Drivers of deforestation, identification of threatened forests and forest co-benefits other than carbon from REDD+ implementation in Zambia

Republic of Zambia
Ministry of Lands,
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Disclaimer:

Detailed and spatially explicit analysis of the drivers of deforestation, identification of threatened forests and forest co-benefits other than carbon from REDD+ implementation in Zambia

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ACRONYMS

CBOs	community-based organizations
CBU	Copperbelt University
DAPP	Development Aid from People to People in Zambia
DFO	district forestry officer
FAO	Food and Agriculture Organization of the United Nations
FBOs	faith-based organizations
FD	Forestry Department
FISP	Farmer Input Support Programme
GHG	greenhouse gas
GDP	gross domestic product
GIS	geographic information system
GMA	game management area
GPS	Global Positioning System
GRZ	Government of the Republic of Zambia
ILUA	integrated land use assessment
IPCC	Intergovernmental Panel on Climate Change
MAL	Ministry of Agriculture and Livestock
NGOs	non-governmental organizations
NMPs	non-material products
NTFPs	non-timber forest products
NRM	natural resources management
PRA	participatory rural appraisal
PES	payment for ecosystem services
REDD+	reducing emissions from deforestation and forest degradation
RUA	resource use assessment
SSI	semi-structured interviews
SPSS	Statistical Package for Social Scientists
UNZA	University of Zambia
WWF	World Wide Fund for Nature
ZAFFICO	Zambia Forestry and Forestry Industries Corporation
ZAWA	Zambia Wildlife Authority

GLOSSARY

Forests are land with a tree canopy cover of more than 10 percent and an area of more than half a hectare. This includes natural forests and forest plantations but specifically excludes stands of trees established primarily for agricultural production (i.e. fruit tree and oil palm plantations) and trees planted in agroforestry systems.

Biodiversity is the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Deforestation is the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum of 10 percent.

Forest degradation concerns the changes within the forest class which affect the forest stand, quality or site negatively. Reduction of the tree canopy above the original threshold of 10 percent is classified as forest degradation.

Forest decline can be defined as the two processes of deforestation and forest degradation, which have both common and specific drivers, and which may or may not be spatially and temporally interrelated and will differ between regions.

Threatened forests are those which may exhibit the following factors: present or threatened destruction, modification, or curtailment of their habitats or range; overutilization for commercial, recreational, scientific or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms, and other natural or manmade factors affecting their continued existence.

Forest types, within biomes, a forest type is a group of forest ecosystems of generally similar composition that can be readily differentiated from other such groups by their tree and under canopy species composition, productivity and/or crown closure.

Tragedy of the commons: the *tragedy of the commons* is a term coined by scientist Garrett Hardin in 1968 describing what can happen in groups when individuals act in their own best self-interests and ignore what is best for the whole group.

Source: FAO 1998; Litman and Harris 2007; Young 2012; International Day for Biological DiversityForest Biodiversity 2011.

EXECUTIVE SUMMARY

This report gives an account of the findings of the study on detailed and spatially explicit analysis of the drivers of deforestation in Zambia, expected forest area changes in the future and identification of the most threatened forests. The study was conducted under the auspices of the Forestry Department and the Food and Agriculture Organization of the United Nations (FAO). Building on Copperbelt University's earlier study of the drivers of deforestation in Zambia by Vinya *et al.* (2012), the purpose of this study is to provide FAO and the UN-REDD programme in Zambia with a national document on the drivers of deforestation and identification of the threatened forests in Zambia.

In Zambia, the deforestation rate currently stands at approximately 250 000 to 300 000 ha per year (ZFAP 1998; PFAP 2005). While forests are constantly removing carbon from the atmosphere, deforestation is releasing carbon back into the atmosphere. This study examines the drivers of deforestation in order to address them better in the development of a national strategy or action plan to reduce emissions from deforestation.

The specific objectives are to:

- make a detailed and spatially explicit analysis of the drivers of deforestation in Zambia through a methodology that will identify direct and indirect causes of deforestation and proximate underlying drivers of deforestation in Zambia;
- estimate the strength and importance of each driver;
- predict the expected forest area changes in the future and identify and map the most threatened forests based on the deforestation rates over the next ten years as compared with the trends in the last 20 years; and
- examine the multiple benefits, i.e. forest co-benefits (biodiversity, water and other environmental benefits), arising from the implementation of REDD+ programmes.

The study areas were selected based on Zambia's agricultural ecology zones, review of statistics from case studies and the major drivers of deforestation observed in the districts selected. The study area in zone I was Sesheke District in Western Province which is endowed with the *Baikiaea* forests, also known as the Zambezi teak forests or locally known as *Mukusi forests.* These forests have attracted massive timber harvesting activities and are prone to forest fires. In zone II, the study area was Kapiri Mposhi District in Central Province, which, according to Gumbo and Mwanga (2011), has high rates of charcoal production as one of its key forest products. In zone III, the study covered Isoka and Nakonde Districts in Muchinga Province (formerly part of Northern Province) and Kabombo District in North-Western Province. The districts are dominated by Miombo woodland and the most predominant species are *Pterocarpus angolensis, Brachystegia Spp, Afzelia quanzensis (Mupapa), Erythrophlem africanum, Faurea saligna, Khaya anthotheca and Mitragyna stipulosa.* Most of these tree species are at high risk due to their high economic value and the demand for charcoal, timber for construction, carpentry and joinery works. Shifting cultivation is predominant and a main driver of deforestation.

The study's analysis was based on ground-truthed evidence from both satellite imagery and field-based evidence. The study used an interdisciplinary data gathering approach that integrated literature search, policy-level consultations, community-level consultations, stakeholder interviews, courtesy calls and field visits. The approach involved two complementary parts: desktop and field-based study. The technical approach and methodology of the two parts were designed to capture two sets of data: spatial and non-spatial.

Spatially explicit simulation of the drivers of deforestation involved forest cover change analysis for all five study districts. Knowledge about the extent of forest cover and its distribution is important for deciding the forest management options and for supporting forest policy decisions. In order to understand forest cover dynamics in each of the five districts, forest cover change analysis quantified the changes in forest cover between the target years 1990, 2000 and 2010. The forest change analysis results revealed that there has been a drastic negative change in the forest cover in each of the five districts.

Although the results from the five districts may not represent the exact situation of the country, the study shows that Zambia is losing on average 255 085 ha of forest cover per year at an average annual rate of 1.1 percent. If the drivers of deforestation and forest degradation are unabated, Zambia will emit about 575 926 085 tonnes of carbon into the atmosphere through deforestation and forest degradation in 30 years from 2010 to 2040 at an average rate of about 75.3 tonnes of carbon/hectare/year. Although the community members identified and ranked their perceived drivers of deforestation, this study concludes that the main drivers of deforestation and forest degradation are expansion of built-up areas, agriculture expansion, wood extraction for charcoal and fuelwood, and timber extraction. Forest fire is another important driver of deforestation and forest degradation, and may be caused by any of the land uses identified. The underlying causes of these drivers include high poverty levels, population growth, and weak policy and law enforcement, which are progressively creating unplanned land-use changes.

The forest ecosystem is threatened by land-use practices that do not take into account the protection of forests. The rate of vegetation loss and carbon emission is alarming and, if unchecked, could lead to serious environmental consequences The Miombo forests are under threat because of continued charcoal production, mining and encroachment for agriculture, while Cryptosepalum forests are threatened by continuous occurrence of forest fires, timber harvesting and shifting cultivation, and Baikiaea forests are threatened by timber extraction, forest fires and encroachment for agriculture. The study recommends the following:

Table 1: Study recommendations

RECOMMENDATION	POLICY LEVEL	IMPLEMENTATION LEVEL
1. Forestry Department institutional capacity must be strengthened in terms of logistical support, employment of more field staff and staff development.	Ministry of Lands, Natural Resources and Environmental Protection; Forestry Department.	National level
2. The institutional structure in the forestry sector needs to engage local communities fully so that there is constant contact with the local people on issues of forestry management.	Forestry Department.	National, provincial and district levels
3. Harmonization of policies related to forestry, land, agriculture, environment and other natural resource utilization and management must be addressed as a matter of urgency to improve oversight and transparency, and promote integrated land-use planning among line ministries.	The Government of the Republic of Zambia through the Cabinet Office.	National, provincial and district levels
4. Community participation in forest management should be promoted and a mechanism formulated for cost-benefit sharing for participating stakeholders.	Forestry Department.	National, provincial, district and local levels
5. Fire management interventions should be instituted at community, private and government levels.	Forestry Department.	National, provincial, district and local levels
6. Public private partnerships (P3s) should be promoted in forest management given the simultaneous role of forests as exploitable resources and providers of public goods and environmental services.	The Government of the Republic of Zambia through the Cabinet Office; Forestry Department; private institutions.	National, provincial, district and local levels
7. Different options should be combined, such as conservation farming, promotion of alternative livelihoods and enforcement of law and policy.	Forestry Department; Department of Energy; Department of Agriculture; NGOs; media houses; law enforcing wings; higher learning institutions.	National, provincial, district and local levels
8. Effective systems and adequate resources should be put in place in order to enhance the co-benefits and contribute to making the REDD+ programme a success.	Forestry Department.	National, provincial, district and local levels
9. Areas that are in proximity or within water catchment areas should be given priority under REDD+ implementation. The community members who live in proximity to these catchment areas should be rewarded through a mechanism for payment for ecosystem services (PES) for preserving the forests.	The Government of the Republic of Zambia through the Cabinet Office. Forestry Department; private Institutions/ utility companies; community members.	National, provincial, district and local levels
10. All programmes or projects developed under REDD+ implementation should take into consideration the interests and needs of community members and other stakeholders who depend on the forests.	Forestry Department; REDD+ Secretariat.	National, provincial and district levels

11. Further studies and actions should be commissioned to respond to concerns that the study of five sample districts was not sufficiently large to give credible information for the whole country, including: • A Forestry Department study with relevant stakeholders: e.g. University of Zambia (UNZA), Copperbelt University (CBU) to establish a link between ground-based relevant parameters and satellite spectral response data; • study using different classifiers and approaches to land-cover mapping and comparison of results with this study; • study focusing more on spatial dynamics in the non-forest classes to help understand the nature and the dynamics of the drivers of deforestation; and • adding 2 to 3 study areas to this study to make the sample size more representative.	Forestry Department; REDD+ Secretariat.	National, provincial and district levels

The study team recommends the following interventions as measures to improve the creation of forest cover, for possible support and development under REDD+ implementation.

Table 2: Recommended interventions under REDD+ implementation and associated drivers of deforestation to be addressed

RECOMMENDED INTERVENTION	DRIVER OF DEFORESTATION TO BE ADDRESSED
Promotion of improved farming practices such as conservation farming will lessen the opening of virgin land for agricultural production, thereby curbing deforestation.	Agricultural expansion
Promotion of alternative energy sources will reduce the destruction of trees for energy.	Fuelwood extraction
Community participation is a key to sustainable forest management. Establishment of community forest nurseries will encourage local communities to participate in plantation establishment as a way of combating deforestation.	Agricultural expansion and fuelwood extraction
Encouragement of natural regeneration and management of indigenous forests is important because most ecosystem services, forest biodiversity and non-timber forest products (NTFPs) are largely derived from indigenous forests. Further, a majority of the rural population in the study areas depend on NTFPs, forest biodiversity and ecosystem services for their livelihoods.	Agricultural expansion, caterpillar collection, bark hives, timber and fuelwood extraction
Poor harvesting methods for some NTFPs (for example caterpillars and wild fruits) lead to deforestation. There is a need to develop and promote sustainable harvesting and utilization methods of NTFPs to ensure stable and constant availability of forest co-benefits for human well-being.	Caterpillar collection, traditional beekeeping (bark hives), and timber extraction
Modern beekeeping is a viable livelihood option for rural communities as in Kabompo District. Effective beekeeping sustains the environment, pollinates trees and crops and provides people with income. The promotion of beekeeping to small-scale farmers, who live near the protected areas, will help to reduce further extension of land for more crops.	Traditional beekeeping (bark hives), agricultural expansion and fuelwood extraction
Development of strategies to promote innovative entrepreneurships that provide alternative livelihoods will lessen dependence on forest resources for people's livelihoods. This will subsequently reduce deforestation and make the forest co-benefits more available to the people.	Agricultural expansion, fire, caterpillar collection, infrastructure development, bark hives, timber and fuelwood extraction
Promotion and attachment of economic market value to most of the NTFPs to help people to derive stable household income from them.	Caterpillar collection, bark hives and timber extraction
Development of a mechanism under the national REDD+ programme for payment of environmental services (PES) that are derived from the forests. The funds realized should be put back into managing the forests affected by the same environmental services.	Agricultural expansion, fire, caterpillar collection, infrastructure development, bark hives, timber and fuelwood extraction
Inclusion of programmes/projects on extension services and value addition under REDD+ implementation because most community members have little knowledge of sustainable harvesting and utilization of forest products. Marketing of products is also a problem because of low quality.	Agricultural expansion, fire, caterpillar collection, infrastructure development, bark hives, timber and fuelwood extraction

INTRODUCTION

General background

The problem

In Zambia, deforestation rates currently stand at approximately 250 000 to 300 000 ha per year with a total of 50 million ha of forest area[1]. The Climate Change Monitoring (2011) update on change in forest cover, quoting the Food and Agriculture Organization, reported that between 1990 and 2010 Zambia lost an average of 166 600 ha or 0.32 percent of forest cover per year. In total, between 1990 and 2010, Zambia lost 6.3 percent of its forest cover or around 3 332 000 ha.

Forests store some 289 giga tonnes (Gt) of carbon (FAO 2012). Deforestation and forest degradation contribute approximately 15 to 17 percent of all greenhouse gases. There can be no cost-efficient solution to climate change that does not include mitigation of these emissions (Sukhdev *et al.* 2011). The importance of carrying out this study cannot be overemphasized. While forests are constantly removing carbon from the atmosphere, deforestation is putting it right back again. This study on the drivers of deforestation is necessary for the development of a national strategy or action plan to reduce emissions from deforestation because these drivers can be better addressed when they are known.

Since REDD+[2] investments are focused on maintaining or enhancing natural capital, either through investments in forests or through slowing, halting or reversing drivers of deforestation and forest degradation (Sukhdev *et al.* 2011), it is important to identify these drivers.

According to Karousakis (2007), projections indicate that approximately 10 to 20 percent of current global forest land will be converted to other uses by 2050 with great consequences for the global carbon cycle. While these studies have been carried out at global and regional levels, this study is more focused on the national level. It will be able to make comparisons of the results with previous studies based on a methodology that combines satellite imagery with practical field-based evidence.

Purpose of the study

Building on the earlier study of the drivers of deforestation in Zambia by Vinya *et al.* (2012), the purpose of this study is to deliver to FAO and the UN-REDD Programme in Zambia a national document on the drivers of deforestation and identification of the threatened forests in Zambia. This study will feed into the readiness process for the REDD+ programme in Zambia, which is a climate change mitigation and adaptation strategy.

The specific objectives are to:

- make a detailed and spatially explicit analysis of the drivers of deforestation in Zambia through a methodology that will identify direct and indirect causes of deforestation and proximate underlying drivers of deforestation in Zambia;
- estimate the strength and importance of each driver; and
- predict the expected forest area changes in the future and identify and map the most threatened forests, based on the deforestation rates over the next ten years as compared with the trends in the last 20 years.

These are expected to contribute to the REDD+ readiness process in terms of:

- developing the national strategy or action plan to reduce deforestation;
- developing a national forest reference emission level and/or forest reference level (interim measure at subnational level);
- developing a robust and transparent national forest monitoring system for the monitoring and reporting of REDD+ activities (interim measure, subnational); and
- establishing a system for providing information on how safeguards for local community and forest biodiversity are being addressed and respected throughout the implementation of the REDD+ activities, while respecting sovereignty.

1 United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries 2009

2 REDD+ stands for countries' efforts to reduce emissions from deforestation and forest degradation and foster conservation, sustainable management of forests and enhancement of forest carbon stocks.

Vegetation types and forest resources of Zambia

Vegetation types of Zambia

According to Fanshawe (1971), the vegetation of Zambia is categorized into three main types: closed forests, woodlands or open forests, and grasslands. These are further divided into sub-vegetation types as shown in Table 3.

Table 3: Vegetation Types of Zambia

Vegetation type	Area, 100 ha	Proportion, %
1. **Closed forest**		
Parinari	420	0.06
Marquesia	430	0.06
Lake basin	15 560	2.07
Cryptosepalum	15 210	2.99
Baikiaea	6 830	0.91
Itigi	1 900	0.25
Montane	40	0.01
Swamps	1 530	0.20
Riparian	810	0.11
2. **Woodland (open forests)**		
Miombo	311 460	41.41
Kalahari	85 460	11.36
Mopane	38 700	5.15
Munga	32 600	4.34
Termitaria	24 260	3.23
3. **Grassland**	206 350	27.44
4. **Open water**	10 500	1.40
Total	**752 060**[a]	**100.00**

[a] This figure does not represent the total land area of the country but only accounts for the area covered by vegetation types of Zambia. According to ILUA (2008), Zambia has a total land area of about 75 261 400 ha. The difference would account for others.
Adapted from: Fanshawe (1971)

The closed forests are small in size compared with other vegetation types in the country. The most notable and economically important sub-components of the closed forests are *Cryptosepalum* and *Baikiaea* forests. In the category of open forests or woodlands, the Miombo woodland is the most extensive and economically important vegetation type. It is characterized by species of the genera *Brachystegia*, *Isoberlinia* and *Julbernadia. Marquesia macroura*, *Pericopisis angolensis*, *Erythophleum africanum* and *Parinari curatelifolia* are frequent associates. Miombo woodlands cover about 352 million ha (about 45 percent of the total land area). Other vegetation types in this category include Kalahari, Mopane and Munga woodlands. Grassland is all land that is naturally without trees, and is found in places with a permanently high water table. It includes dambos, flood plains, and the margins of pans.

Table 4 gives the size of forests areas in each agro-ecological zone per province.

Table 4: Forests by agro-ecological zones per province ('000 ha)

Province	AEZ I (ha)	AEZ IIa (ha)	AEZ IIb (ha)	AEZ III (ha)	Total area cover in ha
Central	1 215	2 987	0	3 708	7 910
Copperbelt	0	0	0	1609	1 609
Eastern	2 118	3 034	0	0	5 152
Luapula	0	0	0	3 465	3 465
Lusaka	1 355	296	0	0	1 651
North-Western	0	315	102	9 624	10 043
Northern	0	1 268	0	5 945	7 212
Southern	1 024	3 649	0	0	4 672
Western	2 679	176	5 190	209	8 254
Total	8 391	11 725	5 292	24 560	49 968

Source: ILUA (2008)

Zambian forests have also been classified into three global ecological zones by integrated land use assessment (ILUA): the tropical moist deciduous forests, the tropical dry deciduous forest and the tropical mountain. Table 5 shows their coverage.

Table 5: Forests by global ecological zones

Global ecological zones	Tropical moist deciduous forests	Tropical dry forests	Tropical mountain
Total area ('000 ha)	28 668	18 752	2 548
Percentage %	57.2%	37.2%	5.6%

Adapted from: ILUA (2008)

Forest resources in Zambia

According to ILUA (2008), Zambia has a total land area of about 75 261 400 ha and the forests cover approximately 49 968 170 ha (about 66.4 percent of the total land area). Forest cover in gazetted forest reserves of Zambia accounts for 9.6 percent of the total land area; with 300 local forests (2 175 770 ha) and 180 national forests (5 181 503 ha). National forests were established for the purpose of protecting those forests with national and international interests, whereas local forests were established for the purpose of protecting the forests with local interests (Ministry of Tourism, Environment and Natural Resources 2008). Other forested areas exist in national parks (6 350 000 ha), game management areas (64 000 000 ha), customary land (45 800 000 ha) and heritage sites (ILUA 2008).

Table 6: Areas covered by protected forests in each province

Province	Areas (ha)		
	National forests	Local forests	Total
Central	368 525	222 403	**592 928**
Copperbelt	478 713	42 562	**521 275**
Eastern	683 349	164 788	**848 137**
Luapula	212 547	170 490	**383 037**
Lusaka	368	29 964	**30 333**
Western	306 526	312 305	**618 831**
Northern	801 593	321 554	**1 123 147**
North-Western	2 004 238	413 469	**2 883 318**
Southern	184 760	487 143	**669 903**
Total	5 040 619	2 630 290	**7 670 909**

Source: ILUA (2008)

In addition to the natural forests, plantation forests of mainly tropical pines and eucalyptus covering an area of about 61 000 ha have been established countrywide with over 80 percent of these found on the Copperbelt Province (Ministry of Tourism, Environment and Natural Resources 2008). The Zambia Forestry and Forestry Industries Corporation Limited (ZAFFICO), which is a parastatal company, manages 50 000 ha (40 000 and 10 000 ha of pines and eucalyptus respectively). Local and regional supply plantations have been established in the provinces to meet local demand for poles and timber. Private individuals at semi-commercial and farm levels manage an estimated 3 000 ha of forest plantation (MTENR 2008).

Sustainable management of these forests requires an in-depth understanding of the status of the ecosystems as the basis for evaluation of its capacity to continue providing *inter alia* the service of carbon sequestration, hence the need for forest cover change analysis.

STUDY AREAS

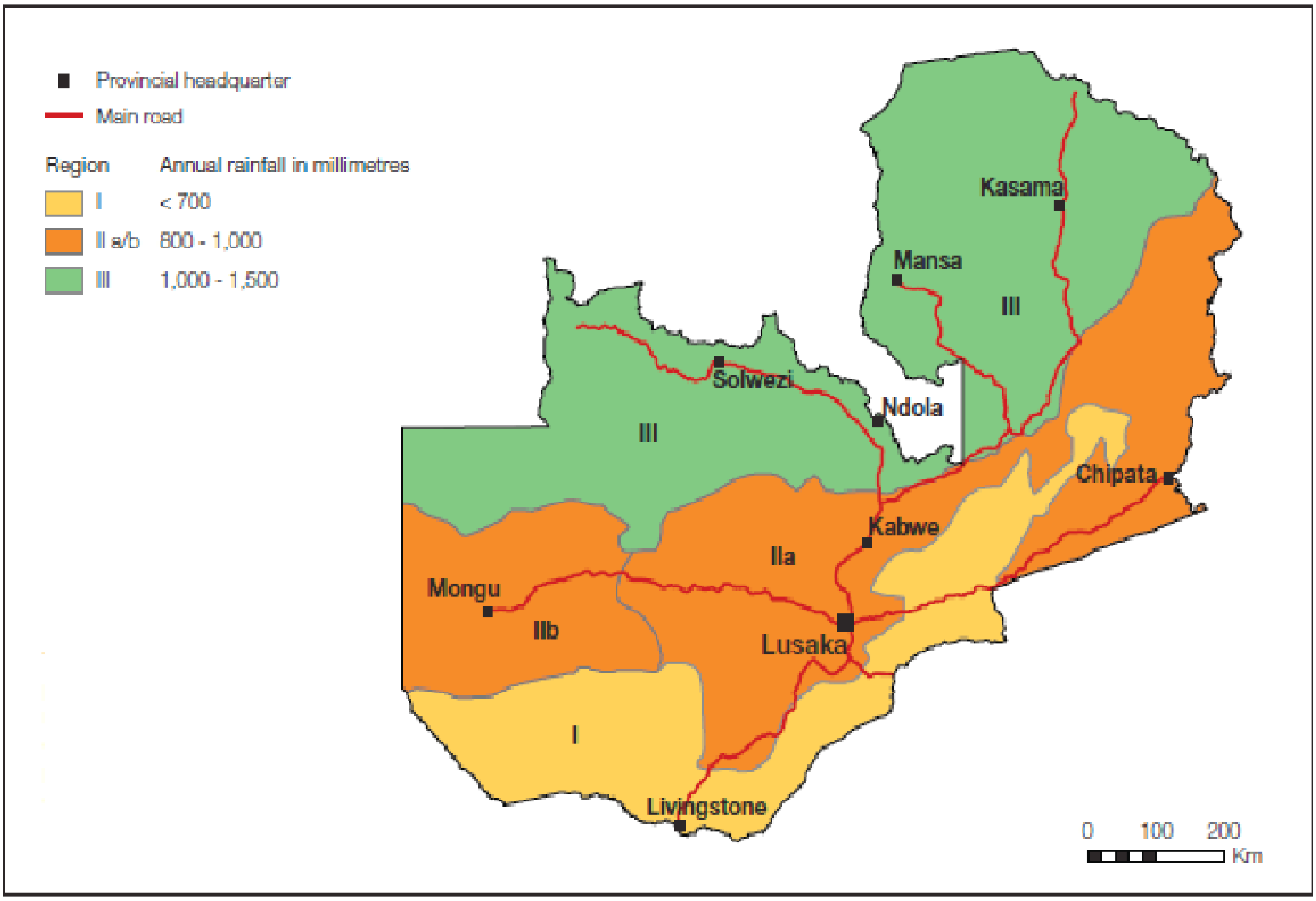
The study areas were selected based on Zambia's agricultural ecology zones (agro–ecological zones), a review of statistics from case studies and the major drivers of deforestation observed in the districts selected. The observed drivers needed to be ground truthed. The agro-ecological zones represent the country's diverse climatic conditions in terms of rainfall, temperature and humidity. Zambia is divided into 36 agro-ecological zones (Figure 1), which are further grouped into three main zones, mainly on the basis of rainfall (*Agricultural water management national situational analysis* 2009).

The study area in zone I was Sesheke District in Western Province, which is endowed with the Baikiaea forests also known as the Zambezi teak forests or locally known as Mukusi forests. These forests are one of the three major vegetation formations in Zambia; they cover Western Province, parts of North-Western, and Southern Provinces. They have attracted massive timber logging activities and are prone to forest fires. This zone used to be considered the bread basket of the nation but for the last 20 years it has been experiencing low, unpredictable and poorly distributed rainfall according to Climate Change and African Agriculture (2006), and the meteorological data suggests that it is currently the driest zone, very prone to drought and with limited potential for crop production (*Journal of ecology and the natural environment* 2012).

In zone II, the study areas were Isoka and Kapiri Mposhi Districts. Kapiri Mposhi District is located in Central Province, which according to Gumbo and Mwanga (2011) has high rates of charcoal production as one of its key forest produce. The district has five forest reserves and one plantation. Chibwe is the only national forest in the district. The local forests are Ipumbu, Kapiri Mposhi, Kabanga and Luembe. Isoka District had five protected forests. With the establishment of a new Mafinga District, three forest reserves are now in Mafinga: Fungwe, Mafinga and Mitanga. Two local forests remain in Isoka District: Mpando and Isoka local forest reserves, and a local supply plantation. The two districts are dominated by Miombo woodland and the most predominant species are *Pterocarpus angolensis, Brachystegia, Julbernadia, Isobelina angolensis* and *Parrinari culaterifolia.*

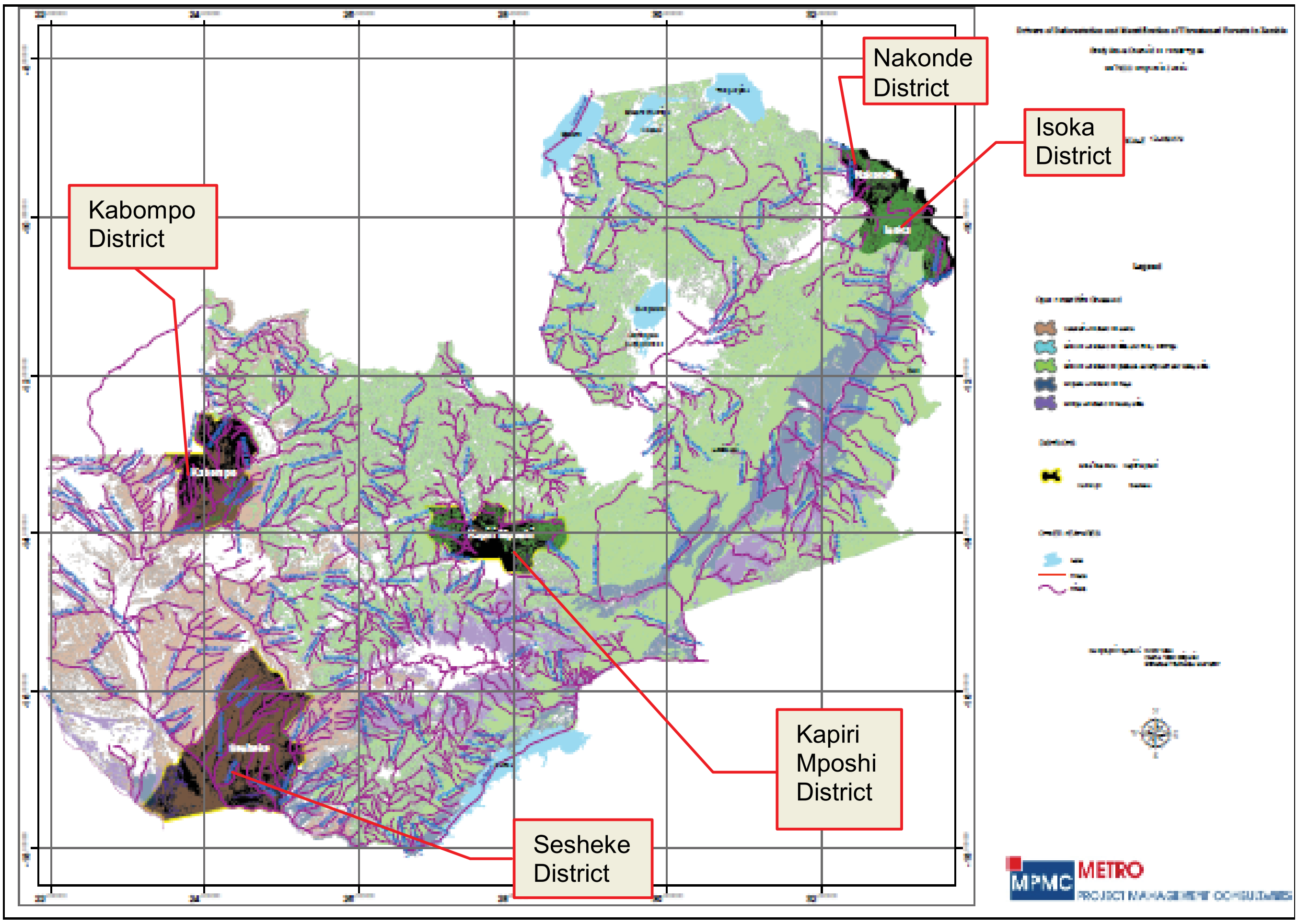
In zone III, the study covered Nakonde District in Muchinga Province (formerly part of Northern Province) and Kabombo District in North-Western Province. The districts are dominated by Miombo woodland and the most predominant species are *Pterocarpus angolensis, Brachystegia Spp, Afzelia quanzensis (Mupapa), Erythrophlem africanum, Faurea saligna, Khaya anthotheca and Mitragyna stipulosa.* Most of these tree species are at high risk because of their high economic value and the demand for charcoal, timber for construction, carpentry and joinery works. Land in this zone is relatively abundant and shifting cultivation (slash and burn) is widespread in some areas. Selection of these areas was based on the timber harvesting, shifting cultivation and charcoal production activities taking place in the areas.

