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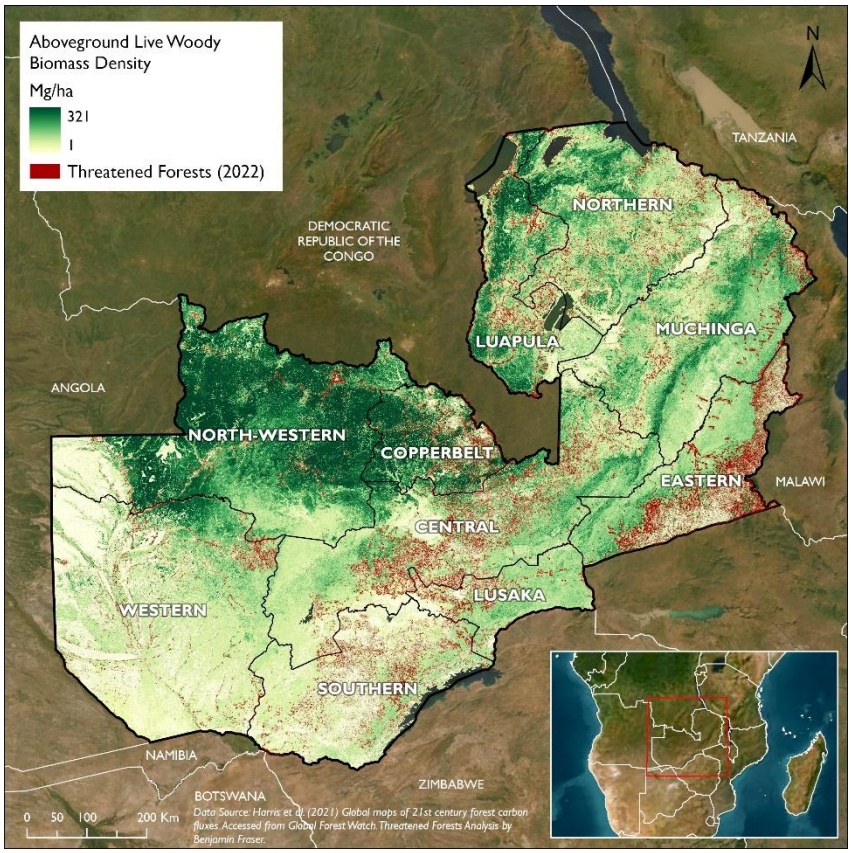

SUSTAINABLE LANDSCAPES OPPORTUNITIES ANALYSIS FOR ZAMBIA

INTEGRATED LAND AND RESOURCE GOVERNANCE TASK ORDER UNDER THE STRENGTHENING TENURE AND RESOURCE RIGHTS II (STARR II) INDEFINITE QUANTITY/INDEFINITE DELIVERY (IDIQ)

Contract Number: 7200AA18D00003/7200AA18F00015
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Cover Photo:	Map of Threatened Forests Analysis for Zambia (see Section 4.3 for detailed discussion and methods)
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ACRONYMS

AFLRO	Atlas of Forest Landscape Restoration Opportunities
AFOLU	Agriculture, Forestry, and Other Land Use
ANR	Assisted Natural Regeneration
BUR	Biennial Update Report (to the United Nations Framework Convention on Climate Change)
CRB	Community Resource Board
CFMG	Community Forest Management Group
CIFOR	Center for International Forestry Research
CO_2e	Carbon Dioxide Equivalent
FAO	Food and Agriculture Organization of the United Nations
FRA	FAO Forest Resource Assessment
FREL	Forest Reference Emissions Level
GDP	Gross Domestic Product
GFW	Global Forest Watch
GHG	Greenhouse Gas
GHSL	Global Human Settlement Layer
ha	Hectare
IDIQ	Indefinite Quantity/Indefinite Delivery
ILUA	Integrated Land Use Assessment
ILRG	Integrated Land and Resource Governance Program
INDC	Intended Nationally Determined Contribution
Mt	Million Tons (metric)
$MtCO_2e$	Million Tons (metric) of Carbon Dioxide Equivalent
NCS	Natural Climate Solutions
NDC	Nationally Determined Contributions
NDP	National Development Plan
NTFP	Non-Timber Forest Product
PNAS	Proceedings of the National Academy of Sciences of the United Nations
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SEDAC	Socioeconomic Data and Applications Center

SL	Sustainable Landscapes
SLIMP	Sustainable Livestock Infrastructure Management Project
SLOA	Sustainable Landscapes Opportunities Analysis
STARR II	Strengthening Tenure and Resource Rights II
USAID	United States Agency for International Development
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping
WRI	World Resources Institute
ZAFFICO	Zambia Forestry and Forest Industries Corporation

EXECUTIVE SUMMARY

This report presents an assessment of land-based greenhouse gas (GHG) emissions mitigation opportunities in Zambia, with an aim to support decision-making for prioritizing sustainable landscape (SL) investments. The report emphasizes that effective land and resource governance is crucial for climate mitigation efforts, particularly in the forest sector. It combines biophysical analysis with an evaluation of policy and institutional frameworks to ensure that SL investments effectively support local systems and address governance challenges, thereby strengthening local ownership of interventions.

Zambia's GHG emissions are predominantly land-based, with 85 percent emanating from agriculture, forestry, and land-use change. The land-use change and forestry sector alone accounted for 60.41 percent of the country's emissions in 2020, while agriculture contributed an additional 24.24 percent. Two Natural Climate Solutions (NCS) assessments found that reforestation and avoided forest conversion were the mitigation pathways with the largest overall cost-effective potential – together these were estimated to represent 75.2 percent of the total land-based mitigation potential in Zambia. Enhancing tree cover in agricultural lands and improving fire management in savannas contribute an additional 14.1 percent together.

For each priority mitigation option, we reviewed national data and literature to ascertain their relevance and potential. We also reviewed major national development, climate, and forest strategies including Zambia's Eight National Development Plan (2022 – 2026), the National Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy and Investment Plan, and its Nationally Determined Contribution to understand national priorities in relation to potential mitigation options. We reviewed the policy and legal framework for forest management, incorporating governance analysis based on the World Resources Institute's Governance of Forests Initiative Indicator Framework to review how these frameworks influence feasibility of implementation. The goal of incorporating this analysis is to ensure that SL investments support local systems for implementation of mitigation solutions including by addressing underlying governance challenges and strengthening local ownership of interventions.

Zambia's forests, which range from open woodlands to closed canopy dry evergreen forests, play a pivotal role in the nation's carbon sequestration but are also under threat due to agricultural expansion, charcoal production, and settlement expansion. The report provides new insights with a Threatened Forests layer for Zambia that combines Global Forest Watch data on forest cover change with indicators related to land cover change pressure, offering a novel perspective on forest threats and land cover change pressures. Our analysis suggests that land use planning should prioritize avoiding conversion in threatened forest areas that occur in more carbon dense forest types, and this approach is also likely more cost effective than the costs of avoiding deforestation in areas with greater pressure from population and urban expansion.

We also note that the NCS analyses focuses on the biophysical potential of mitigation pathways and does not sufficiently account for the practical feasibility of different options. In the case of Zambia, the feasible potential for reforestation as a mitigation option may be significantly lower than is estimated by the NCS assessments. While reforestation potential is likely overestimated in global assessment and more limited in practice due to land policies that incentivize clearing and lack of targeted incentives, in strategic areas intervention planning should incorporate a focus on restoration and trees in agricultural lands in order to meet demand for forest products including charcoal. While some mitigation options such as reforestation are likely overestimated in the NCS analysis, options such as reducing woodfuel use likely present greater mitigation potential in areas of high population density in the corridor from Chingola to Lusaka.

In conclusion, this report provides a critical foundation for targeted interventions in Zambia's land sector. By prioritizing areas with the highest mitigation potential and addressing policy and governance challenges, Zambia can make significant strides in reducing its land based GHG emissions, thereby contributing to global climate mitigation efforts and sustainable development.

1.0 INTRODUCTION

1.1 OBJECTIVES AND APPROACH

The goal of this sustainable landscapes (SL) opportunities analysis (SLOA) for Zambia is to provide decision support for prioritizing SL investments. Opportunities for greenhouse gas (GHG) emissions reduction in the land sector vary greatly in the scale of their mitigation potential, cost, alignment with national and local policy priorities, and the capacity of institutions and natural resource managers to implement them. The report provides USAID, Zambian policymakers, technical partners, civil society, and resource managers with an analysis of the feasibility of mitigation options.

Effective land and resource governance is fundamental to achieving climate mitigation efforts in the forest sector in Zambia.[1] Based on learning from previous analyses of sustainable landscapes opportunities, a focus on the biophysical potential of mitigation options can obscure the underlying land and resource governance needs that are also critical to the long-term success of natural climate solutions. In this report, we combine biophysical analysis of global and national datasets with analysis of the policy and institutional framework for implementation of priority sustainable landscapes interventions. The goal of incorporating this analysis is to ensure that SL investments support local systems for implementation of mitigation solutions including by addressing underlying governance challenges and strengthening local ownership of interventions.

Zambia's Biannual Update Report (BUR) for its Intended Nationally Determined Contribution (INDC) submitted in 2020 found the agriculture, forestry and other land use (AFOLU) sector was responsible for 93 percent of emissions with emissions from Forest Land accounting for approximately 55.95 percent. These estimates are similar to the World Resources Institute's (WRI) Global Climate Watch, which found that nearly 85 percent of Zambia's GHG emissions come from land-based activities: agriculture, forestry, and land-use change.[2] In 2020, the land-use change and forestry sector represented 60.41 percent of Zambia's emissions, equal to 55.09 million metric tons (Mt) of carbon dioxide equivalent (CO_2e) per year.[3] The agriculture sector represented an additional 24.24 percent of national emissions, or 22.11 million metric tons of carbon dioxide equivalent (MtCO2e). The BUR further disaggregates emissions from Forest Land to estimate that 28.3 percent of emissions are due to firewood and charcoal production with the remaining 27.6 percent related to wood removal.[4] Despite representing a significant proportion of Zambia's overall emissions, the forest sector contributed only 4.7 percent on average to the national Gross Domestic Product (GDP) between 2011 and 2020, compared with 6.8 percent for agriculture and 14.8 percent for the mining sector over the same period.[5]

1.2 METHODOLOGY

This report uses Griscom's initial *Natural Climate Solutions* analysis (Griscom et al., 2017) and its update (Griscom et al., 2020) to identify potential land-based climate mitigation opportunities for Zambia based on a globally consistent methodology. We believe these to be the most comprehensive global sources for assessing land-based GHG mitigation potential in terms of comprehensiveness of the pathways covered.

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[1] Gumbo, D., and Mfune, O. 2013. The forest governance challenge in REDD+: core governance issues that must be addressed for REDD+ success in Zambia. Nature and Faune 27(2): 49-53.

[2] The other 15 percent are from energy, waste, and industrial processes.

[3] Zambia Country Profile. 2023. Climate Watch. World Resources Institute, Washington, D.C

[4] Government of the Republic Of Zambia. 2020. First Biennial Update Report to the United Nations Framework Convention on Climate Change.

[5] Government of the Republic of Zambia. 2022. Eighth National Development Plan 2022 - 2026.

Recognizing the limitations of these global estimates to present realistic mitigation options for Zambia's dryland forests, for each priority option we also reviewed available literature to identify national data or analyses that provide additional insight into the relevance and overall potential of the mitigation pathway. We then cross-referenced these options to major national development, climate, and forest strategies including Zambia's Eighth National Development Plan (2022 – 2026), its National REDD+ Strategy and Investment Plan, and its Nationally Determined Contribution (NDC). We incorporated a governance assessment using WRI's Governance of Forests Initiative Indicator Framework to review how existing policy, fiscal, and institutional frameworks may influence feasibility of implementation.

This assessment presents several sets of data that are relevant to prioritizing mitigation pathways for Zambia. In those cases where it was possible, we present spatial data in map form. Of particular note is a Threatened Forests layer for Zambia presented in Section 4. We created the Threatened Forests layer, a new data product developed for this SLOA, by combining Global Forest Watch (GFW) data on forest cover change with indicators of land cover change pressure, including information on croplands, human settlements, forest condition, and tree cover loss drivers.[6] The assessment concludes with a review of the magnitude of mitigation potential, geographic priorities, governance conditions, and opportunities for co-benefits for different land-based mitigation strategies. Figure 1 summarizes key steps in the SLOA process.

FIGURE 1: SLOA PROCESS

1.3 REPORT STRUCTURE

Section 2 presents an overview of Zambia's forests, current trends in land use change, and a summary of global analysis of natural climate solutions for Zambia. Section 3 provides an overview of the underlying policy and institutional context that may influence the feasibility of proposed mitigation options. To present priority options, we align with the structure of Zambia's REDD+ Investment Plan which identifies two Core Priorities: (1) Conservation and Management of High Value Forest Areas and (2) Resilient Landscapes, Sustainable Agriculture, and Energy. We present mitigation opportunities that align with Core Priority 1 in section 4 of this report. Opportunities aligned with Core Priority 2 (including reforestation, reducing woodfuel harvest and use, and improving fire management) are presented in section 5. For each category, we review mitigation potential and estimates where available as well as relevant governance factors to consider. Section 6 presents conclusions, limitations of the analysis, and recommendations.

[6] See Box 1 for a more detailed description of the Threatened Forests methodology.

2.0 OVERVIEW OF ZAMBIA'S LAND-BASED MITIGATION PATHWAYS AND FORESTS

2.1 MITIGATION PATHWAYS

Griscom et al. (2017; 2020) assessed the potential for land-based climate mitigation—using the term Natural Climate Solutions (NCS)—both globally and for individual countries. These estimates provide a systematic starting point for identification of mitigation options. Table 1 presents the definitions of relevant pathways for Zambia.[7]

TABLE 1: DESCRIPTIONS AND CATEGORIZATION OF RELEVANT LAND-BASED CLIMATE MITIGATION OPPORTUNITIES

Category	Mitigation pathway	Description
Forests	Avoided Forest Conversion	Emissions of CO_2 avoided by avoiding forest conversion.[8]
Forests	Reforestation	Conversion of land from non-forest (<25 percent tree cover) to forest (>25 percent) in areas ecologically appropriate and desirable for forests.
Forests	Improved Natural Forest Management	Additional carbon sequestration (aboveground and belowground) resulting from reduced intensity of harvest in native forests managed for wood production.
Forests	Reduced Woodfuel Harvest	Avoided emissions–all gases–due to reduced harvest of woodfuel used for cooking and heating, without reducing heating or cooking utility.
Forests	Improved Plantations	Additional carbon sequestration achieved by extending harvest rotations to biologically optimal rotation lengths.
Forests	Improved Fire Management	Additional sequestration and avoided emissions in above- and below-ground tree biomass due to various forms of fire management.
Agriculture	Trees in Agricultural Lands	Carbon sequestration in both aboveground and belowground tree biomass and soil carbon that results from the integration of trees into croplands at levels that do not reduce crop yields.
Agriculture	Nutrient Management	Avoided N_2O emissions due to reduced fertilizer use and improved application methods.
Agriculture	Optimal Grazing Intensity	Additional soil carbon sequestration due to grazing optimization on rangeland and planted pasture. Shifts grazing from overgrazed to undergrazed areas.
Wetlands and coasts	Peat Restoration	Re-wetting of freshwater wetlands (tropical, temperate, and boreal peatlands) to avoid oxidation of soil carbon and to enhance soil carbon sink.
Wetlands and coasts	Avoided Peat Impacts	Avoided emissions from loss of above- and belowground biomass as well as from loss of soil carbon that would result from degradation or loss of peatlands.

