Analysis of agents, drivers, and underlying causes of deforestation for VCS Methodology VM0015 for BCP Community Forests Program

UNIQUE forestry and land use

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LIST OF ABBREVIATIONS

BCP	BioCarbon Partners
CCBS	Climate, Community and Biodiversity Standards
CDM	Clean Development Mechanism
CFP	Community Forests Program
DFO	District Forest Officer
DNPW	Department of National Parks and Wildlife
EI	Effectiveness Index
FD	Forestry Department
FGD	Focus Group Discussion
GHG	Green House Gas
GIS	Geographic Information System
GMA	Game Management Area
ha	hectare
ILUA	Integrated Land Use Assessment
IPCC	Intergovernmental Panel on Climate Change
LULC	Land Use Land Cover
NPV	Net Present Value
PD	Project Document
REDD+	Reducing Emissions from Deforestation and forest Degradation
SEPAL	System for Earth Observation Data Access, Processing and Analysis for Land Monitoring
tCO_2e	tonnes of Carbon Dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCS	Verified Carbon Standard

1 EXECUTIVE SUMMARY

This report presents the results of the analysis of agents, drivers and underlying causes of deforestation undertaken as part of the requirements for developing the BCP Community Forests Program (CFP) according to the VCS carbon accounting methodology: *VM0015 Methodology for Avoided Unplanned Deforestation, version 1.1*. BCP will apply this methodology to quantify emissions reductions generated by the project. Step 3 of the methodology requires undertaking an analysis of the main agents, drivers, and underlying causes of deforestation and their likely future development.

The methods employed in this study included literature review, land use/cover change analyses, expert consultations, interviews, and focus group discussions. These methods were used to identify and validate agents, drivers, and underlying causes of deforestation. The land use/cover change analysis was also used to quantify historical deforestation in the project reference region.

The study identified the main agents of deforestation in the reference region as being smallholder farmers, charcoal producers and consumers, and firewood collectors and consumers. The main deforestation drivers (activities that cause deforestation) were identified as being smallholder agricultural expansion, charcoal production, and firewood extraction.

The identified underlying causes of deforestation varied according to the drivers and agents: for agricultural expansion, they are: poverty and agricultural dependency, growing rural population, poor farming practices, and weak system of forest resource management. For charcoal production they are: high dependency of a growing urban population on charcoal as a source of energy for cooking and heating, inefficient charcoal production technique, and weak regulatory and institutional system. For firewood extraction, the underlying causes are: high dependency of a growing rural population on firewood, and inefficient utilisation of the wood resource. These factors are responsible for the deforestation observed in the reference region during the historical reference period (2006-2017), which was estimated at 571,040 ha. The study also revealed clear patterns of relationships between historical deforestation and certain demographic and spatial variables, namely: population density, distance to roads and to settlements, and slope. Hence, these variables were identified as the variables that can explain the quantity and location of deforestation in the reference region. From the available evidence (literature review, land use/cover change analyses, expert consultations, interviews, and focus group discussions), the future outlooks of the underlying causes and driver variables indicate that deforestation will likely continue in the reference region at a rate similar to the baseline deforestation. Therefore, we concluded that future baseline deforestation rates would remain **about constant** relative to the historical deforestation – in particular during the project's fixed baseline period (2016 - 2026).

This report presents a great deal of information regarding deforestation in the reference region. Of particular relevance for compiling the project document are the descriptions of the main agents of deforestation (section 4.2), main drivers (section 4.3), driver variables that correlate with historical deforestation (section 4.4), underlying causes (section 4.5), chains of events leading to deforestation (section 4.6), conclusion (section 4.7), and effectiveness index (section 4.8). Summaries of these sections should be presented in the project document.

2 INTRODUCTION

The BioCarbon Partners in collaboration with the Zambia's Forestry Department, and Department of National Parks and Wildlife is developing a large-scale project to reduce deforestation and enhance forest conservation in the Zambezi and Luangwa Valley ecosystems of Zambia's Lusaka and Eastern Provinces. The project, called Community Forests Program (CFP), is USAID-funded and the lead project under USAID's Zambia Global Climate Change initiative. The goal of the CFP is to reduce emissions from deforestation and forest degradation, and generate income from the resulting emission reductions in order to fund conservation and poverty alleviation initiatives in the region. The project covers parts of two provinces, namely Eastern and Lusaka, and aims to facilitate the implementation of activities for Reducing Emissions from Deforestation and forest Degradation and enhancing forest conservation (REDD+) on more than 700,000 hectares of community-managed forests, thus, establishing the largest REDD+ program in the country to-date. Figure 1 shows the project location.