Figure 1: Agro-ecological zones of Zambia



Zone I covers the country's major valleys; Gwembe, Lunsemfwa and Luangwa, and the southern parts of Western and Southern Provinces and accounts for about 15% of the land area. It is a drought-prone area characterized by low rainfall (< 800 mm/yr) and a short, hot growing season. However, there is potential for high-value vegetables, fruits and rice. Zone II is the medium rainfall area (800-1 000 mm/y) covering Central and Eastern Lusaka and Southern Province; Kalahari Sand Plateau; and Zambezi flood plains of Western Province. The region has a total area of 27.4 Mha of which 50% is available for agricultural use. Wetlands, dambos, rivers and lakes allow for agriculture water management activities and, with good market infrastructure, support high-value crops. Zone III has rainfall of 1 000-1 500 mm/yr and a growing season of 120-150 days, occupies 41% of the country including part of the Central African Plateau covering Northern, Luapula, Copperbelt and North-Western Provinces, and parts of Serenje and Mkushi Districts. Due to poor soil conditions, only 53% of the land is suitable for cultivation. This, along with poor market access, limits the number of crop types that can be cultivated. There are large areas of wetlands, dambos, rivers and lakes, but low commercialization restricts irrigated production (*Agricultural water management national situational analysis* 2009).

Figure 2: Selected study areas



APPROACH AND METHODOLOGY

This study conducted an analysis based on ground-truthed evidence from both satellite imagery and field-based evidence. Ground truthing was done through a process of collecting coordinates of visible features like forests, water bodies, cultivated fields, road junctions and other land uses as depicted from the satellite images. The Global Positioning System (GPS) was used to trace and confirm the points on the ground. Annexes 28-32 give the details of the ground-truthed field points for each district.

The study used an interdisciplinary data gathering approach that integrated literature search, policy-level consultations, community-level consultations, stakeholder interviews, courtesy calls and field visits. These were benchmarked by topographic maps 1:50 000 and 1:250 000 and satellite imagery.

The approach consisted principally of two complementary parts or phases: desktop and field-based study. The technical approach and methodology of the two phases was designed to capture two sets of data: spatial and non-spatial. For the latter, data gathering was largely based on stakeholder consultation and inclusion. This is one of the central principles under REDD+, and it ensures sustainability of subsequent activities including the development and implementation of the proposed national REDD+ strategy. Participatory learning was the fundamental platform of the study process. For the desktop phase, the geographical information system (GIS) techniques formed the bedrock of data capture. The following tools, datasets and methods were used in order to meet the set objectives:

- Garmin GPS receivers
- digital camera
- topographic maps covering selected areas at 1:50 000 and 1:250 000 scales
- satellite images
- field sampling
- field observations
- field interviews and on-screen digitizing

Methods for collecting non-spatial data

The approach for collecting this data was generally bottom-up and tapped indigenous knowledge and technologies. Through this approach, the team engaged traditional leaders, local communities and community-based organizations (CBOs).

Task 1: To identify the direct/indirect causes and proximate/underlying drivers of deforestation in Zambia and to estimate the strength and importance of each driver.

Data for task 1 was collected through:

Literature review (i.e. desktop study)

A large amount of information on REDD+ has been generated and documented, including reference material on the drivers of deforestation in Zambia, e.g. the study done by Vinya *et al.* (2012). This was reviewed to identify information gaps and identify how policy is contributing to arrest the negative impacts of deforestation. The information was crucial in making a quick checklist of key national, provincial, district and local-level institutions and stakeholders responsible for addressing the drivers of deforestation and forest degradation. It also provided the extent of spatial distribution of forest degradation according to forest types and the impacts of prevailing land-use practices. It yielded both qualitative and quantitative data.

Participatory learning

This method recognized the fact that, while policy is global, knowledge and information is in people; therefore, the strategy tapped the indigenous knowledge and technologies. Participatory rural appraisal (PRA) was the chief approach used because of its versatility in involving the community in generation of information and encouragement of ownership of the process and outputs. The most appropriate techniques used were interviews and discussions, mapping, ranking and trend analysis. The main tools used were semi-structured interviews (SSI), focus group discussions, ranking (pair-wise matrix), mapping, and seasonal and historical diagramming. The team also applied other types of participatory learning methods, including: resource use assessment (RUA), participatory surveys and analysis (transect walks/drives) and participatory resource mapping.

Figure 3: Participatory learning at Wulongo community in Nakonde

Source: Taken for this study

Using this approach, the team engaged traditional leaders, local communities, CBOs, faith-based organizations (FBOs), NGOs, the private sector, public institutions and individuals in group meetings (see annex 2 for number of meetings in the selected districts). This yielded the local perceptions on the drivers of deforestation; an understanding of local strategies for addressing deforestation and forest degradation; the underlying socioeconomic factors that are impacting forest resource use; and direct observation of the effects of the identified drivers of deforestation.

Resource mapping

Local communities engaged in identifying the forest resources available in their localities. A link was then made between the community maps and satellite images to check and identify the major features as understood and known by the community members. The resource maps also showed the land use, physical land features, fields, location of forest resources, human habitats, and social and economic infrastructure.

Figure 4: Community members drawing a resource map for Kasempa village area near Chibwe National Forest in Kapiri Mposhi District

Consultations

Consultations were held at provincial level with policy implementation supervisors and at district level with ground policy implementers. At local level, consultations were held with traditional leaders. At national level, a review of policy documents was conducted. Consultations helped the team to ground truth the state of the forests before the threats appeared, threats and current local practices that are impinging on the health of the forest. This information was compared with that obtained from the satellite imagery. REDD+ assessment guidelines were used to control the consistency of information quality.

Source: Taken for this study

Figure 5: Consultations with traditional authorities at Chieftainess Nawaitwika's palace in Nakonde

The guidelines covered:

- participation and inclusion;
- rights of indigenous people and forestry dependent communities;
- transparency and access to information;
- consultation and engagement; and
- communication and information.

Ranking the drivers of deforestation by community members

The study team facilitated discussions in a plenary session to enable community participants to identify the drivers of deforestation. The community members further decided the strength and importance of each driver through the pair-wise matrix. The study team selected two to three major drivers related to land use under each district and further subjected them to a detailed explicit spatial analysis.

Methods for collecting spatial data

Task 1: To identify the direct/indirect causes and proximate/underlying drivers of deforestation in Zambia, and to estimate the strength and importance of each driver.

Task 2: To estimate from the drivers of deforestation and historical spatial analysis, expected forest area changes in the future, and identify and map the most threatened forests based on forest types that have been most affected by deforestation over the last 20 years and expected deforestation rates over the next ten years.

Preparation of Landsat satellite data

A forest cover change assessment[3] was developed by the consultants using a total of 41 Landsat satellite image colour composite images. The colour composite images were made of band 4 in near-infrared; band 5 in mid-infrared; and band 3 in visible part of the electromagnetic spectrum. The false colour satellite images were geometrically corrected and projected to UTM Coordinate System, datum WGS 84. The choice of bands for the colour composite images was based on the need to better detect forest cover. The colour composite images for each district were clipped using the district boundaries to generate the district images for each year; i.e. 1990, 2000 and 2010. Three software packages were interactively used in the entire process of image analysis and vector data manipulation: ENVI 4.7, QGIS 1.8.0 and ArcGIS 9.2.

Forest/non-forest cover map production

The classification of Landsat satellite images covering each of the five districts was undertaken using ENVI 4.7 software. The classification method adopted was supervised classification using the Maximum Likelihood Classifier. A total of 15 forest/non-forest thematic maps were produced. Later the forest/non-forest cover maps were converted from raster to vector format to facilitate querying of the maps for area statistics. In order to show the distribution of forests, forest/non-forest maps were produced at 1:10 000.

Forest/non-forest cover map validation

Validation datasets, i.e. points indicating forest and non-forest (water, agricultural farms, settlements, open spaces, etc.), were collected in each district using the GPS receiver and used to validate the 2010 forest/non-forest map only. The forest/non-forest maps for 1990 and 2000 were validated using expert knowledge.

The GPS coordinates were used to create a forest/non-forest point feature map. The validation was further consolidated using higher resolution remote sensing imagery on Google earth and photos taken in the field.

3 The data sets and methodology used for the forest cover change assessment developed for the 5 targeted districts of this study differ from the wall-to-wall land cover change assessment being prepared by the UN-REDD Programme.

The forest/non-forest point feature maps were crossed with each of the forest/non-forest cover maps for 2010 to create a cross table from which error matrices were created. Thereafter, the overall accuracy and the kappa statistic for forest/non-forest cover were computed. The overall accuracy was computed by dividing the correctly classified points by the total number of points multiplied by 100 percent. The kappa statistic was computed using the formula: $K = (po - pe) / (1 - pe)$, where K is the kappa statistic, o is the observed proportion (agreement) of the correctly classified cases, and pe refers to the correctly classified cases expected by chance, also referred to as chance agreement. Note that an overall accuracy of 75 percent and kappa of 0.5 and above is generally acceptable.

Generation of statistics, forest cover change analysis and prediction

The forest/non-forest cover maps in vector format were analysed to determine the changes in forest cover between the years 1990 to 2000, and 2000 to 2010 for each district. The results of the analysis were statistics that show either an increase or decrease in forest cover. Statistics on forest cover were generated for each district for the years 1990, 2000 and 2010. Change maps were generated to show change of forest cover to non-forest and non-forest to forest cover for the years 1990, 2000 and 2010.

Projections were made to predict forest change for the years 2020, 2030, 2040 and 2050. The predictions were based on average forest cover change statistics for the years 1990 and 2000.

Determination of strength and importance of the drivers of deforestation

Spatially, the strength of each driver was determined by the increase in ha of forest cover loss or carbon emission caused by each driver with time.

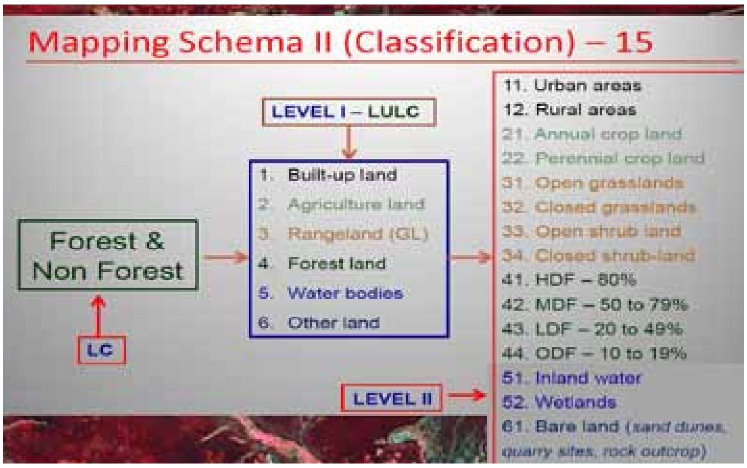
Land-use and carbon-stock change modelling

The information about historic spatial land-use change was generated using land-use change data for forest and non-forest land, qualitative information on drivers of deforestation and degradation (identified through non-spatial data) and official data on population growth, land-use patterns and energy consumption. The generated data was used to project future land-use and carbon-stock changes.

The approach was to focus on 2000-2010 changes on the forest cover maps, draw on qualitative and official data and correlate these sources. Two to three most important spatial drivers were selected on the basis of the major land uses and forest uses in each district. Data compiled included population in 1990, 2000 and 2010, differentiated according to rural and urban population and socio-economic information, including household size, household land, energy consumption and sources, and poverty levels based on 3.5 percent GDP. The macro-data (e.g. population growth) and the deforestation rate for each district were correlated and quantified. Deforestation rates were allocated to the identified land uses and were quantified as well. Non-forest cover was disaggregated according to identified land uses and forest cover to forest degradation levels as categorized by the Intergovernmental Panel on Climate Change (IPCC).

For the purpose of land-use and carbon-stock change modelling, three land-use categories of forest cover were identified: high dense forest of >80 percent crown closure, medium dense forest of crown closure ranging from 50 to 79 percent crown closure and low dense of 20 to 49 percent crown closure. For the non-forest cover, five land-use categories were identified: annual crop land (commercial agriculture), annual crop land (small-scale agriculture), open/closed grassland, inland water/wetlands and urban/rural areas (built-up areas). Other parameters used were the deforestation rate, GDP and population growth. Carbon-stock changes were calculated using carbon-stock estimates from ILUA I, as presented in Kamelarczyk (2009) with expert judgement in annex 8.

Figure 6: IPCC land-use classification



Source: Abel Siampale (2013)

STUDY FINDINGS, ANALYSIS AND DISCUSSIONS

Spatially explicit simulation of the drivers of deforestation

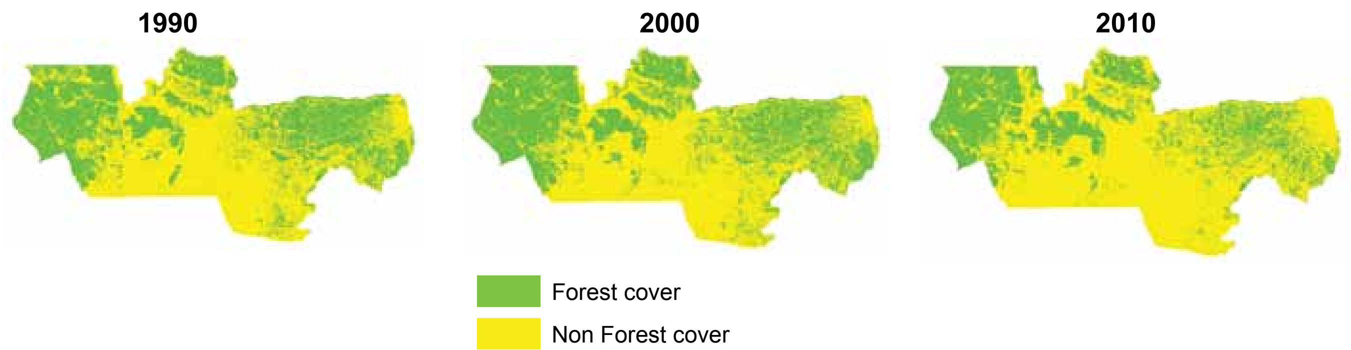
Explicit spatial analysis was performed for each district. The spatial analysis was based on satellite images over a period of 20 years (1990 as the base year). It provided explicit and evidence-based information about the forest cover changes. Field observations, based on in-situ visits, were used to verify the satellite images and to obtain first-hand information from the local people who have been observing the causes of forest cover loss over time.

Kapiri Mposhi District

Distribution of forest/non-forest cover for the years 1990, 2000 and 2010

Kapiri Mposhi District is approximately 1 117 507 ha in size. Based on this area boundary, three forest/non-forest cover maps for the years 1990, 2000 and 2010 were produced. The maps show the distribution of forests and their extent. Figure 7 shows forest cover distribution for Kapiri Mposhi District for the years 1990, 2000 and 2010.

Figure 7: Distribution of forest cover and non-forest cover in Kapiri Mposhi District



Forest cover represents an aggregate of different forest types while non-forest cover represents settlements, roads, crop land, grasslands, swamps, dambos, water bodies and fallows. Statistics for the changes in forest cover and non-forest cover were generated and the spatial extent of change from 1990 to 2010 was determined. Figure 8 shows the results.

Figure 8: State and extent of forest/non-forest cover for Kapiri Mposhi

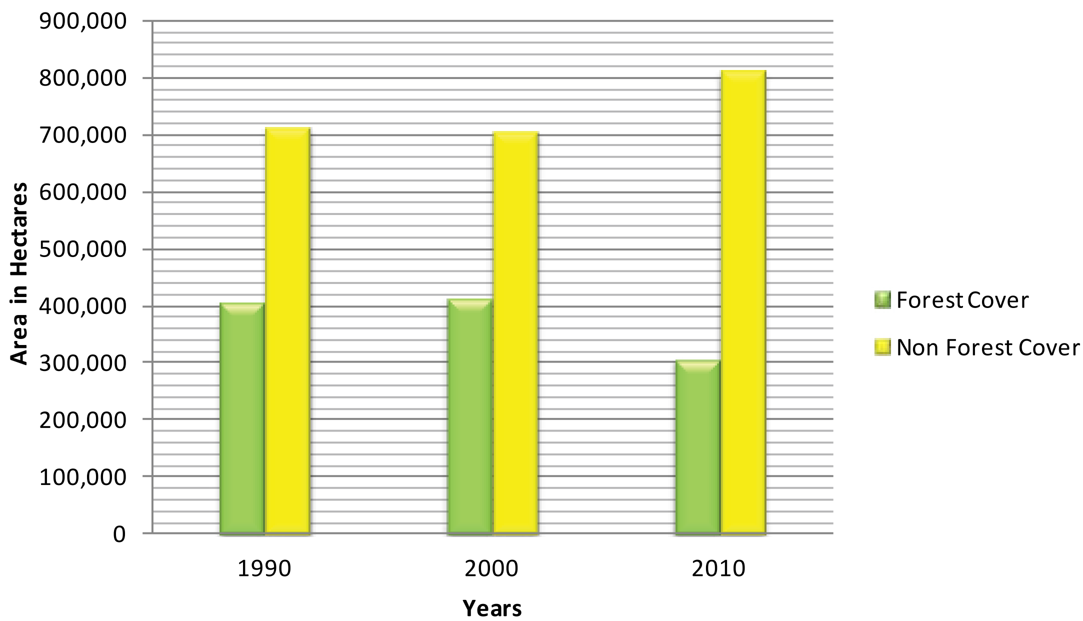


Figure 8 and Table 7 indicate that although Kapiri Mposhi shows a slight increase of 6 639 ha between 1990 and 2000, translating into an average increase of 663.9 ha per year, the district lost approximately 106 089 ha over a period of ten years between 2000 and 2010, translating into an average loss of 10 608.9 ha per year:

Table 7: Forest/non-forest cover changes in hectares for Kapiri

Zone	Name of district	District land area (ha)	Forest cover in hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
II	Kapiri Mposhi	1 117 507	406 912	413 551	6 639	413 551	307 462	-106 089

Note: a negative value indicates a decrease in forest cover.

The spatial analysis and field observations attribute the forest cover loss to settlements, agricultural expansion, and wood extraction for charcoal and fuelwood. Forest fires are caused by any of these land uses. These land uses were considered to be important and were used in carbon-stock modelling for the district. These drivers are fuelled by increased population and high poverty levels in the district. The population of Kapiri Mposhi District grew from 194 752 in 2000 to 240 841 in 2010 at a growth rate of 2.1 percent (CSO 2011). The rural population grew from 155 670 in 2000 to 182 968 in 2010 at a growth rate of 1.24 percent while the urban population grew from 39 082 in 2000 to 57 873 in 2010 at a growth rate of 0.86 percent.

The number of households depending on agriculture increased from 30 870 in 2000 to 36 283 in 2010. The total area planted by commercial-scale farmers increased from 5 328 ha in 2000 to 6 264 in 2010. The area planted by small-scale farmers increased from 60 762 ha in 2000 to 71 873 ha in 2010.

The number of persons depending on charcoal increased from 194 752 in 2000 to 240 841 in 2010. The annual consumption of charcoal increased from 26 213 619.2 kg in 2000 to 33 621 403.6 kg in 2010 at an average consumption of 134.6 kg per person/annum.

The number of persons depending on fuelwood decreased from 194 752 in 2000 to 182 968 in 2010, resulting in a slight reduction of fuelwood consumption from 46 740 480 kg in 2000 to 43 912 320 kg in 2010. It is assumed that others graduated to electricity in 2010 (*Agricultural water management, national situational analysis* 2009; CSO 2012; Kapiri Mposhi District situation analysis 2010).

Land-use and carbon-stock change extrapolation

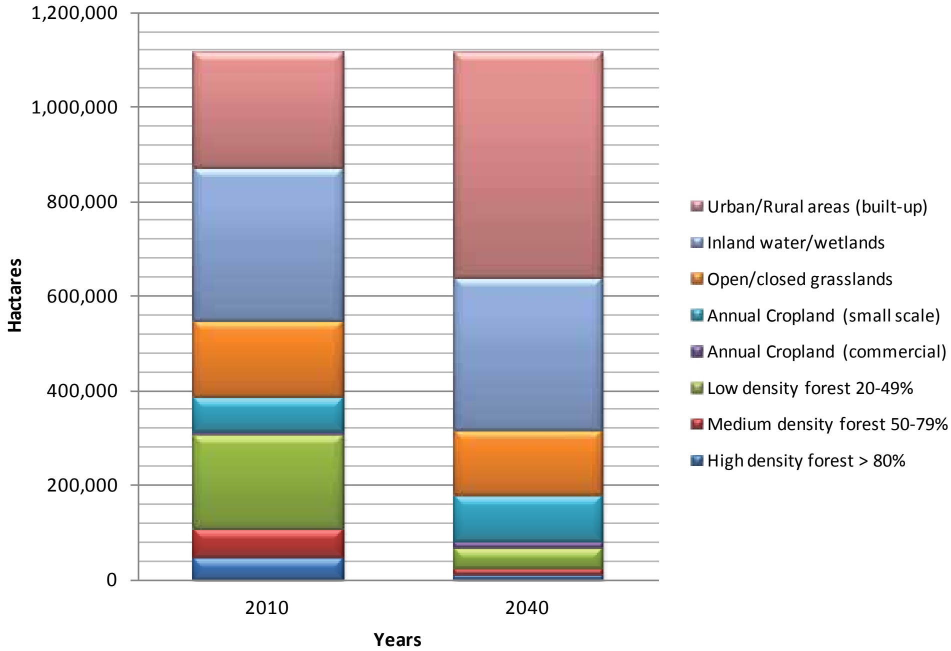
The calculations for land-use and carbon-stock changes are shown in annexes 9 and 10. In order to calculate the expected land-use change for the next 30 years, estimates and assumptions were made using the 2010 values. High dense forests were estimated to cover approximately 15 percent of the generated district forest cover, while medium dense was estimated to cover 20 percent and low dense forests another 65 percent. By correlating them with the annual forest cover loss for the district, which was equivalent to 7 994 ha in 2010, expected changes were calculated by extrapolating this area loss every year until 2040.

To obtain the expected land-use changes under the non-forest cover, the total land covered by commercial agriculture (6 264 ha) 6 264 in 2010 was correlated with the GDP, which was estimated to be 3.5 percent. Land covered by small-scale farmers (71 417 ha) in 2010 was correlated with the district rural population growth rate of 1.24 percent. Open/closed grassland was estimated at 20 percent of the generated non-forest cover area and correlated at a reduction of 0.5 percent, assuming that it will change to other land uses. The inland water/wetlands category was estimated at 40 percent of the generated non-forest cover area and was considered stable at 324 018 ha. The remaining area for non-forest cover was considered to be urban/rural areas (built-up) and was correlated with 1.24 percent rural growth rate.

The results show that if the drivers of deforestation are unabated, high dense forest will decrease from 46 119 ha in 2010 to 10 146 ha in 2040; medium dense forest will decrease from 61 492 ha in 2010 to 13 528 ha in 2040; and low dense from 199 850 ha in 2010 to 43 967 ha in 2040. The conversion of the forest land entails that commercial agriculture will increase from 6 264 ha in 2010 to 12 841 ha in 2040; small-scale agriculture will increase from 71 417 ha in 2010 to 97 984 ha in 2040. Open/closed grassland is expected to decrease from 162 009 ha in 2010 to 137 708 ha in 2040 because part of the land will be converted to other land uses. The hectares for inland water/wetlands category are expected to remain the same and urban/rural areas (built-up) will increase from 246 337 ha in 2010 to 477 314 ha in 2040.

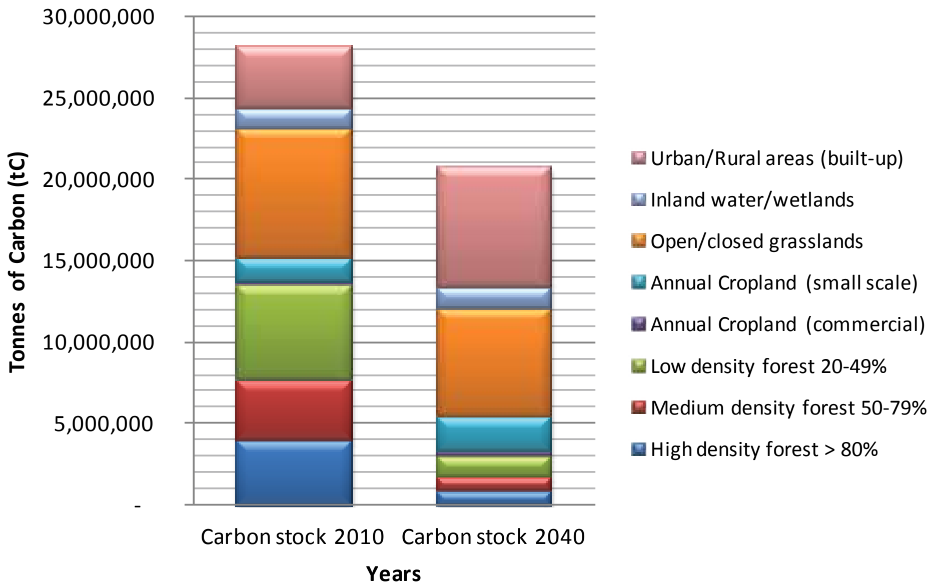
The overall effect is that the forest cover for Kapiri Mposhi will decrease from 307 462 ha in 2010 to 67 642 ha in 2040 and the non-forest cover will increase from 810 045 ha in 2010 to 1 049 865 ha in 2040 if nothing is done to reduce the current forest cover loss rate. Figure 9 shows the projected land-use change pattern between 2010 and 2040.

Figure 9: Land-use changes for Kapiri Mposhi District over thirty years



The calculation of carbon stock for the above land-use categories is shown in annex 11. Figure 10 shows the tonnes of carbon per hectare for each land use in 2010 and 2040. If the drivers are unabated, carbon stocks will decrease from 28 184 289 tC in 2010 to 20 748 641 tC in 2040. The difference is 7 435 649 tC. Any negative value reflects emissions arising from the conversion of the land uses while a positive value reflects greenhouse gas (GHG) benefits (sequestration). This means that if nothing is done to correct the current scenario in Kapiri Mposhi District, it will greatly contribute to GHG emissions.

Figure 10: Carbon-stock changes for Kapiri Mposhi District over thirty years

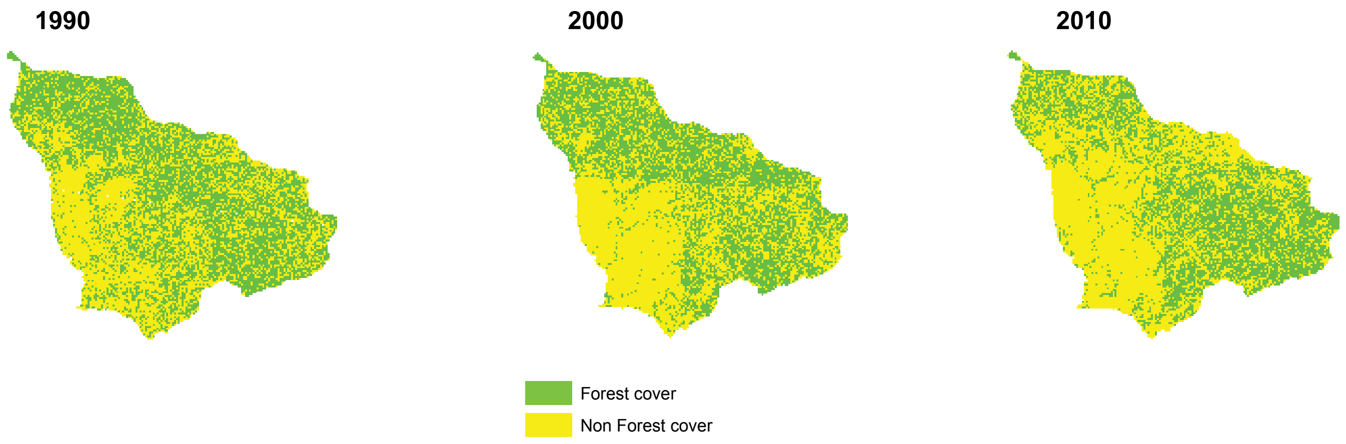


Nakonde District

Distribution of forest/non-forest cover for the years 1990, 2000 and 2010

Nakonde District is approximately 428 425 ha in size. Based on this area boundary, three forest/non-forest cover maps for the years 1990, 2000 and 2010 were produced. The maps show the distribution of forests and their extent. Figure 11 shows forest/non-forest cover distribution for Nakonde District for the years 1990, 2000 and 2010.

Figure 11: Distribution of forest/non-forest cover in Nakonde District



Forest cover represents an aggregate of different forest types while non-forest cover represents settlements, roads, crop land, grasslands, swamps, dambos, water bodies and fallows in the district. Statistics for the changes in forest cover and non-forest cover were generated and the spatial extent of change from 1990 to 2010 was determined. Figure 12 shows the trend in the forest cover changes.

Figure 12: State and extent of forest/non-forest cover for Nakonde

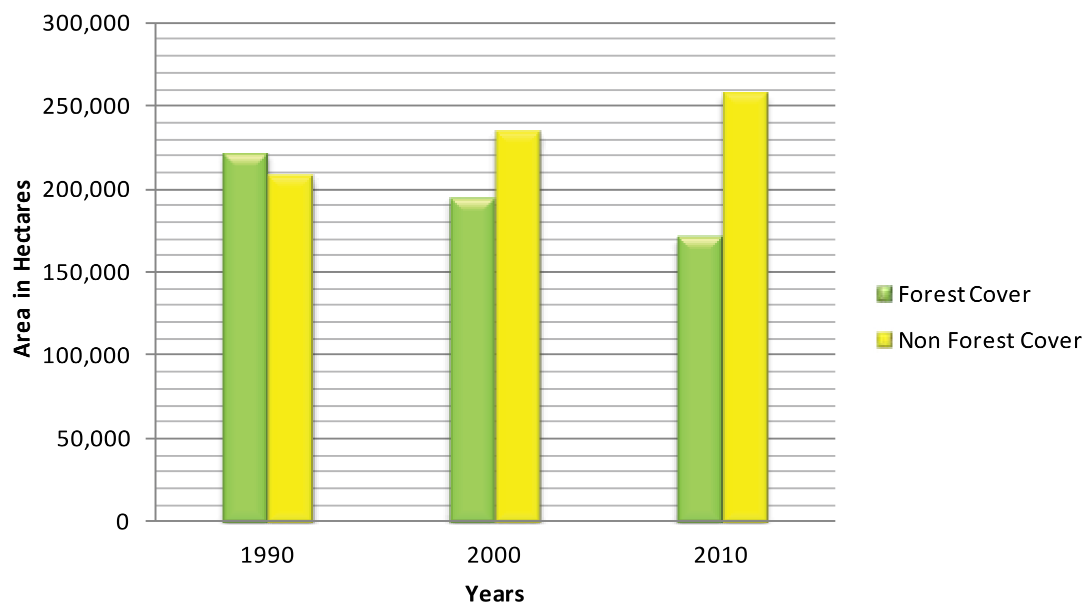


Figure 12 and Table 8 show that there has been a continuous steady decrease of forest cover for the past 20 years. Between 1990 and 2000, the district lost an approximate average of 2 707.7 ha of forest cover per year. The trend continued for the period between 2000 and 2010 where the loss was about 2 278.2 ha per year.