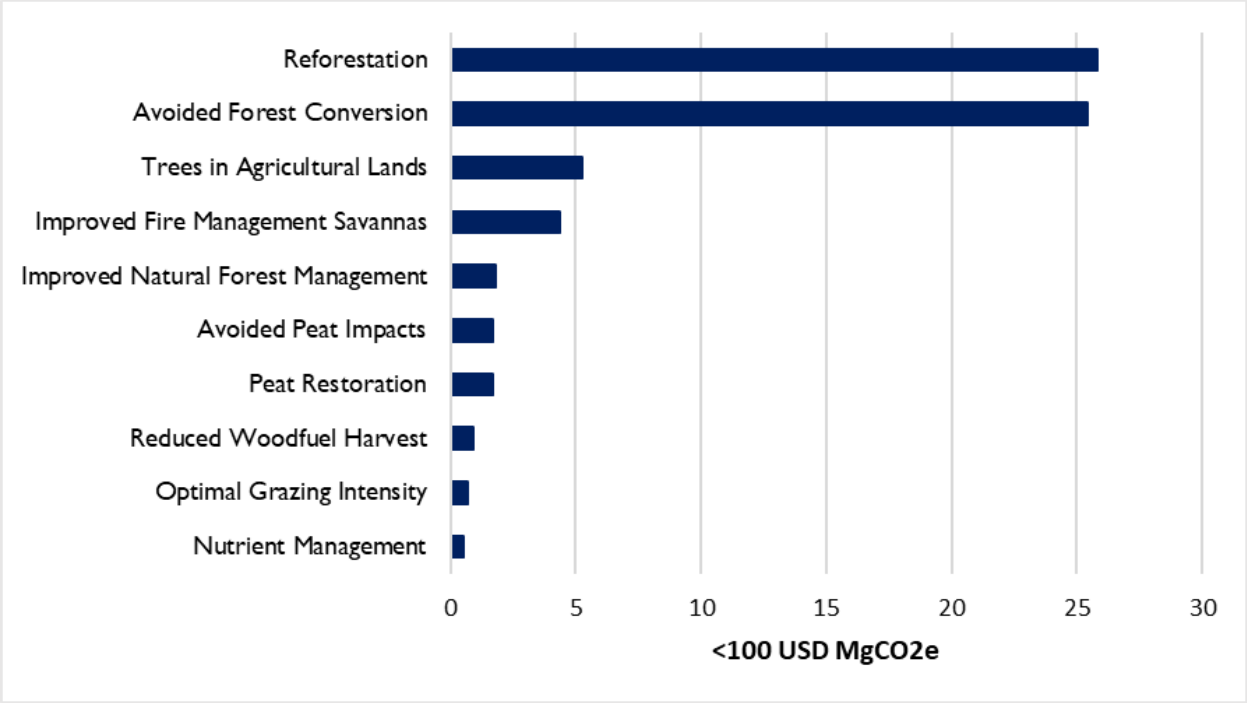
Natural climate solutions identified by Griscom et al. (2017; 2020).

These two papers assessed both the maximum mitigation for these pathways with safeguards for food and fiber production and for biodiversity protection, and the mitigation potential that is cost effective. Griscom et al. (2017) define cost effectiveness by assuming that the social cost of carbon—i.e., the

[7] We excluded all pathways related to ecosystem conditions not found in Zambia such as those related to coastal wetlands.
[8] This pathway as described only captures emissions that occur at the time of forest clearing and does not include the lost potential for future carbon sequestration that results from a reduction in forest area.

economic damage that would result from emitting carbon dioxide—will be $100 per ton in 2030. They then define any emissions reductions that can be accomplished at a lower cost to be cost effective. Figure 2 presents the cost-effective potential of NCS pathways in Zambia, and Table 2 shows estimates for both cost effective potential and maximum potential.

FIGURE 2: MITIGATION POTENTIAL OF 12 NATURAL CLIMATE SOLUTIONS PATHWAYS AT "COST-EFFECTIVE" LEVELS (<100 USD MGCO2E) FOR ZAMBIA



We note that this analysis can obscure local realities or national characteristics, and therefore is best supplemented with information on local context, data, and ecosystem types that may not fit neatly into the methods used. For example, the Griscom analysis focuses its assessment of the potential of improved fire management in savannah areas; it is therefore probable that the mitigation potential for fire management in Zambia is underestimated due to the potential exclusion of opportunities to mitigate fire in open miombo woodlands or mixed forest-savannah mosaics. Specific issues related to the Griscom methodology and interpretation of its findings for Zambia is presented under the discussion of each mitigation option in Sections 4 and 5.

The Griscom analyses find that reforestation and avoided forest conversion are the most cost-effective options, combining to represent a total of 75.2 percent of the total opportunity for Zambia. Strategies to enhance tree cover in agricultural lands and improve fire management in savannahs comprise another 14.1 percent of mitigation potential. It is important to note that the Griscom analyses focus on the total biophysical potential for climate mitigation; therefore, it does not fully account for the practical and economic feasibility of different options. For example, the scale of mitigation through the reforestation pathway that is realistically feasible is likely to be much lower than Griscom's upper-level estimate.

The analysis found that options such as improved natural forest management and reduced woodfuel harvest represent relatively small opportunities in terms of emissions reductions at 2.7 and 1.4 percent of total mitigation potential. However, over 70 percent of Zambians depend on woodfuel as a major energy source, with increasing urban demand for charcoal driving localized extraction particularly in the

Lusaka woodshed[9]. Furthermore, extraction of timber and non-timber forest products (NTFPs), along with woodfuel, constitute important livelihood strategies for many Zambians. National level analysis of total potential may obscure local opportunities for mitigation strategies with significant livelihood co-benefits; it is therefore critical to understand district or landscape scale dynamics including localized drivers and demand for various forest products. We discuss current knowledge regarding the importance of woodfuel harvest as a driver of forest loss in Zambia in more depth in section 5.2. These options are also of considerable local relevance based on priorities of Zambia's national policies as well as the REDD+ Investment Plan.

TABLE 2. MITIGATION POTENTIAL FOR 10 LAND-BASED CLIMATE MITIGATION PATHWAYS (NCS)

	Cost Effective		Maximum with safeguards	
Mitigation pathway	**$MtCO_2e$**	**Percent of total assessed**	**$MtCO_2e$**	**Percent of total assessed**
Reforestation	25.8	37.9%	No estimate	No estimate
Avoided Forest Conversion	25.44	37.3%	31.8	45.88%
Trees in Agricultural Lands	5.28	7.7%	10.36	14.95%
Improved Fire Management in Savannas	4.35	6.4%	14.49	20.91%
Improved Natural Forest Management	1.82	2.7%	2.51	3.62%
Avoided Peat Impacts	1.69	2.5%	1.88	2.71%
Peat Restoration	1.68	2.5%	3.49	5.04%
Reduced Woodfuel Harvest	0.93	1.4%	3.11	4.49%
Optimal Grazing Intensity	0.67	1.0 %	1.11	1.60%
Nutrient Management	0.5	0.7%	0.56	0.81%

With safeguards for food and fiber production and for biodiversity—showing both maximum total potential as well as the cost-effective potential assuming a social cost of carbon of $100 per ton co2 equivalent. Values from Griscom et al., (2017; 2020).

2.2 LAND COVER, FOREST TYPE AND CARBON DENSITY

The mitigation pathways identified as having the largest total potential relate to the forest sector. As such, it is important to understand how ecosystem carbon – forest carbon in particular – is distributed across Zambia. Zambia's forests cover nearly 60 percent of the national land area.[10] Table 3 presents a summary classification of Zambia's forest types while figure 3 presents a map of Zambia's land cover using the 2019 Copernicus Global Land Cover dataset. To enable better visualization of the spatial extent and contrasts between closed (>70 percent canopy cover) and open (15 percent to 70 percent canopy cover) forests, we have included built-up area, and summarized all additional land cover classes under "other."[11]

[9] The WISDOM study uses the term woodshed to indicate the portion of the territory necessary to supply the woody biomass needed by a specific consumption site. In that sense, Lusaka woodshed refers to any forests that are under commercial pressure for charcoal production to meet demand in Lusaka. It is therefore inclusive of the forests on the outskirts of the city but may extend beyond as demand grows and forces production further out.

[10] FAO, the Forestry Department, Ministry of Natural Resources, Ministry of Lands and Natural Resources, 2016. Integrated Land Use Assessment Phase II- Report for Zambia.

[11] This map combines the following land cover types: shrub, herbaceous vegetation, cultivated and managed vegetation, bare/sparse vegetation, permanent water bodies, and herbaceous wetland.

TABLE 3: OVERVIEW OF ZAMBIA'S FOREST CLASSIFICATION AND SUBTYPES

Vegetation type	FAO classification	Regional subtype
Open forest (woodlands)	Semi-evergreen forests	Miombo
	Dry deciduous forests	Kalahari, mopane, munga
Closed forests	Dry evergreen forests	Parinari, Marquesia, Cryptosepalum, lake basin
	Dry deciduous forests	Baikiaea, Itigi
	Moist evergreen forests	Riparian, montane, swamp
Bushland/scrubland	Other wooded land	Termitaria

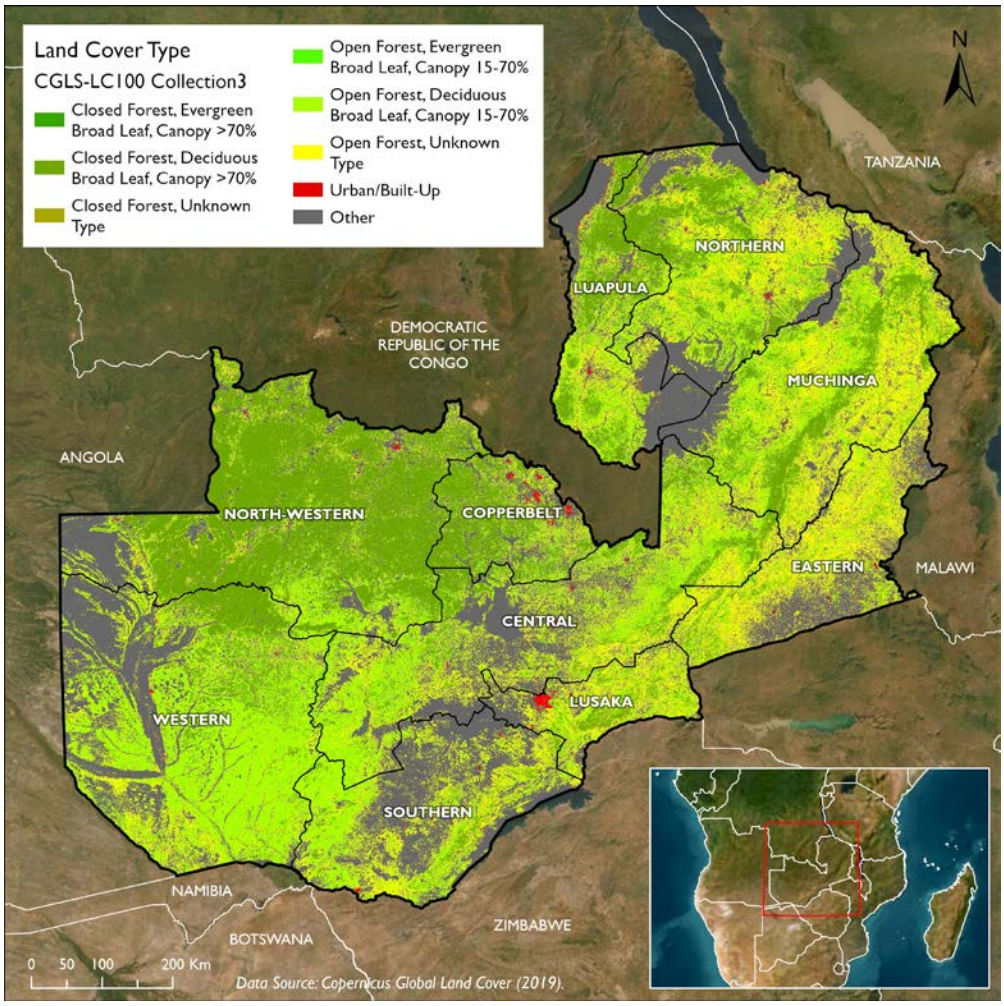
Dry forests, defined as vegetation dominated by wooded plants that cover more than 10 percent of the area, are the dominant forest subtype, with a small percentage of dry evergreen forests located in the Northwestern and Western provinces. Most of Zambia's dry forests are miombo woodlands, which cover an estimated 44 percent of Zambia's total land area and provide an important source of charcoal, firewood, and NTFPs.[12] Other woodland types include Kalahari woodland, an important source of commercial timber found primarily in Northwestern and Western provinces, and mopane and munga woodlands primarily found in the central and southern zones of the country. Table 3 summarizes Zambia's forests by vegetation type, Food and Agriculture Organization of the United Nations (FAO) Forest Resource assessment classification, and regional subtype.[13,14]

[12] FAO, the Forestry Department, Ministry of Natural Resources, Ministry of Lands and Natural Resources, 2016. Integrated Land Use Assessment Phase II- Report for Zambia.

[13] For a detailed description of the dominant species and ecosystem characteristics of Zambia's forest subtypes, see for example

[14] The ILUA II assessment used the global FAO Forest Resource Assessment (FRA) classification system as well as national requirements to produce a new vegetation classification for the country.

FIGURE 3: MAP OF ZAMBIA'S FOREST COVER TYPES



Carbon density—the amount of carbon stored per unit area—varies among these forest types. Supported by the FAO and Finland's Ministry of Foreign Affairs, Zambia's Forestry Department under the Ministry of Lands and Natural Resources at that time conducted the Integrated Land Use Assessment (ILUA) II between 2010 and 2016 building on the first phase of the ILUA completed from 2005 – 2008. The ILUA II analysis provides the most up to date estimates of carbon density across Zambia's forest types that is currently available, though is expected to be updated in the coming years under a European Union-supported program. Data from ILUA I and II was reanalyzed to develop Zambia's most recent Forest Reference Emissions Level (FREL) submitted to the United Nations Framework Convention on Climate Change in 2021. Table 4 presents average estimates from the ILUA II assessment both of carbon density per hectare (ha) by vegetation type as well as estimates of total biomass nationwide. While ILUA II identified forest plantations as having the highest carbon density, this data comes from a few ZAFFICO plantations located in Copperbelt Province where the number of tree stems per ha is higher as compared to tree densities in Zambia's open dryland forests. Furthermore, forest plantations comprise a very limited portion of Zambia's total forest cover, with an estimated 61,000 ha of tropical pine and Eucalyptus plantations primarily in Copperbelt Province.[15] While they are

[15] Ibid

relatively carbon dense per unit area, they do not represent a large portion of Zambia's total forest biomass.