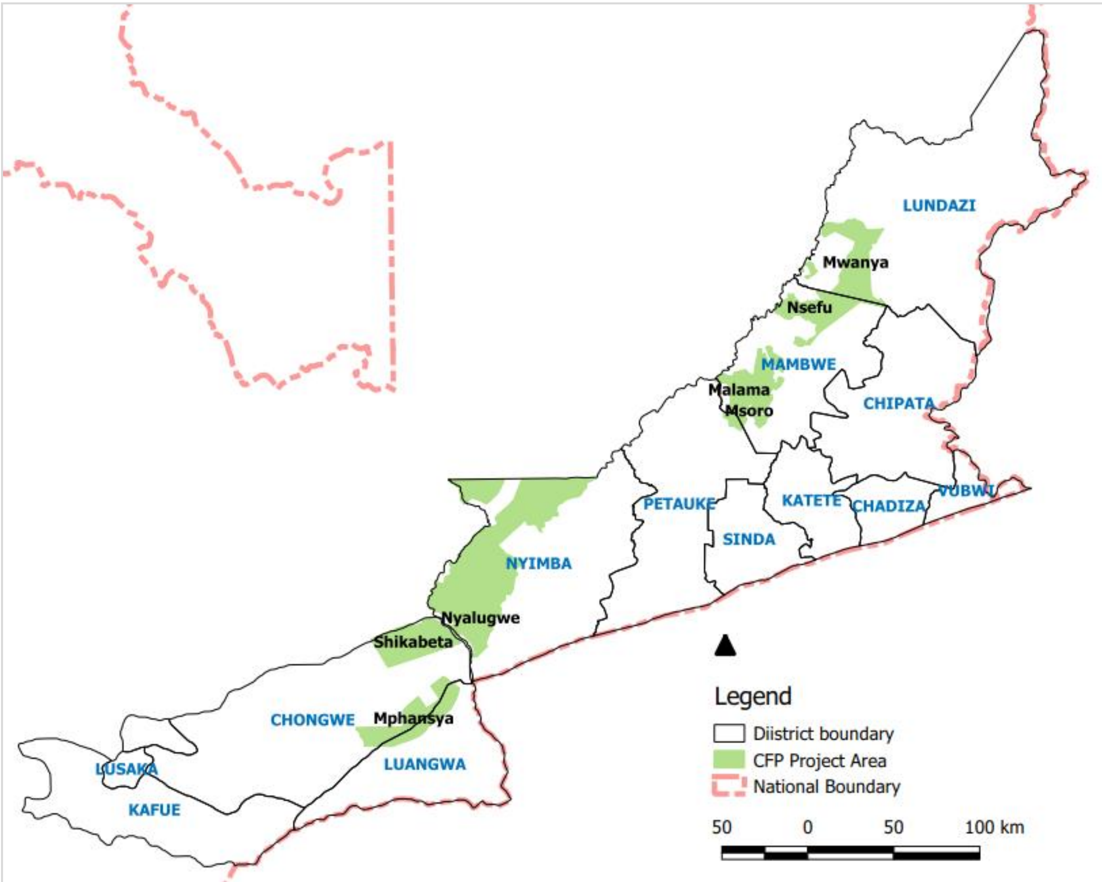

Figure 1: Map of project location

Source: Authors and BCP

The approach BCP is using to operate the REDD+ project in order to benefit community and environmental conservation is described in the project model, which is summarised in Figure 2 below:

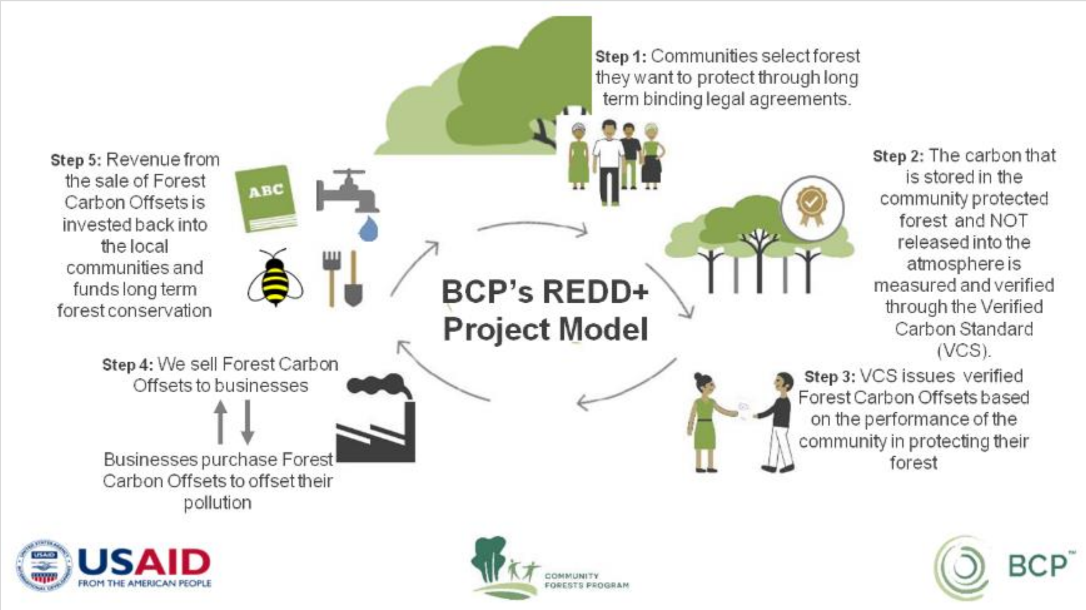

Figure 2: The project's REDD+ Cycle

Source: BCP

The project, whose start date is set as 01 July 2016, will apply the Verified Carbon Standard (VCS) and the Climate, Community and Biodiversity Standards (CCBS) to quantify and certify its generated climate, community, and biodiversity benefits. A summary of the project's key information is presented in Table 1 below.

Table 1: Key project information

Province	District	Chiefdom	Forest cover within project area in the chiefdom in 2017 (ha)
Lusaka	Rufunsa	Mphansya	56,840
Eastern	Nyimba	Luembe	187,134
		Nyalugwe	69,454
	Mambwe	Jumbe	13,477
		Msoro	21,519
		Mnkhanya	29,441
		Malama	23,892
		Nsefu	28,161
	Lundazi	Mwanya	57,480
Total			487,398

Source: Authors and BCP. LULC data from Google Earth Engine

To fulfil part of the requirements for the project development, UNIQUE forestry and land use undertook this study to analyse the agents, drivers, and underlying causes of deforestation and their likely future development. Chapter 3 of this report describes the methods used in the study, while the results are presented in Chapter 4. Additional analyses, namely: opportunity cost and co-benefits have also been included and are reported in Chapter 4. These additional analyses provide valuable information for the CCBS certification as well as the VCS non-permanence risk assessment.

3 METHODS

A number of methods were employed in this study – corresponding to the range of data, analyses, and results that the study aimed to generate; they are described in sections 3.1 to 3.5.

3.1 Literature review

An extensive review of literature on deforestation in Zambia and in the project reference region was undertaken. Through this, a range of agents, drivers, and underlying causes were identified as relevant for deforestation both now and in the future. Past, on-going and planned efforts aimed at tackling deforestation were also identified by reviewing relevant conservation projects' documentation. The literature and materials reviewed (section 5) were gathered from a variety of sources including online search, BCP documentation, UNIQUE's previous assignments in Zambia, and other stakeholders engaged during the study, e.g., FD, DNPW, and other entities.

3.2 Land use/cover change analyses

Land use/land cover (LULC) analyses were performed to estimate historical deforestation extent, rates, trends, and patterns using Landsat images obtained via the Google Earth Engine. The Landsat scenes were used to create LULC maps for 2006, 2009, 2013 and 2017 using the System for Earth Observation Data Access Processing and Analysis for Land Monitoring (SEPAL) cloud-based application. Details of the data used and analyses undertaken are contained in a separate document (*Methodology to analyze the drivers of deforestation from spatial data*).