Table 8: Forest/non-forest cover change in hectares for Nakonde

Zone	Name of district	District land area (ha)	Forest cover in hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
III	Nakonde	428 425	220 962	193 885	27 077	193 885	171 103	22 782

Note: a negative value indicates a decrease in forest cover.

The spatial analysis and field observations attribute the forest cover loss to settlements, agriculture (shifting cultivation), wood extraction for charcoal and fuelwood. Forest fires are caused by any of these land uses. These land uses were considered to be important and were used in carbon-stock modelling for the district. The identified drivers of deforestation are underpinned by increased population and high poverty levels in the district. The population of Nakonde District grew from 75 135 in 2000 to 118 017 in 2010 at a growth rate of 4.6 percent (CSO 2011). The rural population grew from 55 707 in 2000 to 79 907 in 2010 at a growth rate of 2.6 percent while the urban population grew from 19 428 in 2000 to 38 110 in 2010 at a growth rate of 2.0 percent.

The number of households depending on agriculture increased from 6 270 in 2000 to 13 772 in 2010. The total area planted by small-scale farmers increased from 5 448 ha in 2000 to 11 967 ha in 2010.

The number of persons depending on charcoal increased from 19 428 in 2000 to 38 110 in 2010. The annual consumption of charcoal increased from 2 615 008.8 kg in 2000 to 5 320 156 kg in 2010. The number of persons depending on fuelwood also increased from 64 921 in 2000 to 98 962 in 2010. The total fuelwood consumption increased from15 581 040 kg in 2000 to 23 75 880 kg in 2010 (*Agricultural water management, national situational analysis* 2009; CSO 2012; Nakonde DSA 2012).

Land-use and carbon-stock change extrapolation

The extrapolation of land-use and carbon-stock changes for Nakonde District is shown in annexes 12 and 13. Assuming a yearly forest cover loss of 2 053 ha (based on 2010 rate) and that drivers of deforestation are not dealt with, high density forest would decrease from 8 555 ha in 2010 to 5 475 ha in 2040; medium density forest would decrease from 68 441 ha in 2010 to 43 802 ha in 2040, and low density would decrease from 94 107 ha in 2010 to 60 228 ha in 2040. The conversion of the forest land means that small-scale agriculture will increase from 5 448 ha in 2010 to 9 697 ha in 2040. Open/closed grassland is expected to decrease from 51 464 ha in 2010 to 36 025 ha in 2040 because part of the land will be converted to other land uses. The hectares for inland water/wetlands are expected to remain the same and the built-up areas will increase from 174 677 ha in 2010 to 247 464 ha in 2040.

The overall general outlook is that the forest cover for Nakonde District will decrease from 171 103 ha in 2010 to 109 506 ha in 2040 and the non-forest cover will increase from 257 322 ha in 2010 to 318 919 ha in 2040 if nothing is done to reduce the current forest cover loss rate. Figure 13 shows the trend in land-use changes for Nakonde District between 2010 and 2040.

The calculations of carbon stock for the above land-use categories for Nakonde District are shown in annex 14. Figure 15 shows the tonnes of carbon per hectare for each land use in 2010 and 2040. If the drivers of deforestation are unabated, carbon stocks will decrease from 12 982 351 tC in 2010 to 10 733 082 tC in 2040. The difference is 2 249 269 tC. Any negative value reflects emissions arising from the conversion of the land uses while a positive value reflects GHG benefits (sequestration). In this case we have a negative value, implying that if nothing is done to correct the current scenario in Nakonde District, it will greatly contribute to GHG emissions.

Isoka District

Distribution of forest/non-forest cover for the years 1990, 2000 and 2010

Isoka District is approximately 874 897 ha in size. Based on this area boundary, three forest/non-forest cover maps for the years 1990, 2000 and 2010 were produced. The maps show the distribution of forest/non-forest cover and their extent. Figure 15 shows forest/non forest cover distribution for Isoka District for the years 1990, 2000 and 2010.

Figure 13: Land-use changes for Nakonde District over thirty years

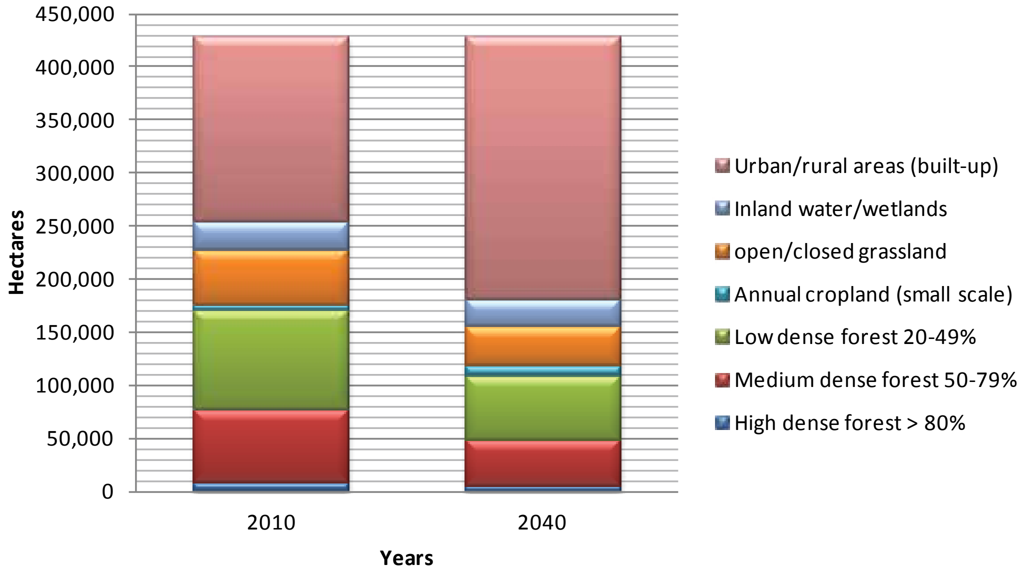


Figure 14: Carbon-stock changes for Nakonde District over thirty years

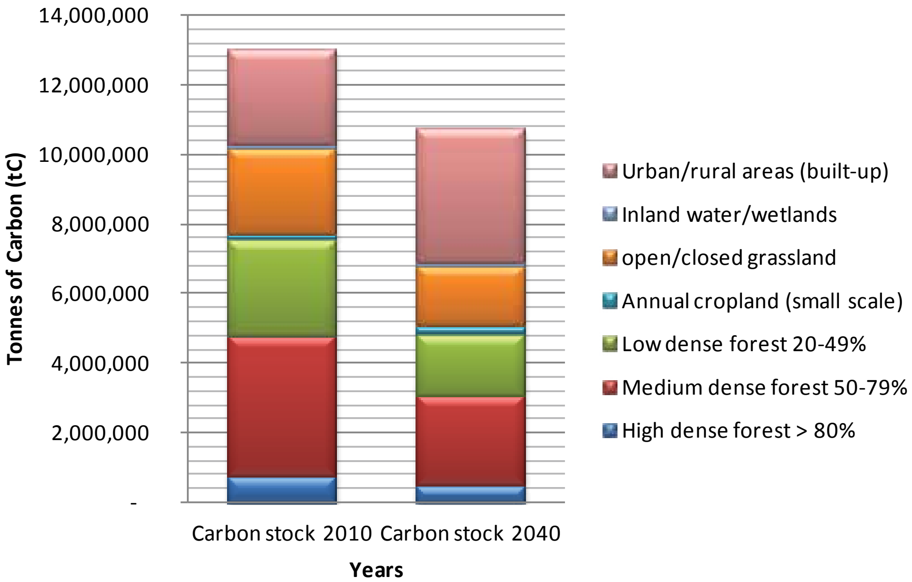
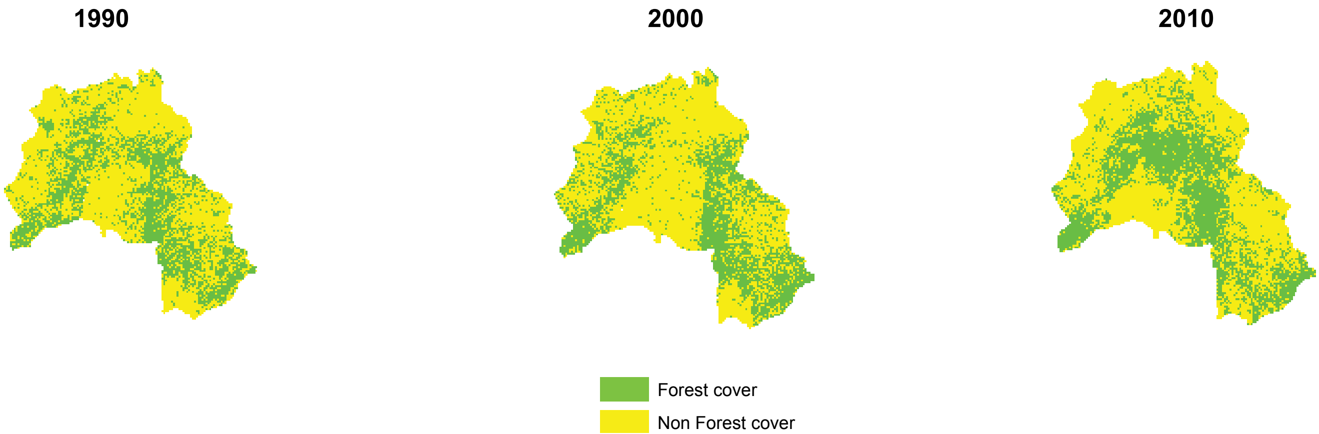
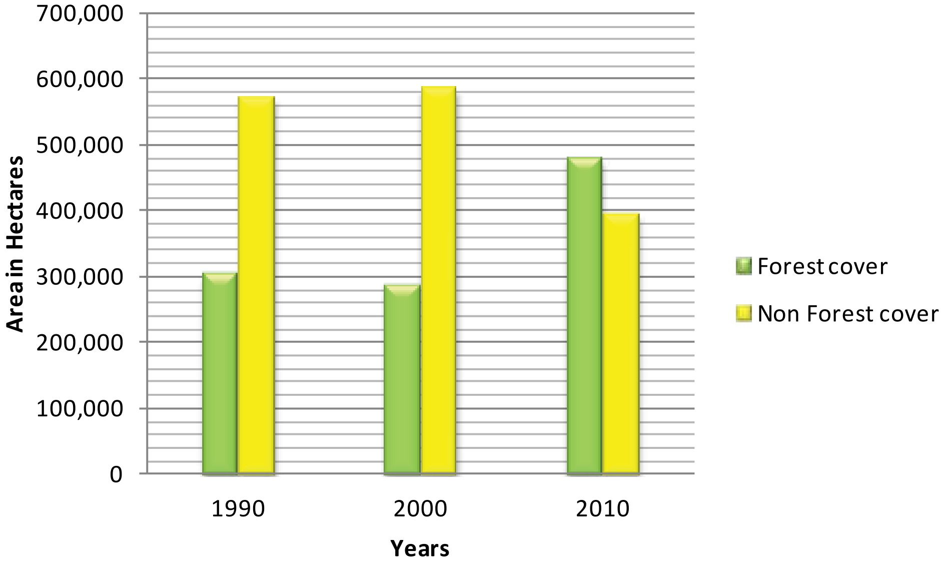


Figure 15: Distribution of forest/non-forest cover Isoka District



The forest cover in Figure 15 represents an aggregate of different forest types while non-forest cover represents settlements, roads, fields, bare lands, grasslands, swamps, dambos, water bodies and fallows in the district. Statistics for the changes in forest cover and non-forest cover were generated and the spatial extent of change from 1990 to 2010 was determined. Figure 16 shows the trend in forest/non-forest cover changes.

Figure 16: State and extent of forest/non-forest cover for Isoka District



The results for Isoka in Figure 16 and Table 9 show that there has been an increase in forest cover between 2000 and 2010 of an average of 19 036 ha per year while the district lost an approximate average of 1 538.8 ha per year between 1990 and 2000.

Table 9: Forest/non-forest cover change in hectares for Isoka

Zone	Name of district	District land Area (ha)	Forest Cover in Hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
III	Isoka	874 897	304 563	289 175	-15 388	289 175	479 535	190 360

Note: a negative value indicates a decrease in forest cover.

The increase in forest cover between 2000 and 2010 could be attributed to the fact that people of Isoka District practise shifting cultivation that allows fallowing.

Figure 17: Transition of shifting cultivated land to fallowing in Isoka District

The people have a tendency of shifting from low lands to the mountains for farming and vice versa. It is therefore assumed that the 2010 satellite images could have been taken when fallows were fully regenerated in the lower lands. Forest degradation in Isoka District is confirmed by the photographs taken in the field. Local community members, traditional authorities and other stakeholders affirmed that all the big trees are gone in Isoka District.

For the purpose of land-use and carbon-stock changes extrapolation, the forest cover loss rate for 1990 to 2000 was used for the 2000 to 2010 period as a forest degradation rate. The term forest degradation has been used for Isoka rather than deforestation because in general the forests are intact but have changed their status from primary to secondary forests.

Figure 18: A regenerating forest in Isoka District, photo taken in 2012

The spatial analysis and field observations attribute the forest cover loss to settlements, agriculture (shifting cultivation), wood extraction for charcoal and fuelwood. These land uses were considered important and were used in carbon-stock modelling for the district. Forest fires could be caused by any land use. These drivers are underpinned by increased population and high poverty levels in the district. The population of Isoka District grew from 99 319 in 2000 to 164 410 in 2010 at a growth rate of 5.2 percent (CSO 2011). The rural population grew from 87 846 in 2000 to 146 782 in 2010 at a growth rate of 4.7 percent while the urban population grew from 11 473 in 2000 to 17 628 in 2010 at a growth rate of 0.5 percent.

The number of households depending on agriculture increased from 11 649 in 2000 to 21 088 in 2010. The total area planted by small-scale farmers increased from 8 524.6 ha in 2000 to 15 431.9 ha in 2010.

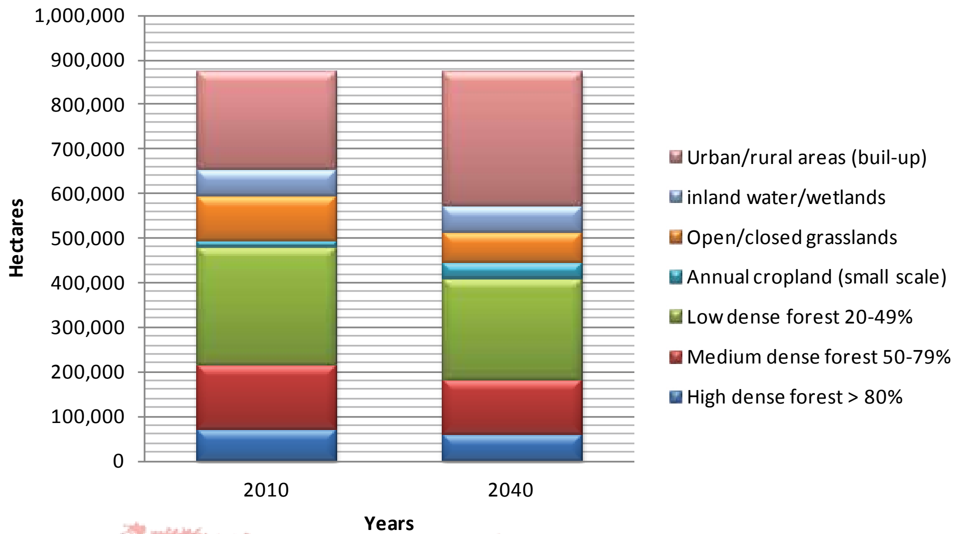
The number of persons depending on charcoal increased from 11 473 in 2000 to 17 628 in 2010. The annual consumption of charcoal increased from 1 579 396.4 kg in 2000 to 2 460 868.8 kg in 2010. The number of persons depending on fuelwood increased from 93 593 in 2000 to 155 596 in 2010. The total fuelwood consumption increased from 22 459 920 kg in 2000 to 37 343 040 kg in 2010 (Agricultural water management, national situational analysis 2009; CSO 2012).

Land-use and carbon-stock change extrapolation

The calculations for land-use and carbon-stock changes for Isoka District are shown in annexes 15 and 16. Assuming an annual forest cover loss of 2 398 ha (based on 2010 figures), high density forest would decrease from 71 930 ha in 2010 to 61 141 ha in 2040; medium density forest would decrease from 143 861 ha in 2010 to 122 281 ha in 2040; and low density would decrease from 263 744 ha in 2010 to 224 183 ha in 2040. The conversion of the forest land will bring about an increase of small-scale agriculture land from 15 432 ha in 2010 to 37 191 ha in 2040. Open/closed grassland is expected to decrease from 98 841 ha in 2010 to 69 188 ha in 2040 because part of the land will be converted to other land uses. The hectares for inland water/wetlands are expected to remain the same and the built-up areas will increase from 221 785 ha in 2010 to 301 608 ha in 2040.

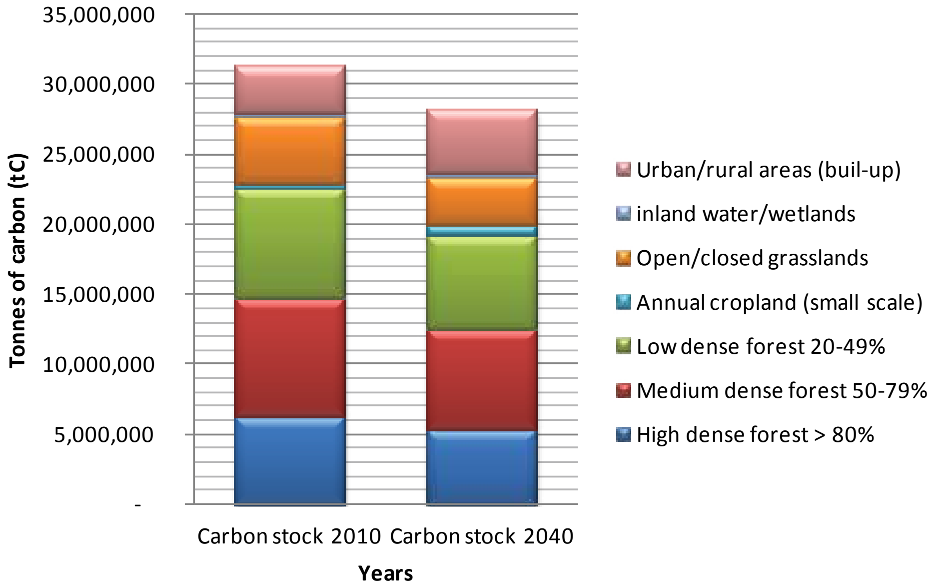
In general, the forest cover for Isoka District will decrease from 479 535 ha in 2010 to 407 605 ha in 2040 and the non-forest cover will increase from 395 362 ha in 2010 to 467 292 has in 2040 if nothing is done to reduce the current degradation rate. Figure 19 shows the trend in land-use changes for Isoka District between 2010 and 2040.

Figure 19: Land-uses changes for Isoka District over thirty years



The calculations of carbon stock for the above land-use categories for Isoka District are shown in annex 17. Figure 20 shows the tonnes of carbon per hectare for each land use in 2010 and 2040. If the drivers of deforestation are unabated, carbon stocks will decrease from 31 328 103 tC in 2010 to 28 221 535 tC in 2040. The difference is 3 106 568 tC. Any negative value reflects emissions arising from the conversion of the land uses, while a positive value reflects GHG benefits (sequestration). In this case we have a negative value implying that if nothing is done to correct the current scenario in Isoka District, it will greatly contribute to the corresponding value of GHG emissions.

Figure 20: Carbon-stock changes for Isoka District over thirty years

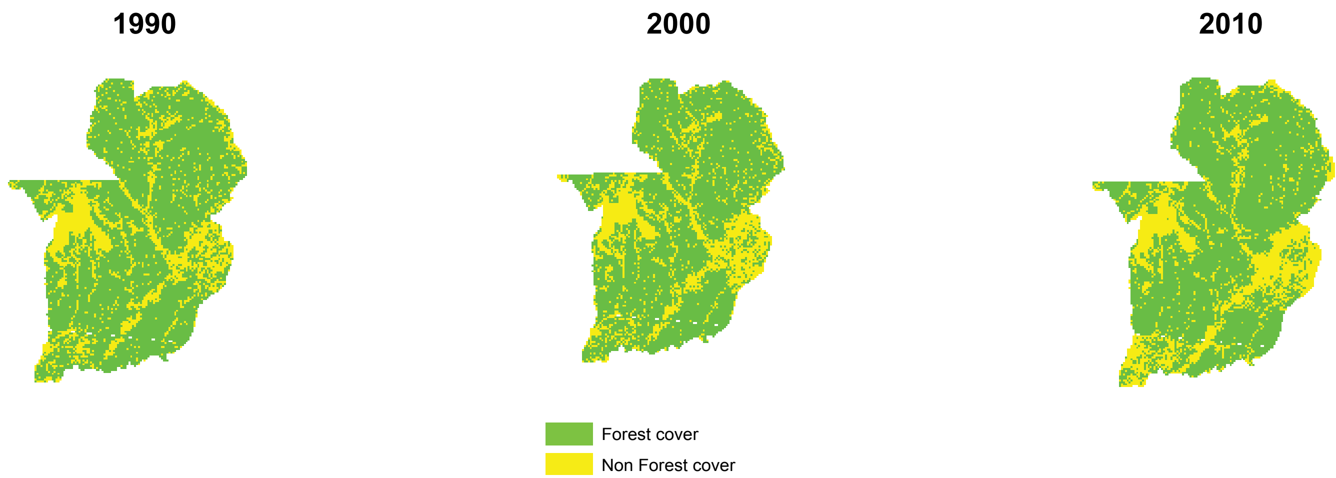


Kabompo District

Distribution of forest/non-forest cover for the years 1990, 2000 and 2010

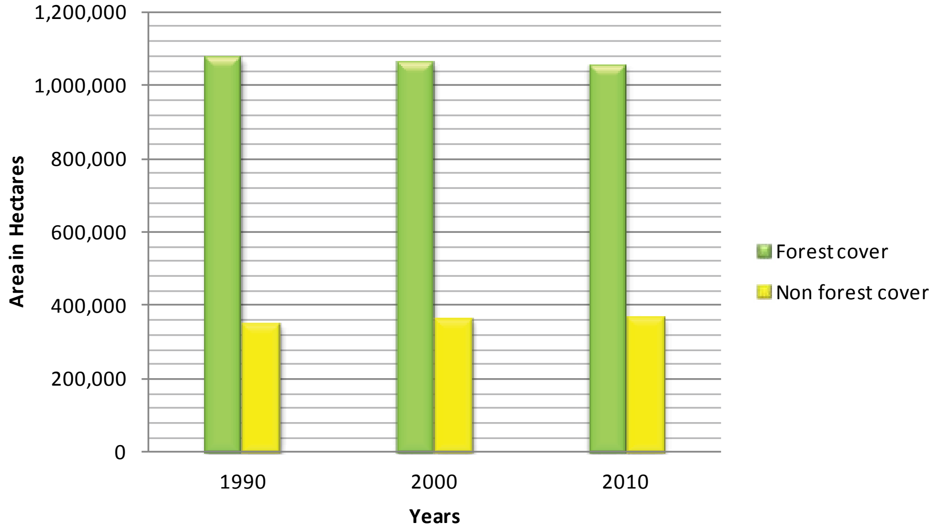
Kabompo District is approximately 1 427 189 ha in size. Based on this area boundary, three forest/non-forest cover maps for the years 1990, 2000 and 2010 were produced. The maps show the distribution of forest/non-forest cover and their extent. Figure 21 shows forest/non-forest cover distribution for Kabompo District for the years 1990, 2000 and 2010.

Figure 21: Distribution of forest/non-forest cover for Kabompo District



The forest cover in the above figure represents an aggregate of different forest types while non-forest cover represents settlements, roads, fields, bare lands, grasslands, swamps, dambos, water bodies and fallows in the district. Statistics for the changes in forest cover and non-forest cover were generated and the spatial extent of change from 1990 to 2010 was determined. Figure 22 shows the trend in forest/non-forest cover in Kabompo District.

Figure 22: State and extent of forest/non-forest cover for Kabompo



Kabompo District results in Figure 22 and Table 10 indicate that, on average, it is the only district that has a higher forest cover percentage of more than 75 percent compared to non-forest cover, which is less than 25 percent. Although the district results show that there is enough forest cover, it continued to lose forest cover each year for the period between 1990 and 2010. Between 1990 and 2000 the district lost approximately 1 373.8 ha of forest cover and continued to lose about 569.8 ha per year between 2000 and 2010.

Table 10: forest/non-forest cover forest cover change in hectares for Kabompo

Zone	Name of district	District land area (ha)	Forest Cover in hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
III	Kabompo	1 427 189	1 074 244	1 060 506	13 738	1 060 506	1 054,808	5 698

Note: a negative value indicates a decrease in forest cover.

The spatial analysis and field observations attribute the forest cover loss to settlements, agriculture (shifting cultivation), wood extraction for charcoal and fuelwood. These land uses were considered to be important and were used in carbon-stock modelling for the district. Timber was considered to contribute more to forest degradation than to deforestation. Forest fires could be caused by any of the land uses identified. The drivers of forest degradation in Kabompo District are caused by increased population and high poverty levels in the district. The population of Kabompo District grew from 71 238 in 2000 to 91 160 in 2010 at a growth rate of 2.5 percent (CSO 2011). The rural population grew from 62 091 in 2000 to 81 434 in 2010 at a growth rate of 2.4 percent while the urban population grew from 9 147 in 2000 to 9 726 in 2010 at a growth rate of 0.1 percent.

The number of households depending on agriculture increased from 10 900 in 2000 to 14 295 in 2010. The total area planted by small-scale farmers increased from 6 250 ha in 2000 to 8 197 ha in 2010.

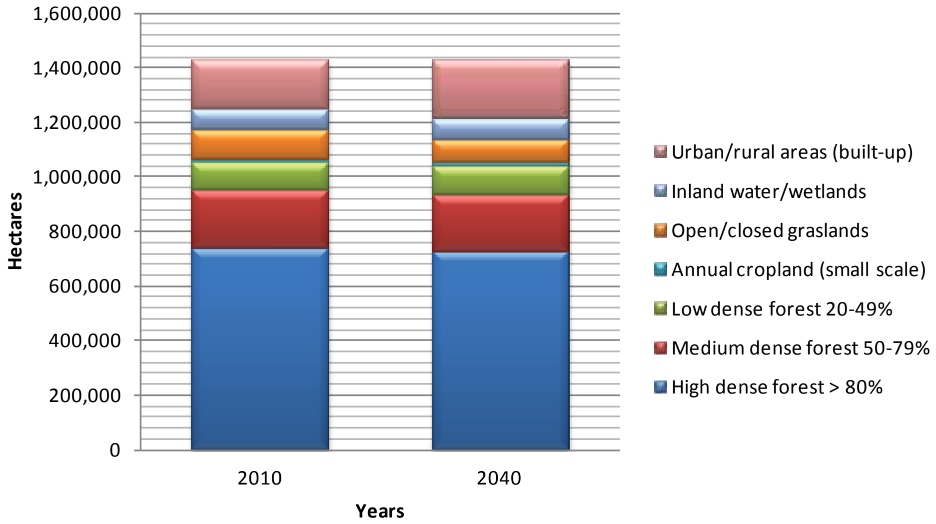
The number of persons depending on charcoal increased from 4 574 in 2000 to 4 863 in 2010. The annual consumption of charcoal increased from 615 660.4 kg in 2000 to 678 874.8 kg in 2010. The number of persons depending on fuelwood increased from 66 665 in 2000 to 86 297 in 2010. The total fuelwood consumption increased from 15 999 600 kg in 2000 to 20 711 280 kg in 2010 (Agricultural water management, national situational analysis 2009; CSO 2012).

Land-use and carbon-stock change extrapolation

The above information was used to calculate the land-use and carbon-stock changes for the district as shown in annexes18 and 19. Assuming an annual forest cover loss of 527 ha (based on 2010 figures), if the forest cover loss rate does not decrease. high density forest will decrease from 738 366 ha in 2010 to 727 290 ha in 2040; medium density forest will decrease from 210 962 ha in 2010 to 207 797 ha in 2040; and low density forest will decrease from 105 481 ha in 2010 to 103 899 ha in 2040. The conversion of the forest land will bring about an increase of small-scale agriculture land from 8 197 ha in 2010 to 14 099 ha in 2040. Open/closed grassland is expected to decrease from 111 714 ha in 2010 to 84 903 ha in 2040 because part of the land will be converted to other land uses. The hectares for inland water/wetlands are expected to remain the same and the built-up areas will increase from 177 994 ha in 2010 to 214 725 ha in 2040.

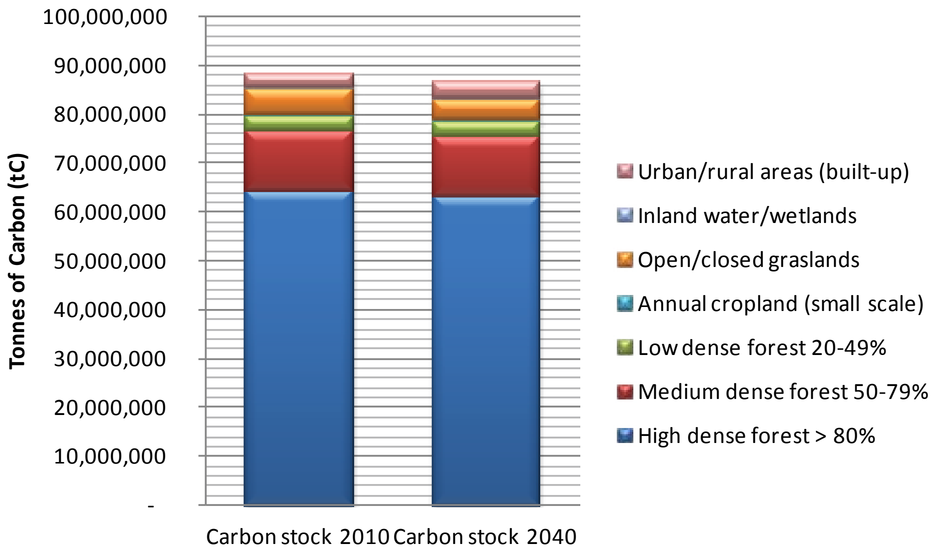
In general, the forest cover for Kabompo District will decrease from 1 054 808 ha in 2010 to 1 038 986 ha in 2040 and the non-forest cover will increase from 372 381 ha in 2010 to 388 203 ha in 2040 if nothing is done to reduce the current forest cover loss rate. Figure 23 shows the land-use changes for Kabompo District between 2010 and 2040.