TABLE 4: SUMMARY OF CARBON DENSITY BY FOREST SUBTYPE IN ZAMBIA[16]

Vegetation	Values per hectare		National total			
	Above ground biomass (tons/ha)	Below ground biomass (tons/ha)	Total biomass (tons/ha)	Area[17] (1000s of hectares)	Total biomass (million tons)	Total carbon (million tons)
Dry evergreen forest	67.8	19.0	86.8	2,057	178.5	87.5
Dry deciduous forest	37.2	10.4	47.6	1,311	62.4	30.6
Moist evergreen forest	34.2	9.6	43.8	562	24.6	12.1
Forest woodland	43.1	12.0	55.1	40,214	2,215.8	1,085.8
Forest plantation	70.8	19.8	90.6	55	5.0	2.4

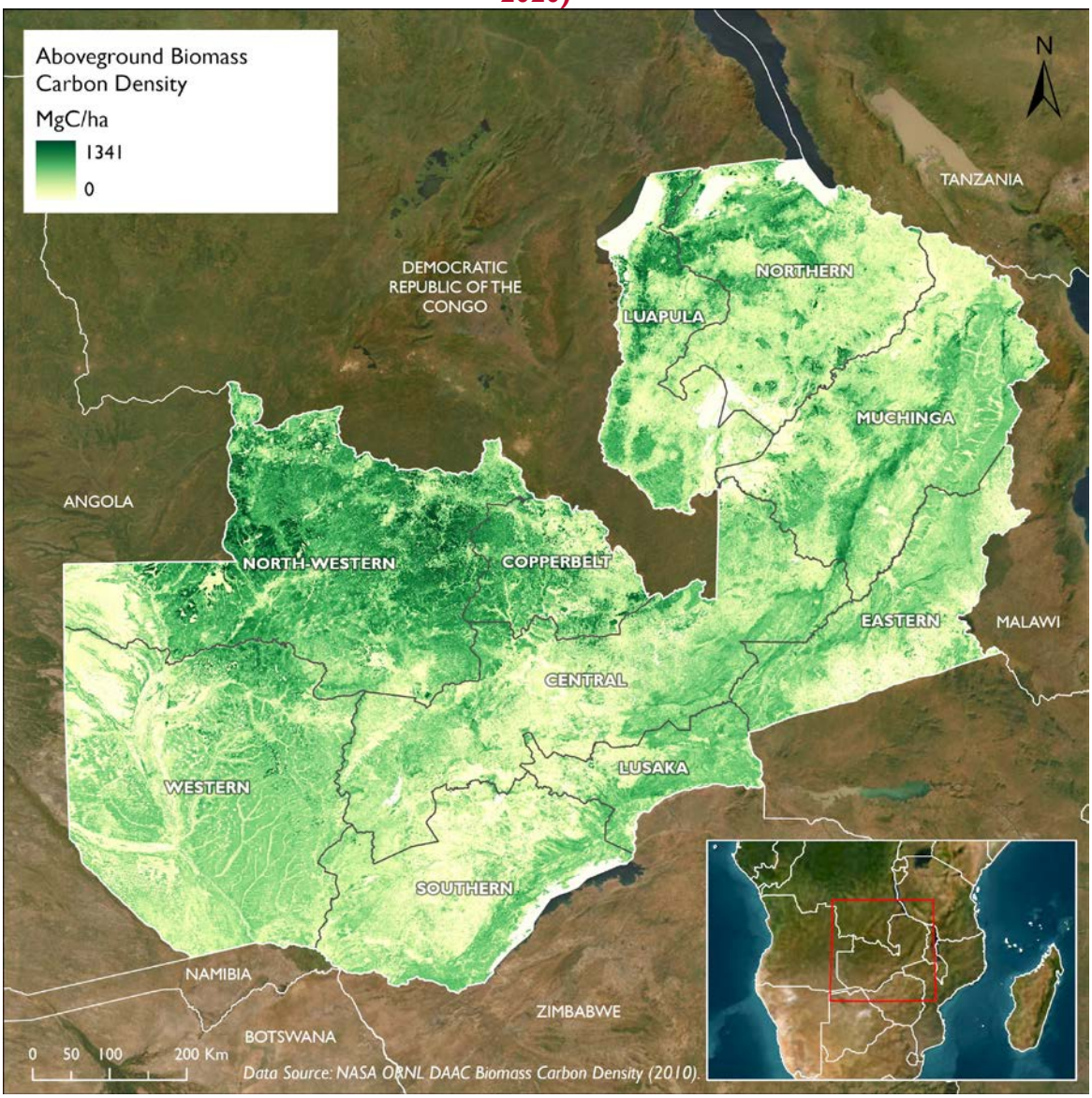
The ILUA II estimates are based on sampling carried out as part of the forest inventory; while this ensures the estimate are specific to forest types within Zambia, analysis from Spawn and Gibbs (2020) presents biomass estimates at a finer spatial resolution of 300 m and thus provide an additional source of information for understanding mitigation priorities as it relates to the carbon density of various forest types (Figure 4). Excluding plantations (due to their limited reach and the methodological issues referenced above), the highest carbon density per unit area in Zambia (based on both Spawn and Gibbs and ILUA II data) is found in the dry evergreen forests that represent a transition from the Guineo-Congolian rainforest to Zambia's dry woodlands. However, these forests compose a relatively small percentage of Zambia's overall forest cover (estimated at 5 percent of total forest land), but account for a larger overall percentage of aboveground biomass (6.5 percent).[18]

[16] Data from FAO, the Forestry Department, Ministry of Natural Resources, Ministry of Lands and Natural Resources, 2016. Integrated Land Use Assessment Phase II- Report for Zambia. For this table we include only lands classified as forest in the ILUA assessment. These figures therefore do not sum to the total area of the country.

[17] These area totals are calculated from ILUA II data. Note differences in area between the ILUA II data (Table 2) and the FAO estimates provided in Table 1 – particularly with the forest woodland and other wooded land categories. The two analyses use different definitions of those two categories and as such those categories are much larger in the ILUA II assessment.

[18] Day, M., Gumbo, D., Moombe, K.B., Wijaya, A., Sunderland, T. 2014. Zambia Country Profile: Monitoring, reporting and verification for REDD+. Occasional Paper 113.Bogor: Indonesia: CIFOR.

FIGURE 4: ABOVEGROUND CARBON DENSITY FOR ZAMBIA (SPAWN & GIBBS 2020)[19]



[19] The spatial distribution of belowground carbon closely follows the distribution of aboveground carbon so a belowground carbon map will look very similar to this.

3.0 OVERVIEW OF GOVERNANCE AND LAND USE CONTEXT

This section presents several key issues related to Zambia's legal, policy, and institutional framework for land and resource governance that influence the implementation of sustainable landscapes strategies. The analysis used select research questions from the Governance of Forests Initiative Indicator Framework, which indicators assessed the actors, rules, and practices that influence land and resource governance.[20] The goal of incorporating this analysis is to understand the broader political and economic context including the extent to which it incentivizes or creates barriers for land-based climate mitigation. Our review includes analysis of overall development priorities, state budget support, and land and resource governance regimes.

3.1 OVERVIEW OF NATIONAL OBJECTIVES AND STRATEGIC PLANNING

Zambia's 8th National Development Plan (2022 – 2026) focuses on four major priority areas:

- ***Economic Transformation and Job Creation***: This pillar focuses on economic transformation anchored on industrialisation with a focus on value addition in agriculture, mining, and manufacturing. Priority will also be given to job-rich sectors such as tourism and agriculture. Further, focus will also be placed on the development of micro, small and medium enterprises across all sectors as they have high income and job creation potential.
- ***Human and Social Development***: This pillar focuses on increasing access to, and improving the quality of education, health and water and sanitation, as well as enhancing social protection to reduce poverty and inequality.
- ***Environmental Sustainability***: This pillar focuses on sustainable utilisation of natural resources and building resilience to the adverse effects of climate change. Priority measures target promoting green growth, safeguarding the environment and natural resources, enhancing climate change mitigation and adaptation as well as strengthening disaster risk reduction.
- ***Good Governance Environment***: This pillar focuses on improving the policy and governance environment as well as on promoting adherence to the rule of law and constitutionalism.

While the National Development Plan (NDP) incorporates broad support for many of the activities that align with cost effective mitigation options, it prioritizes sectors with a more significant contribution to GDP or job creation including agriculture, mining, manufacturing, and tourism. Under the Environmental Sustainability Pillar, two Development Objectives focus on 1) Enhanced Mitigation and Adaptation to Climate Change and 2) Sustainable Environment and Natural Resources Management.

The proposed strategies in the National Development Plan are broadly consistent with other sector-specific plans including the National REDD+ Strategy and the REDD+ Investment Plan, as well as national law and the 2016 National Policy on Climate Change. Furthermore, the National Forestry Policy of 2014, includes broad objectives including participatory forest management, including the active participation of local communities, traditional institutions, private sector and other stakeholders in the management and utilization of forest resources at all levels of decision making, implementation, monitoring, and evaluation.

[20] The GFI Indicator Framework is a comprehensive menu of indicators used to assess strengths and weaknesses of forest governance. Developed by the World Resources Institute and piloted in Brazil, Cameroon, and Indonesia, it presents an adaptive, customizable research methodology that can be tailored to a broad range of management objectives. For more information: https://www.wri.org/research/assessing-forest-governance.

A review of major forest laws and policies finds that linkages with other economic sectors, notably agriculture, mining, and infrastructure, that impact forests are acknowledged but with limited strategies to strengthen coordination or address impacts. For example, the National Forest Policy mentions agriculture and mining generally as drivers of forest loss or degradation but does not incorporate coordination or activities to address sectoral threats in any of its specific objectives. Overall, there is a lack of clear strategies for operationalizing coordination across sectors, although the National Policy on Climate Change adopted in 2016 aims to align sectoral efforts to address climate change under the coordination of the Ministry of National Development Planning. Furthermore, the National Development Plan targets mining and agriculture as major sectors for economic growth; while environmental sustainability incorporates forest management, there is limited analysis of how expansion of mining, agriculture, or manufacturing sectors may impact forests and land use including associated emissions. There is also limited integration of tourism discussions with strategies to strengthen environmental sustainability and forest management, which suggests a potential missed opportunity to align these objectives and channel investments.

The analysis of the coherence and coordination between national policies and objectives finds that climate mitigation including through improved management of forests is well-integrated into the National Development Plan and reinforced by land and forest policies. However, there is limited analysis of Zambia's overall land base and how these broad policy commitments will translate to realistic emissions reductions given the level of priority and investment accorded to land-based interventions.

Projected growth in sectors such as manufacturing and mining may result in higher overall emissions from these sectors without increased investment in clean technology and energy. Furthermore, proposed expansion of the agricultural sector may increase its already significant contribution to national emissions. There is a critical opportunity and need for Zambia to operationalize its commitments by strengthening cost-effective investment in land-based mitigation strategies that can increase removals and balance economic growth objectives with environmental sustainability and climate commitments.

3.2 BUDGET PRIORITIES RELATING TO LAND-BASED CLIMATE MITIGATION

Lack of financial resources to implement programs and enforce laws and policies can pose a critical barrier to effective governance of forest and land resources. Furthermore, analysis of drivers of land use change in Zambia cite the lack of financial incentives to support desired land management practices or channel investments to priority actions. To understand national funding constraints and opportunities in relation to climate mitigation strategies for forests, we reviewed the level of national budget allocated to these priorities in the 2023 national budget as a preliminary indicator of government support.[21]

We reviewed the overall level of resources allocated to forest, land, environment, and agriculture as compared to other national priorities, as well as detailed budget requests for key line ministries including the Ministry of Lands and Natural Resources, Ministry of Green Economy and Environment, Ministry of Fisheries and Livestock, and Ministry of Agriculture. Figure 5 presents budget allocations for the past three years for major line ministries in Zambia.[22] Support to agriculture far outstrips commitments to other sector ministries reviewed, representing 6.7 percent of the overall national budget with an emphasis on enhanced farmer support, farm block development, irrigation development and extension services. Support to the Ministry of Green Economy and the Environment, a newer ministry which has taken up several functions previously assigned to the Ministry of Lands and Natural Resources, received on average $34,906,682/year to support functioning and priority programs.

[21] Government of the Republic of Zambia. 2022. Republic of Zambia Estimates of Revenue And Expenditure (Output Based Budget) For the Year 1st January 2023 to 31st December 2023. Lusaka, Zambia.

[22] We compiled budget estimates based on data available on the proposed 2023 budget. We note that figures for 2021 and 2022 represent allocated budget, whereas 2023 numbers reflected the proposed budget allocation for 2023.

Ministries in charge of water resources, energy, and fisheries and livestock all received higher allocations. We note that the Ministry of Lands and Natural Resources received the smallest portion of funds of the allocations reviewed.

FIGURE 5: ANNUAL BUDGET ALLOCATION FOR RELEVANT SECTOR MINISTRIES IN ZAMBIA 2021 – 2023 IN USD

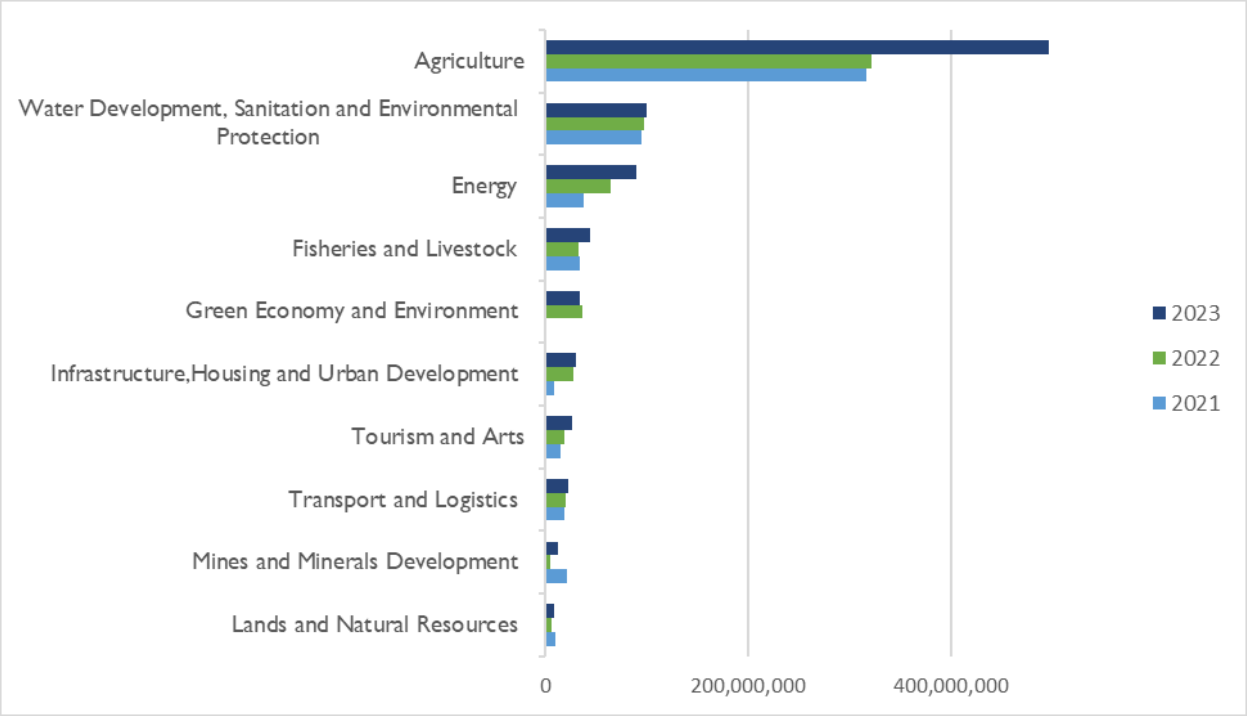


Table 5 summarizes the priority programs for these sectors identified in the 2023 budget that relate to land-based climate mitigation. Expanding forestry extension and community forest management under the Ministry of Green Economy and Environment create opportunities linked to mitigation. Priorities for the Ministry of Agriculture focus on extension and farm block development, with a brief mention of conservation agriculture but otherwise minimal emphasis on climate-resilient agricultural practices. On the other hand, the Ministry of Livestock focuses several programs on strengthening productivity of rangeland management systems including through restoration of degraded areas and support to smallholders to adopt climate-resilient technologies.

In general, the proposed 2023 national budget is closely aligned with NDP priorities and invests in sectors with an important impact, either direct or indirect, on forest resources and land management. Investments in underlying issues of land management and forestry extension represent a smaller proportion of state budget support as compared to sectors with a higher contribution to GDP or those that are critical to powering economic growth (e.g., energy, water). Planned support to programs focused on community forest management are limited, despite the importance of clear and secure land tenure in relation to overall forest condition in Zambia.[23] In addition to national programs, all provincial governments incorporate funds for forest-related programming such as afforestation and reforestation, sustainable forest management, and development of forest industries, but this budget constitutes a modest $379,834/year.