3.3 Expert Consultations, Interviews, and Focus Group Discussions

Expert consultations and interviews were held with local experts, i.e., district government officials, forestry officials, BCP project staff, and the agents of deforestation. Additional information such as project plans, reports, etc. related to deforestation and measures to tackle it were also gathered in the process. Focus Group Discussions (FGDs) were held with local communities, which included representatives from the chiefdoms, village headmen, and members of particular villages. The information gathered through the FGDs helped to better understand the process and activities causing deforestation, the agents and agents' motives for deforestation, underlying causes, and benefits and costs associated with deforestation. The guiding questions used for the FGDs, expert consultations, and interviews are presented in Annex1. Information regarding underlying causes of deforestation and their future trends were thus gathered at the local level and triangulated with the literature review throughout the study. The FDGs conducted in the villages used participatory methods, and involved discussing the historical reasons and patterns of forest loss with the communities, and depicting where and what activities and factors did and would continue to drive deforestation. Local experts served as facilitators in the process.

The project has proposed and is putting in place a number of activities and measures to address deforestation. For the purpose of evaluating and estimating the effectiveness of those activities and measures, an experts' consultation was held in Chipata, Eastern Province. Participants included project stakeholders, i.e., local communities, BCP, FD, DNPW, district governments, etc. Participants were tasked with evaluating to what extent the proposed project activities could reduce deforestation. The results of their evaluations were summarised into what is termed as the project's Effectiveness Index (section 4.8). The fieldwork program and categories of people engaged in consultations, discussions, and interviews are presented in Annex 2.

3.4 Analysis of driver variables and deforestation relationships

In this analysis, the relationship between historical deforestation and two categories of driver variables were examined, namely:

1. Driver variables that explain the quantity (hectares) of deforestation, e.g., population density, population growth, and percentage of rural population.
2. Driver variables that explain the location of deforestation, i.e., distance to existing roads, forest proximity to existing settlements, slope, and elevation.

The analyses for spatial variables were performed using Geographical information System (GIS)[1], while for demographic variables, their relations with deforestation were analysed and inferred from collated literature, expert consultations, FDGs, and interviews. The results are presented in section 4.4.

3.5 Opportunity cost and co-benefits assessments

3.5.1 Opportunity cost

Opportunity cost assessment was done to estimate quantifiable material benefit associated with the drivers (i.e., the deforesting activity) in order to understand benefits that deforestation agents would forego if they did not engage in the deforesting activity in which they are currently. This foregone benefit is thus the opportunity cost – from the standpoint of the agent. The cost and benefit information were collected during the fieldwork – through expert consultations, interviews, and focus group discussions – and from published literature. The accounting was done from the deforestation agents' perspective; thus, only those products with known markets and prices were considered. The opportunity cost assessment followed the guidance of the World Bank (2011), and UNIQUE forestry and land use opportunity cost assessment manual and tools[2]. The authors assessed the opportunity cost using one-hectare (1-ha) land use models for drivers that generate benefits to the agent (Annex 3). The period of assessment was taken as 10 years, corresponding to the project's fixed baseline period[3]. The key figures and assumptions for the opportunity cost assessment, e.g., prices, discount rate, etc. are presented in Annex 3. The opportunity cost is presented both in absolute and relative terms. The absolute term indicates the discounted net benefits to be foregone from the deforestation/degradation activity (driver), and the relative term indicates the discounted net benefits to be foregone to avoid emissions of one tCO_2e. For summarised descriptions of the concept of NPV, and the absolute and relative opportunity cost terms, refer to Annex 4 and Annex 5 respectively.

[1] The used GIS software was ArcGIS from ESRI.
[2] World Bank, 2011; Merger *et al*., 2012.
[3] Fixed baseline period is the period of time for which the validated baseline is fixed, which under the VCS can be up to 10 years.

3.5.2 Co-benefits

Assessment of co-benefits was done to complement the aforementioned opportunity cost assessment. It is well-known that communities and other forest users value forests and forest landscapes for much more than just the well-known material benefits– such as timber and other wood products. Those benefits, which are often difficult to estimate in quantitative terms, are termed here as co-benefits. To assess co-benefits, the authors gathered information regarding the values of forests through expert consultations, interviews, and FGDs at the local level, combined with the review of published literature.

3.6 Study limitations

Remote sensing: The LULC classes used in this study were limited to two: forest and non-forest land use classes because the use of detailed classes (e.g., the IPCC classes of Forest, Grassland, Cropland, Wetlands, Settlement, etc.), yielded poor results (low classification accuracy). Using those two classes (forest and non-forest) is acceptable under the methodology, though detailed classification, e.g., by splitting forest into different classes that reflect their distinct carbon stocks has the benefit of improving the estimates of GHG emissions from deforestation or land use change. In particular, the inclusion of reducing forest degradation would require a stratification of forests into different carbon density classes.

Opportunity cost: The opportunity cost assessment is not a full accounting of environmental goods/services of the forests or the land use activity causing deforestation. A full accounting of environmental goods/services demands several and extensive economic valuation studies – a task not achievable or aimed for within the scope of this assignment. Hence, only well-known or documented land use benefits that are material in nature, e.g., crop sales after cultivation on converted forestlands, and their cost of production – relative to the benefit (revenues from major forest products) and costs of managing the standing forest, were considered. Furthermore, this study used mostly existing secondary data in addition to information collected during the field mission. Considering its wide geographical scope, not all data/information, particularly costs of certain activities, and revenues (benefits) could be precisely determined or quantified. Hence, assumptions were made regarding certain costs and benefit items; these are stated in section 4.9 and in the 1-ha land use models (Annex 3). Therefore, the opportunity cost estimates arrived at should be taken as approximations based on all data available within the scope of this study. The carbon stock values used in calculating opportunity cost/tCO_2e were also obtained from secondary source: Forestry Department Integrated Land Use Assessment II (ILUA II), and IPCC, 2006[4] for default soil carbon stocks. ILUA is the most widely cited and used source of carbon stock data for different LULC types in Zambia – though it is based on a relatively low sample size spread across the country. Hence, the values used were the best available, and are acceptable under the project methodology, but may not be as accurate - especially the IPCC default soil carbon value – as values from a properly conducted project-specific carbon inventory are.

[4] IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Generic methodology applicable to multiple land-use categories.

4 RESULTS

This section starts with a summary of the deforestation observed in the project region in the historical reference period (2006 to 2017). Detailed descriptions of the agents, drivers, and underlying causes of deforestation follow in the subsequent sections (4.2 to 4.7). In addition, an Effectiveness Index (EI) is estimated and presented in section 4.8. Finally, opportunity costs are presented in section 4.9. The opportunity cost analysis has been complemented by the assessment of co-benefits, which describe benefits of forests that are not captured in the opportunity cost analysis.