Figure 23: Land-use changes for Kabompo District over a thirty year period



The calculations of carbon stock for the land-use categories for Kabompo District are shown in annex 20. Figure 24 shows the tonnes of carbon per hectare for each land use in 2010 and 2040. If the drivers of deforestation are unabated, carbon stocks will decrease from 88 446 535 tC in 2010 to 86 646 885 tC in 2040. The difference is 1 799 650 tC. Any negative value reflects emissions arising from the conversion of the land uses while a positive value reflects GHG benefits (sequestration). In this case we have a negative value implying that if nothing is done to correct the current scenario in Kabompo District, it will contribute the same value to GHG emissions.

Figure 24: Carbon-stock changes for Kabompo District over thirty years

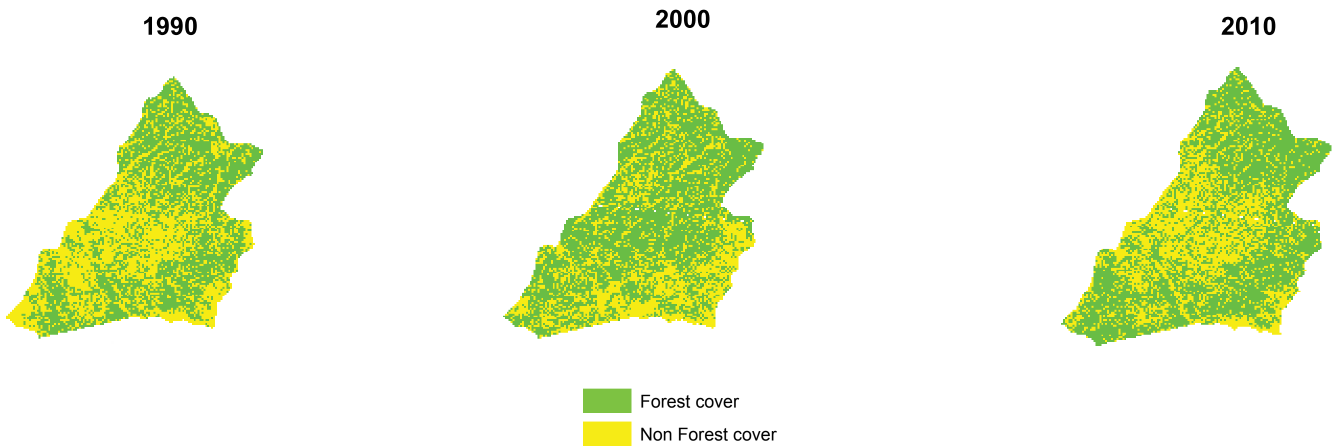


Sesheke District

Distribution of forest/non-forest cover for the years 1990, 2000 and 2010

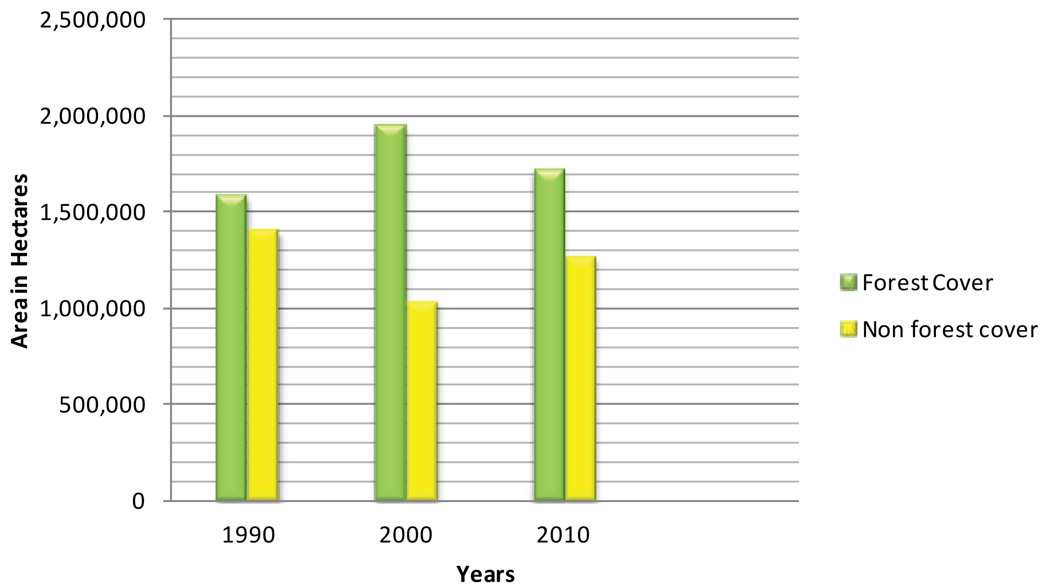
Sesheke District is approximately 2 993 397 ha in size. Based on this area boundary, three forest/non-forest cover maps for the years 1990, 2000 and 2010 were produced. The maps show the distribution of forest/non–forest cover and their extent. Figure 25 shows forest/non-forest cover distribution for the district for the years 1990, 2000 and 2010.

Figure 25: Distribution of forest cover for Sesheke District



The forest cover in Figure 25 represents an aggregate of different forest types while non-forest cover represents settlements, roads, fields, bare lands, grasslands, swamps, dambos, water bodies and fallows in the district. Statistics for the changes in forest cover and non-forest cover were generated and the spatial extent of the change from 1990 to 2010 was determined. Figure 26 shows the trend of forest/non-forest cover changes for Sesheke District for the years 1990, 2000 and 2010.

Figure 26: State and extent of forest /non-forest cover for Sesheke District



Sesheke District results in Figure 26 and Table 11 show that there was an increase of 36 510.5 ha per year of forest cover between 1990 and 2000, but during the period between 2000 and 2010 the district lost an average of approximately 23 293.4 ha per year.

Table 11: Forest/non-forest cover forest cover change in hectares for Sesheke

Zone	Name of district	District land area (ha)	Forest cover in hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
I	Sesheke	2 993 397	1 589 113	1 954 218	365 105	1 954 218	1 721 284	232 934

Note: a negative value indicates a decrease in forest cover.

The spatial analysis and field observations attribute the forest cover loss to settlements, poor agricultural practices (shifting cultivation) and extraction of timber and fuelwood. These land uses were considered important and were used in carbon-stock modelling for the district. Although timber is considered to contribute more to forest degradation than deforestation, the poor forest hygiene during and after logging provides fuel for forest fires that have destroyed the forests in Sesheke District. The forest fires, however, could be caused by any land use. The above drivers of deforestation in Sesheke District are caused by increased population and high poverty levels in the district. The population of Sesheke District increased from 78 169 in 2000 to 94 612 in 2010 at a growth rate of 1.9 percent (CSO 2011). The rural population grew from 64 827 in 2000 to 74 905 in 2010 at a growth rate of 1.2 percent while the urban population grew from 13 342 in 2000 to 19 707 in 2010 at a growth rate of 0.7 percent.

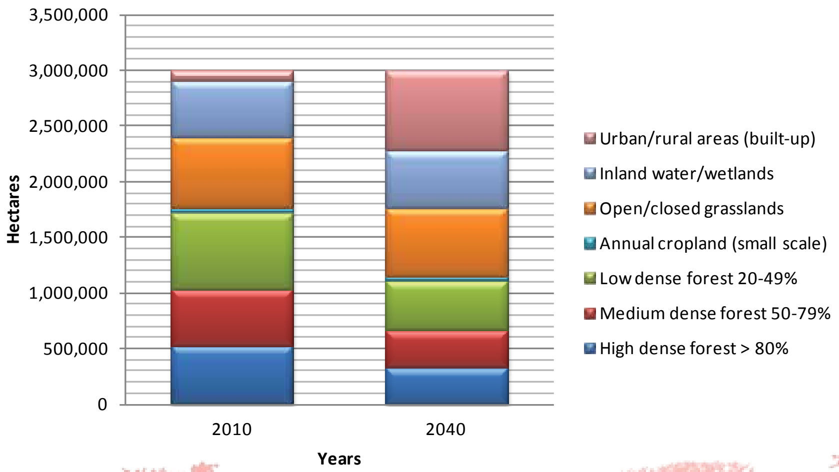
The number of households depending on agriculture increased from 13 127 in 2000 to 16 516 in 2010. The total area planted by small-scale farmers increased from 26 254 ha in 2000 to 33 032 ha in 2010. The number of timber licence holders increased from 14 in 2000 to 15 in 2010. The annual volume of timber exported, however, decreased from 3 188.3 m3 in 2000 to 2 600 m3 in 2010. The number of persons depending on fuelwood increased from 78 169 in 2000 to 94 612 in 2010. The total fuelwood consumption increased from 18 760 560 kg in 2000 to 22 706 880 kg in 2010 (*Agricultural water management, national situational analysis* 2009; CSO 2012; Sesheke DSA 2003).

Land-use and carbon-stock change extrapolation

The above information was used to calculate the land-use and carbon-stock changes for the district as shown in annexes 21 and 22. Assuming an annual forest cover loss of 20 655 ha and that drivers of deforestation remain unabated; high density forest will decrease from 516 385 ha in 2010 to 330 487 ha in 2040; medium dense forest will decrease from 516 385 ha in 2010 to 330 487 ha in 2040; and low dense from 688 514 ha in 2010 to 440 649 ha in 2040. The conversion of the forest land will bring about an increase in small-scale agriculture land from 33 032 ha in 2010 to 244 924 ha in 2040. Open/closed grassland is expected to decrease from 636 057 ha in 2010 to 616 975 ha in 2040 because part of the land will be converted to other land uses. The hectares for inland water/wetlands are expected to remain the same and built-up areas will increase from 94 179 ha in 2010 to 721 032 ha in 2040.

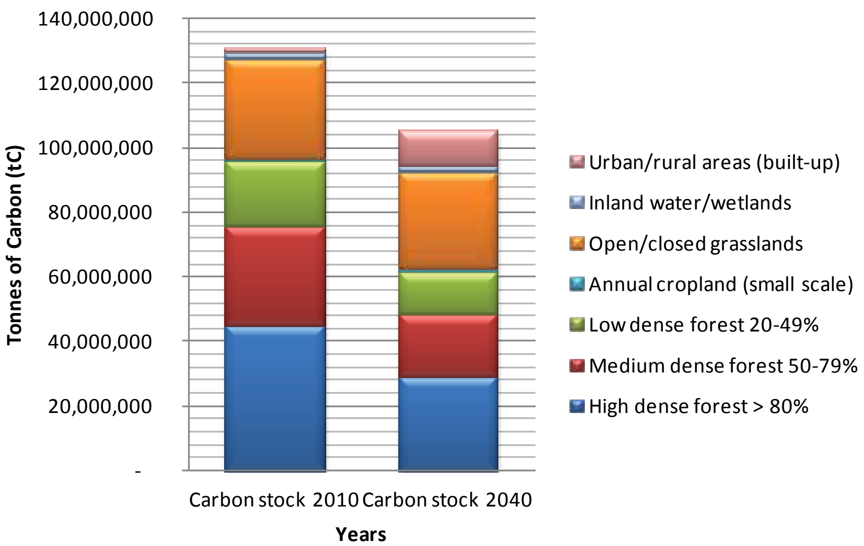
In general, the forest cover for Sesheke District shows that it will decrease from 1 721 284 ha in 2010 to 1 101 622 ha in 2040 and the non-forest cover will increase from 1 272 113 ha in 2010 to 1 891 775 ha in 2040 if nothing is done to reduce the current forest cover loss rate. Figure 27 shows the trend in land-use changes for Sesheke District for the years 2010 and 2040.

Figure 27: Land-use changes for Sesheke District over thirty years



The calculations of carbon stock for the above land-use categories for Sesheke District are shown in annex 23. Figure 28 shows the tonnes of carbon per hectare for each land use in 2010 and 2040. If the drivers of deforestation remain unabated, carbon stocks will decrease from 130 745 384 tC in 2010 to 105 341 654 tC in 2040. The difference is 25 403 730 tC. Any negative value reflects emissions arising from the conversion of the land uses while a positive value reflects GHG benefits (sequestration). In this case there is a negative value implying that if nothing is done to correct the current scenario in Sesheke District, it will greatly contribute the same value to GHG emissions.

Figure 28: Carbon-stock changes for Sesheke District over thirty years



Prediction of future forest cover

The prediction of the future forest cover is based on the calculated forest cover loss rate for each district. Based on these rates, predictions of forest cover for 2020, 2030 and 2040 were calculated as shown in Table 12.

Table 12: Prediction of future forest cover changes

Ecological zone	Name of district	Year 2010	Projected forest cover loss (ha/ year)	Prediction of forest cover (ha)		
				Year 2020	Year 2030	Year 2040
I	Kapiri Mposhi	307 462	7 994	227 522	147 582	67 641
III	Nakonde	171 103	2 053	150 571	130 038	109 505
III	Isoka	479 535	2 398	455 558	431 582	407 604
III	Kabompo	1 054 808	527	1 049 534	1 044 260	1 038 985
I	Sesheke	1 721 284	20 655	1 514 730	1 308 176	1 101 621

Extrapolation of spatial data results

Rate of forest cover loss in Zambia

The combined results of all the five study sites in annex 24 indicate that between 2000 and 2010 about 17 714.3 ha of forest cover were lost per year translating into an average loss of 3 542.86 ha of forest cover per district per year during the same period. Accordingly, we can estimate the rough average loss of forest cover for Zambia between the period 2000 and 2010, although five districts are not sufficient to provide data to represent the whole country. Zambia had 72 districts by 2010 and, therefore, we can roughly estimate that Zambia lost approximately 255 085 ha per year of forest cover between the years 2000 to 2010. The results of this study are in conformity with national deforestation rate estimates which are between 250 000 to 300 000 ha per year.

Average carbon emission for Zambia

Although the results from the five districts are not large enough to represent the whole country, we can estimate an indicative amount of carbon emission for Zambia by 2040 if the drivers of deforestation are unabated. From the results, the average carbon emissions per district by 2040 will be 7 998 973.4 tonnes of carbon. If we use the 72 districts in 2010, Zambia will have emitted 575 926 084.8 tonnes of carbon by 2040 if the drivers of deforestation are unabated. This is an average of 19 197 536.2 tonnes of carbon per year.

Non-spatial analysis of the drivers of deforestation and forest degradation

The results shown in annex 3 were analysed based on the data collected using PRA. Data from the literature review, focus group meetings, consultations, field observations and transect surveys were analysed, packaged and ranked according to the study objectives. The Statistical Package for Social Scientists (SPSS) was used to analyse data generated through semi-structured Interviews. A total of 235 questionnaires were administered and analysed covering 43 institutions and 192 community members including 88 female and 147 male respondents ranging from 19 years to above 60 years old. Respondents included youth, entrepreneurs, farmers, retired officers, indunas and those in formal employment.

Identification and ranking of the drivers of deforestation

Through consultations with community members on the ground, the study found that the drivers of deforestation differed slightly in relation to agro-ecological zones and geographical location (annex 3). The study team matched the community perceptions of the drivers of deforestation to two main categories, i.e. proximate (direct) and underlying (indirect) drivers of deforestation. Geist and Lambin (2001) in Gomez (2011) defined proximate drivers of deforestation as those originating from human activities that have an immediate direct effect on forest cover change. In other words, proximate drivers are land uses that cause a change in land cover and that in terms of scale are seen to operate at the local level. The underlying drivers of deforestation are the political, institutional and economic factors that unchain the proximate drivers of forest cover change (Geist and Lambin 2001).

The identified drivers were ranked by the community members to arrive at the top ranked drivers of deforestation for each study area. Each of these drivers was considered to be a variable that was assigned a score. The scoring method was based on the top five ranked drivers in each study area. The driver that ranked number one was given a score of five while the lowest ranked was assigned a score of one.

The score summation of each driver across the five study areas was done for the proximate and underlying factors and their importance was determined by the percentage score using the following equation:

$$\%\ \text{score} = \frac{\sum (\text{scores for a driver across the study area})}{\text{Total scores for all the drivers}} \times 100$$

The variable values obtained for each driver were useful in ranking all the drivers across the study areas. The proximate drivers were further grouped as shown in annex 4.

The underlying causes were also ranked and grouped as shown in annex 5. High poverty levels, unemployment and inadequate alternative energy and livelihoods were grouped as poverty-related issues. Weak policy and legislation enforcement, lack of community participation in forest management, inadequate consultation and collaboration between government and traditional rulers were grouped as policy and institutional arrangements.

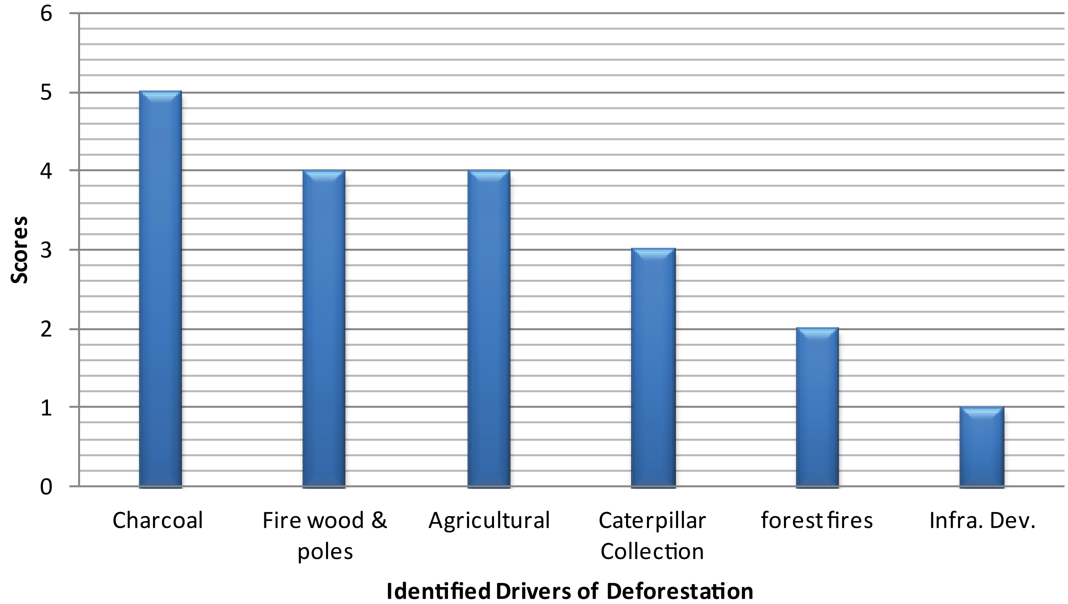
Proximate drivers

The drivers of deforestation were identified at district level. The study team further aggregated them to obtain the average results that were analysed in detail.

Kapiri Mposhi District

The community members and other stakeholders in the district attributed the loss of forest cover to the identified and ranked direct drivers of deforestation as shown in Figure 29. Extraction of wood for charcoal, fuelwood and poles were identified as top drivers of deforestation and forest degradation for the district.

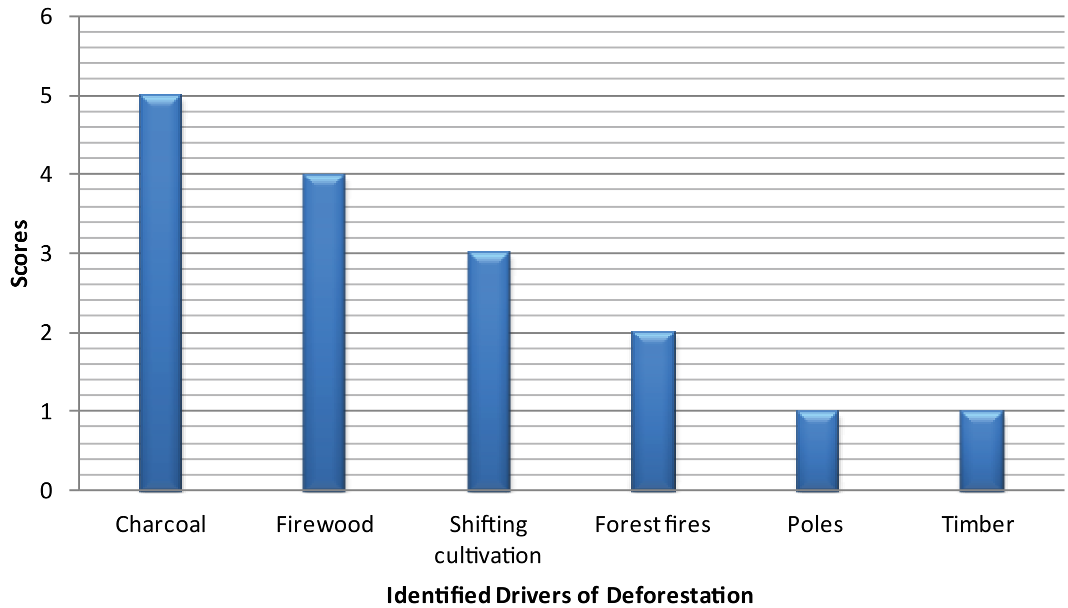
Figure 29: Identified direct drivers of deforestation in Kapiri Mposhi District



Nakonde District

The community members attributed the change in the forest cover to the identified and ranked drivers of deforestation as shown in Figure 30. Extraction of wood for charcoal and fuelwood were identified as top drivers of deforestation and forest degradation for the district.

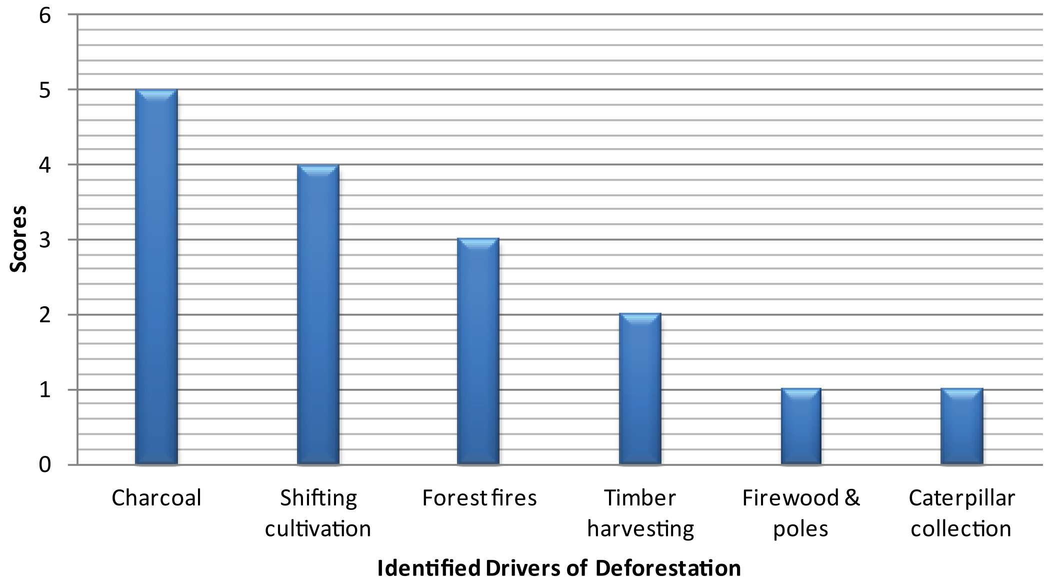
Figure 30: Identified direct drivers of deforestation and forest degradation for Nakonde District



Isoka District

The community members attributed the change in forest cover in Isoka to the identified and ranked drivers in Figure 31. Extraction of wood for charcoal and shifting cultivation were identified as top drivers of deforestation and forest degradation for the district.

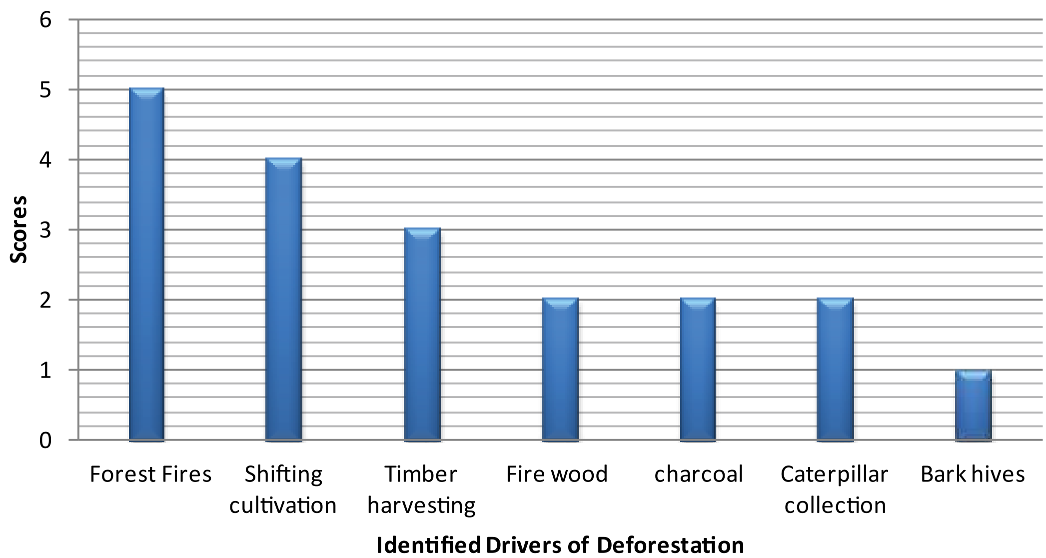
Figure 31: Identified direct drivers of deforestation and forest degradation in Isoka District



Kabompo District

The community members attributed this change to the identified drivers of deforestation shown in Figure 32. Forest fires and shifting cultivation were identified as top drivers of deforestation and forest degradation for the district.

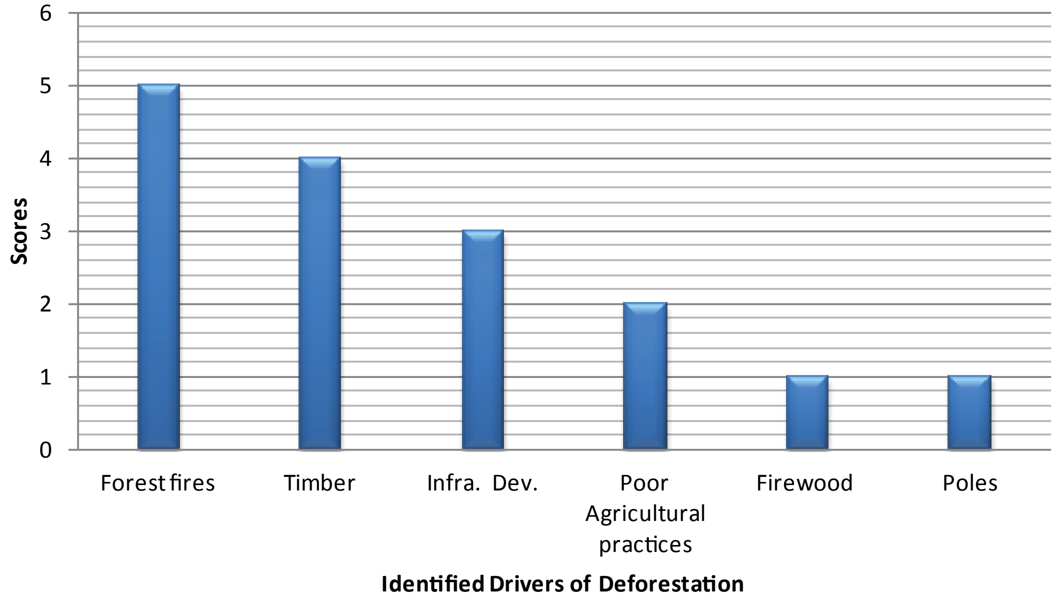
Figure 32: Identified direct drivers of deforestation and forest degradation for Kabompo District



Sesheke District

Community members attributed the change in forest cover to the identified and ranked direct drivers of deforestation shown in Figure 33. Forest fires and timber were identified as top drivers of deforestation and forest degradation for the district.

Figure 33: Identified direct drivers of deforestation and forest degradation for Sesheke District

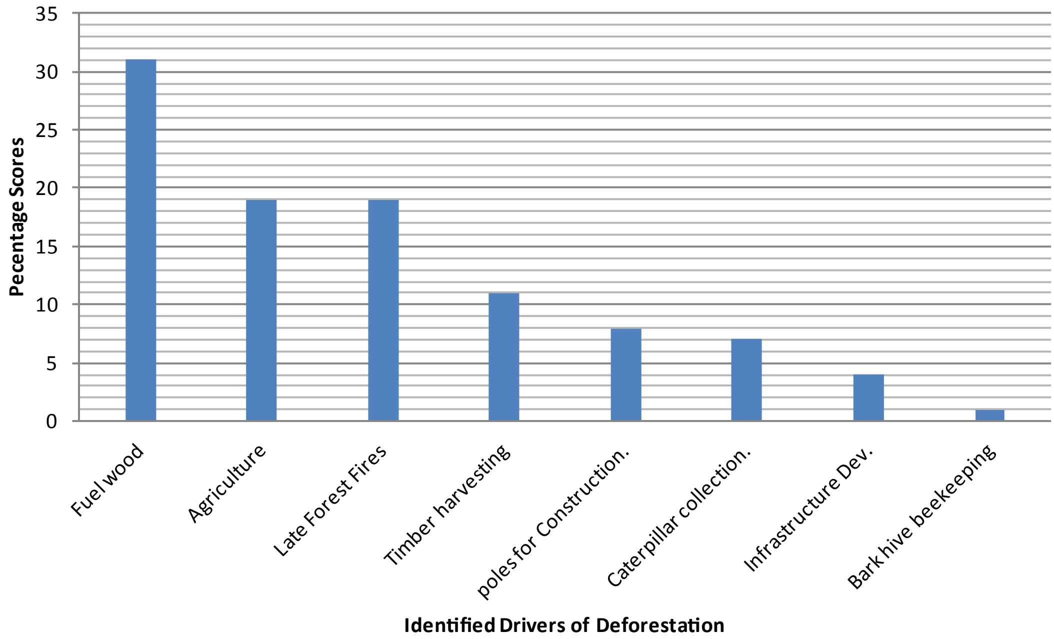


Combined results from the five districts

Figure 34 presents the aggregated and ranked top proximate drivers of deforestation and forest degradation. Annex 3 shows the combined results from the five districts. These include; fuelwood and charcoal, agriculture (shifting cultivation), forest fires, timber and pole harvesting. Other drivers include caterpillar collection, infrastructure development and traditional beekeeping using bark hives.