[23] Stickler, M.M., Huntington, H., Haflet, A. Petrova, S., Bouvier, I. 2017. Does de facto forest tenure affect forest condition? Community perceptions from Zambia. Forest Policy and Economics. Vol. 85, Part 1.

In summary, national priorities and targets incorporate significant opportunities to advance land-based mitigation objectives, but the allocation of funding reflects broader economic growth objectives and deprioritizes investment in forest management and land governance. Based on the profile of Zambia's emissions and available state budget support, an additional focus on integrating a climate lens into sectors that impact land use emissions is critical, particularly in relation to the agriculture sector.

TABLE 5: PRIORITIES RELEVANT FOR LAND-BASED MITIGATION IN 2023 BUDGET FOR SELECTED MINISTRIES[24]

Ministry	Relevant 2023[25] priorities
Ministry of Green Economy and Environment	• Recognize 50 Community Forest Management Groups (CFMGs) to manage 600,000 hectares including training in forest management practices and various forest-based livelihoods which will improve household income and create employment. • Forestry extensions services including dissemination of forestry information to the public. The Ministry will therefore publish 2,000 forest extension materials, 20 television TV Programmes and conduct 100 sensitization meetings. • Support tree planting of 2,500 hectares of forests through procurement of nursery requisites, nursery establishment, management, and tree planting. • Develop the Implementation Plan of the National Policy on Climate Change. The implementation plan of the National Policy on Climate Change will ensure operationalization of green economy and climate change strategies. • Conduct the National Greenhouse Gas Inventory and conduct the NDC carbon stock take that would facilitate monitoring progress towards national emissions reduction and adaptation to the impacts of climate change towards a low carbon and climate resilient economy.
Ministry of Lands and Natural Resources	• Allocated 70 percent of funds to the Land Administration and Regulation Programme which focuses on land registration and titling, land survey, and land policy and management. Work under this program includes identification of customary land for developmental activities as well as management of land disputes. This however has limited applicability to forest management, as it is restricted to state (largely urban) land. • Implementation of Natural Resources Management Programme is focused on biodiversity conservation and protection primarily through the development of conservation plans.
Ministry of Agriculture	• Improve crop production and productivity through interventions that include promotion of conservation agriculture.
Ministry of Fisheries and Livestock	• The Sustainable Livestock Infrastructure Management Project (SLIMP) and Pasture and Rangeland Management will contribute to poverty reduction through the sustainable use of livestock infrastructure for improved production and productivity. • Provide extension services to all livestock farmers and ensure that at least 50 percent of farmers adopt climate smart technologies. • To facilitate promotion of fodder production and sustainable management of rangelands for improved livestock nutrition, the Ministry will rehabilitate 30,000 hectares of degraded rangeland and increase the rangeland carrying capacity by 15,000 hectares.
Tourism	• One of four main tourism sub-programs focuses on Wildlife Conservation and Management.

[24] We reviewed a broader subset of sector ministries to understand opportunities to capitalize on existing programming linked to land-based mitigation; however, the budget document we reviewed includes only high level summaries of priorities. Therefore, this is a partial list that may not incorporate all relevant linkages for example within the energy sector.

[25] We present 2023 priorities to synthesize the most recent national budget; analysis of the budget priorities for 2021 and 2022 revealed similar priorities particularly with respect to natural resource management which emphasized strengthening forest management planning, reforestation and agroforestry initiatives with similar targets set for forest management activities although the 2021 budget set lower targets for tree planting.

3.3 COMMUNITY USE RIGHTS IN THE ZAMBIAN FOREST SECTOR

Community forest management plays an increasingly important role in the Zambian forest sector. The legal framework for accessing rights to customary and forest lands creates specific opportunities and challenges for land-based climate mitigation. For example, Article 254 of Zambia's Constitution recognizes customary land rights and the responsibility of 288 chiefs to administer customary land. Rural households have subsistence use rights to forest products; however, Section 86 of the Forest Act prohibits the removal, felling, cutting, collection, or sale of major forest produce[26] without a license or permit if for commercial use from state, customary, and open areas. While individual rights are recognized to an extent – specifically, the Forest Act allows households to harvest trees for subsistence use including conversion of forests to agricultural uses—on customary and leasehold land, this allows conversion without permitting and creates an incentive for land clearing.

The revised Forest Act of 2015 enables communities to secure rights. The Community Forest Management Regulations of 2018 operationalize these rights by setting out guidelines for communities to register as Forest Management Groups. "Community forest" as defined by the Forest Act and 2018 regulations denotes a forest controlled, used, and managed under an agreement between a community forest management group and the Department of Forests. The community forest agreement grants a range of forest user rights to the community forest management group including collection of NTFPs, harvesting of timber or fuel wood, grass harvesting and grazing of animals, ecotourism, plantation establishment through non-resident cultivation, and the right to enter into contracts to assist with silvicultural operations. The Forest Act also enables Private Forest Management but requires title deed for formal tenure, which limits the ability of smallholder farmers or other communities to exercise this right in practice.

Neither the 2015 Forest Act nor the 2018 Community Forest Regulations set a limit on the duration of community forest management rights. While they are indefinite in duration, certain actions including any transfer of rights are still subject to required approvals from the Direction of Forestry.

The Community Forest Regulations grant a broad range of rights and uses to Community Forest Management Groups; however, the limitations placed on all commercial use may constrain the ability of communities to develop a long-term vision and approach for sustainable resource management. Furthermore, while a Community Forest Management Group may assign any or all its rights to any other person or group (Sec. 33, Forest Act 2015), the final determination of this right rests with the government. Community forests are a primary option for securing management rights to forests, but present a more limited form of tenure in contrast to the Land Act which allows property owners full transfer rights.[27] While Zambia has made significant strides in recognizing customary rights and creating additional opportunities for communities to secure and benefit from those rights through Community Forests, efforts to strengthen tenure security must be paired with adequate incentives to promote long-term climate mitigation strategies.

Community Forest Management however appears to be the main approach to securing carbon rights and providing communities with the opportunity to participate in and benefit from forest management. As of the end of 2023, over 220 CFMGs have been established across Zambia covering over 6 million hectares (almost 10 percent of the country's surface).[28] Many of these have been created with the

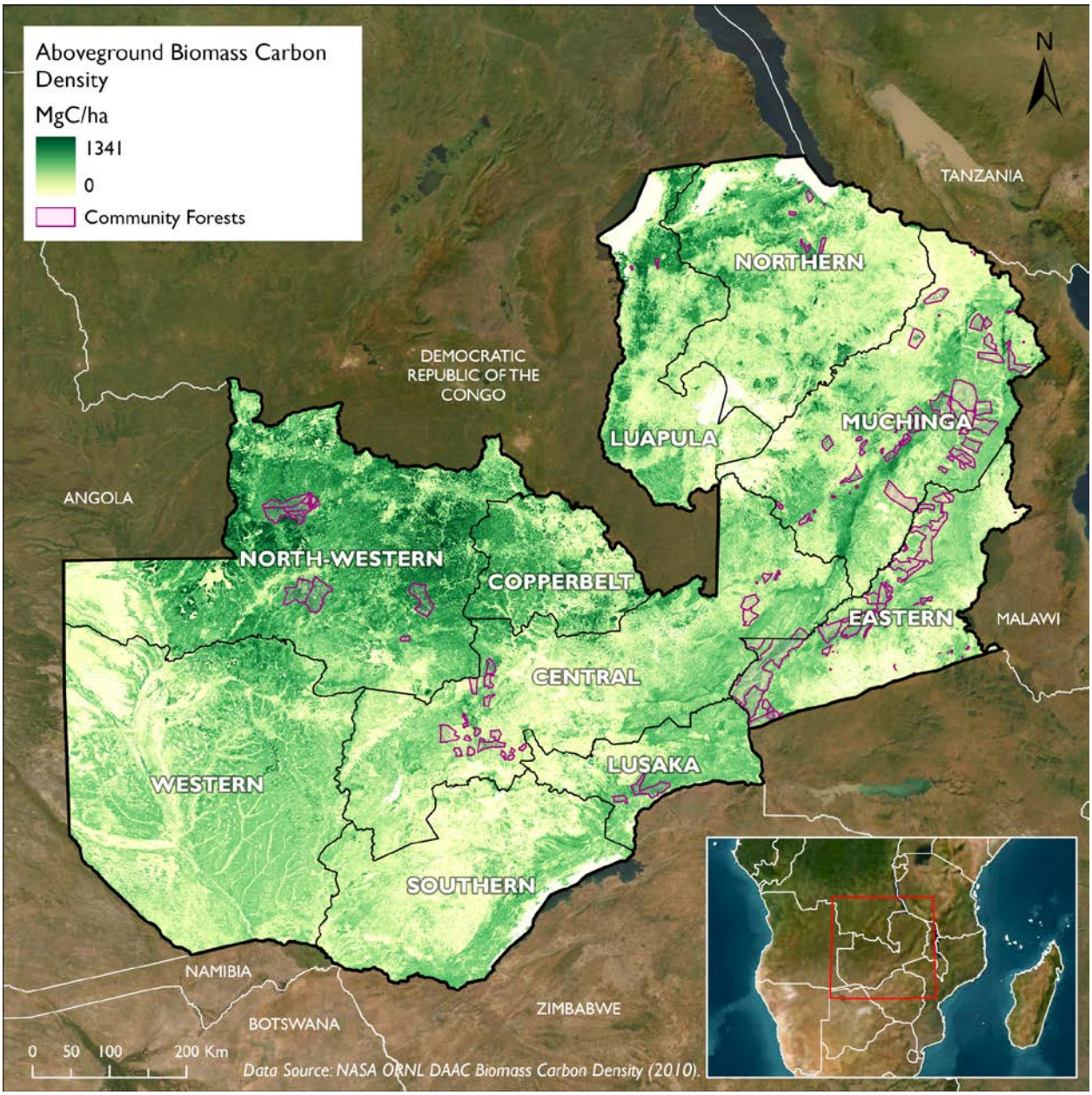
[26] Section 3 of the Forest Act distinguishes between major and minor forest produce. "Major forest produce" is defined as a tree, part of a tree or derivative product such as timber, charcoal, and carbon, other than leaves, flowers, fruits, and seeds.

[27] World Bank and the Forestry Department of the Government of the Republic of Zambia. 2019. Forest Tenure Assessment Tool in Zambia. Washington, D.C.

[28] More information can be found on the Government's CFMG Database that was established with support of USAID. https://cfmg.mgee.gov.zm/

intention of accessing forest carbon funds, and improving forest management, though there has been limited governance support available to these communities up to present. Figure 6 shows community forests and aboveground biomass.

FIGURE 6: COMMUNITY FORESTS AND ABOVEGROUND BIOMASS[29]



[29] Note that the community forest locations presented here represent only approximately half of the over 200 registered community forests across the country, as the associated maps have not historically been managed or digitized centrally.

4.0 CONSERVATION AND MANAGEMENT OF HIGH VALUE FOREST AREAS

In this section we examine mitigation options related to avoided deforestation, with an emphasis on conservation and management of high value forest areas as proposed under Core Investment Priority 1 of Zambia's REDD+ National Investment Plan which defines its approach as prioritizing areas with high forest cover that are under the most direct threat. It therefore aims to support conservation of existing forests, including through sustainable forest management, improved agricultural practices, and eco-tourism. Based on the forest sector's overall contribution to Zambia's greenhouse gas emissions, investing in forest protection presents a significant opportunity for land-based climate mitigation estimated at 37 percent of total cost-effective mitigation potential. For this reason, we include discussion of these options supplemented with national analyses and data where available. The following sections describe forest cover change in Zambia including geographic distribution, threats, and trends related to different land use classifications, and discuss implications of these findings for strategies to avoid or reduce forest conversion.

4.1 FOREST COVER CHANGE IN ZAMBIA

While the first ILUA estimated annual loss at an average of 250,000 – 300,000 ha/year, this estimate is higher than more recent analyses and Zambia's FREL. Table 6 summarizes published national estimates as well as comparable analysis from Global Forest Watch. The wide range of estimates is due in part to differences in methods used to define and estimate forest loss. We note that analyses such as Griscom et al depend heavily on global datasets, potentially overlooking crucial nuances related to forest type in Zambia. For example, global maps of forest cover change such as those developed by Hansen et al use a threshold of 50 percent canopy cover, which may undercount open canopy dryland forests including miombo woodlands which represent a significant percentage of Zambia's forest cover.[30]

TABLE 6: SUMMARY OF NATIONAL FOREST LOSS STATISTICS FOR ZAMBIA

Assessment	Annual forest loss (ha/year)	Time period
ILUA	250,000 – 300,000	The ILUA first phase assessment was completed in 2008
ILUA II	79,000 – 150,000	Phase II of the ILUA was conducted between 2010 – 2016
Zambia's updated Forest Reference Emission Level	191,569	2009 – 2018
Global Forest Watch	160,000	2016 – 2022[31]

This issue highlights the need for more context-specific methodologies and data sources in assessing and addressing deforestation in Zambia. For this reason, we present analysis of deforestation and forest degradation dynamics in Zambia based on several national analyses including the ILUA II and data available in the FREL. Due to the lack of available spatially explicit estimates at national level, we continue to rely on the Hansen et al. dataset to map trends over time and calculate forest loss statistics for relevant geographic and land use categories.

[30] Mayes, M.T, Mustard, J., and J. Melillo. 2015. Forest cover change in Miombo Woodlands: modeling land cover of African dry tropical forests with linear spectral mixture analysis. *Remote Sensing of Environment.* https://www.sciencedirect.com/science/article/abs/pii/S0034425715300134

[31] Note that we use 2016 – 2022 due to methodological changes with the Hansen dataset over time. For more information regarding these changes: https://www.globalforestwatch.org/blog/data-and-research/tree-cover-loss-satellite-data-trend-analysis/

Prioritizing mitigation options must consider a range of factors including degree of threat, degree of degradation or conversion, and overall impact of current and projected loss on emissions based on available data on carbon density. To understand subnational trends, we reviewed available data from the FREL and ILUA II assessments to understand the overall ranking of Zambia's ten provinces with respect to total forest cover, total loss during the 2009 – 2018 time period (Figure 7), and estimated emissions associated with this loss (Table 7). This analysis used FREL information on average carbon stock/ha and total deforestation. While this provides an indicative ranking to inform design of mitigation options, these estimates represent emissions from gross rather than net deforestation (i.e., estimates do not include estimated removals from forest regrowth) and do not incorporate emissions from forest degradation. Furthermore, due to lack of consistent area-based provincial data on forest type, we applied an average of provincial estimates of biomass/ha.