4.1 Deforestation quantities in the historical reference period

The results of LULC analyses showed that 571,040 ha of forests were lost in the reference region between 2006 and 2017 – the historical reference period. This translates to an average annual deforestation rate of 1.0% (**Fehler! Verweisquelle konnte nicht gefunden werden.**). In terms of trend, however, the analyses showed that there was net forest loss (deforestation) within the reference region in the 2013-2017 period, and no net deforestation in earlier periods (2006-2009, and 2009-2013) in the historical reference period. Estimated forest gains in those periods were higher than forest losses, resulting into net forest gains, though the gains consistently declined over time, and by the latest period (2013-2017), there was net deforestation.

Table 2: Deforestation in the historical reference period

Period	Net forest loss or gain (ha)	Rate of forest loss or gain (%/year)	Remarks
2006-2017 (historical reference period)	**-571,040**	**-1.0%**	**Loss**
2006-2009	278,964	1.8%	Gain
2009-2013	207,624	0.9%	Gain
2013-2017	-1,057,629	-4.6%	Loss

Source: Authors and BCP; LULC data from Google Earth Engine.

Positive numbers indicate forest gain and negative numbers forest loss (deforestation).

The deforestation rate estimated over the historical reference period is comparable to other estimates of long-term deforestation rate in the region: Vinya *et al*., 2012, using Chidumayo, 2012 data, reported average deforestation rate for the Eastern province of 0.9% - for the period 1965 to 2005. At the national level, deforestation rate is estimated to range from around 1 to 2% depending on the source of data or analyses used to estimate it (Vinya *et al*., 2012).

4.2 Agents of deforestation

The agents of deforestation as well as the drivers, which are described in the subsequent sections, have been identified using information collated from expert consultations, FGDs, and interviews, and literature sources including: Kalinda et al, 2008; COMACO, 2011; Vinya et al., 2012; Gumbo et al, 2013; Day et al., 2014; Robert et al., 2015, and several others, which are referenced in section 5, and cited in the body of this report.

Within the reference region there are a number of entities whose actions are responsible for causing forest loss. These entities are the agents of deforestation, and the main agent groups identified in this study are:

1. Smallholder farmers;
2. Charcoal producers and consumers; and
3. Firewood collectors and consumers.

These agent groups are discussed in detail in section 4.2.1 to 4.2.3. Other agent groups include migrants and settlers, road infrastructure developers, illegal timber harvesters, miners, and forest fires users. These agent groups are not considered as main agent groups. However, they have also been described in sections 4.2.4 to 4.2.8.

4.2.1 Smallholder farmers

Smallholder farmers are a predominant deforestation agent in the project reference region. Large-scale farming is not common here. Smallholder farmers are characterised by having small farm sizes, an average of 2 hectares or less, and the practice of subsistence farming. They are highly dependent on agriculture, and have little to no alternative means of livelihood. They clear forestland to practise low-input cultivation, resulting in low yields and rapid exhaustion of the soils. Maize is the most common crop grown, in addition to other crops such as sunflower, beans, cotton, and tobacco. When the soils have become less- or unproductive, new lands are cleared. According to consultations and interviews, all rural households are engaged in small-scale farming. Even the few people having alternative incomes such as from charcoal production or salaried jobs (e.g. school teachers) are involved in small-scale farming. In the reference region, the percent of rural population ranges from 60 to 97% (see section 4.4.1 for details). With annual average human population growth rate of about 2 to 4% in the region, this agent group is exerting enormous pressure on forest loss, and expected to continue doing so for the foreseeable future.

4.2.2 Charcoal producers and consumers

Charcoal producers can be categorised into two groups: 1) occasional producers – those who produce charcoal infrequently since they do not depend on it as their primary means of livelihood; and 2) regular producers – those who are involved in charcoal production as their main source of income and livelihood. The first group produces charcoal in order to take care of occasional cash needs or as an opportunistic additional income during land clearing for cultivation, or as a safety net against poor crop yields experienced in a particular year or season. The second group produces charcoal regularly for sale either independently or in collaboration with charcoal traders.

While charcoal production occurs in rural areas, its consumers are concentrated in urban areas – including Lusaka and other urban centres both inside and outside the two provinces. Rural consumption of charcoal is minimal. In urban areas, charcoal is preferred to firewood because it is less bulky and has higher heat content per unit weight compared to firewood –though it is more expensive than firewood.

Charcoal producers can be found across the entire project reference region although there are areas of concentrations: For example, in Nyimba district, Eastern Province, such areas include Mchimazi, CH (Contract Haulage), Unyanya along the Great East Road (T4) to the Luangwa valley (river), that separates Eastern and Lusaka Provinces. A similar trend is observed in Rufunsa district on the Lusaka Province side.

Charcoal producers often move from place to place in search of abundant wood resources, and sometimes in response to increased enforcement of production and trade regulations. Though the population of charcoal producers is unknown and hard to determine due to lack of monitoring coupled with frequent producers' mobility, according to interviews, in areas where productions are concentrated, more than half of the households are reportedly engaged in charcoal production – either as occasional or regular producers[5]. With increased urbanisation rate[6], the number of charcoal consumers is on the increase and can be realistically expected to grow in the foreseeable future, driving demand and production upwards – as charcoal is cheaper than alternative energy sources such as electricity or gas[7].

4.2.3 Firewood collectors and consumers

Every household in rural areas collects and/or uses firewood as the primary source of energy for cooking and heating. Besides households, other main collectors and consumers of firewood are institutions – including educational/training institutions; cottage and small-scale businesses such as burnt-brick makers, and restaurants and lodges; and small to medium-sized industries such as beer breweries. Firewood is preferred by all these groups of users because it is a cheaper and readily available energy source. As rural population continues to grow, so will the collection and consumption of firewood– because alternative energy sources for cooking and heating that are affordable and readily accessible by the rural population and institutional consumers are non-existent.

According to consultation and interviews, rural households traditionally collected mainly dead or dry wood for firewood, hence, did not cut standing live trees in significant numbers. However, with increasing users' population, tree cutting for firewood is now common since deadwood

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[5] A rough estimate is that, there were **more than 50,000 people** engaged in charcoal production on full-time basis and earning a living from charcoal production in Zambia in 2008 (Kalinda et al., 2008).

[6] Urbanisation rate of Zambia is estimated at about 4.4% p.a. (The World Factbook, 2017).

[7] To illustrate this: according to Zambia Electricity Supply Corporation, 1 kilowatt hour (KWh) of electricity for residential users consuming less than 200 kWH per month in Zambia costs 0.15 ZMW excluding taxes, i.e., 18 % Value Added Tax (VAT) and 3% government exercise duty. The amount of charcoal required to generate 1 kWH is about 0.14 kg, which would cost 0.08 ZMW. Hence, electricity is twice as costly as charcoal is, even without adding the 18 % VAT and 3% government exercise duty to the electricity price.

alone is insufficient to cater for all firewood needs. The average firewood consumption of a household is estimated at about 1.6 ton/year in Zambia (Kalinda et al., 2008).