Source: created for this study

Figure 34: Ranking of proximate drivers of deforestation



Fuelwood and charcoal

This study found that fuelwood is a highly ranked driver ahead of poor agricultural practices. According to Chitondo (1997) about 0.7 to 1.0 percent of forest area is lost annually through deforestation as a result of agricultural expansion and charcoal production. Vinya *et al.* (2011) in the preliminary study on the drivers of deforestation in Zambia also found that fuelwood was the most frequent driver in nearly all the seven provinces sampled for their study.

Nkomeshya (1997) writes that the most encroached and/or depleted forest reserves are found near the urban areas. This gives an indication of high charcoal demand and consumption and also reflects the fact that the predominant land-use system is charcoal production in forests near to urban centres. Rural communities are completely dependent on fuelwood for cooking and heating. Kalumiana (1997) reports that fuelwood is the largest source of energy in Zambia, followed by petroleum, electricity and coal. It was estimated that about 19.4 million m^3 of fuelwood were consumed in 1996 (ZFAP 1997).

The high demand for fuelwood has resulted in non-species selective cutting regimes applied by many fuelwood producers, culminating in severe depletion of the forest ecosystems and the resultant land degradation. Most visited areas in Kapiri Mposhi, Isoka and Nakonde are almost bare especially near the district centres, providing evidence of increased fuelwood demands. Further evidence can be verified by encroachment and charcoal production even in protected forest areas.

Fuelwood for commercial use

This study found that there is an increased demand for fuelwood for burning earth-made bricks. This is more evident in Kapiri Mposhi, Nakonde and Isoka Districts. At the end of the rainy season, starting from about April to the onset of the rains in October, many trees even as small as 7 cm diameter juvenile stems are indiscriminately cut for fuelwood to heat up kilns to burn bricks. The demand for fuelwood to burn bricks has been triggered by the need to have better semi-permanent houses and to construct guest houses especially in Nakonde District, which is a border town with a high demand for travellers' accommodation. This has also been coupled with the high cost of cement, which is not affordable by most community members, to mould blocks. The use of burnt pan bricks has also engulfed the central districts of Kapiri Mposhi, Nakonde and Isoka. The business owners and those in formal employment have resorted to the use of burnt bricks for construction because they are cheaply sourced.

In Kapiri Mposhi, an opaque beer brewing company is providing a market for fuelwood. On a daily basis light trucks deliver fuelwood to the plant for brewing beer. The use of fuelwood to brew opaque beer is seen as cheaper than the use of electricity. The new market for fuelwood has doubled the problems of deforestation in Kapiri, which is already a charcoal production area. Consequently, Chibwe National Forest and Kapiri Mposhi local forests have been heavily deforested and degraded. This finding supports the view of FAO (1998) that trade in fuelwood will continue to increase as long as current unemployment levels continue to rise and sources of income continue to dwindle. Because forests are considered common property resources and/or gifts from God, they are more vulnerable to exploitation as a cheaper raw material base. People are not aware of the importance of forests as a solid foundation for national development. Since people have no capital to venture into other businesses, trade in fuelwood offers a business opportunity with almost zero capital investment. Unless people are educated about the true value of forests and other income-generating ventures promoted, such trends will mean increased trade in fuelwood, which will rank among the top income-generating activities. This is exacerbated by serious inadequacies in supervision and control of exploitation by the Forestry Department. This trade, however, will not be sustainable in the long run as wood stocks diminish and as more people join the trade.

Fuelwood for domestic use

The study found that community members depended entirely on fuelwood for cooking and heating because of lack of alternative sources of energy. Almost all the study areas revealed that fuelwood is the number one source of energy. The study revealed that in former days, when the population was still small, fuelwood collection in the forest did not contribute to forest cover loss because community members were collecting dead wood. The story is not the same today because fresh trees are being felled for fuelwood because of increased demand. A review and assessment of fuelwood in Zambia by FAO (1998) showed consumption and demand is expected to continue rising as the population in most areas continues to increase because of migration from rural to urban areas, high birth rates and decreased child mortality (assuming that AIDS will be controlled, together with other fatal diseases that negatively affect the population). However, current trends have always shown upward population growth rates irrespective of such adverse factors.

Charcoal production

As can be seen from the data analysis above, communities in all the five districts visited during the field study identified poverty, lack of employment and alternative livelihoods as the main challenges facing most of the ordinary people in Zambia today. Mwitwa and Makano (2012) made the same observation in their assessment of the supply and demand of charcoal in Eastern and Lusaka Provinces. The study also ground truthed the worrying signs of charcoal emerging in

North-Western and Western Provinces observed by Vinya *et al.* (2011). It found that in North-Western Province, especially Kabompo itself, charcoal production was not very pronounced except for a few traces in Solwezi District. However, charcoal production could expand in Solwezi District because of the opening up of mines.

It is evident that as long as poverty levels remain high and the market continues to grow, charcoal production will continue. According to this study, charcoal has also entered the export market. This was evident from the findings in Nakonde District. Heavy trucks were observed carrying bags of charcoal across the border into Tanzania (Figure 35).This was confirmed by a study carried out by a community-based organization known as the *Imiti Ikula Empanga* based in Chinsali, Isoka and Nakonde Districts that revealed that about 50 to 60 bags of charcoal per day were crossing the Zambian border into Tanzania (*Imiti Ikula Empanga* 2012).

Figure 35: Foreign truck ready to cross the border with Zambian charcoal

Source: Taken for this study

The study also observed that charcoal was the only major merchandise being marketed along the road sides all the way from Mpika District to Nakonde District. According to the 2010 census, the population of Nakonde stands at 118 017, of which 53 449 are male above the age of 18, with 23 023 households most of which depend on forests for their livelihoods (*Nakonde District situation analysis report* 2012). The report also confirmed the study observations that charcoal production is among the major sources of livelihood in the district, especially for rural communities and that the most common means of earning a livelihood in Nakonde is producing and/or trading in charcoal.

Similar observations were made in Kapiri Mposhi where charcoal production and trade is widespread. On the other hand, charcoal production and trade is not a prominent feature in Sesheke and Kabompo.

The bias here is towards socio-economic interests while environmental interests are overlooked. Initially charcoal production and trade look lucrative but the long-term impact can be very serious. In the 1960s and early 1970s, charcoal was produced within a six kilometres radius of the city centre; yet today the area within the radius of 60 km of Lusaka District is considered a fuelwood deficit area, with no capacity for charcoal production for its consumption (Mwitwa and Makano 2012). Charcoal production coupled with unsustainable agricultural methods can cause an area to be deforested to a point of being wood deficit (see Figure 36).

Figure 36: Loss of forest cover through cutting of trees for charcoal production

Source: Taken for this study

Agriculture

The importance of agriculture to both the household and national economy cannot be overemphasized: 60 percent of Zambia's population depends on it for both food and income security; and 68 percent of the people are poor and depend upon land resources for their survival (ILUA 2008). According to research carried out by Development Aid from People to People in Zambia (2011), out of the 58 percent of the land suitable for agricultural production in Zambia, only 14 percent is currently under cultivation. However, the information gathered from the field indicated that there is a perception in the country today that there is scarcity of land for settlements and farming.

This study identified the following drivers of deforestation as related to agriculture:

Expansion of land and lack of inputs

The study reveals that the need for agricultural land is increasing mainly because of the population growth and lack of farming inputs (fertilizer). The community members informed the study team that there is a direct correlation between the increase in the number of people in a particular area and the corresponding increase in demand for farming land. The study revealed that, on average, a household requires at least one hectare to practise reasonable farming. Soil fertility diminishes when land is overused for agriculture and hence the rural community opts to open up forest where soils are still fertile. This is because most rural people cannot afford bags of fertilizer to increase their yield. To offset the missing commodity, most rural farmers extend their fields in an effort to increase the yield grown without fertilizer. This in turn entails that more forests are opened.

In 2001/2002, the Government of Zambia (GRZ) intervened in the agricultural sector when it introduced an input subsidy via its Farmer Support Programme (FSP) now called Farmer Input Support Programme (FISP). FISP started providing seed and fertilizer at a 50 percent subsidy. Currently it is much higher than that. In 2006 FISP, along with the government maize marketing activities via the Food Reserve Agency, consumed about 90 percent of the Ministry of Agriculture and Co-operatives (MACO) budget (see Table 13), according to Campbell *et al.* (2010).

Table 13: 2006 Ministry of Agriculture and Co-operatives (MACO) Poverty Reduction Programmes (ZMK Billions)

Research	1
Maize marketing	50
Fertilizer support programme	199
Commercialization	2
Livestock diseases and fisheries	4
Irrigation	2
Land development	6
Other	6
TOTAL	270

Note: Only 15% of farmers benefited from the fertilizer support programme.
Adapted from: Campbell *et al* (2010)

The amount of money spent in the support programme may fluctuate from one year to the next. However, despite the large fertilizer and maize marketing subsidy, the majority of the small-scale farmers interviewed complained of not having enough inputs, hence needing to engage in charcoal production. Statistics show that in Zambia about 80 percent of all smallholders grow maize, but of this total 64 percent do not have access to fertilizers to replenish the minerals extracted by this demanding crop (Campbell *et al.* 2010). It seems, therefore, that as long as the population continues to grow and fertilizers continue to be unobtainable, farmers will continue poor farming practices and forests will continue to be opened, hence increasing deforestation.

Shifting cultivation (chitemene system)

In the past shifting cultivation was very popular in the Northern and Luapula Provinces, and to lesser extent parts of North-Western and Western Provinces. It used to be practised on traditional land. The main reason for its growing practice is said to be soil infertility and expensive agricultural inputs. It seemed sustainable with small populations. However, growing populations have made this system very unsustainable. This is taking its toll on very important forests like the teak forests *(Baikiaea)* in Western Province where people have encroached on the protected forests on the pretext of lack of fertile land. Its combination with late wild fires is devastating these important forests.

It is also becoming widespread in the *Cryptosepalum* forests of North-Western Province where, in combination with fire, it is damaging the forest. The *Baikiaea* forests and *Cryptosepalum* forests make up the bulk of the closed forest formation in Zambia. The same system of agriculture has also always been and still is a very serious threat to the Miombo woodlands both in the Northern, Western, North-Western, Luapula Provinces and parts of Central Province where millet and cassava are staples.

Source: Taken for this study

Figure 37: Shifting cultivation (chitemene) in north-western Kabompo

Late forest fires

The ranking scores reveal that fire and agriculture rank second as causes of deforestation because they both affect all forests and vegetation types. Fire as a driver is more prominent in Sesheke and Nakonde Districts. In Sesheke District, the community members observed that, in the past, forest management was good because the community worked together with the Forestry Department, especially in forest fire break maintenance, forest fire control, and forest fire surveillance using towers and warning systems. They confirmed that the towers no longer exist because they have been vandalized and parts taken away. Another case is that of Nakonde local forest number P:303 in Nakonde District. This forest has a total area of 417 ha of which 150 ha is a plantation. It has been experiencing a series of fire sweeps (Table 14) because the boundaries were last maintained in 2007 (Nakonde DSA 2012).

Table 14: Fire challenges in Nakonde local forest number P:303

Species	Area (ha)	Status
Pine (*Pinus kesiya* and *Pinus Oocarpa*)	100	Clear felled by 2008; 70 ha reforested; fire damage and theft resulting in sparsely stocked area; vigorous weed growth.
Eucalyptus	50	Poorly stocked stands due to repeated fires and theft.
Indigenous forest	267	Has been disturbed by charcoal producers and fuelwood harvesters.

Source: Nakonde DSA (2012)

Frost (1992a) also reports that widespread and uncontrolled burning is common during the dry season in the Western Province of Zambia destroying large areas of rangelands, woodlands and forests. Some fires are started deliberately by livestock owners seeking to promote a green flush for their animals, by rodent hunters clearing vegetation to catch their prey more easily, by people creating firebreaks around their homesteads or seeking to improve visibility, or by individuals playing with fire. The fires are also ignited by people clearing land for cultivation, smoking out beehives, making charcoal, cooking or trying to keep warm. The uncontrolled fires can spread accidentally from their sources into the surrounding bush where they usually burn themselves out some distance away, often crossing into a different vegetation type.

Gambiza *et al.* (2000) reveals that many of the woodlands are beginning to show signs of damage from too frequent and intense fires. This is exacerbated by timber extraction, which is opening up the woodland canopy and allowing more light to reach the herbaceous layer, thereby promoting increased production of grass and fire-resistant shrubs that fuel the fires. Fires kill the more fire-sensitive trees and suppress the re-growth of the more resistant species. This is preventing the re-establishment of the woodland canopy, which would suppress herbaceous production and reduce fuel loads, fire frequency and intensity.

Caterpillar harvesting

Caterpillar harvesting is more common in Kabompo and Isoka Districts. It was identified as one of the drivers of deforestation and it can be a very aggressive form of deforestation that targets selected species harbouring caterpillars. Caterpillar collection is a periodic traditional livelihood strategy that peaks during October and November. From the field observations, the collection of caterpillars involves cutting the host tree, thereby causing serious forest degradation in some areas. The preferred host tree species are mainly *Brachystagia spiciformis* and *Julbernardia paniculata,* which form a major part of the forest species composition. Caterpillars invade almost all the standing trees regardless of age and size, and the caterpillar collectors move in and cut down most of the trees in order to access the caterpillars. In the process they leave behind a lot of litter on the forest floor, which becomes a serious fire hazard. The late forest fires then sweep over the forest floor and often leave behind large fire holes that eventually open the forest cover. One fire hole can be as large as a quarter of a hectare. The loss of forest cover also results in the loss of sources of nectar and pollen for honey production especially in Kabompo District. Cutting down these trees means deprivation of honey production, resulting in decreased food and income earnings for those that are dependent on honey production.

Historically, collection mainly involved the lopping of branches rather than bringing down of the whole tree. Coppicing is often expected to ameliorate the situation. This scenario is aggressively changing because caterpillar collectors are now felling the whole tree just to collect a handful of caterpillars, forgetting that they will need the same tree to harbour the caterpillars the following year.

Mbata and Chidumayo (2003) found that caterpillars provide an alternative source of dietary animal protein and are associated with several cultural and spiritual processes and beliefs which bind the *Bisa* people together as one tribe. Edible caterpillars are bartered and sold at markets in Lusaka and Copperbelt. As long as this demand exists, community members will continue to fell the trees.

Figure 38: Small trees cut for caterpillar collection

Source: Taken for this study

Infrastructure development

Development agents tend to neglect the negative impacts of infrastructure development on the forests; hence very few mitigation measures are taken to ameliorate the land degradation that takes place during such developments. A case in point is the quarrying taking place along the Katima Mulil–Senanga road currently under construction and the sand mining taking place in Chibwe Forest in Kapiri Mposhi.

Case study: Sesheke and Kapiri Mposhi Districts

This study found that quarrying along the Zambezi is leaving behind a degraded landscape. It is damaging the seepages that form the mini-wetlands (*matapa*), which are very important gardens for the communities along the Zambezi River. The detours (road construction traffic deviations) pass through the same communities' upland gardens, displacing them and forcing them to move into the forests further upland. Pressure on this area is likely to continue for some time as Namibia is also quarrying this area for its road construction programme. It is very important for Zambia to take note of the impact of quarrying on forests because the country will be undertaking large road infrastructure development projects. For example, the Link Zambia 8000 entails major construction of 8 000 km of roads to link provinces to each other and the country to neighbouring countries. Pave Zambia projects, recently announced by the Government, will largely cover the urban roads.

Figure 39: Sand mining eating away Chibwe National Forest

Source: Taken for this study

The study also found that sand mining was being done largely to support building construction projects undertaken by both individuals and the Government (especially the Ministry of Education) in both Kabwe and Kapiri Mposhi Districts. The *modus operandi* is detrimental to the forest ecosystem as the vegetation along the river bank and surrounding forests is being cleared and forest cover loss is growing by the day.

Big abandoned trenches from sand mining were seen by the study in Kapiri Mposhi's Chibwe National Forest. Sand mining in these areas is being done unsustainably, and the miners usually operate without after-use plans and legal government documentation. Kabwe and Kapiri Mposhi and many recently created districts are in their development renaissance, and infrastructure development will demand resources like sand.

What is happening in Kapiri Mposhi may spread to most of these areas in Zambia, the forests taking the brunt of the impact.

Timber and pole harvesting

Although most timber traders argue that timber harvesting does not contribute to deforestation, this study found that community members and other interest groups believe that it is actively contributing to deforestation. According to the community members, timber harvesting has selectively eliminated timber species because concession holders and illegal timber dealers no longer cut only the mature, allowable sizes but are cutting everything, including the small trees.

Malambo and Siyampungani (2008) report that timber harvesting of valuable species such as *Pterocarpus angolensis, Brachystegia floribunda, Afzelia quanzensis, Erythrophleum africanum, Pterocarpus rotundifolius, Dalbergia melanoxylon* and *Isoberlinia angolensis* is prominent. Other valuable species also include *Baikiaea plourijuga and Geuibourtia coleosperma.* Timber harvesting takes the form of single tree selection harvesting and thus the woodland appears to remain intact for some time, but later it slowly changes.

The problem is worsened because the Forestry Department is not adequately staffed to be able to monitor logging operations. Forest hygiene (clearing the forest litter from logging operations) is at the minimum. This situation is more evident in Sesheke District. The traditional authorities have observed that timber concessions are issued by the Forestry Department without consultation and consent of the Royal Establishment and forestry exploitation is taking place with little or no supervision. Consequently, concessioners neglect to follow the management plans they present to the Forestry Department prior to obtaining a timber exploitation licence. Some are said to be dishonest in declaring the quantities of timber they have exploited in an effort to underpay the expected royalties; some even purchase unlicenced timber from illegal dealers; very few observe forest hygiene like piling and burning of branch wood, trimming of stumps and management of residues from sawmilling. Non-observance of the management plan and forest regulations has a negative effect on the health of the forests.

The study found that the timber extracted in Kabompo is used mainly for making doors, roof construction and furniture, while in Sesheke timber is exploited for furniture, rail slippers and export to other countries. This is a source of income for small producers.

Community members and other stakeholders observed that the need for building poles is also on the increase. After the change of government in 1991, Zambia witnessed a construction boom and an increased demand for construction poles. As long as there is a demand for timber and poles locally and abroad, coupled with the continued skeleton forestry staff, this driver is capable of wiping out all the valuable timber species. Timber extraction also opens up the woodland canopy and allows more light to reach the herbaceous layer, thereby promoting increased production of grass and shrubs that fuel fire.

Traditional beekeeping

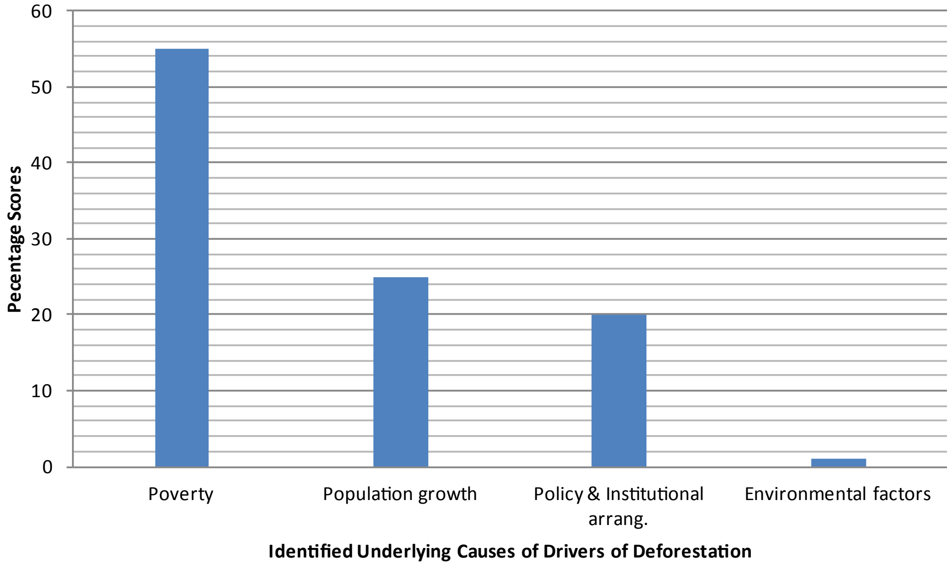
In Kabompo, North-Western Province, the study found that honey production was a major source of livelihood for a large rural population. On average an individual beekeeper produces about one tonne of liquid honey per honey season translating into two tonnes per annum. Most of the beekeepers use traditional bark hives scattered in the forest instead of apiaries with conventional top bar frame hives. The reason for this, according to the beekeepers, is that they lack support in terms of modern beekeeping technology and infrastructure.

Traditional bark hive making is not environmentally friendly because stripping the bark results in killing the trees that are the host tree species from which bees collect pollen and nectar for their honey production. In Kapiri Mposhi District, the use of bark hives was not as pronounced. Beekeepers were using more frame hives and log hives. A good number of beekeepers were adapting the mud hive concept, which is more environmentally friendly and cost effective in terms of start-up capital.

Underlying Drivers

Underlying drivers of deforestation are the political, institutional and economic factors that unchain the proximate drivers of forest cover change (Geist and Lambin 2001). The study revealed that there are four main categories of causes that underpin the proximate drivers of deforestation: high poverty levels, population growth, policy and institutional arrangements, and environmental factors.

Figure 40: Percentage score for each underlying driver of deforestation



Source: Created for this study

High poverty levels

As seen from Figure 40, poverty was the most highly ranked driving force behind the proximate drivers of deforestation. In this study all issues related to lack of employment, income, livelihoods and energy were considered ingredients of high poverty levels. Respondents in all five study areas explained that high poverty levels are the biggest problem they are facing. A review of the poverty situation shows that the incidence of poverty in Zambia has continued to be high despite recording a slight decline from 62.8 percent in 2000 to 60.5 percent in 2010. Results further show that the problem of poverty in the country has continued to be more of a rural than an urban phenomenon. Despite experiencing a decline in rural poverty from 80.3 to 77.9 percent between 2006 and 2010, levels of poverty in rural areas are still exceptionally high compared to urban poverty (CSO 2011).

Further characterization of poverty by level of intensity reveals that the majority of the population was afflicted by extreme levels of poverty. Out of the total estimated population of 11 and 13 million persons in 2006 and 2010, respectively, over 42 percent were classified as extremely poor. The percentage of the extremely poor marginally declined from 42.7 percent in 2006 to 42.3 percent in 2010, compared to moderate poverty, which decreased from 20.1 percent to 18.2 percent during the same period. Results further reveal that there were proportionately more extremely poor persons in rural areas (about 58 percent) than in urban areas (about 13 percent) during the review period (CSO 2011).

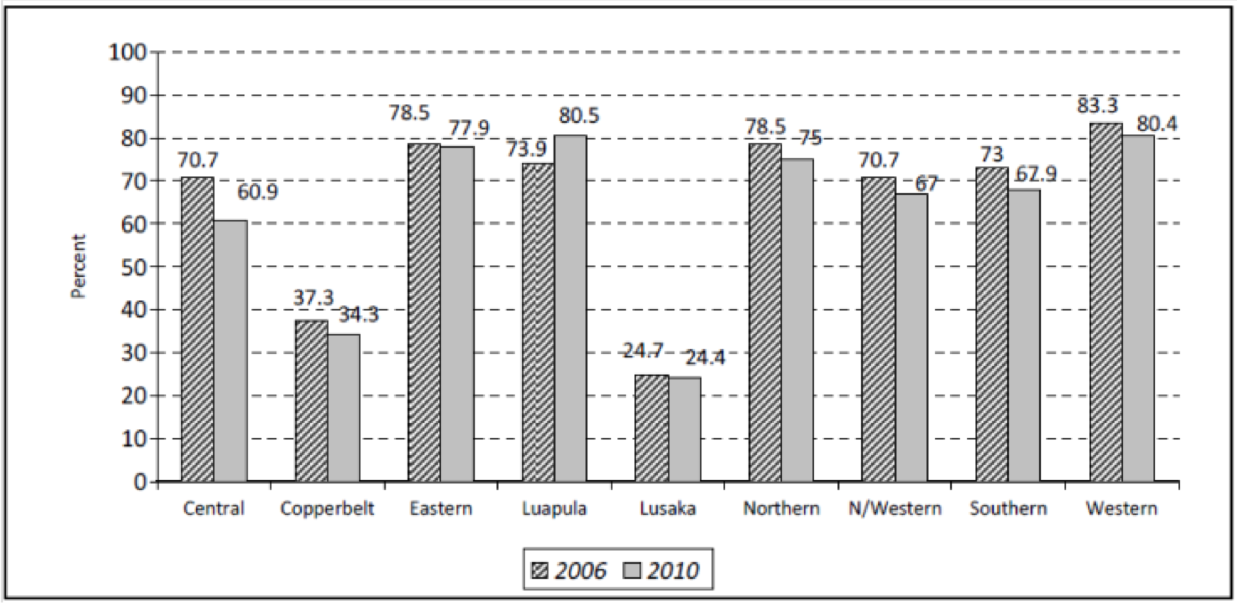
Table 15: Distribution % of the population by poverty status and residence, 2006-2010

Year	Residence	Poverty Status		
		Extremely Poor	Moderately Poor	Non-Poor
2006	Total	42.7	20.1	37.2
	Rural	5805	21.8	19.6
	Urban	13.0	16.7	70.3
2010	Total	42.3	18.2	39.5
	Rural	5707	20.2	22.1
	Urban	13.1	14.4	72.5

Source: Living conditions monitoring survey 2006 and 2010

The provincial analysis of poverty reveals that levels of poverty have continued to be high in predominantly remote provinces such as Luapula, Western, Eastern and Northern. The opposite is true for highly urbanized regions such as Lusaka and the Copperbelt Provinces where levels of poverty have remained exceptionally low (CSO 2011).

Figure 41: Poverty changes by province, 2006-2010



Source: Living conditions monitoring survey, 2006 and 2010

The high poverty levels have taken a toll on the forests especially in the rural areas where there are insufficient economic safety nets. Most community members in the study areas indicated that lack of sufficient income to take care of their daily needs such as food, clothing, education for children, farming inputs, shelter and access to quality health facilities, have forced them to turn to the forest for help. Most of them testified that they do not like engaging in illegal activities and that they feel bad that the forests are disappearing, but they have no choice because they need to survive. Sustainable forest management demands that resources are managed for the current and future generation, but this seems not to be true for a poverty-stricken population that strives every day to put food on the table. The situation suggests that they do not mind what happens tomorrow or in the future because they have to battle to survive today. As long as the poverty levels are high, deforestation will increase.

Population increase

Population increase was identified by the community members and other stakeholders as one of the main underlying causes of forest cover loss. The community members confirmed that as the population increases, demand for land for agricultural purposes also increases, as does the demand for charcoal, fuelwood, poles and timber. Zambia's population captured by the 2010 census of population and housing stood at 13 092 666. This is an increase from the population of 9 885 591 captured during the 2000 census of population and housing conducted exactly ten years earlier. Of the 13 092 666 population enumerated in the 2010 census, 7 923 289 or 60.5 percent reside in rural areas, while 5 169 377 or 39.5 percent reside in urban areas. Population grew at 2.8 percent per annum between 2000 and 2010 (CSO 2011).

Although all the study areas visited showed that there were some pockets of well wooded forest, anthropogenic activities suggest that they are fast losing this status because of demand for land as a result of population increase and the south-to-north in-migration. Of the five study areas, Kapiri Mposhi District has been one of the main recipients of this south-to-north population in-migration to the extent that almost all the gazetted forests along the railway line are encroached for settlement and farming. Chief Nkole of the Swaka people in the district lamented that part of his land given to the state for the purported well-planned resettlement scheme turned out to be a hub of unscrupulous immigrants who are destroying the once beautiful forested area through charcoal production.

Some community-based organizations have also voiced their concerns over deforestation. *Imiti Ikula Empanga* (the growing trees are the future forests), a CBO operating in Muchinga Province, observed that deforestation has increased because population growth has increased the need for more land and houses. Local people are thus harvesting a lot of poles and reeds along the streams to construct houses. The demographic factors that affect the environment increase demand for land for agriculture and settlements as well as for fuelwood, timber and building poles, etc. If these demands are not met through sustainable land-use planning, deforestation will manifest itself in its various forms.

Table 16: Average annual rate of population growth by province, 2000-2010

Province	2000 Census	2010 Census	Growth rate 2000–2010 (percent)
Zambia	9 885 591	13 092 666	2.8
Central	1 012 257	1 307 111	2.6
Copperbelt	1 581 221	1 972 317	2.2
Eastern**	1 231 283	1 592 661	2.6
Luapula	775 353	991 927	2.5
Lusaka	1 391 329	2 191 225	4.6
Muchinga*	524 186	711 657	3.1
Northern**	809 400	1 105 824	3.2
North-Western	583 350	727 044	2.2
Southern	1 212 124	1 589 926	2.8
Western	765 088	902 974	1.7

* Figures adjusted following the new provincial demarcations.
Note: *Muchinga was created in 2011.
Source: 2000 and 2010 censuses of population and housing

Policy and institutional arrangements

Policy and institutional arrangements were identified as the third important underlying cause of deforestation by all the study areas visited. Inadequate policy, law enforcement and institutional arrangements open the door to direct causes of deforestation.

Policy and legislative enforcement

Geist and Lambin (2001) report that policy and legislation are important factors as far as forest management is concerned. Accordingly, a non-conducive policy climate is responsible for deforestation. This study found that the current forest policy has failed to address the prevailing forestry issues in the country. Policy is inadequately articulated and differences exist between policy and the complex reality of implementation. Forest management has weakened; there is no proper allocation of sufficient resources or staffing. This has bred patron-client relations, where resource users are at the mercy of officers, or officers have allegiance to powerful licences, vested private interests, and corruption. Further evidence of this is weak or no environmental control and, hence, continued deforestation.

Case studies

1. Policy failure is very evident in the Baikiaea forests. Staffing in the once vibrant Zambia teak forests is almost non-existent; transport logistics are not available to the skeleton staff; staff accommodation at Machile and Masese forest stations has crumbled into ruins; fire towers are gone, to cite but a few cases. The resultant situation is that:
    - the *Baikiaea* forests are being indiscriminately burnt down by fires;
    - protected teak forests (*Baikiaea*) are being encroached for settlement and shifting cultivation;
    - logging supervision is at its lowest; and
    - forest extension services are non-existent and, as a result, relations between the once supportive community and its traditional leadership and the Government have broken down.