FIGURE 7: 2009 – 2018 ESTIMATED DEFORESTATION AND FOREST DEGRADATION BY PROVINCE (HA)

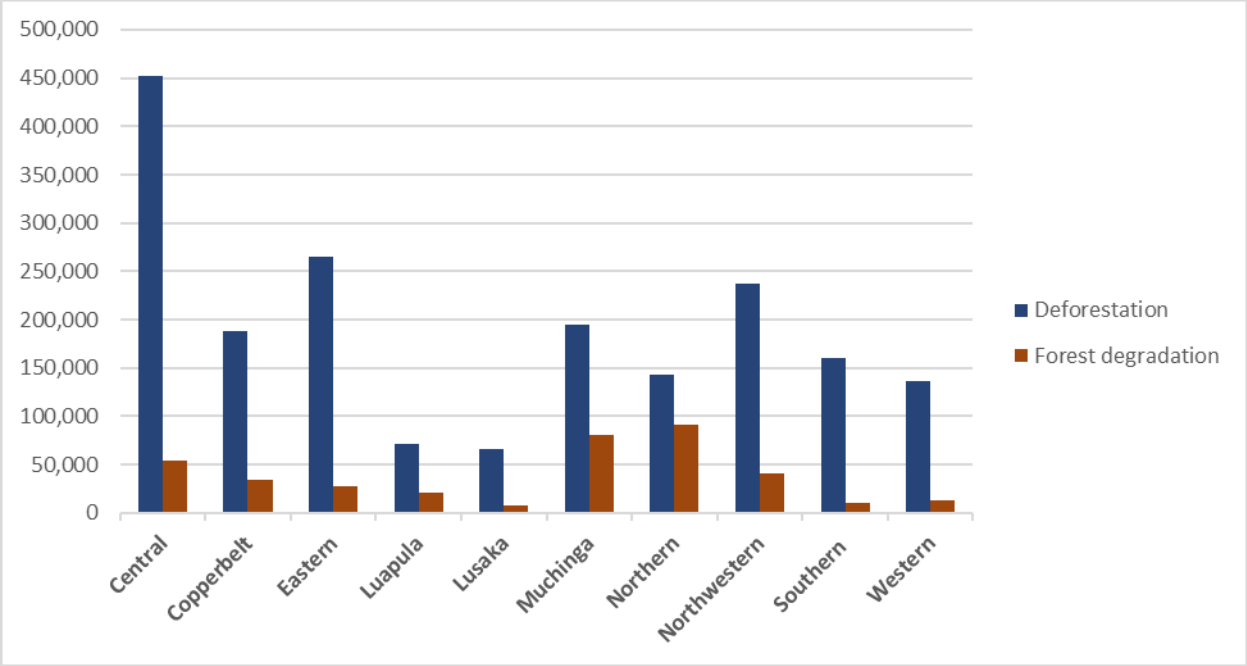


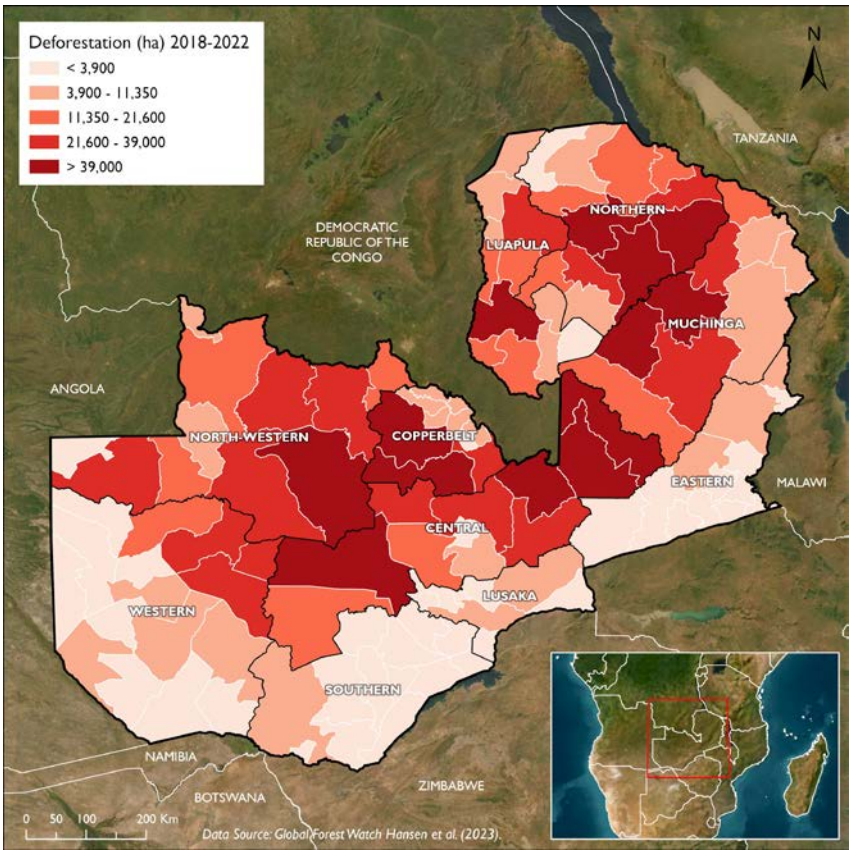
TABLE 7: TOTAL DEFORESTATION IN ZAMBIA BY CAUSE AND RELATIVE RANKING BY PROVINCE FOR 2009 – 2018

Province	Total forest area (ha) based on 2014 land cover map	Forest Land AGB (million tons)	Forest loss (ha)	Annual rate of forest loss	Relative rank among provinces				Estimated percentage of provincial deforestation (%)		
					Forest cover	Forest loss (ha)	Estimated emissions	Forest loss (%)	Forest to cropland	Forest to grassland	Forest to settlement
Central	5,701,471	216.0	451,962	0.99%	4	1	1	2	82.8	15.5	1.7
Northwestern	8,833,712	609.0	237,792	0.34%	1	3	2	8	54.3	37.1	8.6
Eastern	3,599,412	99.3	264,990	0.92%	7	2	3	3	76.3	10.5	13.2
Copperbelt	1,896,348	95.9	188,388	1.24%	9	5	4	1	85.2	7.4	7.4
Muchinga	6,359,200	229.8	194,541	0.38%	3	4	5	7	58.6	34.5	6.9
Northern	4,277,891	177.5	143,181	0.42%	5	7	6	6	68.2	22.7	9.1
Western	6,840,231	252.2	136,738	0.25%	2	8	7	10	61.9	38.1	-
Southern	3,756,345	85.2	160,152	0.53%	6	6	8	5	75.9	24.1	-
Luapula	3,269,517	117.0	71,526	0.27%	8	9	9	9	80.0	20.0	-
Lusaka	1,409,189	59.8	66,686	0.59%	10	10	10	4	62.5	37.5	-

The FREL estimates indicate that Central And Eastern Provinces had the highest total loss despite ranking fourth and seventh, respectively in total forest cover, followed by Northwestern and Muchinga Provinces. While we present total hectares of estimated deforestation and degradation to understand the total mitigation potential in each province, we also calculated the overall rate of loss to understand the intensity of the pressure. Copperbelt Province observed the highest rate of loss despite ranking ninth in forest cover, followed by Central and Eastern. Based on the FREL data, with the exception of Northwestern, the provinces with higher forest cover are not necessarily witnessing the most rapid loss or the highest gross deforestation. Central, Eastern, and Northwestern provinces combine for 49.8 percent of estimated deforestation, while Northern, Muchinga, and Central provinces account for 58.9 percent of estimated forest degradation. While forest to cropland is the dominant type of conversion, there are notable impacts associated with settlement expansion in several geographies including Eastern and Northern provinces. These trends provide some insight into the types of strategies to deploy to address localized trends in forest cover change.

To complement our understanding of the spatial distribution of forest loss with a focus on recent trends, we also mapped total forest loss at the district level using the Hansen et al. dataset for the 2018 – 2022 period (Figure 8)[32]. Table 8 lists the 15 districts with the highest loss over the period, 5 of which are found in Central Province. The analysis of Hansen data also found relatively little loss in Eastern Province during the 2018 – 2022 period as compared to the previous period covered by the FREL, which may indicate that the rate of loss has slowed compared to clearing in the previous period.

FIGURE 8: ESTIMATED GROSS DEFORESTATION BY DISTRICT 2018-2022



[32] In this data set, "tree cover" is defined as all vegetation greater than 5 meters in height, and may take the form of natural forests or plantations across a range of canopy densities. We address the potential limitations of summing pixels of loss by aggregating results to the district administrative level to display.

TABLE 8: HIGHEST DEFORESTATION BY DISTRICT 2018 – 2022

Province	District	Total deforestation (ha)
Muchinga	Kanchibiya	60,345
Copperbelt	Lufwanyama	59,966
Northern	Mungwi	59,066
Muchinga	Shiwamg'andu	58,342
Northern	Kasama	58,190
Central	Mumbwa	53,811
Central	Chitambo	50,660
Luapula	Mansa	50,522
Central	Mkushi	48,564
Central	Serenje	46,397
Northern	Lunte	45,272
Northwestern	Kasempa	45,232
Copperbelt	Mpongwe	43,258
Central	Kapiri Mposhi	39,051
Northwestern	Solwezi	38,057

4.2 THREATS AND DRIVERS OF FOREST LOSS IN ZAMBIA

Drawing from Zambia's national REDD+ strategy and additional studies such as USAID/Zambia's Environmental Threats and Opportunities Assessment, Table 9 presents a summary of direct drivers and underlying threats to forest cover change in Zambia. While these analyses broadly reflect stakeholder consensus and understanding of trends, many early analyses used to inform the REDD+ strategy did not quantify the scale of each driver of forest loss. We also draw from the more recent ILUA II and FREL to provide insight into national estimates of overall forest loss from different drivers.

TABLE 9: SUMMARY OF MAJOR DRIVERS OF FOREST LOSS

Drivers	Key factors or challenges
Agricultural and Land Management Practices	• Low productivity, extensive agricultural practices • Poor livestock management • Use of fire for land preparation • Lack of incentives for agricultural intensification • Low adoption of climate smart agricultural systems and/or conservation agriculture, agroforestry, and green manuring • Insufficient agricultural extension services
Energy Demand	• Felling of trees for charcoal production and use of charcoal/firewood as the main energy source • Inadequate alternative energy sources • Weak implementation of renewable energy policies • Lack of incentives for renewable energy adoption
Forest Management and Extractive Use	• High demand for valuable timber species with challenges in monitoring and regulating timber off-take • Uncontrolled harvesting, encroachment in protected areas, and overexploitation in forest concession areas • Reliance of agribusiness and mining industries on wood fuel • Increase in the number of migrants seeking income and turning to marginal livelihoods • Poor infrastructure for patrols • Lack of required technology to collect and share monitoring data • Inadequate reward systems for officials or for community support

Drivers	Key factors or challenges
Land Use and Infrastructure Development	• Lack of integrated land use planning • Harvesting timber for mining infrastructure • Road expansion • Urbanization
Underlying Drivers	• Weak customary governance and policies that incentive land clearing • Inadequate management plans and governance • Lack of participatory land use planning and coherent land tenure policies • Inadequate organization, funding, and education for government employees in natural resource management • Limited alternative livelihoods

While agriculture is the dominant direct driver of forest loss in Zambia, estimates of the overall contribution vary and there is robust debate as to the overall contribution of charcoal particularly in urban and increasingly peri-urban areas. ILUA II estimates based on analysis of land cover maps estimates that agriculture accounts for 60.78 percent of forest loss whereas estimates in the FREL are higher at 72.16 percent.[33] Several studies attempt to unpack the complex dynamics and provide more definitive data on the relative importance of woodfuel/charcoal vs. agriculture. We discuss these analyses and their conclusions in greater detail in Section 5.2.

An important consideration in analyzing what drives forest clearing is the importance of livelihood stacking for Zambian households. Despite debates regarding the relative influence of each driver, in practice agriculture and woodfuel are rarely mutually exclusive livelihood options and therefore require solutions embedded in understanding of economic and social factors that drive participation in different value chains. Charcoal production and trade can provide quick infusions of income for poorer households, particularly during the dry season when income from agriculture is lower.[34] For example, a Producer Survey of over 600 charcoal producers in four districts in Zambia found that over 80 percent also had experience in agriculture (including livestock), over half conducted these activities in conjunction with charcoal production.[35]

Rural populations depend significantly on subsistence agriculture which is characterized by low agricultural productivity. Furthermore, the existing tenure regime creates disincentives for forest protection. The Forest Act allows households to harvest trees for subsistence use including conversion of forests to agricultural uses. On customary and leasehold land, this allows conversion without permitting and creates an incentive for land clearing. Customary leaders allocate land as a form of social power, welcoming immigrants into their areas to strengthen their control over larger areas as well as to assert their authority. In other areas, charcoal focused cartels create agreements with communities and laborers to access fuelwood to feed urban centers. Furthermore, there is limited uptake of climate-smart agriculture, agroforestry, or conservation-oriented agricultural practices and lack of incentives to adopt these practices. While the Forest Act enables Private Forest Management, smallholders are limited in their ability to access these rights which require title deed for formal tenure, which remains relatively rare. As a result, the lack of viable options to secure and benefit from natural resources in the long-term discourages productive investment, exacerbated by lack of a conducive enabling environment for business development.

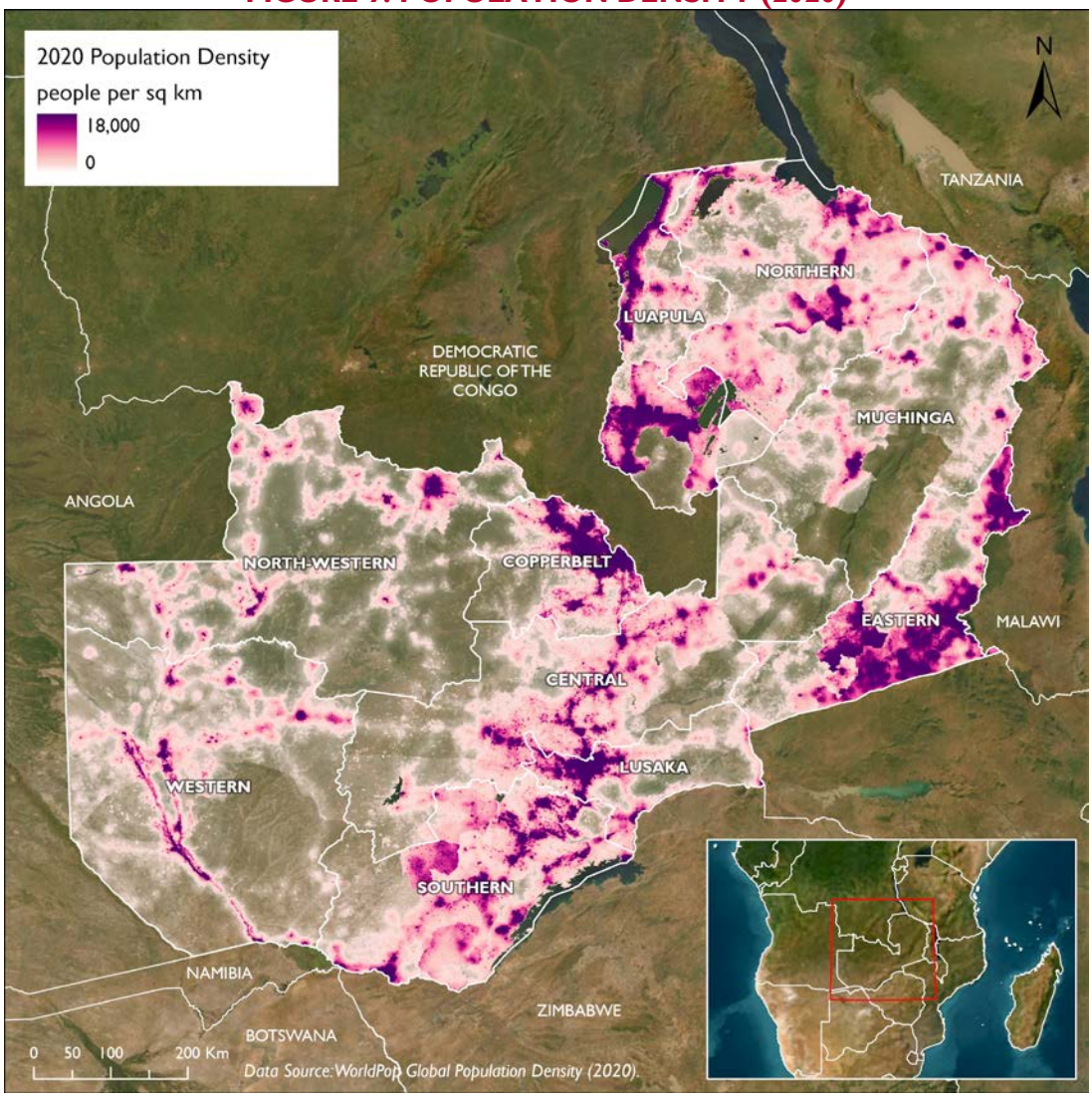
Agricultural expansion in many rural zones relies heavily on fire to prepare land for planting. Bush clearing coupled with the regeneration of grasses after burning can result in increased fire occurrence

[33] Government of the Republic of Zambia. 2021. Forest Reference Emissions Level. Lusaka: Ministry of Green Economy and Environment.
[34] USAID Zambia. Political Economy Analysis of Zambia's Charcoal Value Chain. 2021. Lusaka, Zambia.
[35] USAID Zambia. Charcoal Producer Survey Baseline Report. 2022. Lusaka, Zambia.

particularly during the dry season. Zambia lacks an effective policy and management framework for fire management, for example guidelines on early versus late burning or use of fire breaks. Historical biases and practices within communities, compounded by low productivity pastoralism and livestock management, contribute to fire-driven deforestation. Lack of fodder for livestock also leads to conversion of forests to grasslands, further intensifying the pressure on forested areas. Underpinning these challenges is the lack of established systems for monitoring and controlling fires, and a land tenure regime that incentives clearing in support of land claims as described above. The diversification of household-level livelihood strategies, encompassing agriculture, small-scale timber extraction (including for charcoal), and the collection of NTFPs also contribute to Zambia's deforestation and forest degradation although distinguishing the specific impacts of agricultural clearing and degradation from other extractive uses has not been feasible with most of the remote sensing methodologies to date.