Institutional consumers on the other hand mainly cut standing live trees, in addition to harvesting wood from forestland that is being cleared for agriculture. They are an important group because their activity is endorsed by the government – since they provide a revenue source to the FD through payment of harvesting/royalty fees for firewood collected legally. It was acknowledged during consultations with FD officials that many of them are, however, also collecting firewood without payment or following legal procedures.

4.2.4 Migrants and settlers

Migrants and settlers contribute to forest loss by acting as any of the agents described in the previous sections (4.2.1 to 4.2.3). In addition, they cut trees to create space for building houses. According to consultations and interviews, there are intricate migration patterns in the project reference region. This involves people moving from one place to another within the same district, and from one district to another with the Provinces, and from other Provinces into the two provinces. Migration is not always known or monitored by authorities; hence, the number of migrants is unknown. However, according to the 2010 population census, only the Eastern Province and Northern Province had net in-migration in the country (CSO, 2012). Migrations that get detected by district authorities usually happen very late – when migrants have already settled on and cleared forested lands.

4.2.5 Road infrastructure developer

The major road infrastructure developer is the government – be it village, district, provincial or national-level governments. Road infrastructure is a key development priority in Zambia and the project region; thus, its impact on forest loss can only be mitigated since roads are highly desired by all stakeholders. Deforestation due to road infrastructure is thus considered an inevitable development trade-off. This deforestation occurs due to both the creation of new roads and expansion of existing ones. At times roads can have an indirect effect: it opens access to erstwhile remote places, and can trigger other deforestation activities in that area – such as new settlements, cultivation and charcoal production. According to FGDs, lack of road access, and remoteness of a place acted as a key barrier to community members engaging in charcoal production; thus, underscoring the influence of roads on charcoal production.

4.2.6 Illegal timber harvesters

Illegal timber harvesters target specific trees for timber. They cut those trees without applying sustainable forest management practices such as allowable cut, minimum diameter, and site rehabilitation after harvest. The most preferred timber species are: *Pterocarpus chrysothrix* (locally called *Mukula*), *Pterocarpus angolensis*, and *Afzelia quanzensis*. In general, about 19 species are reported to be widely harvested in the country (Gumbo et al., 2013). Illegal timber harvesters do cause forest degradation and not necessarily deforestation. A degraded forest is of course more vulnerable to conversion because it is more open and thus easier to clear and convert into cropland than an intact one is. Though the FD issues licences for legal harvesting and trade of timber, illegal timber harvesting is still common. According to interviews, there is, however, some noticeable reduction in illegal harvesting practice particularly for the *Mukula* tree. This is attributed to the deployment of the national army (Zambian National Service) in the control of illegal timber harvesting.

4.2.7 Miners

Miners contribute to deforestation in three main ways: 1) by clearing forests to create suitable road infrastructures where none exist; 2) by clearing forests at the mines to create space for the mining and ancillary infrastructure; and 3) by attracting new human population to the area – resulting in settlements and other activities such as cultivation. Small-scale mining is common and there are numerous mines and miners in the region – particularly for gold and other precious metals. The impact on forest loss is, however, judged to be minimal because of the scale, and the predominance of gold mining, which tends to be concentrated along a few streams, rivers and wetlands – as water is required in the separation process. Hence, it is medium to large-scale mining that are primarily to blame for the contribution of miners to forest loss. There are reportedly a few medium to large-scale mining projects (either at prospecting, preparatory, or active mining phases) in the reference region[8], though there is possibility for further increase in their number since the government has interest in increasing revenue flows from the mining sector (Day et al., 2014).The contribution of miners as a sole agent of deforestation is considered very small since they use existing roads, and only build more were no suitable roads exist; while the impact of induced human influx to the mines on deforestation is part of other agent groups', i.e., settlements, smallholder farmers, charcoal producers, and firewood harvesters.

4.2.8 Fire users

The four main categories of fire users are: 1) hunters –including hunters of wildlife and honey, and rural households who hunt edible mice on or near croplands using fires[9]; 2) small-scale farmers, who use fires in the process of clearing land for cultivation; 3) livestock keepers – who set fires to initiate growth of fresh pasture; and 4) protected areas managers – who set fires as part of their fire management and vegetation control strategy in National Parks (NP) and Game Management Areas (GMAs). The fires set are often not adequately controlled and thus quickly spread and burn large areas. With a large number of fire users setting uncontrolled fires, forest fires are extremely rampart, and each year most of the forest areas are burnt in the region (Hollingsworth *et al*. 2015). In a project study undertaken by UNIQUE, using fire monitoring (satellite) data from the Moderate Resolution Imaging Spectroradiometer (MODIS)[10], an average of about 670,000 ha of forests/vegetated land were estimated to have burnt annually between 2000 and 2014 in

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[8]These include: a company only identified as Yang Feng in Mwanya chiefdom Lundazi district; another mining operation only identified as G.T.D in Kamwesha area, Rufunsa district, and Sinozoncha Resources Mining Company, which applied for mining license in Ukwimi area, Petauke district targeting gold, copper, cobalt and silver.
[9]Edible mice – locally called *Mbeba*, is a delicacy in this region.
[10] MODIS data can be accessed via the web link here.

the Eastern Province alone. Fires are generally considered part of the ecological process of the region's miombo forests; the vegetation is quite adapted to it and does recover after burning. Fires also do not pose a big threat in mopane and riparian vegetation due to low grass cover. However, devastating fires still occur especially when it is late burning, too frequent, and very dry – resulting in death of some trees or their parts. Hence, forest fires lead to forest degradation, but not necessarily deforestation.

4.3 Drivers of deforestation

Drivers of deforestation are the activities or occurrences that directly cause loss of forests. From the LULC analyses, literature review, and consultations and interviews, three main drivers of deforestation were identified in the project reference region: 1) agricultural expansion, 2) charcoal production, and 3) firewood extraction. These drivers, which are principally subsistence in nature, are discussed in section 4.3.1 to 4.3.3. Other drivers include settlements, road infrastructure and mining; these are described in sections 4.3.4 to 4.3.7.

4.3.1 Agricultural expansion

Expansion of small-scale agriculture is by far the most important driver of deforestation in the reference region. The region contributes a substantial part of crop production in the country – in some cases producing a quarter to a half of the total production of a particular crop in the country in a particular year – for example: maize, sunflower, cotton and tobacco (Tembo and Sitko, 2013).