2. Another case of policy failure can be seen in Chibwe National Forest (a Miombo open woodland) in Kapiri-Mposhi District. Here sand mining has reached alarming levels. On the surface it may seem negligible, but this study found that this activity, which once was a small-scale venture that supported the livelihoods of the local communities, has:
    - been taken over by powerful people who have displaced the local community and introduced more sophisticated sand mining equipment than the hoe and shovel used by the local people;
    - displaced people's livelihoods. People are, therefore, resorting to charcoal production as an alternative means

of livelihood This has led to poverty in the local community; degradation of land at the sand mining site; overexploitation of forest resources (especially trees) in Chibwe National Forest; destruction of trees along the stream bank causing a reduction of water flow in the stream. As a result. Chibwe National Forest is fast being lost to deforestation.

Figure 42: Sand mining: a threat to Chibwe National Forest

Source: Taken for this study

3. The third case is that of timber, charcoal and non-wood forest produce (devils claw) exports. Public policies have failed to implement value added requirements on timber extraction, and the country continues to lose large volumes of timber in exports. Charcoal is also illegally exported to Tanzania at the Nakonde-Tunduma border as observed by this study. Devils claw is in high demand in Namibia, South Africa and Botswana. It is currently heavily exploited in Sesheke and has caused concern to the district administration, FD and the World Wide Fund for Nature (WWF).

4. Weak forest extension policies are another serious concern. A case in point is the traditional beehive making practices in Kabompo District. This cannot be underestimated as beekeeping is one of the most important livelihoods for the people of North-Western Province. It is important to facilitate the best and most sustainable practices in all aspects of forest resource utilization.

5. Sustainable forest management requires adequate resources to operate efficiently. The study revealed that although there are few forestry staff at a station, working under challenging circumstances, they raise and deposit more revenue into the central government treasury than they receive for operations. The district offices are not permitted to use any revenue raised directly at source. Once revenue is deposited into the central treasury, the Government decides the use of the money according to priority areas that may not be forestry-related. For instance, Kapiri Mposhi District forestry office raised a total revenue for the year 2011 of Kwacha (K)115 766 400, but received only a fuel cheque of K1 792 000 and K264 000 for operations for the whole year. This is a policy matter that the Government must address. If the Government is serious about addressing the issue of deforestation, a reasonable percentage of the sum total raised should to go back to the district for continued support to sustainable forest management. As long as the district forestry offices are insufficiently funded, deforestation will continue to increase.

Lack of alternative energy sources

There is high demand for energy in Zambia today, both to sustain the economy and for domestic use. Charcoal is produced in the rural areas mainly by rural communities and consumed in the urban areas. The urban communities are constantly faced with the challenge of the cost of electricity. They see charcoal as a cheaper energy and income alternative. Charcoal production and trade is beneficial to both men and women. Alternative and renewable energy sources such as solar are available in most hardware shops at the moment but are too expensive for the majority of Zambians and have not been popularized to the point of adoption. This means that about 90 percent or more of the rural population will continue to be fuelwood dependent population. Fewer and fewer households will use alternative and renewable energy sources because of their increasing cost and because prices for electric devices such as stoves and heaters are unaffordable to most people, especially rural communities.

Case study

Nakonde District: According to the Nakonde Integrated Development Plan (IDP) status quo report 2010 in the *District situation analysis for Nakonde* (2012), charcoal and fuelwood account for 79 percent of energy consumed in Nakonde. Generally urban and peri-urban populations use charcoal for cooking purposes, while rural populations use mostly fuelwood. This, coupled with high demand for charcoal and fuelwood in neighbouring Tanzania where the law against illegal cutting of trees is stiffer, continues to exert pressure on the forests. According to the report, charcoal smuggled out from Nakonde and other parts of Zambia went as far as Kenya and Uganda. The forest resources were dwindling rapidly from over-dependency on forests because of limited alternatives to energy sources (as illustrated in table 17) and construction materials.

Table 17: Sources of energy for cooking in Nakonde District

Energy source	Number of people
Electricity: households connected to the grid	331
Wood	963
Paraffin	109
Charcoal	692
Coal	13

Source: District situation analysis for Nakonde District (2012)

"The challenges of reducing deforestation in Zambia include, among others, improving linkage and coordination among relevant institutions in NRM; regularly updating information on the status of forests in the country; enhancing complementarities of relevant policies and institutions; making NRM policies supportive and inclusive; developing a close relationship between infrastructure development and forest conservation; eliminating or minimizing political interference in forest resource management; promoting secure land tenure systems; developing clear policy and guidelines that effectively address issues of benefit sharing mechanisms".

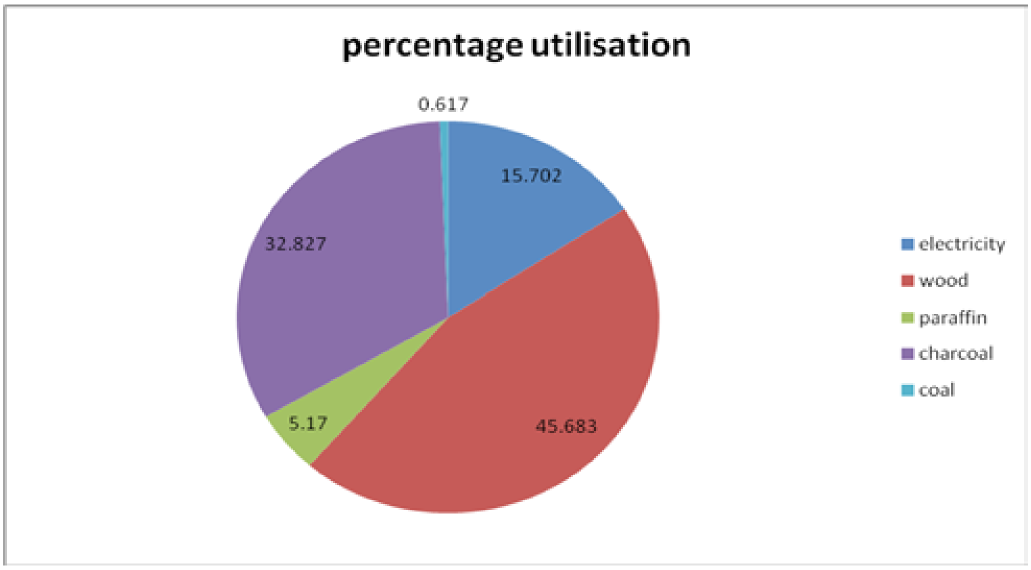
Figure 43: Charcoal being sold on the road side

Source: District situation analysis for Nakonde (2012)

High poverty and unemployment levels in the district make it difficult for people to afford electricity, rendering charcoal and fuelwood the only alternative.

Forty-five percent of the sampled population use charcoal while 32.83 percent use wood. If combined, the total percentage of people using wood products for cooking stands at approximately 79 percent. From the sampled population, it is clear that fuelwood and charcoal are the most used sources of energy for cooking. This puts pressure on the forest, causing loss of vegetation cover and consequently deforestation, which contributes to global warming and climate change in the long run. Furthermore, the district does not have clean sources of energy such as gas (*District situation analysis for Nakonde District* 2012).

Figure 44: Percentage utilization of different energy sources



Source: Created for this study

Institutional-based factors

Stakeholder participation is key to natural resource management (NRM). Therefore, it is important to look at the perspectives of different stakeholders, including government institutions, non-governmental institutions, private sector institutions, community-based institutions and traditional institutions.

"The challenges of reducing deforestation in Zambia include, among others, improving linkage and coordination among relevant institutions in NRM; regularly updating information on the status of forests in the country; enhancing complementarities of relevant policies and institutions; making NRM policies supportive and inclusive; developing a close relationship between infrastructure development and forest conservation; eliminating or minimizing political interference in forest resource management; promoting secure land tenure systems; developing clear policy and guidelines that effectively address issues of benefit sharing mechanisms".

Source: Vinya *et al.* (2012)

This study affirms the importance of synergies in policy and legislative frameworks in curbing deforestation, as seen by Vinya *et al.* in the preliminary study on the drivers of deforestation in Zambia. Primary and secondary service centres such as schools, health centres, cooperative depots and shops have been established to service people who have illegally settled in protected forest areas. These services have given the impression that the Government has consented to people occupying these forests, legitimizing the demand for the excision or de-gazetting of protected forests. There is, therefore, a need to harmonize settlements with the need for forest protection.

Case Studies

1. The Sichinga forest in Sesheke District was partly excised for a joint agriculture scheme between the Governments of Zambia and Namibia. This scheme has been abandoned because of lack of cooperation between the institutions, and people are now allocating themselves land parcels with impunity, claiming they have been given this land by traditional authorities. An informal settlement called *Lyambango* (meaning something done at will) has also emerged at the same forest. Since it is an informal settlement, it cannot be serviced by the district council in terms of water and electricity. The people are using the forest for their energy needs and are even girdling *mukusi* trees to dry them up quickly for fuelwood. Here the Forestry Department, Department of Agriculture, the Sesheke District Council and the traditional authorities could have sat down to discuss the best way to manage this land.

2. The provision of primary and secondary service centres such as schools, health centres, cooperative depots and shops to service people living illegally in gazetted forests gives the impression that the Government has consented to people occupying these forests, legitimizing the demand for the excision or de-gazetting of such protected forests. A case in point is the construction of a highschool in Kapiri Mposhi local forest without consultation with Forestry Department. This scenario again shows the lack of coordination between local government, central government and the traditional authorities on issues pertaining to forestry.

3. The positive impacts of forest protection have decreased due to the restructuring of the Department of Forestry in the late 1990s, leading to the loss of forest rangers and forest guards who understood the importance of forest patrols, forest boundary maintenance, early burning and prosecution of forest offenders. These have been replaced by a cadre of extension assistants whose preoccupations are market patrols and road blocks. This has been exacerbated by the emphasis on raising more forest revenue at the expense of forest protection. This has exposed this cadre to corrupt practices. It is important for all concerned to realize that each bag of charcoal or log represents a tree lost; each truck of charcoal or timber seen on the market or road block is a forest lost.

4. The staffing levels of most forest stations especially at district level are very low. For example, it was found that at the Isoka District forestry office, there was only one technical staff, i.e. the district Forestry Officer (DFO). In Nakonde District, the forestry office had only three technical staff, which is not adequate for such a busy town as Nakonde. It seems that the distribution of staff in the department is not even. For example, the Kapiri Mposhi District office had about seven technical officers, which was much higher than in other stations.

Source: DSA Nakonde (2012)

Figure 45: Patrols and inspections at Wulongo check point in Nakonde District

Inadequate consultation and collaboration between the Government and traditional rulers

Chiefs observed that there is inadequate consultation and collaboration between them and the Government on developmental issues, leading to environmental degradation such as deforestation.

Case Studies

His Royal Highness, Chief Nkole of the Swaka speaking people of Kapiri Mposhi District, in a discussion on forest resource protection and management in his chiefdom, expressed worry over rampant indiscriminate cutting of trees for charcoal production. The chief specifically expressed concern about the manner in which trees were being cut for charcoal production in the newly established government agricultural scheme in Katanino forest area. His earlier understanding was that upon acquiring the land from him, the Government would improve road infrastructure, schools, clinics and water supply (sink bore holes). To the contrary, he was seeing massive clearing of trees not for agricultural production but charcoal manufacturing. If not controlled, this would impact negatively on climate change. The chief had already noticed change in the rainfall pattern due to deforestation. The chief was equally worried over where to take his subjects who had been evicted from the scheme to make way for new settlers.

The Senior Chief Sikufele of Kabompo District confirmed that there had been a serious reduction in forest cover and forest products in his chiefdom over the years. He noted with dismay that despite forests providing his subjects with many things, some people did not care to conserve the forests. He identified inadequate forest extension services, inadequate staffing (forest guards), inadequate logistics; lack of alternative livelihoods for the community; and inadequate incentives and motivation for community participation in forest management as some of the reasons why deforestation is taking place.

Finally the senior chief said he had enough traditional land on which to settle his subjects in all the areas bordering forest reserves. He, therefore, found it strange for any of his subjects to encroach on a forest reserve either for farming or settlement.

Indunas at Mwandi Palace gave the historical background of forest management, dating back to the 1930s. They pointed out that forests were managed by the Government in conjunction with the Barotse Royal Establishment. The key features of this management are:

- traditional rules and regulations that were applied alongside the legal and policy framework;
- the position of the *Induna* (*Induna Anasambala*) in charge of forests in the royal court who worked closely with the district forestry officer (DFO), and village forest *Indunas* who worked alongside the government forest guards: and
- the sharing of revenues between the Government and the Barotse Royal Establishment.

According to the Indunas, forest management was well covered. Forest patrols were carried out to ensure that forests were not encroached and that there was no illegal off-take of forest products. There was also supervision of timber concessions to ensure forest hygiene; fire break maintenance around the indigenous forests was ensured as well as fire detection at fire towers; and finally fire fighting, which was compulsory for all villagers living around the forests. They observed that these roles have been diminished because of the breakdown in institutional collaboration between the Government and the Barotse Royal Establishment that has resulted in:

- dilapidation and neglect of infrastructure at the key forest stations in Machile and Masese;
- inadequate staffing to manage the forests;
- neglect of forest fire towers, which have been stolen or removed, and neglect of firebreaks around the indigenous

Baikiaea forests, putting these valuable forests at great fire risk;

- negating the role of community participation in forest management and removing of incentives and motivations for community involvement;
- no collaboration in the issuance of forest licences resulting in the neglect of monitoring timber exploitation; and finally
- neglect of provision of transport, plant and equipment for forest management at the two major stations.

The sum total of this neglect is the gradual loss of the teak (*Baikiaea*) forests, leaving behind a very ugly landscape.

- The private sector comes in the form of commercial timber concessions and pit-sawyers concessions. These are backed by their various timber producers' associations. Their main concern is timber extraction and trade. It has been observed that the concessioners are neglecting to follow the management plans they present to FD prior to obtaining a timber exploitation licence. Some are said to be dishonest in declaring the quantities of timber they have exploited in an effort to underpay the expected royalties. Some even purchase unlicenced timber from illegal dealers. Very few observe forest hygiene like piling and burning of branch wood, trimming of stumps and management of residues from sawmilling. The non-observance of the management plan and forest regulations is a clear indication of lack of participation in forest management and has a negative effect on the health of the forests.

Environmental factors

Environmental factors were identified as the fourth important underlying cause of deforestation. The extreme climatic conditions over zones influence the quality of forest cover in all the agro-ecological regions of Zambia. Because of these differences in climatic conditions, the recovery rate of a forest once deforested or degraded differs from region to region. The environmental factors related to the forests by agro-ecological zone are described below.

The *Baikiaea* forests are in agro-ecological zone I (AEZ I). This area is prone to drought and experiences almost desert conditions. According to JICA Report Number 61 (1996), Sesheke District receives less than 700 mm of rainfall per annum. The report further states that the district has experienced a 22 percent decline in precipitation over a period of 20 years prior to 1996. It is the most arid region and most prone to droughts. The actual rainfall period is much shorter, starting in mid-November and usually ending in late February or early March at the latest. The area experiences very harsh temperatures, being frosty between May and July and very hot between August and December. The frost tends to kill young regeneration while the hot temperatures completely dry the forest range making it very prone to forest fires. The Mopane woodlands (*Colosermum Mopane*), which stretch into Luangwa, are not spared by these fires.

The other environmental factor is the edaphic characteristics of the heavy Kalahari sands, which are rich in trace elements. The sand layer is 5 to 6 m deep and more porous than other soil types and, therefore, able to hold considerable amounts of water in its depths. The deep rooting system of the Mukusi is able to access this moisture as it comes up through capillarity action. It thus supports good stands of the *Baikiaea* species, making it an evergreen tree in the tropical dry forests (Smith *et al.* 2000). The water permeability also replenishes ground water, which in turn is linked to the catchments for most of the rivers that have considerable plains along their courses. These plains support wetland agriculture and livestock and wildlife rangelands. Deforestation has taken its toll on this ecological function. The key environmental factor here is fire.

Chibwe National Forest in Kapiri-Mposhi is a *Brachystegia* (Miombo) forest falling in agro-ecological zone II (AEZII) with well-distributed rainfall throughout the rainy season. The temperatures range between 23 °C and 25 °C, sometimes reaching a 32 °C high. Soils in this region are clayey to loamy with high agricultural potential. These forests have a very high potential for supporting river catchments and possess tree species that produce good quality charcoal, poles and timber. The threats are anthropogenic as there are little or no natural environmental factors posing a threat.

Kabompo is in agro-ecological zone III (AEIII). It has two of the three major vegetation formations: closed forests consisting of *Cryptosepalum* and *Baikiaea* forests (the most extensive closed forests covering parts of North-Western and Western Provinces) and the woodlands (open forests) mainly consisting of Miombo, with an annual rainfall well above 1000 mm. It has leached soils with very low reserves of trace elements giving it moderate agricultural potential. The only environmental factor affecting this area are late fires. The *Cryptosepalum* forests are very prone to late fires due to their closed nature. These fires leave a number of fire holes in the forests.

Source: Taken for this study

Figure 46: Cryptosepalum forest

Isoka and Nakonde Districts, also in AEZ III, have mainly Miombo vegetation. There has been heavy anthropogenic impact on the vegetation. Most of the area is covered by secondary regeneration, which is also prone to late fires because of the invasion of grass.

Other underlying drivers

The study also brought out other causes that were not ranked by the community members but were picked up from the discussions with various stakeholders.

Dual land tenure system

In Zambia, the ownership of all land is vested in the president and land can be categorized either as state land, which is titled, or as customary land held in trust by traditional authorities. According to the Land matrix 2012 in Widengard *et al.* (2012), official figures state that 6 percent is state land and 94 percent customary land. However, these figures date back to 1964 and are likely to have changed since then. This is due to the Land Act 1995, which allowed for the transformation of customary land to state land.

There are few resources available to manage these lands, no mechanism in place for land-use planning and no land administration or registration systems. The Land matrix report further revealed that a 2009 committee on agriculture and lands study claimed that only 37 percent of land in Zambia is effectively controlled by traditional authorities and Zambians within a given chiefdom receive land at no charge from the chief or their village headmen. The lands are managed by the chiefs, often through their village headmen. There is no security of tenure. The continued ability to use the land depends on the chief who has limited accountability to his subjects, as most chiefdoms are hereditary in nature (although there are considerable variations between different chiefdoms in terms of land management practices).

Private investors can approach village headmen and chiefs directly in search of land and either the chief or the village headman is supposed to verify that the land is available and that no one claims it. Then, the land is surveyed and the district council checks whether there are any conflicting claims before it makes a recommendation to the commissioner of lands. The commissioner then gives out an official title for the land and the land is then transformed from customary land to state land. Once the title is given out, the private investor becomes the legal lessee of the land. Land can only be leased, usually for 99 years and outright purchases are not possible. Land-use decisions by the chiefs appear to be made in an ad hoc manner with land acquisition processes that are ripe for corruption. Chiefs' rights and autonomy over their customary land is in contrast to a more appropriately planned and balanced landscape that considers the suite of different values, needs, and land uses across the landscape. By giving out land to investors, the traditional ruler's chiefdom is shrinking as the land is irrevocably transformed to state land. Local authorities such as chiefs, who often play a key role in allocating land rights, fail to act in the community's interest.

Indirect land-use change: a threat to forests

Indirect land-use change may be of particular concern as it can take effect in neighbouring areas or across the country and is likely to become increasingly important as projects such as biofuel production are developing. A case in point is the Jatropha project, which is scheduled to take off in Nakonde and Isoka Districts.

Case study: Jatropha plantation in Nakonde and Isoka Districts of Zambia

The multibillion kwacha biofuel project covering Nakonde and Isoka Districts in Muchinga Province was scheduled to take off after thorough consultations with all the interest groups. A US$450 million biofuel project investment promotion and protection agreement (IPPA) between the Government of the Republic of Zambia and Kaidi Biomass Zambia Limited (KBZ) was signed, which would involve various development activities. Phase one of the project included setting up biofuel feedstock plantations, construction of processing plants, construction of biomass power plants, and construction of local infrastructure. A Lusaka Times newspaper article dated 14 July 2011 reported that Chieftainess Nawaitwika of the Namwanga people of Nakonde District in Northern Province (now Muchinga Province) said that she was impressed with the government investment in the border town. The traditional ruler said she was optimistic that this programme would create employment for the people of Nakonde and bring infrastructure development, poverty reduction and other multiplying effects that would boost the local economy and Zambia as a whole. However, the then Muchinga Province minister told Chieftainess Nawaitwika that the project needed to be scrutinized first. The Government was concerned with the manner in which land was allocated to investors and that the 80 ha given to Kaidi Biomass Zambia Limited (KBZ) in Nakonde and Isoka was too much. The biomass company successfully obtained 38 ha and 42 ha of land in Nakonde and Isoka respectively to set up a multibillion biofuel project.

Although such development projects seem attractive, the question is: what are the impacts? This study agrees with Oxfam (2011) in Widengard *et al.* (2012) that little is known about the short and expected long-term effects of these investments.

There are few documented examples of large-scale land acquisitions that have resulted in positive impacts for local communities. In contrast, there are many examples from the media, academia, civil society and the intergovernmental bodies that point to land deals that have failed to provide benefits and have destroyed livelihoods and undermined human rights (Oxfam 2011). Questions arise regarding consultation, who is recognized as the vendor or leaser, who used the land prior to the acquisition, the displacement of former land users, and compensation, employment and other potential benefits and if investors really target marginal land. Indirect effects of agrofuels (especially food security and environmental effects) should also be taken into consideration.

Economic down turn

Most local people interviewed by this study identified the period starting from around 1990/2000 as the period when the big changes in forest cover loss started. They attributed this to the change of government and the economic reforms that took place. Simatele (2006) quoting the World Bank (1984) reports that during the early years of independence, Zambia benefited from high copper prices on the world market. Copper constituted over 90 percent of the foreign exchange earnings, about 70 percent of the government budget and over 40 percent of GDP. The revenue from copper was used to finance the provision and expansion of free social services such as education and health. Many commodities were subsidized, especially those in agriculture.

In the mid-1970s, copper prices on the world market began to decline. The oil shock of 1973/74 and the resulting world recession reduced the demand for copper and led to reductions in export revenue. The reliance of the manufacturing industry on imported raw materials and spare parts also led to reduced capacity utilization and a fall in real GDP. The result was a shortage of foreign exchange and a negative current account. With no improvement in copper receipts and no attempt at serious diversification of the economy, the country accumulated large arrears on loan repayments. The Government responded by increasing borrowing and putting more trade barriers and other controls in place.

With the implementation of the structural adjustment programmes (SAPs), marketing boards and other parastatals were abolished and all subsidies removed on inputs. By 1992, the dismantling of the marketing boards was under way. Prices were liberalized, subsidies removed and all active government participation in agribusiness withdrawn. On the wider macro level, interest rates were liberalized, administrative controls on banks removed and the exchange rate floated. Liberalization of financial markets and the removal of controls on credit and its pricing meant that farmers had to compete for credit with other potential borrowers in the country. The abolition of the National Agriculture Marketing Board (NAMBOARD) affected the transportation of both inputs to the production centres and output to the consumption centres.

The structural adjustment programmes led to the privatization of companies which in turn led to closure of a number of key companies which were deemed to be loss making ventures, and retrenchments of public service employees (Simatele 2006). Employment opportunities were few. Many could not face the uncertainty of going back to their original villages and so stayed in their towns with no immediate livelihood options. Poverty simultaneously set in among both urban and rural dwellers because of loss of incomes and market failures. For the first time going back to the land made a lot of sense. Most of these people found protected forests an easy target to occupy as they did not need the permission of traditional authorities. At first, encroachment took the form of establishing gardens in the gazetted forests. When they faced no resistance they entered to build their homes. Later primary and secondary service centres such as schools, health centres, cooperative depots and shops were established in these areas, and now with these growing populations most forests have come under pressure for de-gazetting.

Negative attitudes of the local people towards behaviour change

One of the major problems noted by some local stakeholders in Isoka District was the attitudes of the local people. They observed that changing the mindset of the people from charcoal production to other income generating activities was a big challenge. Despite high potential for fish farming in the district, because of the availability of dambos (*Agricultural water management national situational analysis* 2009) and raw material feed from crops such as rice, most of the people did not want to manage these things but were more interested in quick money; i.e. they did not want to input and wait for things to mature.

Geographical position of the country

In terms of social stability of the country, the southern region has had relative stability unlike the northern region (neighbouring the Democratic Republic of Congo and Luanda). Hence, the southern part has been extensively exploited, which has led to migrations northwards, increasing pressure on areas that have been less exploited thus far.

Lack of access to technology

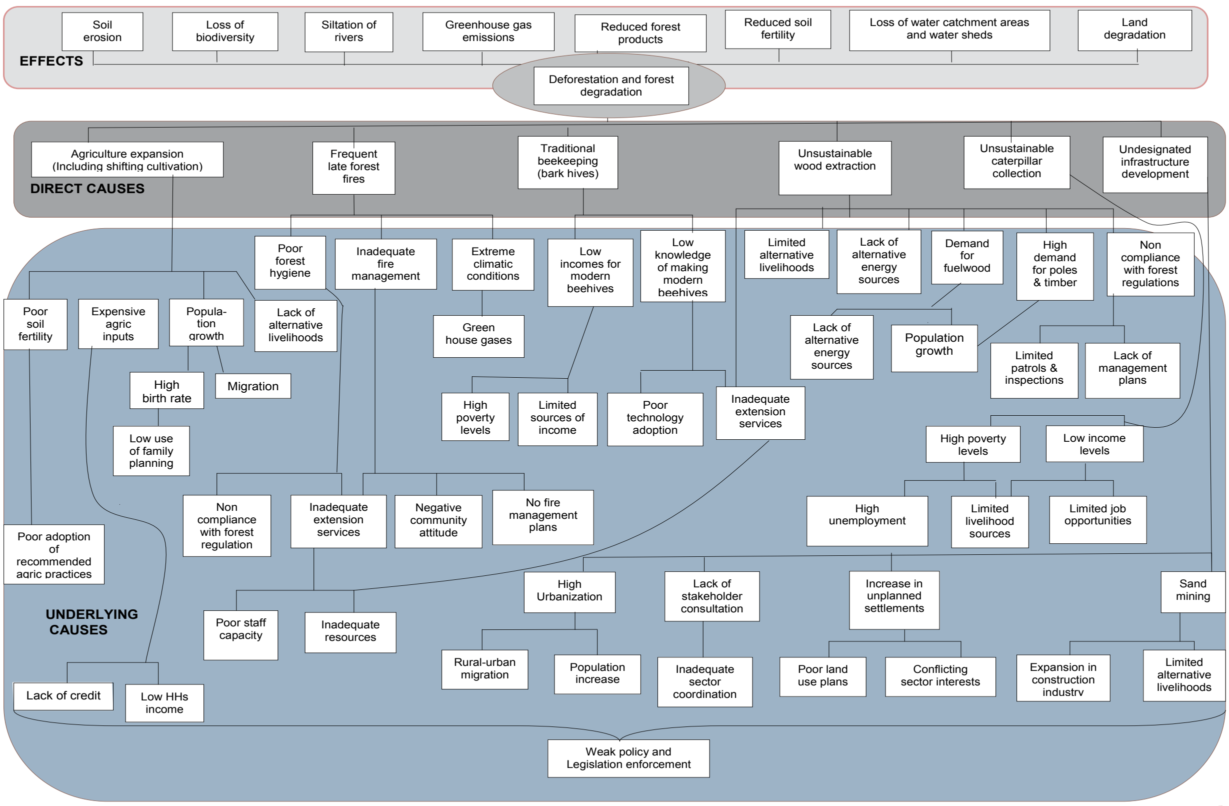
The overall process of invention, innovation and diffusion of technology is quite slow in the forestry sector. An example is that of the lagging technology in the district forest offices. Most districts visited during the study had no computer facilities or internet and some of the district staff are still computer illiterate. The use of satellite imagery is still highly limited.

Problem tree analysis

The drivers of deforestation can best be summarized in a problem tree. The main problem is deforestation, which is caused by the immediate human activities that are fuelled by unemployment, lack of income, high poverty levels, weak policy and law enforcement, population growth, negative attitude towards management of forest resources, and political, economic and environmental factors. If the problem is not dealt with, the immediate effects will be continued forest cover loss resulting in widespread catastrophic environmental consequences, loss of biodiversity and productivity, increased soil erosion, land degradation, siltation, greenhouse gas emissions and other negative impacts emerging in many places.

It is expected that further projects and programmes will be developed to deal with the root causes of deforestation shown in Figure 47.

Figure 47: Problem tree analysis for the drivers of deforestation and forest degradation



Source: Created for this study

Comparative analysis of the two approaches and threatened forests

A driver can be a threat if it has potential to perpetuate forest cover loss. In this study, two approaches were applied, spatial and non-spatial, to identify the drivers of deforestation and forest degradation as they relate to forest cover loss in Zambia. The spatial approach is a technical one that enabled the team to quantify forest cover loss; while the non-spatial approach helped to bring out a broader understanding of drivers from the community and other stakeholders' points of view.

Table 18 shows that some drivers were identified by both spatial and non-spatial approaches; e.g. agricultural expansion and shifting cultivation, wood extraction for charcoal and fuelwood and timber extraction. Forest fire was identified as a driver in all the study areas using the non-spatial approach. However, the spatial approach looked at forest fire as being caused by any of the land uses, e.g. agriculture and timber extraction.

From the drivers identified by the two approaches, the team was able to come up with the threats to the major vegetation formations in Zambia as seen in Table 18.

Table 18: Threatened forests by type

District	Spatial driver	Non-spatial driver	Threatened vegetation type	Types of threats	Status
Kapiri Mposhi	Settlements, agricultural expansion; and wood extraction (charcoal and fuelwood).	Charcoal; fuelwood and poles; agriculture; caterpillar collection; forest fires; and infrastructure development.	Miombo woodlands	Charcoal burning; sand mining; and encroachment for agriculture; settlements.	Some forests still available but fast being decimated.
Nakonde	Settlements; agriculture (shifting cultivation); and wood extraction (charcoal and fuelwood).	Charcoal; fuelwood; shifting cultivation; forest fires; building poles and timber.	Miombo forests	Charcoal burning; shifting cultivation; and settlements.	Original forests are gone, but forest has potential for regeneration if threats are controlled.
Isoka	Settlements; agriculture (shifting cultivation); and wood extraction (charcoal and fuelwood).	Charcoal; shifting cultivation; forest fires; timber harvesting; fuelwood, poles; and caterpillar collection.	Miombo forests	Charcoal burning; shifting cultivation; and settlements.	Original forests are gone, but forest has potential for regeneration if threats are controlled.
Kabompo	Settlements; agriculture (shifting cultivation); and wood extraction (charcoal and fuelwood).	Forest fires; shifting cultivation; timber harvesting; fuelwood; charcoal; caterpillar collection; and bark hive making.	Cryptosepalum Miombo forests	Forest fires; timber harvesting; shifting cultivation; and settlements.	Relatively intact but under pressure from threats.
Sesheke district	Settlement; agriculture (shifting cultivation); and extraction of timber and fuelwood.	Forest fires; timber; infrastructure development; poor agricultural practices; fuelwood and poles.	Baikiaea forests (Zambezi teak) Miombo forests Mopani forests	Forest fire; timber harvesting; encroachment for agriculture and settlements.	Forests available but seemingly neglected to fire, timber extraction and encroachment for agriculture.