Settlement expansion also drives deforestation; ILUA II estimates that 36.05 percent of forest cover loss was due to settlement expansion while the FREL submitted in 2021 puts this figure at closer to 5 percent. To better understand the potential threats associated with settlement expansion as it relates to population pressure, we mapped available data on population density (Figure 9). Available data shows that while areas of higher population density overlap areas of higher forest loss in Central and Eastern provinces, areas of higher loss observed in Northwestern province as well as several districts in Muchinga province do not overlap with areas of higher population density. Understanding of the specific dynamics of forest cover change and current threats in those areas requires additional information including on potential patterns of internal migration and local governance.

FIGURE 9: POPULATION DENSITY (2020)



Underlying governance challenges also influence forest loss. The absence of participatory land use planning, limited state budget support, and open access create hurdles for effective land and forest management. Furthermore, there is a lack of incentives to encourage improved land management practices, compounded by insufficient investment. The relatively small size of household landholdings also poses a unique challenge for tailoring interventions to promote sustainable land use practices such as providing extension services, creating incentives of facilitating access to finance, or other support.

4.3 AVOIDED FOREST CONVERSION

The two global analyses on Natural Climate Solutions assess the mitigation potential of avoided forest conversion by using baseline emissions derived from Tyukavina et al.[36] which defined "forest" as >25 percent tree cover and limits this pathway to predominantly tropical and sub-tropical climate domains where forest conversion is most active. The analysis identifies this pathway as having the second largest mitigation opportunity option in terms of cost-effective mitigation potential. While the previous sections

[36] Tyukavina et al. (2015). Aboveground carbon loss in natural and managed tropical forests from 2000 to 2012. *Environmental Research Letters*. Available at https://iopscience.iop.org/article/10.1088/1748-9326/10/7/074002.

presented overall trends in forest loss in Zambia and current drivers, to inform a more detailed prioritization of land-based mitigation options we carried out two new analyses: an analysis of threatened forests based on historical loss and available information on proximate drivers of forest loss, and an analysis of tree cover loss within several different land use categories for which national datasets were available. The following sections present the results, followed by a summary of key takeaways.

4.3.1 THREATENED FORESTS ANALYSIS

To better visualize how the level of threat faced by forests relates to differences in carbon density, we developed a Threatened Forests layer for Zambia that overlays degree of threat with forest carbon density (Box 1).

Box 1: Overview of Threatened Forests Analysis

To develop the Threatened Forests layer for Zambia, we used Google Earth Engine to analyze forest loss from 2000 to 2022 using the forest mask derived from the Hansen et al., 2013 global dataset (with a baseline from 2000). We incorporated several additional global datasets including the Global Human Settlement Layer,[37] Tree Cover Loss Dominant Driver,[38] Forest Condition,[39] Global Croplands,[40] and Land Use and Land Cover, development Threats.[41] We buffered deforestation, human settlements, and croplands by 1km to show areas potentially threatened by these activities. Each buffer area was weighted as present or not present to ensure equal weight to each factor. In addition, we intersected the Threatened Forests layer with aboveground biomass estimates to highlight forests with both high degree of threat and higher carbon density.

The analysis integrates several global data layers; many of these also aggregate globally available. Reliance on these datasets as well as equal weighting of threats may obscure local nuances. In addition, the global forest cover loss data uses gross rather than net deforestation; therefore, the layer does not capture regrowth that may occur in areas identified as threatened by the analysis.

This analysis highlights areas that are most at risk for future deforestation based on current understanding of settlements, croplands, recent deforestation, forest condition, and several other datasets. Figure 10 presents the Threatened Forests layer overlaid with aboveground biomass. Figure 11 visualizes the highest potential biomass loss at the district level.

The results show that a significant percentage of the most threatened forests are located in areas of high population density in Central and Eastern provinces, with additional patches in higher forest cover zones that include the northeastern zone of Western Province bordering Kafue National Park and the northern zone of Northwestern province. Among these threatened areas, forests in Northwestern, Western, and Luapula include more carbon dense closed forest types that would represent a priority for conservation.

[37] EU, Global Human Settlement Layer (GHSL). https://ghsl.jrc.ec.europa.eu/download.php
[38] Tree Cover Loss Dominant Driver: https://data.globalforestwatch.org/documents/tree-cover-loss-by-dominant-driver-2022/about
[39] Forest Condition: https://developers.google.com/earth-engine/tutorials/community/forest-vegetation-condition
[40] Global Croplands. Global Land Analysis and Discovery. https://glad.umd.edu/dataset/croplands
[41] NASA Socioeconomic data and applications center (SEDAC) https://sedac.ciesin.columbia.edu/data/set/lulc-development-threat-index/data-download

FIGURE 10: THREATENED FORESTS ANALYSIS AND ABOVEGROUND BIOMASS CARBON DENSITY

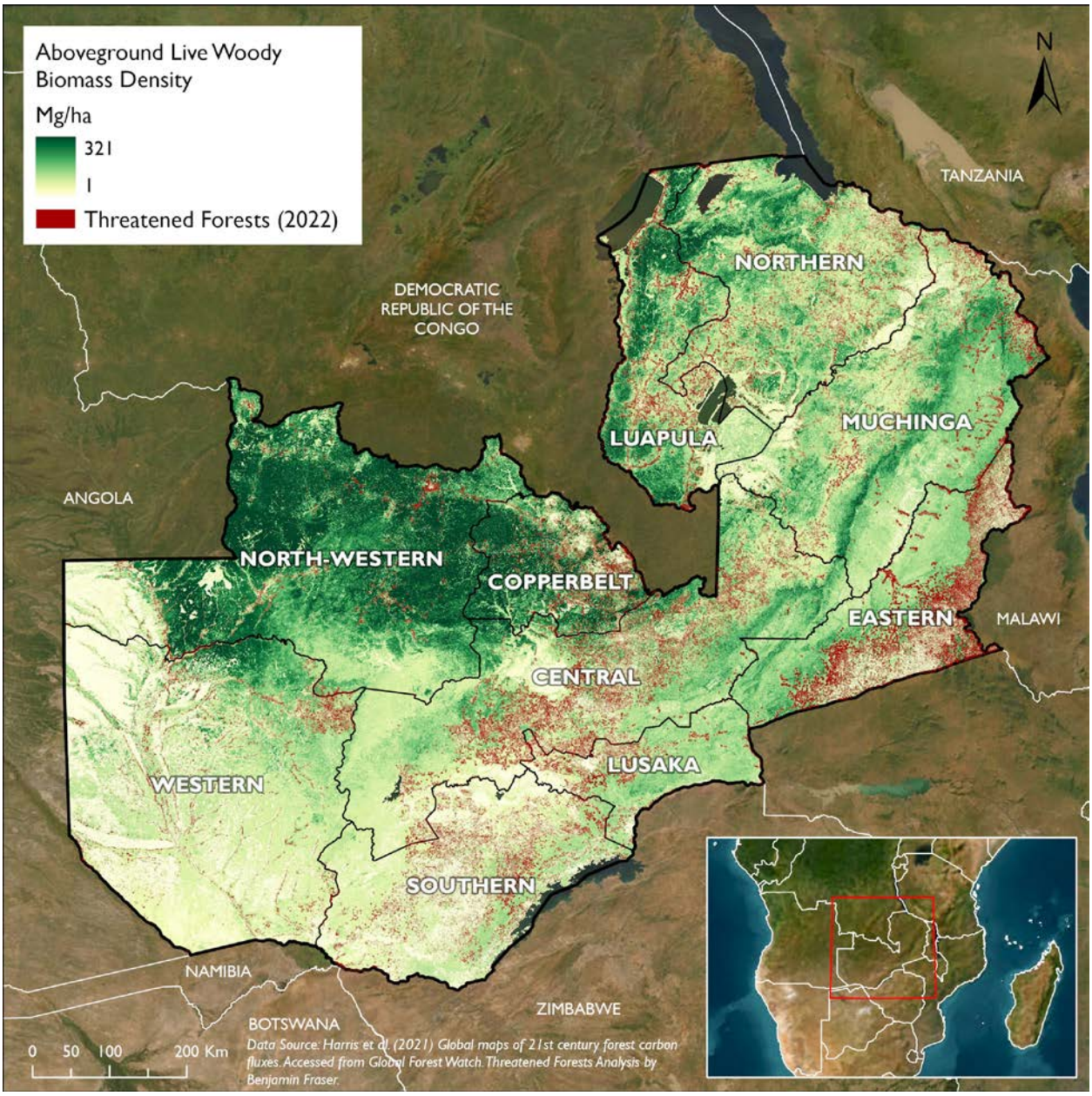
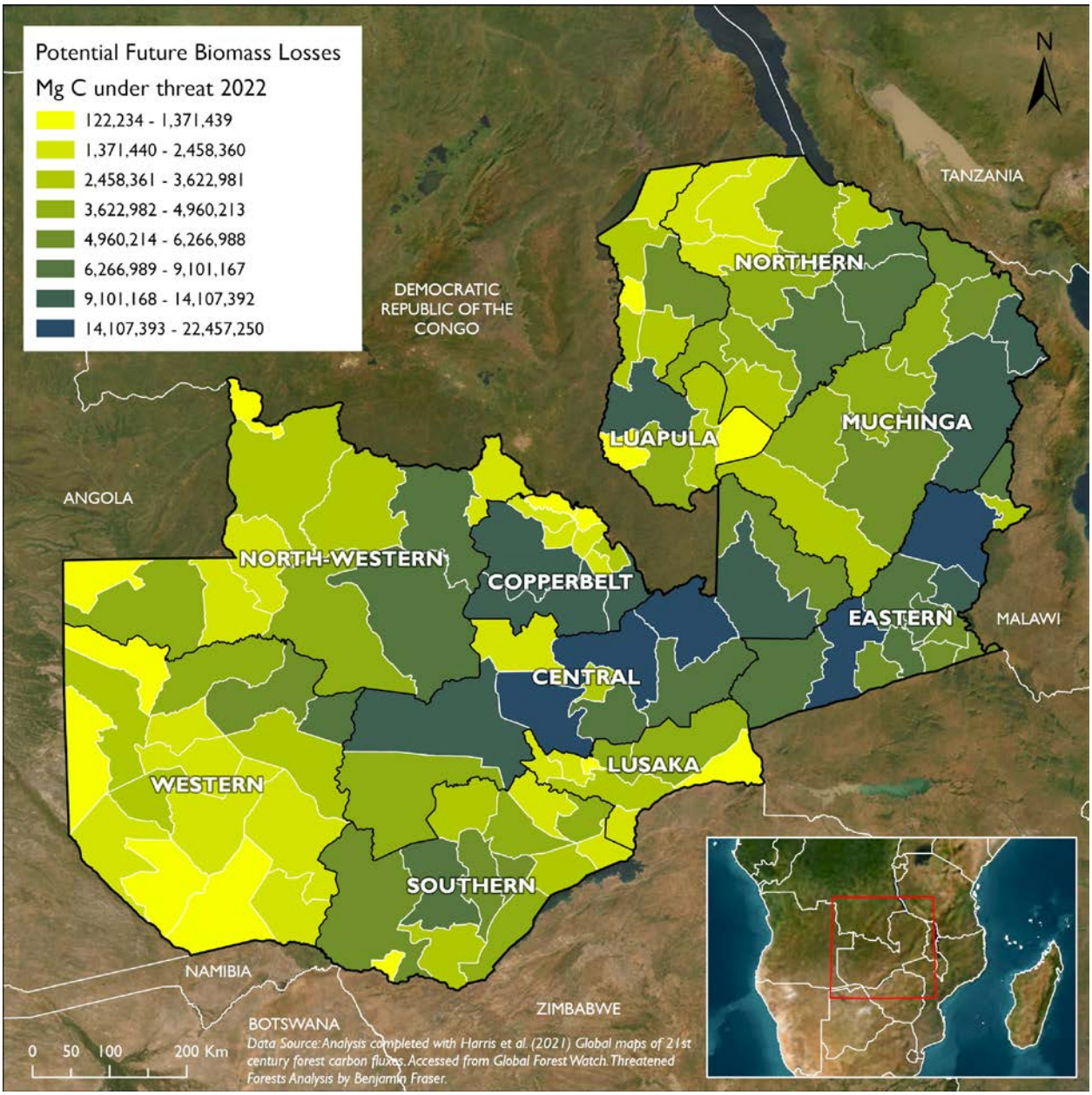


FIGURE 11: POTENTIAL FUTURE BIOMASS LOSSES BY DISTRICT

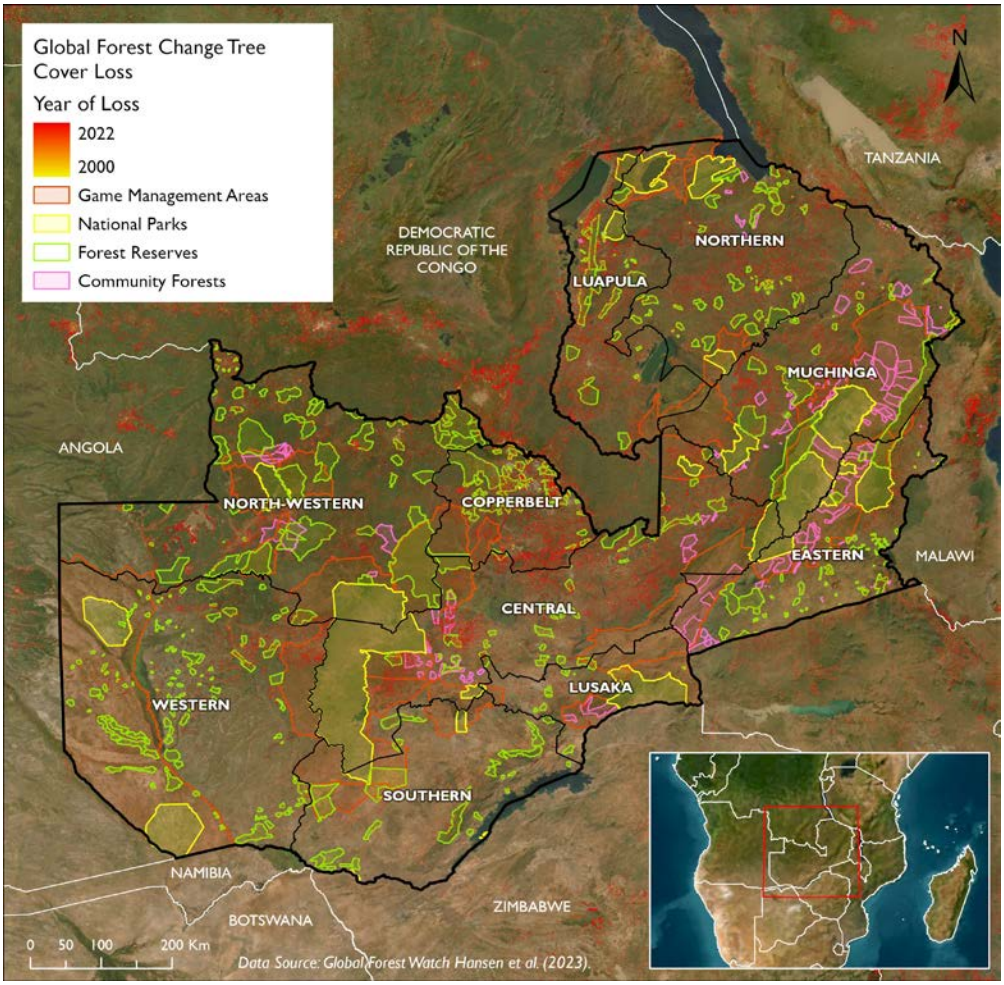


Based on the Threatened Forests analysis, priorities for avoided conversion based on currently threatened areas of higher biomass loss overlap significantly with areas of higher population density throughout Central and Eastern provinces. While improved land use planning and resource governance interventions can focus on avoiding conversion in these areas, these strategies may not be cost effective in areas with greater pressure from population and urban expansion. Intervention planning should also incorporate a focus on restoration and trees in agricultural lands in order to meet demand for forest products including charcoal, and to increase removals which will be necessary to offset planned expansion of other sectors by the National Development Plan. Policymakers and resource managers should also continue to evaluate evolution of threats including population pressure and migration – several zones of high forest cover and biomass including certain zones of Northwestern provinces are not currently under a high degree of threat but represent critical opportunities to maintain carbon stocks and establish effective, forward-thinking policies to support clear tenure and land use planning.

