and the variables derived from them. Examples of derived variables include Forest Reference Emission Level.

The resampling process for the output data (emissions) was carried out using the @RtaRESULT function. Following the same logic as for the input data, only a single value randomly selected from the sample of 15,000 iterations is displayed in the cell.

To illustrate the output data resampling, two examples are presented below.

Example 1:
The figure below illustrates an example of the resampling process for emissions associated with logging in 2020. Additional details are available in the [FL_ΔCL_MC] tab.

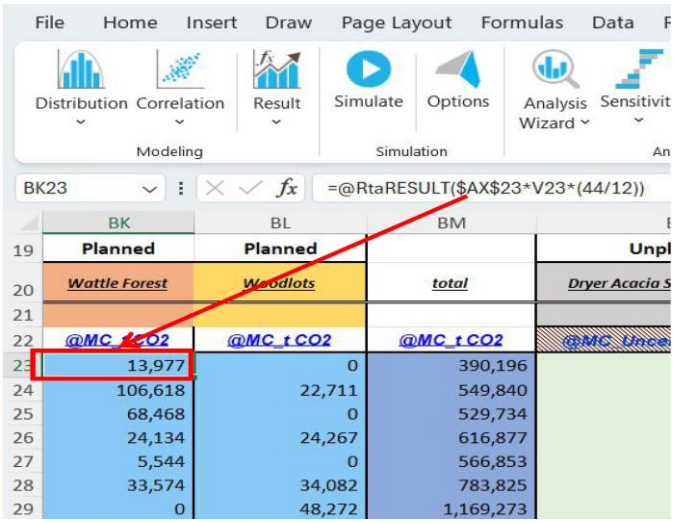


Figure 20: Illustration of the resampling process for emissions from logging.

Example 2:
The following illustration presents an example of the resampling of emissions for Moister Savannah Forest (FMOSAV) that is converted to Annual Crops (CANN) during the year 2020. For further information, please refer to the [Land_ΔCO2_BIOMASS_MC] worksheet.

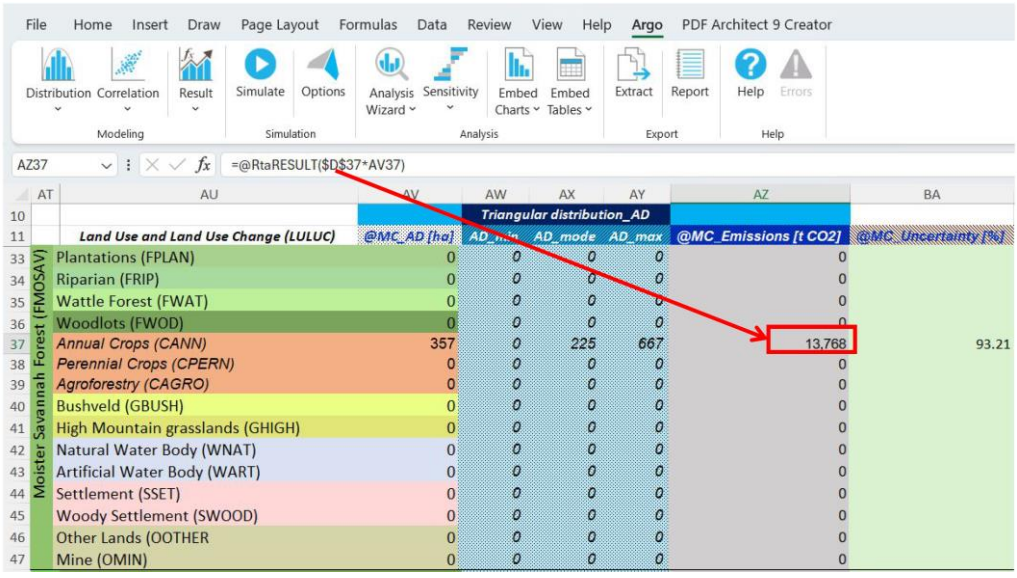


Figure 21: Illustration of the emissions resampling process for Moister Savannah Forest converted to Annual Crops.