Historically, crop cultivation in the region involved practising shifting cultivation with long fallow periods to allow the soils to regain its fertility as a result of re-growth of vegetation. The practice was as follows: after clearing forested land and planting on it repeatedly for 4 to 5 years, the land was abandoned and left to fallow for a long time – sometimes 20-30 years. During this period, forests would have re-grown on the land. However, with increasing sedentary population, this practice has all but disappeared. According to FGDs and published literature, a few farmers who still practise fallow do so in areas with abundant land, and for short periods of about 1-3 years (Kwesiga et al., 2005). Hence, permanent conversion of forests to agricultural land is now the norm, which is driving deforestation in the region. Figure 3 below shows examples of new forest conversion to agricultural land in the project region. Fires are commonly used in the process.

Figure 3: Deforestation due to agricultural expansion

Source: Authors

According to MTNER (2002) quoted in Vinya et al., 2012, land clearing for agriculture accounts for an estimated 90% of deforestation in the country. In addition, from both our consultations and a previous survey by COMACO in the region, the evidence shows that the majority but not all deforested lands have been converted to agriculture. Some of the deforested lands have been simply left bare as are result of charcoal production, with about 30% of the deforested bare lands attributed to charcoal production alone in one analysis (COMACO, 2011). Hence, we concluded that the majority of deforestation – some 70-90% can be attributed to agricultural expansion, with the rest being attributable to other drivers, which are subsequently discussed.

4.3.2 Charcoal production

Charcoal production results in deforestation because of the nature of the production system: Charcoal producers practise mainly clear-cutting as opposed to selective cutting of trees, which is recommended – as it allows smaller diameter and other trees to remain growing on the site. Selective cutting is likely to be confined to places where preferred species are abundant (Gumbo et al., 2013). However, all charcoal producers met in this study indicated that selective tree cutting is not a common practice. In addition to clear-cutting, the construction of earth kilns used in the conversion of the wood to charcoal results in further tree clearing at the production sites; sometimes the kilns can measure up to 40 m long by 40 m wide. Besides not practising selective tree cutting, other cutting techniques, which are recommended for sustainable tree utilisation, such as making a clean and slanting cut close to the tree base, are also not followed by charcoal producers. These poor harvesting practices greatly diminish the ability of cut trees to re-grow after charcoal production.

Figure 4: Charcoal along the Great East Road in Rufunsa district

Source: Authors

How much charcoal production (Figure 4) contributes to deforestation is hard to exactly quantify because of the intricate link between it and agriculture: Forests may be cleared for charcoal production and later taken over for cultivation[11]; or the forest is cleared with the objective of cultivation and the harvested wood opportunistically used for charcoal production. Therefore, the primary reason for clearing is not possible to exactly ascertain and attribute deforestation to it. Nonetheless, to put it into perspective, considering household consumption alone, and using population data (CSO, 2012) and consumption figures (Kalinda et al., 2008) of 1.4 tonnes/household/year, we estimated charcoal consumption at the urban household level in the districts comprising the reference region to result in extraction of about 797,400 tonnes of wood per year in 2016. Taking 81% of the extracted wood as non-renewable (thus leading to deforestation)[12], this consumption would equal to about 8,100 ha deforested due to charcoal production in the reference region districts per year[13]. With average annual deforestation in the reference region during the historical reference period estimated at 51,913 ha/year, the above estimate of charcoal-induced deforestation translates to 16% of total deforestation in the historical reference period. Therefore, in addition to expert consultations and review of available literature, we concluded that charcoal production is a major driver of deforestation – contributing some 15-30% of all deforestation[14].

4.3.3 Firewood extraction

Household generally harvest both dead/dry wood and live trees for use as firewood. However, when dead/dry wood supply is insufficient they cut trees and dry them before use (Kalinda *et*

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[11] The marginal cost for clearing such lands is very low (Robert et al, 2015).

[12]The non-renewable biomass fraction (fNRB) for Zambia is 81% (UNFCCC CDM, 2012).

[13] This takes into account conversion efficiency of wood to charcoal in the earth kilns, the predominant method used for charcoal production, which is only 12% at the lowest level, and between 20 and 25% at the moderate level (Hibajene and Kalumiana 2003 quoted in Gumbo et al., 2013). Average forest biomass was taken as 79.4 t.d.m/ha (Kalinda et al., 2008) – based on ILUA I forest inventory.

[14]In the literature, charcoal production contributions to overall deforestation are reported as follows: 30% in Chongwe, Lusaka province (Gumbo et al., 2013, quoting Chidumayo, 2001); 30% in Nyimba district, Eastern Province (COMACO, 2011). Robert et al, 2015, using a modeling approach also concluded that deforestation in the region is mainly driven by agriculture expansion, charcoal production, and fuelwood extraction, but no estimates for its share of deforestation were reported.

al., 2008). Institutional, cottage and business users, however, primarily obtain firewood through cutting of live trees (Figure 5).

Figure 5: Heaps of firewood from live trees at roadside and near un-burnt bricks

Source: Authors

Based on the process of fuelwood extraction, and discussions with various stakeholders, we concluded that firewood extraction would contribute primarily to forest degradation – as long as the harvested area is left alone to regenerate. The time required for such tree regeneration is estimated at between 8 to over 20 years (Chidumayo and Gumbo, 2010). However, the harvested sites are usually not left to recover for this period of time; hence, permanent loss of the forest cover occurs – either as a result of agriculture eventually expanding to the harvested sites or persistent exposure to other disturbances such as grazing, fires, and combinations of these. This makes estimating the direct contribution of firewood collection to deforestation hard to exactly determine. Nonetheless, considering household consumption alone – using population data (CSO, 2012) and average consumption figures (Kalinda et al., 2008) of 1.6 tonnes/household/year, we estimated firewood consumption at the household level alone in the districts comprising the reference region to be 588,700 tonnes in 2016. To put it into perspective, taking 81% of the extracted wood as non-renewable (thus leading to deforestation)[15], this consumption would equal to about 6,000 hectares deforested due to firewood extraction annually[16]. The average annual deforestation in the region during the historical reference period was estimated at 51,913 ha/year; hence, the above estimate of firewood-induced deforestation is equivalent to 12% of total deforestation in the historical reference period. From this breakdown and expert consultations, firewood extraction was thus estimated to contribute considerably to deforestation – at about 10-15% of total deforestation.