4.3.2 DEFORESTATION TRENDS BY LAND USE ALLOCATION

Based on the current understanding of drivers of forest loss and spatial extent of threatened forests, we reviewed proposed strategies to avoid forest conversion based on the priority measures in the REDD+ Investment Plan. The Plan proposes to support sustainable management of forests in protected areas (forest reserves, national parks), open areas (customary lands) and critical upper watersheds. To review deforestation trends within major land uses, we calculated forest loss for 2018 – 2022 using the Hansen et al. dataset, intersecting this data with four major land use types: National Parks, Forest Reserves, Game Management Areas, and Community Forests. The selected land use types, governed by the 2015 National Wildlife Act and Forest Act, range from strict protection in National Parks to allowing a broader range of resource use and benefits in Forest Reserves, which consist of both National and Local Forests.[42] Zambia legislation also enables establishment of Game Management Areas for sustainable use of wildlife, many of which have been established as buffer zones around the existing park network; GMAs are governed by a Community Resource Board (CRB) that receives a share of revenues from trophy hunting. They are required to have a management plan that outlines conservation and development zones although few are approved. Figure 12 presents a map of available data on these land use categories with tree cover loss from 2001 – 2022.

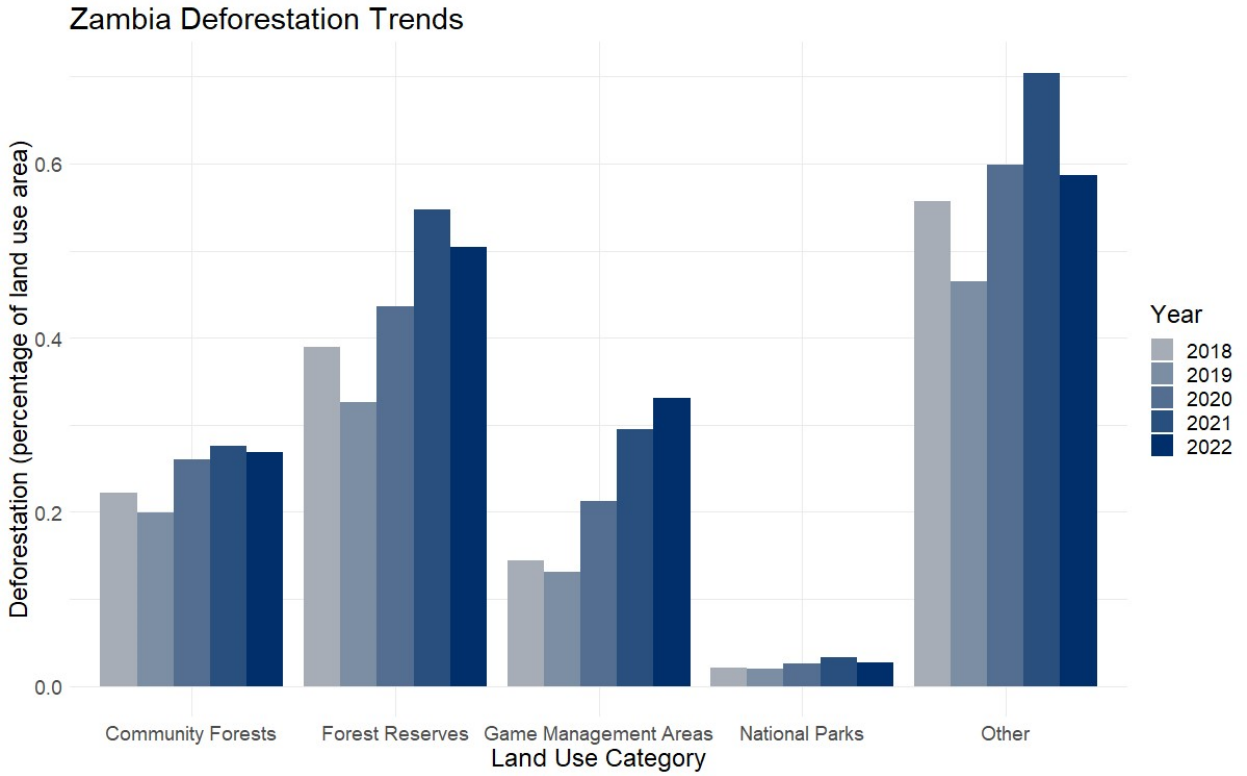
FIGURE 12: TREE COVER LOSS AND SELECTED LAND USES IN ZAMBIA



[42] For additional discussion of land tenure dynamics in Zambia, see World Bank and the Forestry Department of the Government of the Republic of Zambia. 2019. Forest Tenure Assessment Tool in Zambia. Washington, D.C.

Summary statistics, normalized by land use area, show that an overall higher proportion of loss in Zambia over the last 5 years is occurring outside of these four land use classifications (Figure 13). As expected, due to the specific protections in place, loss in National Parks is significantly lower than other land use categories, with Forest Reserves showing the overall highest average deforestation by land area compared to both Community Forests and Game Management Areas. Other recent analyses note increased encroachment on Forest Reserves during the past five years, citing as a potential cause an influx of new producers and traders entrants into the charcoal value chain as well as weak governance and enforcement in reserve areas.[43] While we note that direct causal conclusions cannot be drawn based on the analysis provided, the findings suggest that proposed strategies to strengthen governance regimes and clarify rights to open access forestland is an important strategy to reduce forest loss.

FIGURE 13: DEFORESTATION TRENDS BY LAND USE TYPE



Community forests are a recent land use option, with the Regulations passed in 2018, and it is not yet possible to draw firm conclusions regarding their effectiveness. It is possible that the lower rates of loss observed in these areas indicate a tendency to allocate these forests in areas under lower threat and clearing remains smaller in scale. However, deforestation rates in community forests remained relatively constant from 2018-2022 while rates in game management areas and forest reserves increased sharply. This may suggest that the community forest management regime itself is playing a role in limiting deforestation.

[43] USAID Zambia. Political Economy Analysis of Zambia's Charcoal Value Chain. 2021. Lusaka, Zambia.

5.0 RESILIENT LANDSCAPES

In this section we examine mitigation options related to resilient landscapes with an emphasis on actions proposed under Core Investment Priority 2 of Zambia's REDD+ National Investment Plan on Resilient Landscapes, Sustainable Agriculture, and Energy. Priority interventions include sustainable agriculture, tree planting, natural regeneration, efficient biomass energy and promotion of enterprises to increase household incomes. To align with the Griscom analyses, we group these under three main categories to review options related to reforestation, restoration, and trees in agricultural lands, reduced woodfuel harvest, and improved fire management. We note that reduced woodfuel harvest as analyzed by Griscom represents a small contribution to total cost-effective mitigation potential; however, these options are critical in relation to local livelihoods for Zambia.

5.1 REFORESTATION, RESTORATION, AND TREES IN AGRICULTURAL LANDS

The two global analyses on Natural Climate Solutions[44] assess the mitigation potential of reforestation by estimating the potential carbon sequestration that would be achieved by converting non-forest (< 25 percent tree cover) to forest (> 25 percent tree cover) in areas where forests are the native cover type. These analyses point to reforestation as having the largest cost-effective mitigation potential of any NCS pathway in Zambia. However, the practical potential for reforestation as a mitigation pathway is likely significantly lower than the estimate provided by the two NCS studies due to both methodological issues and the lack of established practice in Zambia. The NCS studies were based on analyses presented in the Atlas of Forest Landscape Restoration Opportunities[45] (AFLRO). The AFLRO is generally perceived as being an upper-bound estimate that may overestimate the area of formerly forested land that can realistically be reverted to forest cover when existing land uses are considered. Furthermore, as discussed below, there is relatively little established uptake of active restoration, agroforestry, or plantations in Zambia. The most recent Rural Agricultural Livelihoods Survey found that only about 5 percent of Zambian households adopt agroforestry techniques, with the highest adoption in more populated areas including Southern, Lusaka, Central, and Eastern provinces.

The commercial plantation sector in Zambia is relatively small to date, although it has expanded in recent years. The ILUA II assessment in 2016 stated that there were 55,000ha of plantation in Zambia, entirely found in Copperbelt Province. Data reported by Mukosha and Siampale (2009) was that there were 61,000ha nationally, of which about 80 percent were in Copperbelt Province. The rate of new plantation establishment was 12,000ha between 2011 and 2016 – or about 2,400ha per year. This planting is almost entirely in tropical pine species and *Eucalyptus* species. ILUA II stated that the provinces with the greatest potential for the establishment of plantations were Luapala, Southern, Muchinga, Eastern, and Copperbelt. Recent media reports suggest that the Zambia Forestry and Forest Industries Corporation (ZAFFICO) is expanding plantation establishment in three of these provinces (Muchinga, Luapala, and Copperbelt) as well as two others that were not identified by ILUA II (Northern and Northwestern). As noted in Section 3, the 2023 budget identifies several targets related to restoration including 2,500 hectares of reforestation prioritized by the Ministry of Green Economy and restoration of lands degraded by livestock production.

Studies on commercial plantations of pine and *Eucalyptus* in areas of former miombo woodland in southern Africa indicate that they sequester carbon relatively rapidly and result in total ecosystem

[44] Griscom et al., 2018 and Griscom et al., 2020.
[45] WRI. Atlas of Forest Landscape Restoration Opportunities. Interactive map available here: https://www.wri.org/applications/maps/flr-atlas/#

carbon stocks higher than the original native ecosystems. A study by Guedes and colleagues[46] found sequestration rates of 7.24 tons of carbon per year per hectare in plantations of *Pinus taeda* (loblolly pine) and rates of 8.54 tons per hectare in *Eucalyptus grandis* (rose gum) plantations. Total carbon stocks in mature stands of both types of plantation were also significantly higher than found in the native miombo woodlands by about a factor of three. It is of course important to note here that displacing native woodlands for commercial plantations would have highly negative impacts on biodiversity and on ecosystem function. For that reason, support to commercial plantation ventures is only advisable in contexts where robust environmental safeguards are in place, particularly for monitoring the potential for ecosystem conversion.

Assisted Natural Regeneration (ANR) is a technique that focuses on enhancing the rate of passive natural regeneration through techniques that include enhancement planting of native species, removing barriers to natural regeneration such as livestock grazing, and reducing fires and wood harvesting. With its designed focus on native ecosystems, ANR is an ideal technique for maximizing biodiversity benefits while also leading to improved carbon sequestration. Existing ANR efforts in Zambia are relatively small-scale. These include the WeForest program in Copperbelt that as of mid-2023 reported having restored 4,283ha of miombo woodland through eight years of implementation. The Center for International Forestry Research (CIFOR) has also engaged in ANR piloting in miombo woodlands in Nchelenge District, Luapula Province, and in Mufulira District, Copperbelt Province. The CIFOR program reported positive regeneration results in test plots and that community members were enthusiastic about the ANR approach and the results they observed.[47] ANR is also a component of a Forestry Department project in Central Province that is focusing on climate resilient community-based regeneration.[48] That project has three focal areas: ANR, fire management, and alternative efficient energy technologies. That project is being piloted in Serenje and Chitambo districts and has a target of 15,000 hectares restored.

ANR can be relatively cost-effective and can achieve more rapid results than passive regeneration strategies. In many landscapes, external pressures such as wood harvest and livestock grazing render passive restoration relatively unrealistic, leaving ANR as the lowest-cost avenue towards natural forest regeneration at scale. However, the relatively limited scale of ANR to date in Zambia points towards challenges. There are limited incentives for restoration efforts other than those that are directly supported by donors. Some landholders may also have a disincentive to support ANR if it requires them to reduce their livestock grazing and if those changes affect their claim to tenure over a parcel of land.

5.2 REDUCED WOODFUEL HARVEST AND USE

While the Griscom NCS analyses identify reduced woodfuel harvest as 1.4 percent of the total cost effective mitigation potential for Zambia, or 0.93 MtCO2e, the social and economic importance of wood products including charcoal as a major energy source and social safety net for Zambians underscores the importance of analyzing this issue in greater depth.[49] In 2010, Zambia's national demand for wood products, including charcoal, fuelwood, construction material, and timber, was estimated at 13 million tons (dry mass). Approximately 82 percent of this demand was for fuelwood and charcoal; while significant demand comes from the residential sector, there is some evidence of an increased demand for industrial use including mines and other industrial processes. A conservative estimate of the potential annual productivity is 71.9 million tons, with 46.8 million tons that are physically and legally accessible. This suggests a strong surplus nationally – with 46.8 million tons of accessible dry mass regrowing each

[46] Guedes et al. (2018). Plantations of *Pinus* and *Eucalyptus* replacing degraded mountain miombo woodlands in Mozambique significantly increase carbon sequestration. *Global Ecology and Conservation*. https://www.sciencedirect.com/science/article/pii/S2351989417302482

[47] CIFOR factsheet on ANR work in Nchelenge and Mufulira: https://www.cifor.org/publications/pdf_files/factsheet/8669-ANR-Factsheet.pdf

[48] Biannual Update Report (BUR) on Zambia's INDC's. 2020.

[49] USAID Zambia. Political Economy Analysis of Zambia's Charcoal Value Chain. 2021. Lusaka, Zambia.

year while only 13 million tons are being harvested. However, this national total does not capture important areas of opportunity for GHG mitigation in specific geographies.