2.4.3. Uncertainty estimation

The uncertainty assessment methodology is based on IPCC Approach 2, which relies on the Monte Carlo simulation method.

For each input variable, a sample of size was simulated according to a triangular distribution. The cell then displays a single value, randomly selected from this sample.

Under the assumption that a sample size is sufficiently large for the distribution of results to converge toward a normal distribution, the following equation was applied to estimate the uncertainties.

Equation 2 Uncertainty: $U = \left(\frac{1.96 \times \sigma}{\mu} \right)$.

In this expression[7],

- represents the standard deviation of the random sample,
- is the mean of the random sample,
- The value 1.96 corresponds to the Z-score associated with a 95% confidence level, where Z denotes the random variable following a standard normal distribution .

Equation 2 is implemented using the "OpSTDEV" and "OpAVERAGE" functions of the Argo simulation tool.
One example is presented to illustrate the uncertainty estimation procedure for emissions.

Example:
The figure below illustrates an example of uncertainty estimation process for emissions associated with Moister Savannah Forest (FMOSAV) that is converted to Annual Crops (CANN) during the year 2020.
For further information, please refer to the [Land_ΔCO2_BIOMASS_MC] worksheet.

[7] The notations used are those relating to population parameters. Indeed, the substantial sample size ensures, through asymptotic normality, that the sample statistics converge toward the true population values.

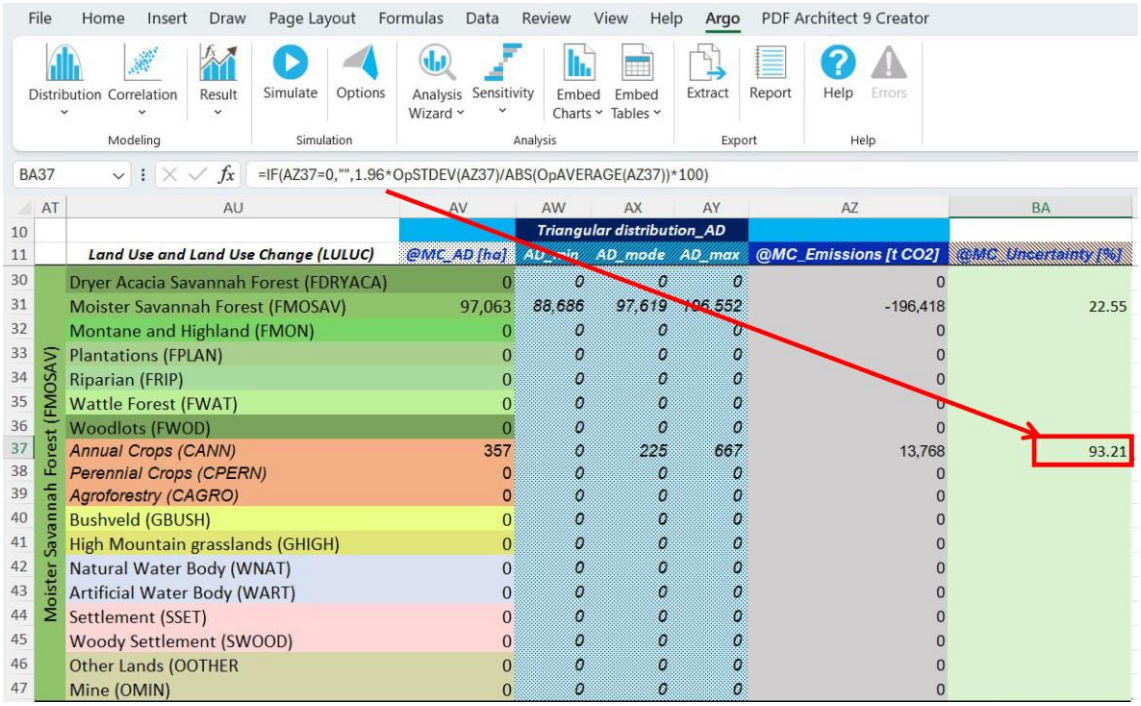


Figure 22: Illustration of uncertainty estimation for emissions.