For the purpose of estimating the project's Effectiveness Index (section 4.8), and opportunity cost assessment (section 4.9), the following estimates of the contributions of the main drivers

[15]The non-renewable biomass fraction (fNRB) for Zambia is 81% (UNFCCC CDM, 2012).

[16]Average forest biomass was taken as 79.4 t.d.m/ha (Kalinda et al., 2008) – based on ILUA I forest inventory.

to overall deforestation were thus applied: **agricultural expansion: 75%; charcoal production: 15%, and firewood extraction: 10%**.

4.3.4 Other drivers

These drivers of deforestation are not considered as main drivers based on available information, but they are described here to provide a complete picture of all deforestation drivers in the region. They include settlements, road infrastructure and mining. Illegal timber harvesting and forest fires cause forest degradation; hence, they are not further described.

Settlements result in deforestation due to the need to remove trees on house building sites. Additional trees are also cut to be used as building materials – especially for rural dwellings. The allocation of forests for new settlements in rural areas is usually done by the traditional authority in the area, i.e., headman, *induna*, and chief/chieftainess[17]. Urban authorities also allocate areas that may be forested for expansion of planned urban settlements in accordance with the plan of the district. Road infrastructures cause deforestation both as result of the creation of new roads and expansion of existing ones. Diversions during road construction further contribute to forest loss. In the ongoing rehabilitation of the Great East Road, which passes through the reference region, reforestation has been incorporated in the road building project to compensate for the loss of forest caused. This practice of compensatory reforestation is, however, not common; and during consultations stakeholders argued that it is not commensurate to the forest lost. In other road infrastructural projects – especially in the case of secondary and rural road networks, this practice does not exist.

The impact of mining on deforestation in the project region is still low but may gradually grow if the number of medium to large-scale mining increases. Mining partly makes use of existing road networks; hence, they cause deforestation where new roads have to be opened, or existing ones expanded. In this regard, the amount of deforestation caused by mining depends on the density and quality of existing road networks. Deforestation may thus result from mining due to clearing of forests to create additional road infrastructure, for the mining and ancillary infrastructure at the site, and due to the impact of influx of human population attracted by opportunities at the mines. However, the deforestation activities of the influx of human population already fall under other (major) drivers, e.g., agricultural expansion and firewood extraction.

4.4 Driver variables explaining quantities and locations of deforestation

4.4.1 Drivers explaining quantities of deforestation

FGDs, expert consultations and interviews, and literature consistently pointed out demographic variables such as increasing population as directly influencing deforestation. Hence, a closer examination of demographic variables, namely, population density, rate of population growth, and

[17] *Induna* is a local name/title for chief's/chieftainess' advisor. Chieftainess is a female chief.

proportion of rural population was undertaken[18]. The explorations indicated the following relationship for each variable with historical deforestation (Table 3 and Figure 6).

1. Population density (number of persons per square km): showed an unambiguous relationship with deforestation – whereby the higher the population density, the higher the rate of deforestation. Similarly, the higher the population density, the higher the absolute deforestation.
2. Rate of population growth (annual population growth rate in %): this variable did not reveal a distinct correlation with both absolute deforestation and deforestation rate.
3. Proportion of rural population (ratio of rural population to total population in %): this variable also did not reveal a distinct correlation with both absolute deforestation and deforestation rate.

Table 3: Demographic variables versus deforestation in the historical reference period

Project districts	Population density (persons/km²)	Annual population growth rate (%)	Proportion of rural population (%)	Absolute net forest loss or gain (ha/year)	Rate of net forest loss or gain (%/year)	Rank in absolute net forest loss or gain	Rank in deforestation rate
Chadiza	42	2.5%	97%	-2,950	-2.7%	8th	3rd
Chama	6	3.3%	93%	4,469	0.4%	11th	10th
Chipata	69	2.2%	74%	-12,218	-4.0%	2nd	2nd
Rufunsa	5	3.4%	94%	1,426	0.2%	9th	9th
Kafue	25	4.2%	60%	-6,212	-2.0%	5th	5th
Katete	62	2.6%	91%	-7,219	-4.7%	4th	1st
Luangwa	7	2.5%	80%	4,294	1.9%	10th	11th
Lundazi	23	3.2%	95%	-11,851	-1.6%	3rd	6th
Mambwe	13	3.8%	91%	-5,992	-1.4%	6th	7th
Nyimba	9	1.9%	91%	-3,291	-0.4%	7th	8th
Petauke	37	2.7%	90%	-12,367	-2.6%	1st	4th

Source: CSO, 2012; Authors and BCP. Positive figures indicate net forest gain, while negative figures indicate net forest loss (deforestation).

[18] Note that other variables such as prices of agricultural products, cost of rural wages, which are suggested by the methodology, could not be examined due to lack of reliable historical data/information on them.