The team also noted that forests can be threatened by other local and global factors. Local factors in Zambia include: untapped forest resources and no value addition to forest resources (e.g. export of logs). The southern region of Zambia has been threatened by timber export (Western, Southern and Central Provinces). Mineral endowment in North-Western Province, for example, if not well exploited will threaten the forest. Global demand for wood could pose a threat. According to the International Forestry Industry (2011), for example, China's total wood demand was anticipated to increase from 250 million m^3 in 2010 to 350 million m^3 by 2015 (a conservative projected growth rate of 8 percent per year), possibly moving as high as 450 million m^3 by 2020. The projected wood deficit (or the role of imports) is expected to grow from 100 million m^3 to at least 150 million m^3 in 2015 and up to 200 million m^3 in 2020 (round wood equivalent). This may be a threat to global forest resources, Zambia inclusive. This is a big challenge for Zambia because at local level there are no proper mechanisms in place.

Alternative livelihood options

The study also brought out alternative livelihood options for the community members who are behind the main drivers of deforestation. It is not easy, however, for people to switch from one livelihood to another. For example, it is not easy for a charcoal producer to stop manufacturing charcoal and switch to beekeeping, fish farming or conservation farming. There are a number of challenges and limitations that may hinder a person from adopting a possible alternative livelihood option.

- Some alternative livelihood options may need capital injection to take off. Unless the initial capital is available, it is difficult to venture into that option, even if it is feasible.
- People may be ignorant of the existing alternative livelihood options. This calls for awareness raising.
- Financial support by the government for local communities to undertake alternative livelihood options may be limited.

This study has identified the following alternative livelihood options in Table 19 for possible implementation under the UN-REDD programme for Zambia.

Table 19: Alternative livelihood options identified

Identified driver	Actors/ background	Proposed options
Charcoal (Kapir, Isoka and Nakonde)	Locals produce, externals buy; market driven (urban demand); important source of income for communities.	• Fuelwood plantations for communities/locals, based on national nursery programme (final income-generating activity); • community-based/owned coupe management system, currently abandoned by FD (as income gap bridging activity); • alternative energy sources for urban areas; • fuelwood/charcoal efficient stoves; • law enforcement: more management control, less revenue control; • national incomes from forest revenues should stay within forestry sector (forest fund?); • beekeeping; fish farming.
Fuelwood (Sesheke/ Kapiri) Kabompo)	Brick kilning and beer brewing; local demand for housing improvement and new houses; domestic use as energy source.	• Community fuelwood plantations; • enterprise fuelwood plantations; • enterprise out-grower schemes; • coupe management; • alternative energy sources for rural households (solar for light, efficient stoves for cooking); • fuelwood/charcoal efficient stoves; • beekeeping; fish farming.
Logging (legal, but unsustainable, currently stopped) (Sesheke)	Market driven (South Africa, China, local construction and furniture, local cooperatives).	• Coupe management (management blocks); • management plans (better enforcement/monitoring of plans); • forest hygiene; • environmental impact assessments (EIAs); • forest certification (to add value and access new markets); • local-level value adding; • enrichment planting (improve condition and value of forest); • community participation in forest management.
Agriculture small scale (all study areas)	Demand for land (local and subsistence), food, income. Supply national markets. Supply to food/ beverage industries.	• Sustainable agriculture; • conservation farming (i.e. productivity increase); • post-harvest food processing (increase value, waste reduction, etc.); • preservation of food (e.g. drying): security all year long; • agroforestry systems; • seed improvement; fish farming; beekeeping; • capacity building, training, extension services.

CONCLUSIONS

This study concludes that the main drivers of deforestation and forest degradation are the major land uses and land-use changes which include: expansion of built-up areas, agricultural expansion, wood extraction for charcoal and fuelwood, and timber extraction. Forest fire is another important driver of deforestation and forest degradation but it is caused by any of the land uses identified. These drivers are mainly unchained by high poverty levels, population growth, and weak policy and law enforcement, which are progressively creating unplanned land-use changes.

The forest ecosystem is threatened because of land-use practices that do not take into account the protection of forests. The rate of vegetation loss and carbon emission is alarming and if it remains unchecked it could lead to serious environmental consequences.

The best ecological zones to deliver forest co-benefit results faster under REDD+ implementation are zones III and II. Zone I is the slowest zone to deliver results. In terms of their importance, the co-benefits are more important to zone II, followed by zones III and zone I. However, if the national values are considered, ecological zone III is the most highly valued zone because it is the source of all the important big rivers of Zambia. Water catchment management yields much higher values because these benefit the country and not just individuals. The protection of water catchment areas is the only co-benefit that is ecologically, socially and economically sound.

NTFPs are the other co-benefits that are ecologically and economically sound, especially beekeeping. Although the development of environmentally friendly income-generating activities is rated the slowest when it comes to speedy delivery of ecosystem services, it is an activity worth supporting. Effective beekeeping sustains the environment, pollinates trees and crops and gives people income.

RECOMMENDATIONS

Based on the study findings, the study team recommends the following:

Table 20: Study recommendations

Recommendation	Policy level	Implementation level
Strengthen Forestry Department institutional capacity in terms of logistical support, employment of more field staff and staff development.	Ministry of Lands, Natural Resources and Environmental Protection; Forestry Department.	National level
Ensure that the institutional structure in the forestry sector is one that trickles down to local communities so that there is constant contact with the local people on issues of forestry management.	Forestry Department.	National, provincial and district levels
Harmonize policies related to forestry, land, agriculture, environment and other natural resource utilization and management as a matter of urgency to ensure reduced oversight, improved transparency, and promote integrated land-use planning among line ministries.	The Government of the Republic of Zambia through the Cabinet Office.	National, provincial and district levels
Promote community participation in forestry management and formulate a mechanism for cost-benefit sharing for participating stakeholders.	Forestry Department.	National, provincial, district and local levels
Institute fire management interventions at community, private and government levels.	Forestry Department.	National, provincial, district and local levels
Promote public private partnerships (P3s) in forestry management, given the simultaneous role of forests as exploitable resources and providers of public goods and environmental services.	The Government of the Republic of Zambia through the Cabinet Office; Forestry Department; private Institutions.	National, provincial, district and local levels
Combine different options such as conservation farming, promotion of alternative livelihoods and enforcement of law and policy.	Forestry Department; Department of Energy; Department of Agriculture; NGOs; media houses; law enforcing wings; higher learning institutions.	National, provincial, district and local levels
Put in place effective systems and adequate resources in order to enhance the co-benefits and contribute to making the REDD+ programme a success.	Forestry Department.	National, provincial, district and local levels
Give priority to areas that are in proximity to or within water catchment areas under REDD+ implementation. The community members who live in proximity to these catchment areas should be rewarded through a mechanism for payment for ecosystem services (PES) for preserving the forests.	The Government of the Republic of Zambia through the Cabinet Office; Forestry Department; private Institutions/utility companies; community members.	National, provincial, district and local levels
Ensure that all future REDD+ programmes or projects take into consideration the interests and needs of community members and other stakeholders who depend on the forests.	Forestry Department; Redd+ Secretariat.	National, provincial and district levels.
Commission further studies and actions to respond to concerns that the study of five districts was insufficient to provide credible information for the whole country. These include the following: • Forestry Department with relevant stakeholders (UNZA, CBU) to establish a linkage between ground-based relevant parameters with satellite spectral response data. • Try different classifiers and options for land cover mapping and compare results with this study. • Focus more on spatial dynamics in the non-forest classes to help understand the nature and the dynamics of the drivers of deforestation. • Add 23 study areas to this study to make the sample size more country representative.	Forestry Department; Redd+ Secretariat.	National, provincial and district levels

The study team recommends the following interventions for possible support and development under the REDD+ implementation, as a measure to allow forest cover creation:

Table 21: Recommended interventions under REDD+ implementation and associated drivers of deforestation to be addressed

Recommended intervention	Driver of deforestation to be addressed
Promote improved farming practices such as conservation farming that will lessen the opening of virgin land for agricultural production, thereby curbing deforestation.	Agricultural expansion.
Promote alternative energy sources to reduce the destruction of trees for energy.	Fuelwood extraction.
Community participation is a key to sustainable forest management. Establishment of community forest nurseries will encourage local communities to participate in plantation establishment as a way of combating deforestation.	Agricultural expansion and fuelwood extraction.
Encourage natural regeneration and management of indigenous forests since most ecosystem services, forest biodiversity and NTFPs are largely derived from indigenous forests. Further, a majority of the rural population in the study areas depend on NTFPs, forest biodiversity and ecosystem services for their livelihoods.	Agricultural expansion, caterpillar collection, bark hives, timber and fuelwood extraction.
Poor harvesting methods for some NTFPs (e.g. caterpillars and wild fruits) lead to deforestation. There is therefore a need to develop and promote sustainable harvesting and utilization methods of NTFPs to ensure stable and constant availability of forest co-benefits for human well-being.	Caterpillar collection, traditional beekeeping (bark hives), and timber extraction.
Modern beekeeping is a viable livelihood option for rural communities as has been observed in Kabompo District. Effective beekeeping sustains the environment, pollinates trees, crops and gives people income. The promotion of beekeeping to small-scale farmers, who live near the protected areas, will help to reduce further extension of land for more crops.	Traditional beekeeping (bark hives), agricultural expansion and fuelwood extraction
Strategies that promote innovative entrepreneurships that provide alternative livelihoods will lessen dependence on forest resources for people's livelihood. This will subsequently reduce deforestation and make the forest co-benefits more available to the people.	Agricultural expansion, fire, caterpillar collection, infrastructure development, bark hives, timber and fuelwood extraction.
Attach and promote economic market value to most of the NTFPs so that people can realize stable household income from them.	Caterpillar collection, bark hives and timber extraction.
Develop a mechanism under the national REDD+ programme for payment of environmental services that are derived from the forests. The funds realized should be put back into managing the forests affected by the same environmental services.	Agricultural expansion, fire, caterpillar collection, infrastructure development, bark hives, timber and fuelwood extraction.
Include programmes/projects on extension services and value addition under REDD+ implementation. It was noted that most community members had little knowledge about sustainable harvesting and utilization of forest products. Marketing of products was also a problem due to low quality.	Agricultural expansion, fire, caterpillar collection, infrastructure development, back hives, timber and fuelwood extraction

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ANNEXES

Annex 1. Outputs, data, methods and tools

Output (What was the study output?)	Data/Information needs (What did we need to know?)	Methods (How was the data captured?)	Tools used (What techniques did we use?)
A detailed and spatially explicit analysis of the drivers of deforestation.	The direct and indirect causes of deforestation.	• Resource use assessment • Participatory surveys and analysis (transect walks/drives) • Participatory resource mapping • Literature search	• Semi structured interviews • Key informant interviews • Transects (walks, drives, etc.) • Natural groups interviews • Brainstorming
	Root (primary) causes of drivers of deforestation in Zambia.		• ENVI 4.7, QGIS 1.8.0 and ArcGIS 9.2. • Problem tree analysis • Root cause analysis
	Quantitative strength and importance of each driver.		matrix or pair-wise ranking
Expected forest changes if drivers of deforestation continue unabated; identification and mapping of most threatened forests.	• Status of forests • Characteristics of threatened forests • General forest cover changes • Progressive forest cover changes of threatened forests	• Literature search • Observations (field visits) • Interviews • Trend analysis • Observations • Remote sensing	• ENVI 4.7, QGIS 1.8.0 and ArcGIS 9.2. • Statistical Package for Social Scientists • Time line • Geographic information system • Remote sensing • Satellite images interpretation

Source: Created for this study

Annex 2. Summary of district stakeholders meetings

S/N	District	Stakeholders	Number of meetings
1	Sesheke	• District commissioner • Senior agricultural officer • Indunas at Mwandi palace • Machile community • Masese community • District Environment Natural Resources Committee (DENRC)	1 1 1 1 1 1
2	Kapiri Mposhi	• District commissioner • Chief Nkole and the Indunas • Chibwe National Forest community (Kasempa, Yuda) • District Environment Natural Resources Committee (DENRC)	1 1 1 1
3	Kabompo	• District commissioner • Chief Sikufele • principal extension office • Manyinga community • Kabompo forest area • District Environment Natural Resources Committee (DENRC)	1 1 1 1 1 1
4	Isoka	• District commissioner • Chief Kafwimbi • Chuwi, Mwaiseni, Mandala, Nsama communities • DENRC	1 1 1 1
5	Nakonde	• District commissioner • Chieftainess Waitwika • Wulongo communities • DENRC	1 1 1 1

Source: Created for this study

Annex 3. Top ranked drivers of deforestation as identified by stakeholders

Study area	Ranking	Proximate drivers	Score	Underlying drivers	SCORE
Kapiri Mposhi	01	Charcoal production	05	Population growth	05
	02	• Fuelwood for brick making and breweries • Poor agricultural practices • Poles	04	Lack of employment	04
	03	Caterpillar collection	03	High poverty levels	03
	04	Late forest fires	02	Weak policy and legislation enforcement	02
	05	Infrastructure development	01	• Lack of community participation in forest management • Lack of alternative energy and livelihoods	01
Kabompo	01	late forest fires	05	Weak policy and legislation enforcement	05
	02	shifting cultivation	04	High poverty levels	04
	03	timber harvesting	03	Population growth	03
	04	• Fuelwood for home use • Charcoal • Caterpillar collection	02	Lack of employment	02
	05	Bark hives	01	Lack of alternative energy and livelihoods	01
Sesheke	01	Forest fires	05	High poverty levels	05
	02	Timber harvesting	04	Weak policy and legislation enforcement	04
	03	Infrastructure development	03	Inadequate consultation and collaboration between government and traditional rulers	03
	04	Poor agricultural practices	02	Lack of employment	02
	05	• Fuelwood for home use • Poles	01	Environmental factors (drought)	01
Isoka	01	Charcoal production	05	Population growth	05
	02	Shifting cultivation	04	High poverty levels	04
	03	Forest fires	03	Lack of employment	03
	04	Timber harvesting	02	Weak policy and legislation enforcement	02
	05	• Fuelwood for brick making • Poles • Caterpillar collection	01	Lack of alternative energy and livelihood	01
Nakonde	01	Charcoal production	05	Population growth	05
	02	Fuelwood for brick making	04	Lack of employment	04
	03	Shifting cultivation	03	High poverty levels	03
	04	Late fires	02	Lack of alternative energy and livelihoods	02
	05	• Poles • Timber production	01	Weak policy and legislation enforcement.	01

Key: Ranked 1 = 05. Ranked 2 = 04, Ranked 3 = 03, Ranked 4 = 02, Ranked 5 = 01
Source: Created for this study

Annex 4. Ranked aggregated proximate drivers of deforestation for all the study area

Ranking	Driver	Sub-driver	Scores summation	Percentage (%) score	
01	fuelwood[a]	charcoal	15	16	31
		fire wood for commercial use	11	12	
		fire wood for domestic use	3	3	
02	poor agricultural practices	shifting cultivation and agricultural expansion	17		19
02	late forest fires		17		19
03	timber harvesting		10		11
04	poles for construction		7		8
05	caterpillar collection		6		7
06	infrastructure development		4		4
07	traditional beekeeping (use of bark hives)		1		1
				100	

[a] Charcoal production, fire wood for commercial and domestic use were categorized as fuelwood.
Source: Created for this study

Annex 5. Ranked aggregated underlying drivers of deforestation for all the study area

Ranking	Driver	Sub-driver	Scores summation	Percentage (%) score	
01	poverty-related factors	high poverty levels	19	25	55
		unemployment	15	20	
		inadequate alternative energy sources	4	5	
		inadequate alternative livelihoods	4	5	
02	population growth		18		24
03	policy and institutional arrangement	weak policy and legislation enforcement	14	18	20
		lack of community participation in forest management	1	1	
		inadequate consultation and collaboration between government and traditional rulers	1	1	
04	environmental factors	extreme climatic conditions (drought) and edaphic factors	1		1
		Total	77	100	

Source: Created for this study

Annex 6. Sample Field Questionnaire

Questionnaire No.: |__||__|

IDENTIFICATION OF THE DIRECT AND INDIRECT CAUSES OF DEFORESTATION FOR LOCAL COMMUNITIES, INCLUDING ELDERLY AND INSTITUTIONS

Interviewers Details	
Name:	
Institution:	
Phone Number:	
Signature:	
Date:	

District: |__||__| (use below codes)

Codes for Districts	2=Kabompo	4=Isoka
1= Kapiri Mposhi	3=Sesheke	5=Nakonde

Community: ______________________________

INTERVIEWEES DETAILS	
A1. Gender	1=Female 2=Male
A2. Age (Over 60 is considered elderly)	1=15 yrs to 18 yrs 2=19 yrs to 25yrs 3=26 yrs to 35 yrs 4=36 yrs to 59 yrs 5=over 60 yrs
A3. Occupation (Status)	1=Student 2=Formerly Employed 3=Self Employed/Entrepreneur 4=Retired 5=Farmer 99=Other, Specify_____________________

DEFORESTATION VIEWS	
B1. Do you think the state of the forest today is the same as it was 20 years ago? (*Use 40 years if elderly, if younger than 35 years, use 10 years*)	1=Yes 2=No
B2a. If the answer to B1 is yes, what has kept it that way? (*choose answer below*)	B2b. If the answer to B1 is no, what has changed during this period? (*choose answer below*)
1=Tree planting by Government 2=Effective forest extension services 3=Involvement of traditional leadership and community in FM 4=NGO/CBO/CSO activities 5=Tree planting activities by Corporate social responsibility 6=Policy and legislation enforcement 7=Other, specify_______________	1=Reduction in number of trees 2=Reduction in tree size and species 3=Soil erosion 4=Soil degradation 99=Other, specify_____________________
B3. When did the change start to happen? (Only to be answered by elderly in local community)	1=Less than 5 years ago 2=between 6 to 10 years ago 3=between 11 to 20 years ago 4=between 21 to 30 year ago 5=over 31 years ago

B4. With reference to your answer in question B3, which activities can you identify as causing forest loss and degradation? (*use code below to List at least 5 in order of importance*) Enter 0 for other	|__| |__| |__||__| |__||__| |__||__| |__||__|

1=Shifting cultivation 2=Timber exploitation 3=Charcoal production 4=Forest fires 5=Forest encroachment 6=Agricultural production 7= Pole cutting and trading	8=Lack of employment 9=Food insecurity 10=Lack of income 11= Lack of capacity among forest extension officers 12=Change in weather patterns 13=Agriculture production 14= Lack of community participation/ knowledge in forest management	15=Need for source of energy 16=Infrastructure development 17=Resource security 18=Industrialization 19=People migrating into the area for agriculture 20=Increase in electricity tariffs 21= Weak policy and legislation enforcement 22=Lack of alternative livelihoods

B5. Are you involved in any forest conservation activities?	1=Yes 2=No
B6. If your answer to question B5 is yes, what activities are you engaged in that are related to forest conservation?	1) Tree planting 2) Conservation farming 3) Agro-forestry 4) Appropriate beekeeping technologies 5) Appropriate timber harvesting technologies Other, specify.....................................
B7. What impact has this change had on your household? (*Select as appropriate*) NOT to be answered by Institutions	1= Improved income 2=Low agriculture production due to soil degradation 3=Employment opportunities 4=High levels of agric. production due to more land use 99=Other, specify_________________
B8. What impact has this change had on the environment?	1=Soil erosion 2=Soil degradation or loss of natural soils 3=Change in rainfall patterns 99=Other, specify_________________
B9. What do you think has been the impact of the forest cover loss on the forestry co-benefits?	1= Water 4) Agriculture production and pastures 2=Wood for fuel 5) NWFP 3= Timber
B10. What do you think should be done to mitigate or reverse the negative changes?	1= Plant more trees 2= Improve NRM skills 3=Promote use of renewable energy 99=Other, specify_________________
B11. What suggestions can you give for improving the management of the forests? (*Select as appropriate*)	1= Capacity building for forest extension officers 2=Involvement of community in forest mgt 3=Participation of different stakeholders in FM 4=Organizational change in the forestry department 99=Other, specify_________________
B12. What do you think are the most threatened forests in your area?	Please mention them 1=National forest ______________________ 2=Local forest ________________________ 3=Traditional land ______________________ 4=Game management areas___________ 5=National parks ________________________ 99=Other, specify____
B13. What are the reasons for your answer in question B11 above?	1=Modification 2=Overutilization 3=Disease 4=Inadquate regulatory mechanisms 99=Other, specify_______________________________________
B14. Would you like these forests to be preserved?	1=Yes 2=No
B15. If the answer to question B14 is yes, what do you think should be done to preserve these forests?	1= Plant more trees 2=Promote the use of renewable energy 3=Institute forest management plans 5=Improve extension service 99=Other, specify_________________

B16. What could be your role in preserving these forests? (*Only to be answered by Institutions*)	1= Plant more trees 2=Promote the use of renewable energy 3=Enforce policy and legislation 4= Awareness raising and sensitisation on the importance of forest conservation 5- Advocating against deforestation 99=Other, specify__________________
B17. What alternative income options would you engage in to preserve these forests?	____
B18. What difference have forest extension officers brought in compared to forest guards and forest rangers?	1= Planted more trees 2=Done more sensitization on forest conservation 3=Have enforced policy and legislation more 99=Other, specify______________________________________
B19. Have you heard of the UN REDD+ programme? (for Institutions only)	1=Yes 2=No
B20. If yes to question B19, what do you know about the programme? (*for Institutions only*)	____
B21. From question B19 above, what direct benefits do you expect from the programme other than carbon? (*for Institutions only*)	1=Better FM practices 2=Promotion of trade in other NWFP 3=Promotion of renewable energy as a source of energy 4=Introduction of community social programmes (Infra, sch, HC, etc.) 99=Other, specify_______________________
B22. From question B19, what indirect benefits are you expecting from the programme? (*for Institutions only*)	1=Job creation 2=Poverty reduction 3=Improved livelihoods 4=Income generation 5=Socio-economic benefits (education, health, etc.) 99=Other, specify_________________________
B23. Is there a possibility that the drivers of deforestation will reduce?	1=Yes 2=No
B24. If the answer to question B23 is No, what is your perception of the future trends?	1= Increase in deforestation rates 2=Reduction in deforestation rates 3=Deforestation rates remain on the same level 99=Other, specify_________________________
B25. If the answer to question B23 is Yes, what do you think will bring about this reduction?	1=Better FM practices 2=Promotion of trade in NWFP 3=Promotion of renewable energy as a source of energy 4=Restructuring of the Forestry Department 99=Other, specify_________________________

Annex 7. Dual land system in Zambia: a threat to forests

In Zambia, the ownership of all land is vested in the President and land can be categorized either as state land, which is titled, or as customary land held in trust by traditional authorities. According to the Land Matrix 2012 in Widengard et al (2012), official figures state that 6 percent is state land and 94 percent customary land. However, these figures date back to 1964 and are likely to have changed since. This is due to the Land Act 1995, which allowed for the transformation of customary land to state land. Customary land is under the control of the traditional chiefs, and to a limited extent village headmen. Close to 40 percent of the customary land is administered by Wildlife and Forestry authorities as national parks, game management areas (GMAs) and forest reserves.

There are few resources available to manage these lands, no mechanism in place for land-use planning and no land administration or registration systems. The Land Matrix report further revealed that a 2009 Committee on Agriculture and Lands study claimed that only 37 percent of land in Zambia is effectively controlled by traditional authorities and Zambians within a given chiefdom receive land for no charge from the chief (or their village headmen), and the lands are managed by the chiefs (often through their village headmen). There is no security of tenure: the continued ability to use the land depends on the chief, and the chief has limited accountability to his subjects as most chiefdoms are hereditary in nature (although there are considerable variations between different chiefdoms in terms of land management practices).

Private investors can approach village headmen and chiefs directly in search of land and either the chief or the village headman is supposed to verify that the land is available and that no one claims it. Then, the land is surveyed and the district council checks whether there are any conflicting claims before it makes a recommendation to the Commissioner of Lands. The Commissioner then gives out an official title for the land and the land is then transformed from customary land to state land. Once the title is given out, the private investor becomes the legal lessee of the land. Land can only be leased, usually for 99 years and outright purchases are not possible. Land-use decisions by the chiefs appear to be made in an ad hoc manner with land acquisition processes that are ripe for corruption. Chiefs' rights and autonomy over their customary land versus a more appropriately planned and balanced landscape that considers the suite of different values, needs, and land uses across the landscape. By giving out land to investors, the traditional ruler's chiefdom is shrinking as the land is irrevocably transformed to state land. Local authorities such as chiefs, who often play a key role in allocating land rights, fail to act in the community's interest.

Source: Widengard *et al* (2012)

Annex 8. Carbon-stock estimates from ILUA I as presented by Kamelarczyk (2009)

Land use	Above ground carbon (tC/ha)	Below ground (tC/ha)	Soil (tC/ha)	Total	Comment
High dense forest > 80%	43.75	12.25	31	87	BCEF average function
Medium dense forest 50-79%	21.88	6.13	31	59	Assume 40% density
Low dense forest 20-49%	10.94	3.06	15.5	29.5	Assume 20% density
Commercial agriculture	11.96	4.79	5	21.75	Assume annual crops land use
Small-scale agriculture	11.96	4.79	5	21.75	Assume annual crops land use
Open/closed grassland	12.5	5	31	48.5	
Inland water/wetlands	2.83	1.13		3.96	Depending on type of this land use, soil carbon can be 0 (e.g. in lakes or very high e.g. in swamps. Since we do not know this, we put soil carbon at 0
Settlements	7.5	3	5	15.5	Assume rural settlement area
Total				-	

Annex 9. Socio-economic data for Kapiri Mposhi District for 2000 and 2010

Kapiri Mposhi	Data for 2000	Data for 2010	Source	Annual change in %
Population in district (number of persons)	194 752	240 841	CSO (2011)	2.10%
Rural (number of persons)	155 670	182 968	CSO (2011)	1.24%
Urban(number of persons)	39 082	57 873	CSO (2011)	0.86%
Household size (persons)	6	5	CSO (2011)	
Number of household depending on agriculture (households)	30 870	36 283	Ministry of Agriculture crop survey focus 2009/2010	
Total area planted commercial-scale agric. (ha)	5 329	6 264		1.24%
Total area planted small-scale agric. (ha)	60 762	71 417		1.24%
Land use per household (ha)		2		
Agricultural product	Maize	Maize		
Number of persons depending on charcoal (persons)	194 752	240 841	Based on the total population	
Annual charcoal consumption per person (kg)	134.6	139.6	FAO (1998)	
Total charcoal consumption in district (kg)	26 213 619	33 621 404	Consumption multiplied by number of persons depending on fuelwood	2.20
Charcoal going to other districts (kg)	na	6 711 390	Kapiri DSA (2010)	
Number of persons depending on fuelwood (persons)	194 752	182 968	Based on the total population	
Annual fuelwood consumption per person (kg)	240	240	FAO (1998)	
Total fuelwood consumption (kgs)	46 740 480	43 912 320	Consumption multiplied by number of persons depending on fuelwood	-0.64
Total number grazing animals (cattle and goats)	na	70 035	Kapiri DSA (2010)	1.24%
Stocking density (livestock units/ha)	na	1	Expert judgement	
Total grazing area (ha)	na	70035	Calculated from stocking density	

Annex 10. Land-use changes for Kapiri Mposhi District

Forest categories	Crown closure	Area in 2010 (ha)		Area in 2040 (ha)	Attributed uses / Drivers
Total forest area 2010	Na	307 462		67 642	
High dense (15% of forest cover)	>80%	46 119		10 146	conservation, NYFPs, basic uses
Medium dense (20% of forest cover)	50-79%	61 492		13 528	charcoal, firewood, poles
Low dense (65% of forest cover)	20-49%	199 850		43 967	charcoal, sand mining,
Non-forest categories (level I)	**Non-forest categories (Level II)**	**Area for 2010 (ha)**	**Agreed growth rate p.a.**	**Area for 2040 (ha)**	**Comment**
Total in 2010	Details	810 045		1 049 865	
Agriculture lands	Annual/perennial crop land (commercial)	6 264	3.5%	12 841	Assuming correlation with GDP
Agriculture lands	Annual/perennial crop land (small scale)	71 417	1.24%	97 984	Assuming correlation with population growth
Rangeland	Open/closed grasslands	162 009	0.5%	137 708	Assuming change to other land uses/ agriculture
Water bodies	Inland water/wetlands	324 018	Stable	324 018	Stable
Built-up areas	Urban/rural areas	246 337	1.24%	477 314	Assuming correlation with population growth

Annex 11. Carbon-stock changes for Kapiri District

Land use	Area in 2010 (ha)	Area in 2040 (ha)	Increase/ De-crease (ha)	Carbon stock bio-mass and soil (tC/ ha)	Land use	Carbon stock 2010 (2010 figures multiplied by carbon stock biomass) (A)	Carbon stock 2040 (2040 figures multiplied by carbon stock biomass) (B)	Increase/ Decrease ha(difference between B and A)	Driver
High dense forest > 80%	46 119	10 146	- 35 973	87	High dense forest > 80%	4 012 353	882 702	-3 129 651	Charcoal and agriculture
Medium dense forest 50-79%	61 492	13 528	- 47 964	59	Medium dense forest 50-79%	3 628 028	798 152	-2 829 876	Charcoal and agriculture Others
Low dense forest 20-49%	199 850	43 967	- 155883	29.5	Low dense forest 20-49%	5 895 575	1 297 027	- 4 598 549	Others
Annual crop land commercial	6 264	12 841	6577	21.75	Annual/ perennial crop land (commercial)	136 242	279 292	143 050	
Annual crop land (small-scale)	71 417	97 984	26 567	21.75	Annual/ perennial crop land (small-scale)	1 553 320	2 131 152	577 832	
Open/closed grasslands	162 009	137 708	- 24 301	48.5	Open/ closed grasslands	7 857 437	6 678 838	- 1 178599	Others
Inland water/ wetlands	324 018	324 018	-	3.96	Inland water/ wetlands	1 283 111	1 283 111	-	
Urban/rural areas	246 337	477 314	230 977	15.5	Urban/rural areas	3 818 224	7 398 367	3 580 144	
Total	1 117 507	1 117 507	-		Total	28 184 289	20 748 641	- 7 435 649	