Section 3. Presentation of results

3.1. Annual emissions and uncertainties

This section summarizes the annual emissions from deforestation and forest degradation over the 2016–2020 reference period, along with their uncertainties.
These results are derived from the estimation methodology detailed in Section 2. The details of the estimation process are presented in the [FREL_DD_MC] tab, and the summary of the results is available in the [Summary_FREL_DD] tab of the calculation tool.
The table below presents the results.

Table 37: Annual emissions from deforestation and forest degradation over the 2016–2020 reference period.

REDD+ activity	Land use category	IPCC equations	2016	2017	2018	2019	2020
Degradation	FL remaining FL (Carbon Losses) [t CO2e]	eq. 2.11 gross	1 418 090	1 102 176	602 769	1 149 655	738 001
	Uncertainty [%]		23.13	27.37	34.92	23.64	29.74
	Biomass Burning in FL [t CO2e]	eq. 2.27 gross	13 576	5 569	4 693	15 177	5 538
	Uncertainty [%]		73.30	75.65	78.96	72.09	78.59
	TOTAL degradation [t CO2e]		**1 431 665**	**1 107 745**	**607 462**	**1 164 833**	**743 539**
	Uncertainty [%]		**22.88**	**27.20**	**34.55**	**23.29**	**29.44**
Deforestation	Forest land converted to CL [t CO2e]	eq. 2.16 net	47 204	16 029	22 475	53 429	22 255
	Uncertainty [%]		53.38	111.98	84.49	49.92	94.70
	Forest land converted to GL [t CO2e]	eq. 2.16 net	16 710	31 702	1 109	9 243	9 465
	Uncertainty [%]		70.68	66.35	129.06	71.97	73.85
	Forest land converted to WL [t CO2e]	eq. 2.16 net	7 274	7 274	7 274	7 274	7 274
	Uncertainty [%]		163.01	163.85	164.80	162.93	163.74
	Forest land converted to SL [t CO2e]	eq. 2.16 net	11 094	3 073	3 073	11 708	3 688
	Uncertainty [%]		70.48	71.19	70.88	67.66	71.65
	Forest land converted to OL [t CO2e]	eq. 2.16 net	0	33 300	0	0	0
	Uncertainty [%]			74.96			
	TOTAL deforestation [t CO2e]		**82 282**	**91 378**	**33 933**	**81 655**	**42 682**
	Uncertainty [%]		**66.35**	**62.40**	**94.43**	**62.50**	**83.64**

REDD+ activity	Land use category	IPCC equations	2016	2017	2018	2019	2020
	TOTAL DD [t CO2e]		**1 513 947**	**1 199 123**	**641 394**	**1 246 487**	**786 221**
	Uncertainty [%]		**21.63**	**24.91**	**32.67**	**21.80**	**27.99**

3.2. Forest Reference Emissions Level and Uncertainty

The FREL was estimated as the arithmetic mean of emissions from deforestation and forest degradation over the 2016–2020 reference period:

Forest Reference Emissions Level:

Equation 3

$$FREL = \frac{E_{2016} + E_{2017} + E_{2018} + E_{2019} + E_{2020}}{5}$$

In this expression, represents the emissions from deforestation and forest degradation for year t .

The uncertainty associated with the FREL was estimated following the estimation methodology detailed in Section 2. The details of the estimation process are available in the [FREL DD_MC] tab of the calculation tool.

The table below presents the results.

Table 38: FREL and Uncertainty.

5-year historical average (2016-2020) [t CO2e]	1 077 435
Uncertainty [%]	*15.00*

Bibliography Annex II

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (H. S. Eggleston, L. Buendia, K. Miwa, T. Ngara, & K. Tanabe, Eds.), Volume 1: General Guidance and Reporting, Chapter 3: Uncertainties. Japan : IGES. Available at : www.ipcc-nggip.iges.or.jp
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