Current sub-optimal resource management and harvesting practices in woodfuel production are leading to forest degradation – the loss of forest biomass over time even as the forest remains standing - especially in areas supplying major markets. There is a significant annual degradation due to excessive wood resource exploitation. Most of the demand for wood products is concentrated along the main urban axis in the center of the country: about 47 percent of demand is along the corridor that includes (North to South) Chingola, Kitwe, Ndola, Kabwe, and Lusaka. The ILUA II assessment estimated that more than 153,000 households in Zambia collect or produce charcoal. Unlike many NTFPs, the great majority of charcoal-producing households produce for sale rather than for household use; 42 percent of these households reported that charcoal was their largest source of forest-based income. Of the charcoal-producing households, 73 percent produce charcoal from "primary" forests and 23 percent produce charcoal from secondary forests. The percentage sourcing from primary forests was highest in Luapula (97.3 percent) and Copperbelt (95.3 percent) Provinces. Only 2.2 percent of charcoal-producing households nationally sourced their wood from plantations – illustrating the small relative scale of plantations in Zambia more generally.

There is a robust discussion over whether deforestation in Zambia is largely driven by charcoal production. or driven by agricultural expansion with charcoal production representing a secondary activity that takes place opportunistically as clearing occurs. Global forest loss analyses do not sufficiently distinguish between drivers, focusing on identifying where the loss is occurring, while national analyses such as ILUA II and the FREL present varying estimates of what drives forest loss that are not spatially explicit. It is therefore difficult to provide a single answer to this question as the drivers of land cover change are complex, vary by location, and act in combination with each other.

Several existing studies examined this question and arrived at different results. The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) analysis (2016) [50] generally concludes that in most cases, charcoal production is secondary to agricultural expansion as a driver of forest loss. A more recent analysis (2022) by Sedano et al.[51] draws a different conclusion and finds that charcoal production is the primary driver of a large amount of forest clearing and expands the frontier of land clearing beyond where it would have been if agricultural expansion were acting on its own.

The WISDOM analysis is a key resource for understanding the impact of firewood and charcoal use on Zambia's forest biomass – and by extension, on GHG emissions from Zambia's forests and woodlands. The WISDOM analysis assesses the balance between woodfuel supply and woodfuel demand through a spatially-explicit analysis of Zambia that shows where in the country that woodfuel use is more sustainable (i.e., where the natural rate of regrowth can replenish most of the offtake) and where it is less sustainable (where the harvest is leading to more degradation of the forest estate). Supply is determined by an assessment of existing forests and assumed growth rates, while the demand is determined by an assessment of the best available data on firewood and charcoal usage. The study's approach also includes information on transportation and distances in order to determine where woodfuel is harvested.

The WISDOM analysis found that in much of the country, wood harvesting, especially charcoal making, is a by-product of farming expansion rather than a primary driver of deforestation. In this context, charcoal production is opportunistic and is frequently not the primary driver of land use change. The local supply/demand balance shows a significant national surplus, and the spatial analysis confirms that all

[50] Drigo, R. 2016. Analysis of demand, supply and sustainability of wood products in Zambia. Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM).

[51] Sedano, F.; Mizu-Siampale, A.; Duncanson, L.; Liang, M. (2022). Influence of Charcoal Production on Forest Degradation in Zambia: A Remote Sensing Perspective. Remote Sensing 14, 3352. https:// doi.org/10.3390/rs14143352

provinces, except Lusaka, show surplus conditions. In much of the country, woodfuel harvest is mostly sustainable, with the rate of natural regrowth compensating for the rate of harvest. This is part of the reason the Griscom et al. estimates for the mitigation potential in the woodfuel sector are low at the national scale. However, this surplus condition is not the case through the urban corridor described above, and especially not in Lusaka. Along the urbanized corridor, the "woodshed" (i.e., the area from which fuelwood and charcoal is harvested to supply a given urban area), is harvested beyond the sustainable level, and reductions in consumption will lead to a reduced rate of decline in forest biomass. The implication of this finding is that efforts to reduce woodfuel consumption along the urban corridor will indeed have important benefits in terms of reducing GHG emissions, particularly if the emphasis for designing interventions or programs is focused on areas of the highest threat as identified by the Threatened Forests Analysis. Focus on reducing woodfuel consumption in more remote and rural areas will have a more limited impact in reducing net GHG emissions.

The districts that are at greatest risk for degradation risk can either be prioritized in terms of their predicted percentage loss (i.e., what percentage of the standing biomass is expected to be lost each year) or in terms of the total amount of loss predicted (i.e., what total volume of biomass is expected to be lost each year). Considering the percentage loss, the five districts with the greatest risk for degradation resulting from woodfuel harvest are Kabwe, Luanshya, Ndola, Masaiti, and Kafue (Table 10). The districts at greatest risk in terms of total amount of biomass loss predicted are Chibombo, Masaiti, Kapiri Mposhi, Kabwe, and Kafue. These estimates of degradation risk prioritization are based on the WISDOM analysis.

TABLE 10: DISTRICTS IDENTIFIED BY WISDOM ANALYSIS AS THOSE PREDICTED TO HAVE THE HIGHEST LOSS OF FOREST BIOMASS RESULTING FROM WOODFUEL USE, PRIORITIZED BY TWO DIFFERENT METHODS

Districts ranked by predicted loss as a percentage of total		Districts ranked by predicted total biomass loss	
District	**Percentage change**	**District**	**Tons dry mass**
Kabwe	-1.60%	Chibombo	126,661
Luanshya	-1.06%	Masaiti	77,680
Ndola	-0.86%	Kapiri Mposhi	73,882
Masaiti	-0.81%	Kabwe	54,880
Kafue	-0.81%	Kafue	54,714

A more recent analysis by Sedano et al. (2022) analyzed tree cover loss in three forest reserves in Zambia - Katanino in the Copperbelt province and Kapiri Mposhi and Mkushi in the Central province. In two of the three reserves, researchers found that the locations of charcoal production remained as degraded forest following the charcoal production rather than converted to agriculture. This varied among the three study sites – in Katanino and Mkushi, less than 25 percent of the area of charcoal production was cultivated within the first eight years, whereas in Kapiri Mposhi, more than 75 percent of charcoal production areas were converted to agriculture within seven years of charcoal production. Sedano et al. also notes that forest degradation is gradually expanding longer distances from urban centers, from 190 km from Lusaka in 2010 to nearly 350 km from Lusaka in 2020. While the study area was limited to three reserves, all three are found within the two provinces with the highest overall rate of loss and suggest that targeted strategies to address local dynamics of woodfuel remain a critical priority for mitigating emissions from forest loss in these areas.

We note that the WISDOM analysis from 2016 relied on older data than the 2022 Sedano study. Given the rapid scaling up of the geographic extent of charcoal production documented by Sedano, it is reasonable to expect that its relative importance as a driver of forest change increased between the two

studies. The other important point to note is that Sedano et al. focused on three sites, all of which are close to the central corridor of high population density that the WISDOM study acknowledged as having a woodfuel supply deficit. While the two studies draw different conclusions based on the available data and the geographic coverage of their study areas, the general WISDOM conclusion that there is a woodfuel supply surplus across much of the less-populated parts of the country likely still stands.

While it is clear that the interactions between charcoal production and agricultural clearing are complex and follow different pathways as a function of population pressure, economic need, and proximity to markets, it is reasonable to conclude that these drivers work synergistically. Addressing them will therefore require holistic, systems-based approaches that shift demand through price competitive alternatives, influence consumer behavior, and also create other avenues for income generation for charcoal producers and traders. These efforts must also acknowledge the complexity of forest disturbance pathways, and also incorporate measures to strengthen governance of open access areas and forest reserves that may be targets as charcoal production expands outward from urban centers.

5.3 IMPROVED FIRE MANAGEMENT IN SAVANNAS

Fire is an important element of Zambia's forest ecology as well as a frequently used land management tool. Miombo woodlands are characterized by frequent dry season fires, and research estimates that fires occur on 15 percent or more of the land due to forest clearing, understory burning to flush out game animals for hunting, or to generate forage for livestock.[52] Based on Griscom et al. (2017; 2020), improving fire management represents 6.4 percent of total cost-effective mitigation potential for Zambia for a total of 4.35 MtCO2e. However, we highlight that the NCS analyses only estimate the potential for improving fire management in savannas. This figure likely underestimates potential for Zambia due to the use of fire in forest and land management regimes and the significant percentage of Zambian forests that are relatively open dry forest or a mixed forest-savanna.

While these forests are fire-adapted systems that can cope with regular burning, intensive use of fires can affect the rate of natural regrowth and associated carbon storage including in soil. National data from Zambia does not provide detailed estimates of emissions from fires or their location; Zambia's submitted FREL notes that annual fires often burn herbaceous materials, and these emissions are often captured in subsequent regrowth, and excludes emissions from fire from the reference level.[53] The ILUA II includes relatively limited information on fires, noting ground fires are most common and affect 84 percent of Zambia's forest area. The largest impact from this burning occurred in Muchinga province, with the smallest impact found in Southern. Estimates from analysis of drivers of deforestation provided by GFW estimate that of 2.23 Mha of tree cover loss in Zambia between 2001 and 2022, approximately 22,600 hectares of tree cover loss were due to fires representing a relatively small impact on total forest loss.

The Forestry Department is collaborating with Zambia's Environmental Management Agency to support fire awareness training programs and support monitoring. Fire is widespread and tightly linked to agricultural clearing and other land use management practices; as a result, it contributes to forest degradation and clearing, but improved fire management practices must likely be paired with strategies to address underlying drivers of demand for land clearing for agriculture or livestock production.

[52] Day, M., Gumbo, D., Moombe, K.B., Wijaya, A., Sunderland, T. 2014. Zambia Country Profile: Monitoring, reporting and verification for REDD+. Occasional Paper 113.Bogor: Indonesia: CIFOR.

[53] Government of the Republic of Zambia. 2021. Forest Reference Emissions Level. Lusaka: Ministry of Green Economy and Environment.

6.0 CONCLUSION

Zambia's forests play a pivotal role in the nation's carbon sequestration but are also under threat due to agricultural expansion, industrialization, urban charcoal use and settlement expansion. While national strategies recognize the critical importance of safeguarding these ecosystems to achieve climate mitigation goals, current investments combined with an enabling environment with several critical weaknesses in terms of resource governance and tenure security poses challenges for implementation.

While NCS analyses focuses on the biophysical potential of mitigation pathways, in the case of Zambia these global estimates do not sufficiently account for unique characteristics of Zambia's dryland forests, or the practical feasibility of different options. While mitigation options such as reforestation are likely overestimated in the NCS analysis, options such as reducing woodfuel use may present greater mitigation potential. While there are robust national analyses such as the ILUA II, data and analysis from these assessments presents much of its information by forest type or geographic unit. There is significantly less spatially explicit sub-national data that could inform a more robust assessment of national mitigation potential linked to policy priorities, or with an emphasis on hotpots of forest loss or degradation.

Prioritizing SL options depends upon priorities of the program, whether its goal is solely to maximize climate benefit per unit of investment or instead it seeks to also improve other outcomes such as biodiversity, water quality, social equality, or livelihoods. Additionally, geography may affect the choice of strategies if there are regions that a program has reason to target because of existing activities or other priorities. Below we present summary insights for the major priorities in the REDD+ Investment Plan.

KEY INSIGHTS FOR STRATEGIES FOR CONSERVATION AND MANAGEMENT OF HIGH VALUE FOREST AREAS

- Based on our analysis of deforestation trends for various land uses, open access areas have higher overall rates of deforestation, suggesting investment in strengthening local land governance through securing rights and establishing clear management norms can support land-based mitigation. This is consistent with key strategies highlighted in the REDD+ investment plan focused on strengthening participatory approaches to forest management.
- Based on observed patterns of loss from the Threatened Forests Analysis, forests in Northwestern, Western, and Luapula incorporate more carbon dense closed forest types that would represent a priority for conservation. The Threatened Forests analysis suggests that land use planning should prioritize avoiding conversion in these areas of higher threat and carbon density – this approach is also likely more cost effective than the costs of avoided deforestation in areas with greater pressure from population and urban expansion.
- The REDD+ Investment Plan proposes to expand protected areas around headwaters and other high carbon areas. While National Parks had lower overall rates of forest loss, proposed strategies to expand these areas should carefully consider existing land governance as well as the degree of threat in the surrounding area, or consider a broad suite of options for strengthening protection in ways that do not restrict subsistence livelihoods of nearby populations.
- Efforts to strengthen governance of open access areas should consider creating additional economic incentives for greater forest protection in addition to clarification of rights. The REDD+ investment plan proposes ecotourism including expanding game ranching and community-public-private partnerships.

KEY INSIGHTS FOR RESILIENT LANDSCAPES

- While reforestation represents an important land-based climate mitigation pathway based on global analysis, the absence of enabling conditions in Zambia is likely to limit its effectiveness in practice. The objective of reforestation and restoration efforts as well as their design will be a significant predictor of success. Required permits for commercial use of trees may discourage significant investment, although there may be opportunities to incentivize or support greater use of assisted natural regeneration or other restoration practices that support subsistence use.
- The average landholding in Zambia is relatively small-scale although there is some variation across geographies. Given that small-scale land clearing remains a significant driver of forest loss, efforts to reduce this trend through restoration efforts would require significant support and incentives that would also result in high transaction costs.
- Large-scale investments in restoration, which could support additional co-benefits such as watershed protection, likely require donor or government investment and could focus on critical watersheds near urban centers. Strategies such as active or passive regeneration are likely the best approach for areas that are degraded but with less direct threat or pressure.
- Given the small size of existing reforestation efforts, while individual reforestation is unlikely to result in significant volumes of emissions reductions or carbon credits, investment in these strategies can support critical co-benefits including supporting climate resilience (e.g., use of shade trees), watershed protection, and soil fertility.
- Interventions in the woodfuel sector in Zambia that are most likely to reduce GHG emissions include demand reduction that is targeted to Zambia's high population corridor from Chingola to Lusaka, and promoting sustainable charcoal and woodfuel production. In particular, this could rely on the high potential for coppicing in miombo woodlands.
- Additional strategies to consider, particularly in alignment with national priorities for growth as well as budget allocation, including mitigating agricultural expansion through improvements in existing farming techniques or through improved zoning and enforcement around encroachment.

In conclusion, this report provides a critical foundation for targeted interventions in Zambia's land sector. By prioritizing areas with the highest mitigation potential and addressing policy and governance challenges, Zambia can make significant strides in reducing its land based GHG emissions, thereby contributing to global climate mitigation efforts and sustainable development.

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ANNEX 1: LIST OF DATASETS

- Land cover: Copernicus Global Land Cover (2019, 100 m resolution): https://lcviewer.vito.be/2019
- Annual deforestation: Hansen et al. Global Forest Watch (2023, 30 m resolution): https://glad.earthengine.app/view/global-forest-change
- Population density: WorldPop Unconstrained individual countries (2020, 1 km resolution): https://hub.worldpop.org/geodata/summary?id=44687
- Aboveground biomass: Spawn et al. ORNL DAAC AGB and BGB Carbon Density (2020, 300 m resolution): https://daac.ornl.gov/VEGETATION/guides/Global_Maps_C_Density_2010.html
- Administrative boundaries: GADM Database of Global Administrative Areas: https://gadm.org/data.html (2022)
- Land use categories (national parks, forest reserves, community forests, game management areas): courtesy of the Integrated Land Resource and Governance project, Community Forest Management Groups in Zambia, World Database on Protected Areas (2023)
- Human Settlements (i.e., Development / Urbanization): EU, Global Human Settlement Layer (GHSL): https://ghsl.jrc.ec.europa.eu/download.php
- Tree Cover Loss by Dominant Driver: GFW: https://data.globalforestwatch.org/documents/tree-cover-loss-by-dominant-driver-2022/about
- Forest Condition: https://developers.google.com/earth-engine/tutorials/community/forest-vegetation-condition
- Global Croplands: Global Land Analysis and Discovery: https://glad.umd.edu/dataset/croplands
- Land Use and Land Cover, development Threats (2015), NASA Socioeconomic data and applications center (SEDAC), https://sedac.ciesin.columbia.edu/data/set/lulc-development-threat-index/data-download

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