Annex 12. Socio-economic data for Nakonde District for 2000 and 2010

Nakonde	Data for 2000	Data for 2010	Source	Annual change in %
Population in district (number of persons)	75 135	118 17	CSO (2011)	4.60%
Rural (number of persons)	55 707	79 907	CSO (2011)	2.60%
Urban (number of persons)	19 428	38 110	CSO (2011)	2.00%
Household size (persons)	4.9	3.2	CSO (2011)	
Number of household depending on agriculture (households)	6 270	13 772	Based on the rural population	2.60%
Total area planted commercial-scale agric. (ha)	-	-		
Total area planted small-scale agric. (ha)	5 448	11 967	Ministry of Agriculture crop survey focus 2009/2010	2.60%
Land use per household (ha)	1.2	1.2		
Agricultural product	Maize	Maize		
Number of persons depending on charcoal	19 428	38 110	Based on urban population	
Annual charcoal consumption per person (kg)	134.6	139.6	FAO (1998)	
Total charcoal consumption in district (kg)	2 615 008.8	5 320 156	Annual consumption multiplied by the urban population	5.08
Charcoal going to other districts (kg)	-	2 986 767	Nakonde DSA	
Number of persons depending on fuelwood	64 921	98 962	Rural population plus 50% of urban population	
Annual fuelwood consumption per person (kg)	240	240	FAO (1998)	
Total fuelwood consumption (kg)	15 581 040	23 750 880	Consumption multiplied by number of persons depending on fuelwood	3.44
Fuelwood going to other districts (kg)	-	-		
Industrial fuelwood or charcoal (kg)	-	-		
% of persons (households) depending on livestock	-	3 000	Department of Agriculture in Nakonde	
Total number grazing animals (cattle and goats)	-	144 000	Information collected from Ministry of Agriculture in Nakonde	2.60%
Stocking density (livestock units/ha)	-	1	Expert judgement	
Total grazing area (ha)	-	144 000	Calculated from stocking density	

Annex 13. Land-use changes for Nakonde District

Forest categories	Crown closure	Area in 2010 (ha)	Applied deforestation rate	Area in 2040 (ha)	Attributed uses / Drivers
Total forest area 2010	-	171 103	-1.20%	109 506	
High dense (5% of forest cover)	>80%	8 555	-	5 475	Conservation, NTFPs, basic uses
Medium dense (40% of forest cover)	50-79%	68 441	-	43802	Charcoal, fuelwood
Low dense (55% of forest cover)	20-49%	94 107	-	60 228	Charcoal, fire
Non-forest categories (level I)	Non-forest categories (level II)	Area for 2010 (ha)	Agreed growth rate p.a.	Area for 2040 (ha)	Comment
Total in 2010	Details	257 322		318 919	
Agriculture lands	Annual/perennial crop land (commercial)	-	3.5%	-	Assuming correlation with GDP
Agriculture lands	Annual/perennial crop land (small scale)	5 448	2.60%	9 697	Assuming correlation with population growth
Rangeland	Open/closed grasslands	51 464	1.00%	36 025	Assuming change to other land uses/ agriculture
Water bodies	Inland water/ wetlands	25 732	stable	25 732	Stable
Built-up areas	Urban/rural areas	174 677	2.60%	247 464	Assuming correlation with population growth

Annex 14. Carbon-stock changes for Nakonde District

Land use	Area in 2010 (ha)	Area in 2040 (ha)	Increase/ Decrease (ha)	Carbon stock biomass and soil (tC/ha)	Land use	Carbon stock 2010 (2010 figures multiplied by carbon stock biomass) (A)	Carbon stock 2040 (2040 figures multiplied by carbon stock biomass) (B)	Increase/ Decrease ha (difference between B and A)	Driver
High dense forest > 80%	8 555	5475	-3080	87	High dense forest > 80%	744 285	476 325	267 960	Agriculture, shifting, charcoal, fuelwood
Medium dense forest 50-79%	68 441	43 802	-24 639	59	Medium dense forest 50-79%	4 038 019	2 584 318	1 453 701	Agriculture, shifting, charcoal, fuelwood
Low dense forest 20-49%	94 107	60 228	- 33 879	29.5	Low dense forest 20-49%	2 776 157	1 776 726	999< 431	Others
Annual crop land (commercial)	-	-	-	21.75	Annual/ perennial crop land (com-mercial)	-	-	-	
Annual crop land (small scale)	5 448	9 697	4 249	21.75	Annual/ perennial crop land (small scale)	118 494	210 910	92 416	
Open/ closed grasslands	51 464	36 025	- 1 439	48.5	Open/ closed grasslands	2 496 004	1 747 213	748792	Others
Inland water/ wetlands	25 732	25 732	-	3.96	Inland water/ wetlands	101 899	101 899	-	
Urban/rural areas	174 677	247 464	72 787	15.5	Urban/rural areas	2 707 494	3 835 692	1 128 199	
Total	428 425	428 425			Total	12 982 351	10 733 082	2 249 269	

Annex 15. Socio economic data for Isoka District for 2000 and 2010

Isoka	Data for 2000	Data for 2010	Source	Annual change in %
Population in district (number of persons)	99 319	164 410	CSO (2011)	5.20%
Rural (number of persons)	87 846	146 782	CSO (2011)	4.70%
Urban (number of persons)	11 473	17 628	CSO (2011)	0.50%
Household size (persons)	5.2	4.8	CSO (2011)	
Number of households depending on agriculture	11 649	21 088	Ministry of Agriculture crop survey focus 2009/2010	4.70%
Total number planted commercial-scale agric. (ha)	-	-		
Total number planted small-scale agric. (ha)	8 524.6	15 431.9		4.70%
Land use per household (ha)	1.4	1.4		
Agricultural product	Maize	Maize		
Number of persons depending on charcoal	11 473	17 628	Based on urban population	
Annual charcoal consumption per person (kg)	134.6	139.6	FAO (1998)	
Total charcoal consumption in district (kg)	1 579 396.4	2 460 868.8	Annual consumption multiplied by the urban population	3.58
Charcoal going to other districts (kg)	-	2 986 767	Expert judgement, related to Nakonde data	
Number of persons depending on fuelwood	93 583	155 596	Rural population plus 50% of urban population	
Annual fuelwood consumption per person (kg)	240	240	FAO (1998)	
Total fuelwood consumption (kg)	22 459 920	37 343 040	Consumption multiplied by number of persons depending on fuelwood	3.99
Fuelwood going to other districts (kg)	-	-		
Industrial firewood or charcoal	-	-		
% of persons (households) depending on livestock		-		
Total number grazing animals (cattle and goats)	-	18 858	Information collected from Ministry of Agriculture in Isoka	4.70%
Stocking density (livestock units/ha)	-	1	Expert judgement	
Total grazing area (ha)	-	18 858	Calculated from stocking density	

Annex 16. Land-use changes for Isoka District

Forest categories	Crown closure	Area in 2010 (ha)	Area in 2040 (ha)	Attributed uses / Drivers
Total forest area 2010	-	479 535	407 605	
High dense (15% of forest cover)	>80%	71 930	61 141	Conservation, NTFPs, basic uses
Medium dense (30% of forest cover)	50-79%	143 861	122 281	Charcoal, fuelwood, anything
Low dense (55% of forest cover)	20-49%	263 744	224 183	Charcoal, fire, anything else

Non-forest categories (level I)	Non-forest categories (level II)	Area for 2010 (ha)	Agreed growth rate p.a.	Area for 2040 (ha)	Comment
Total in 2010	Details	395 362		467 292	
Agriculture lands	Annual/ perennial crop land (commercial)	-	3.5%	-	Assuming correlation with GDP
Agriculture lands	Annual/ perennial crop land (small scale)	15 432	4.70%	37 191	Assuming correlation with population growth
Rangeland	Open/closed grasslands	98 841	1.00%	69 188	Assuming change to other land uses/agriculture
Water bodies	Inland water/ wetlands	59 304	Stable	59 304	Stable
Built-up areas	Urban/rural areas	221 785	4.70%	301 608	Assuming correlation with population growth

Annex 17. Carbon-stock changes for Isoka District

Land use	Area in 2010 (ha)	Area in 2040 (ha)	Increase/ Decease (ha)	Carbon stock bio-mass and soil (tC/ha)	Land use	Carbon stock 2010 (2010 figures multiplied by carbon stock biomass) (A)	Carbon stock 2040 (2040 figures multiplied by carbon stock biomass) (B)	Increase/ Decrease ha (difference between B and A)	Driver
High dense forest > 80%	71 930	61 141	- 10 789	87	High dense forest > 80%	6 257 910	5 319 267	- 938 643	Agriculture shifting, charcoal, fuelwood
Medium dense forest 50-79%	143 861	122 281	- 21 580	59	Medium dense forest 50-79%	8 487 799	7 214 579	- 1 273 220	Agriculture shifting, charcoal, fuelwood
Low dense forest 20-49%	263 744	224 183	- 39 561	29.5	Low dense forest 20-49%	7 780 448	6 613 399	- 1 167 050	Others
Annual crop land (commercial)	-	-	-	21.75	Annual/ perennial crop land (commercial)	-	-	-	
Annual crop land (small scale)	15 432	37 191	21 759	21 75	Annual/ perennial crop land (small scale)	335 646	808 904	473 258	
Open/closed grasslands	98 841	69 188	- 29 653	48.5	Open/ closed grass lands	4 793 789	3 355 618	- 1 438 171	Others
Inland water/ wetlands	59 304	59 304	-	3.96	Inland water/ wetlands	234 844	234 844	-	
Urban/ rural areas	221 785	301 608	79 823	15.5	Urban/ rural areas	3 437 668	4 674 924	1 237 257	
Total	874 897	874 897	-		Total	31 328 103	28 221 535	- 3 106 568	

Annex 18. Socio economic data for Kabompo District for 2000 and 2010

Kabompo	Data for 2000	Data for 2010	Source	Annual change in %
Population in district (number of persons)	71 238	91 160	CSO (2011)	2.50%
Rural (number of persons)	62 091	81 434	CSO (2011)	2.40%
Urban (number of persons)	9 147	9 726	CSO (2011)	0.10%
Household size (persons)	5	5	CSO (2011)	
Number of household depending on agriculture	10 900	14 295	Ministry of Agriculture crop survey focus 2009/2010	2.40%
Total area planted commercial scale agric. (ha)	-	-		
Total area planted small scale agric. (ha)	6 250	8 ,197		2.40%
Land use per household (ha)	2	2		
Agricultural product	Maize	Maize		
Number of persons depending on charcoal	4 574	4 863	50% of urban population	
Annual charcoal consumption per person (kg)	134.6	139.6	FAO (1998)	
Total charcoal consumption in district (kg)	615 660	678 875	Annual consumption multiplied by 50% of urban population	0.93
Charcoal going to other districts (kg)	-	-		
Number of persons depending on fuelwood	66 665	86 297	Rural population plus 50% of urban population	
Annual fuelwood consumption per person (kg)	240	240	FAO (1998)	
Total fuelwood consumption (kg)	15 999 600	20 711 280	Consumption multiplied by number of persons depending on firewood	2.27
Fuelwood going to other districts (kg)	-	-	No data	
Industrial fuelwood or charcoal (kg)	-	-	No data	
% of person (households) depending on livestock	-	-	No data	
Total number of grazing animals (cattle and goats)	-	958	Information collected from Ministry of agriculture in Kabompo	2.40%
Stocking density (livestock units/ha)	-	1	Expert judgement	
Total grazing area (ha)	-	958	Calculated from stocking density	

Annex 19. Land-use changes for Kabompo District

Forest categories	Crown closure	Area in 2010 (ha)	Area in 2040 (ha)	Attributed uses / Drivers
Total forest area 2010	Na	1 054 808	1 038 986	
High dense (70% of forest cover)	>80%	738 366	727 290	Conservation, NTFPs, basic uses
Medium dense (20% of forest cover)	50-79%	210 962	207 797	Charcoal, fuelwood, anything else
Low dense (10% of forest cover)	20-49%	105 481	103 899	Charcoal, fire, anything else

Non-forest categories (level I)	Non-forest categories (level II)	Area for 2010 (ha)	Agreed growth rate p.a.	Area for 2040 (ha)	Comment
Total in 2010	Details	372 381		388 203	
Agriculture lands	Annual/peren-nial crop land (commercial)	-	3.5%	-	Assuming correlation with GDP
Agriculture lands	Annual/perennial crop land (small scale)	8 197	2.40%	14 099	Assuming correlation with population growth
Rangeland	Open/closed grasslands	11 ,714	0.8%	84 903	Assuming change to other land uses/agriculture
Water bodies	Inland water/ wetlands	74 476	Stable	74 476	Stable
Built-up areas	Urban/rural areas	177 994	2.40%	214 725	Assuming correlation with population growth

Annex 20. Carbon-stock changes for Kabompo District

Land use	Area in 2010 (ha)	Area in 2040 (ha)	Increase/ Decrease (ha)	Carbon stock bio-mass and soil (tC/ha)	Land use	Carbon stock 2010 (2010 figures multiplied by carbon stock biomass) (A)	Carbon stock 2040 (2040 figures multiplied by carbon stock biomass) (B)	Increase/ Decrease ha (difference between B and A)	Driver
High dense forest > 80%	738 366	727 290	- 11 076	87	High dense forest > 80%	64 237 842	63 274 230	- 963612	Agriculture and fuelwood
Medium dense forest 50-79%	210 962	207 797	- 3 165	59	Medium dense forest 50-79%	12 446 758	12 260 023	- 186 735	Agriculture and fuelwood
Low dense forest 20=49%	105 481	103 899	- 1 582	29.5	Low dense forest 20=49%	3 11 ,690	3 065 021	- 46 669	Others
Annual crop land (commercial)	-	-	-	21.75	Annual/ perennial crop land (commercial)	-	-	-	
Annual crop land (small scale)	8 197	14 099	5 902	21.75	Annual/ perennial crop land (small scale)	178 285	306 653	128 369	
Open/closed grasslands	11 1714	84 903	- 26 811	48.5	Open/closed grasslands	5 418 129	4 117 796	- 1 300334	Others
Inland water/ wetlands	74 476	74 476	-	3.96	Inland water/ Wetlands	294 925	294 925	-	
Urban/rural areas	177 994	214 725	36 731	15.5	Urban/rural areas	2 758 907	3 328 238	569 331	
Total	1 427 189	1 427 189	-		Total	88 446 535	86 646 885	- 1 799 651	

Annex 21. Socio economic data for Sesheke District for 2000 and 2010

Sesheke	Data for 2000	Data for 2010	Source	Annual change in %
Population in district (number of persons)	78 169	94 612	CSO (2011)	1.90%
Rural (number of persons)	64 827	74 905	CSO (2011)	1.20%
Urban (number of persons)	13 342	19 707	CSO (2011)	0.70%
Household size (persons)	5	5	CSO (2011)	
Number of households depending on agriculture	13 127	16 516	Ministry of Agriculture crop survey focus 2009/2010	1.20%
Total area planted small-scale agriculture (ha)	2 6254	3 3032	Calculated	1.20%
Land use per household (ha)	2	2	Expert judgement	
Agricultural product	Maize	Maize		
Number of licence holders dealing in timber	14	15	Sesheke DSA (2003) and information collected from the provincial Forestry office in Western Province	
Average volume of timber per licence holder (m3)	156	127		-1.85%
Average volume of timber per ha	11	11		
Timber going out of the districts (m3/year)	3 188	2 600		-1.85%
Number of persons depending on fuelwood	78 169	94 612	Based on the total district population	
Annual fuelwood consumption per person (kg)	240	240	FAO (1998)	
Total fuelwood consumption (kg)	18 760 560	22 706 880	Consumption multiplied by number of persons depending on fuelwood	1.74
Total number grazing animals (cattle and goats)	-	56 203	Information collected from Ministry of Agriculture in Sesheke	1.20%
Stocking density (livestock units/ha)	-	1	Expert judgement	
Total grazing area (ha)	-	56 203	Calculated from stocking density	

Annex 22. Land-use changes for Sesheke District

Forest categories	Crown closure	Area in 2010 (ha)	Area in 2040 (ha)	Attributed uses / drivers
Total forest area 2010	Na	1 721 284	1 101 622	
High dense (30% of forest cover)	>80%	516 385	330 487	Conservation, NTFPs, basic uses
Medium dense (30% of forest cover)	50-79%	516 385	330 487	Charcoal, fuelwood, anything else
Low dense (40% of forest cover)	20-49%	688 514	440 649	Charcoal, firewood , anything else

Non-forest categories (level I)	Non-forest categories (level II)	Area for 2010 (ha)	Agreed growth rate p.a.	Area for 2040 (ha)	Comment
Total in 2010	Details	1 272 113		1 891 775	
Agriculture lands	Annual/perennial crop land (commercial)	-	3.5%	-	Assuming correlation with GDP
Agriculture lands	Annual/perennial crop land (small scale)	33 032	1.20%	44 924	Assuming correlation with population growth
Rangeland	Open/closed grasslands	636 057	0.1%	616 975	Assuming change to other land uses/ agriculture
Water bodies	Inland water/wetlands	508 845	stable	508 845	Stable
Built-up areas	Urban/rural areas	94 179	1.20%	721 032	Assuming correlation with population growth

Annex 23. Carbon-stock changes for Sesheke District

Land use	Area in 2010 (ha)	Area in 2040 (ha)	Increase/ decrease (ha)	Carbon stock biomass and soil (tC/ha)	Land use	Carbon stock 2010 (2010 figures multiplied by carbon stock biomass) (A)	Carbon stock 2040 (2040 figures multiplied by carbon stock biomass) (B)	Increase/ decrease ha (difference between B and A)	Driver
High dense forest > 80%	516 385	330 487	- 185 898	87	High dense forest > 80%	44 925 495	28 752 369	- 16 173 126	Agriculture, shifting, charcoal, fuelwood
Medium dense forest 50-79%	516 385	330 487	- 185 898	59	Medium dense forest 50-79%	30 466 715	19 498 733	- 10 967 982	Agriculture, shifting, charcoal, fuelwood
Low dense forest 20=49%	688 514	440 649	- 247 865	29.5	Low dense forest 20=49%	20 311 163	12 999 146	- 7 312 018	Others
Annual crop land (commercial)	-	-	-	21.75	Annual/ perennial crop land (commercial)	-	-	-	
Annual crop land (small- scale)	33 032	44 924	11 892	21.75	Annual/ perennial crop land (small-l scale)	718 446	977 097	258 651	
Open/closed grasslands	636 057	616 975	-19 082	48.5	Open/closed grasslands	30 848 765	29 923 288	-925 477	Others
Inland water/ wetlands	508 845	508 845	-	3.96	Inland water/ wetlands	2 015 026	2 015 026	-	
Urban/rural areas	94 179	721 032	790 422	15.5	Urban/rural areas	1 459 775	11 175 996	9 716 222	
Total	2 993 397	2 993 397	-		Total	130 745 384	105 341 654	-25 403 730	

Annex 24. Combined results of forest and non-forest cover changes statistics

Forest/non-forest cover statistics for study areas generated from district land cover maps for the years 1990, 2000, 2010

No.	Name of district	District land area (ha)	Forest cover in hectares			Non-forest cover in hectares		
			Year 1990	Year 2000	Year 2010	Year 1990	Year 2000	Year 2010
1	Kapiri Mposhi	1 117 507	406 912	413 551	307 462	710 595	703 956	810 045
2	Nakonde	428 425	220 962	193 885	171 103	207 463	234 540	257 322
3	Isoka	874 897	304 563	289 175	479 535	570 334	585 722	395 362
4	Kabompo	1 427189	1 074 244	1 060 506	1 054 808	352 945	366 683	372 381
5	Sesheke	2 993 397	1 589 113	1 954218	1 721 284	1 404 284	1 039 179	1 272 113

Note: District land cover maps developed following supervised classification of Landsat imagery.

Forest/non-forest cover forest cover change statistics for study areas generated from respective district land cover maps for the years 1990, 2000, 2010

No.	Name of district	District land area (ha)	Forest cover in hectares					
			Year 1990	Year 2000	Change	Year 2000	Year 2010	Change
1	Kapiri Mposhi	1 117 507	406 912	413 551	6 639	413 551	307 462	106 089
2	Nakonde	428 425	220 962	193 885	- 27 077	193 885	171 103	22 782
3	Isoka	874 897	304 563	289 175	15 388	289 175	479 535	190 360
4	Kabompo	1 427 189	1 074 244	1 060 506	13 738	1 060 506	1 054 808	5 698
5	Sesheke	2 993 397	1 589 113	1 954218	365 105	195 4218	1 721 284	232 934

Note: a negative value indicates a decrease in forest cover.

Annex 25. Variables used in scoring the speed of delivery of co-benefits

Table A

Variable	Zone I	Zone II	Zone III
Rainfall	Less than 800 mm (1)	800 – 1000 mm (2)	1000 – 1500 mm(3)
Soil fertility	Less fertile (2)	Fertile (3)	Poor (1)
Vegetation regeneration potential	Low (1)	Medium (2)	High (3)

Notes for table A:
The numbers in table A above are scored from 1 (low) to 3 (high). The rainfall ranges are basically three: zone I has less than 800 mm (scored 1), zone II has 800 – 1000 mm (scored 2) and zone III has 1000 – 1500 mm (scored 3). The soil fertility also differs in each zone: zone I is less fertile (scored 2), zone II is fertile (scored 3) and zone III is poor (scored 1). The vegetation regeneration potential depends on the type of vegetation in each zone and is characteristic to regenerate naturally. This element is also affected by the amount of rainfall and soil types. Zone I is the driest zone, very prone to drought and with limited potential for crop production (scored 1), Zone II is dominated by Miombo woodlands that has high potential for regeneration but is disturbed by increased farming activities that are attracted by good rainfall and fertile soils (scored 2). Zone III has the highest rainfall, dominated by Miombo woodland that has high potential of regeneration and poor acidic soils that do not support agriculture activities, hence encouraging regeneration and tree growth (score 3).

The values in table A above were used for scoring in the table below:

Table B: Numerical values for score card

Option	Agro-ecological zone	Ecosystem services – delivery and quality of results					
		Biodiversity conservation	Water regulation and quality	Soil conservation and quality	NTFPs	Climate regulatory services	Non material benefits
Assisted natural regeneration (including planting of exotic and indigenous species in degraded areas, and law enforcement)	Zone I	1	1	1	1	1	2
	Zone II	2	3	2	2	3	3
	Zone III	3	2	3	3	3	3
Improvement of good agricultural practices	Zone I	1	1	2	1	1	2
	Zone II	3	3	2	3	3	2
	Zone III	3	3	3	3	3	3
Development of alternative energy sources	Zone I	1	1	1	1	1	1
	Zone II	3	3	2	3	2	2
	Zone III	3	3	2	3	2	2
Development of environmentally friendly income generating activities (e.g modern beekeeping)	Zone I	1	1	1	1	1	1
	Zone II	2	1	1	2	1	1
	Zone III	2	2	2	2	2	2

Annex 26. Variables used in scoring the importance of co-benefits

Variable	Zone I	Zone 11	Zone III
Population density approximation	Lower (1)	High (3)	Low (2)
Reliance on the co-benefits	Low (2)	High (3)	High (3)

Agro-ecological zone	Ecosystem services – importance					
	Biodiversity conservation	Water regulation and quality	Soil conservation and quality	NTFPs	Climate Regulatory Services	Non-material benefits
Zone I	1	2	2	1	2	2
Zone II	3	3	3	3	3	3
Zone III	3	2	2	3	3	3

Notes: 1 = Less important, 2 = important, 3 = more important

Annex 27. Summary of study areas where various data was collected

1. **Kapiri Mposhi** (in Chibwe National Forest and Kapiri local forest):
    - DNRC; agriculture, planning, forestry and council officers;
    - Chief Nkole and Indunas;
    - Community group discussions (CACs, CRBs, ADCs or JFM committees); and
    - Key informants (10).

Information: farming systems, forest use.

2. **Nakonde-Isoka** (in Chilanga open area, Kapiri Longa-Isoka side, Odd Fife (agriculture camp), Brahim community, Nakonde plantation, Tenga and Bulongo villages-Nakonde side):
    - DNRC; Agriculture, planning, forestry and council officers;
    - Chiefteness Nawa Itwika and Indunas;
    - Community group discussions (CACs, CRBs, coffee associations, ADCs or JFM committees); and
    - Key informants (10).

Information: farming systems, forest use.

3. **Kabompo** (Manyinga, Kabompo, forest reserve near Kabompo, North-Western bee products- members of the beekeeping association):
    - DNRC; Agriculture office and FTC, planning, provincial and districts forestry and council officers;
    - Chief Mumena and Indunas;
    - Community group discussions (CACs, CRBs, ADCs or JFM committees); and
    - Key informants (10).

Information: farming systems, forest use.

4. **Sesheke** (Masese forest and surrounding villages, timber concessions, project areas, Machile area):
   - DNRC; Agriculture office and FTC, planning, provincial and district forestry and council officers;
   - Chief Inyambo and Indunas;
   - Timber concessioners;
   - Community group discussions (CACs, project groups, CRBs, ADCs or JFM committees); and
   - Key informants (10).

Information: Timber and fire, vegetation changes (mutemwa trees, mukusi system), farming system, forest changes.

Annex 28. Ground-truthed points for Kapiri District

District Name: Kapiri-Mposhi | Forest: Kapiri local forest | Form 2: Field Sample Points

ID	Cluster No.	Colour	Description	Easting	Northing
49	1		Stream	0695262	8477227
52	2		Palace	0698115	8476598
54	3		Stream	0687989	8474434
23	4		Dam (spill way, Mushimbili)	0686145	8467998
57	5		Ncube stream	0682993	8470535
59	6		Kapiri technical highschool	0680381	8463704

District Name: Kapiri-Mposhi | Forest: ChibweNational forest | Form 2: Field Sample Points

ID	Cluster No.	Colour	Description	Easting	Northing
	1		Kasempa village (Charcoal Centre)	0679877	8447527
	2		Settlement along Kambosha Stream	0682822	8443410
	3		Kambosha Stream/ZESCO power line	0683496	8441020
	4		Dambo/Chibwe forest	0681726	8441118
	5		Chibwe forest	0681436	8440648
	6		Chibwe forest	0680797	8441146
	7		Chibwe forest/farm ex-IG	0678469	8433382
	8		Temporal settlement/forest	0680833	8430944
	9		Chibwe forest/stream	0679307	8432263
	10		Chibwe forest/sand mining	0674363	8440864

Annex 29. Ground-truthed points for Nakonde District

District Name: NAKONDE | Form 2: Field sample points

POINT ID	CLUSTER NO.	COLOUR	DESCRIPTION	EASTINGS	NORTHINGS
	1	Yellow	These were not rocks but teachers' houses at a school	0464000	8967000
	2	Pink	Light forest (correct)	0465000	8957000
	3	Green	Not water but a thick regenerating forest	0469000	8968000
	4	D/Brown	Village (correct, it was a school with staff houses)	0460000	8951000

Annex 30. Ground-truthed points for Isoka District

District Name: ISOKA | Form 2 Field sample points

POINT ID	CLUSTER NO.	COLOUR	DESCRIPTION	EASTINGS	NORTHINGS
	1	Yellow	Rocks (correct)	0469000	8888000
	2	Blue	Scattered cultivation (correct)	0467000	8886000
	3	L/blue	Forest (correct)	0468000	8894000
	4	Green	Not water but thick secondary regenerating forest	0465000	8885000
	5	White	Open bush (correct)	0467000	8887000
	6	D/brown	Swamp (correct)	0464000	8883000
	7	L/brown	Not dambo but open fields	0467000	8888000
	8		Katonga swamp	0464250	8885035
	1	Yellow	Rocks	469000	8888000
	2	Blue	Scattered cultivation	467000	8886000
	3	Pink	Light forest		
	4	L/Blue	Forest	468000	8894000
	5	Green	Water	465000	8885000
	6	White	Open bush	467000	8887000
	7	D/Brown	Swamp	464000	8883000
	8	L/Brown	Dambo	467000	8888000
	9	D/Blue			

Annex 31. Ground-truthed points for Kabompo

District Name: Kabompo | Forest: Litoya/Manyinga forest | Form 2: Field Sample Points

ID	Cluster No.	Colour	Description	Easting	Northing
	1	Red	Grass land		
	2	Yellow	Forest	0212547	8489372
	3	Blue	Chifuwe stream/swamp	0215113	8488064
	4	Pink	Light forest	0217379	8489767
	5	L/Blue	Forest	0209205	8488862
	6	Green	Kabompo river	0198824	8493669
	7	White	Light (open) forest	0212169	8489687
	8	D/Brown		0211279	8486581
	9	L/Brown	Scattered cultivation	0202377	8492632
	10	D/Blue			

Forest: Kabompo forest

ID	Cluster No.	Colour	Description	Easting	Northing
	1		Kabompo Forest/road	0209249	8484667
	2		Traditional forest/Chifuwe stream	0211262	8482872
	3		Kabompo Forest	0210886	8482681
	4		Kabompo Forest	0210355	8482422
	5		Kabompo Forest	0202343	8481309
	6		Kabompo Forest	0203610	8478717
	7		Kabompo Forest	0205625	8475474
	8		Dambo (KabompoForest)	0206185	8474505
	9		Kabompo Forest	0206535	8473872
	10		Kabompo Forest (Kamezhi Stream)	0206734	8473254
	11		Plain (Kabompo Forest)	0201930	8482143
	12		Kabompo Forest	0201577	8486913
	13		Kabompo Forest	0201910	8489357
	14		Kabompo Forest (shifting cultivation site)	0202031	8491944

Annex 32. Ground control points for Sesheke

District Name: Sesheke | Form 2: Field Sample Points

ID	Cluster No.	Colour	Description	Easting	Northing
	1		Sichinga forest (PA)	024 18.245	17 23.853
	2		Moonze forest (PA)	024 17.900	17 23 808
	3		Maize fields	024 17.898	17 23 808
	4		Maize fields	024 16.909	17 23.405
	5		Liyambango settlement	024 17.195	17 27.469
	6		End of Sichinga forest (PA)	024 17.194	17 27.470
	7		Sichinga forest (PA)	024 17.060	17 28.258
	8		Masese Mukusi research plot	024 17.133	17 28 .520
	9		Masese forest	024 17.000	17 28.329
	10		Masese forest	024 06.171	17 13.778
	11		Mangamu East	024 22.834	17 27.251
	12		Kalomo	028 24.361	15 27.513
	13		Lumino forest (PA)	024 49.253	17 07.053
	14		Open woodlands Milombe	024 47.850	17 08.551
	15			024 38.540	17 17.111
	16		Kangumbu area of Lumino PA	024 38.539	17 17.110
	17		Machile	024 54.626	17 00.876
	18		Situmpa forest	025 09.445	16 47.400
	19		Kasaya 1 (Mopane wood land)	025 06.146	17 28.416
	20		Research plot	024 39.203	17 22.153
	21		Lusu open woodlands	024 02.327	17 14.876
	22		Quarry (large)	024 06.171	17 13.778
	23		Fields	024 04.874	17 04.032

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