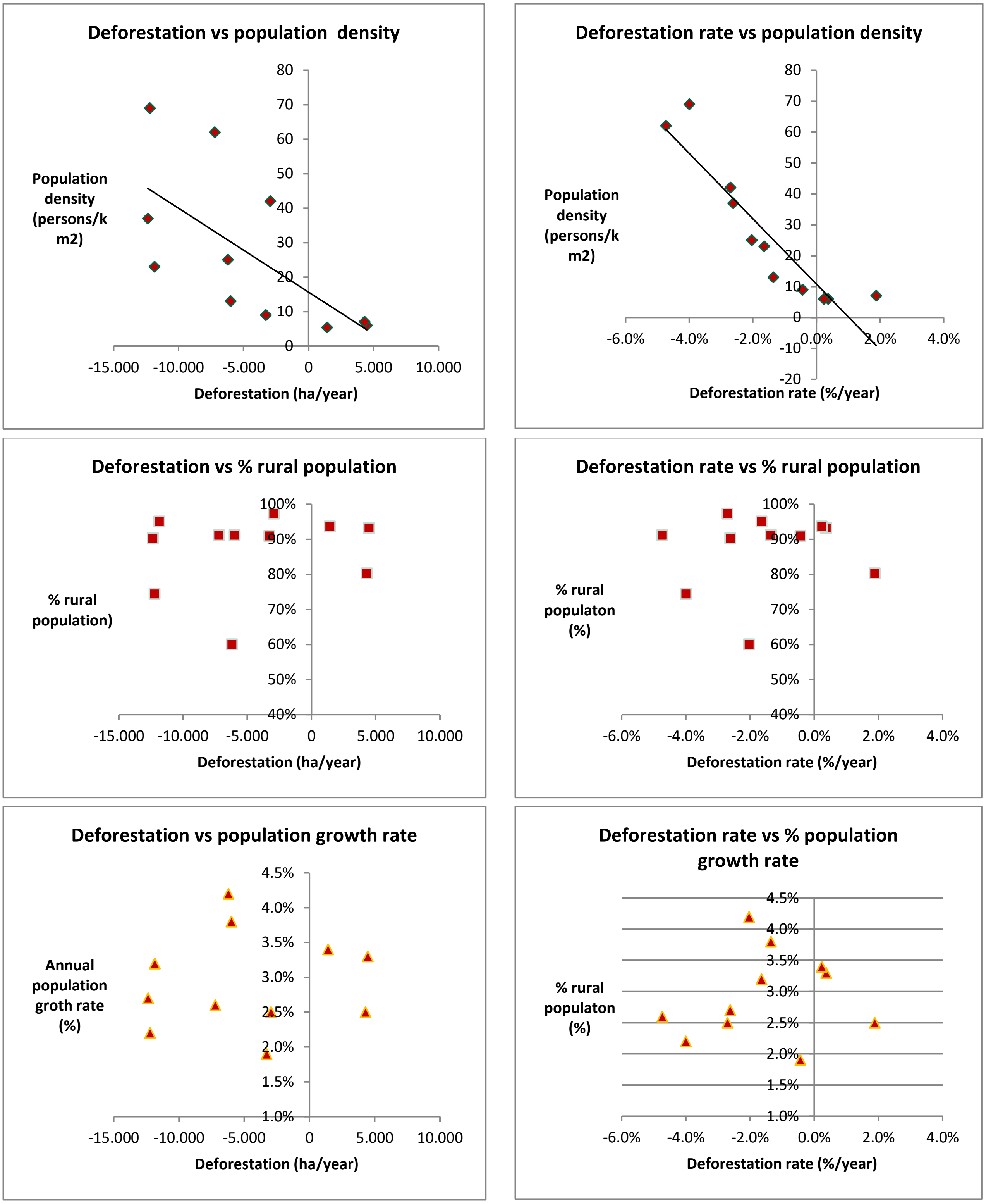

Figure 6: Demographic variables versus historical deforestation

Source: Authors

From the above results, population density was thus identified as the driver variable that possesses a clear relationship with historical deforestation, and thus, can explain the quantities of deforestation in the historical reference period in the project reference region.

4.4.2 Drivers variables explaining locations of deforestation

The following spatial variables were examined for their relations with the locations of deforestation occurring in the historical reference period:

1. Distance to roads, i.e., deforestation versus distance (km) from existing roads;
2. Distance to settlements, i.e., deforestation versus distance (km) from existing human settlements;
3. Slope, i.e., deforestation versus slope (degree); and
4. Elevation, i.e., deforestation versus elevation (metres above sea level).

The results, presented in Table 4, shows that most historical deforestation (81%) occurred farther away from roads – from 1 km and above. As for settlements, most of the deforestation (93%) occurred from a distance of 0.5 to 5 km. This pattern is due to the fact that most of the areas near roads or settlements have already been deforested; hence, there is little forest cover left to exploit.

Regarding slope, all deforestation in the historical reference period occurred in slopes ranging from 0 to 10^o - while modest forest gains were estimated for slopes of above 10^o. FGDs held with community backed this trend: community members asserted that there is steady migration from the plateau (high elevation areas) to the lower and flat plains (low elevation areas) – resulting into increased clearing of forestland for agricultural expansion, wood extraction and settlements. As for elevation, most of the historical deforestation occurred in elevation ranges of 500 to 1,500 m, which also partially backs the assertion of increased migration to low lying areas – although some forest gains also occurred in the lowest elevation range (0 to 500m) in the historical reference period; hence, making the relationship of elevation and deforestation unclear.

Table 4: Location variables versus deforestation in the historical reference period

Variable	Category	Deforestation occurring in historical reference period	% of total deforestation occurring in historical reference period
Distance to roads (km)	0 - 0.5	-150,539	9.7%
	0.5 - 1	-55,589	9.4%
	1 - 2	**-53,491**	**17.3%**
	2 - 5	**-98,762**	**37.2%**
	> 5	**-212,659**	**26.4%**
Distance to settlements (km)	0 - 0.5	-20,212	3.6%
	0.5 - 1	**-20,545**	**11.2%**
	1 - 2	**-63,791**	**28.6%**
	2 - 5	**-163,514**	**53.1%**
	> 5	-302,978	3.5%
Slope (°)	**0 - 10**	**-598,303**	**100%**
	10 - 20	2,648	9.7%
	20 - 30	18,773	68.9%
	> 30	5,842	21.4%
Elevation (m)	0 - 500 m	50,463	99.8%
	500 - 1000 m	-218,604	35.2%
	1000 - 1500 m	-402,994	64.8%
	1500 - 2000 m	106	0.2%
	> 2000	-10	0.0%

Source: Authors and BCP; LULC data from Google Earth Engine. Positive numbers indicate forest gain, while negative numbers indicate forest loss.

A clear relationship with historical deforestation could thus be deduced between three of the four driver variables, i.e., distance to roads, distance to settlements, and slope. Hence, we concluded that the driver variables that can explain the locations of deforestation observed in the historical reference period are distance to existing roads, distance to existing human settlements, and slope.

4.5 Underlying causes of deforestation

Underlying causes are the factors or forces that have influence on the agents and drivers of deforestation and ultimately on deforestation itself. These factors are described for each main agent and driver identified in section 4.2 and section 4.3 respectively.

4.5.1 Underlying causes of agricultural expansion

There are four main factors driving agricultural expansion by smallholders in the reference region: 1) a growing rural population; 2) poverty and agricultural dependency; 3) poor farming practices; and 4) weak system of forest resource management.

Growing rural population

The reference region is characterised by rapid human population growth rate – ranging from 1.9 to 4.2% p.a. (CSO, 2012). Over 80% of the population are rural, and highly dependent on exploitation of land resources. The growing population demands more land to cultivate food and earn income, thus, clearing forests and driving deforestation upwards. Discussions with stakeholders affirmed that agriculture and charcoal production are the two main livelihood activities in rural areas, and unsurprisingly also the main drivers of deforestation. The population variable that correlates well with deforestation is population density, as discussed in section 4.4.1.

According to projections by the Central Statistical Office (CSO), future human population growth in the region is projected to remain high – ranging from 1.7% to 4.0% p.a. between 2011 and 2020 (CSO, 2013). These projections thus indicate that only a marginal decline in population growth rate can be expected to occur in the region during the project's fixed baseline period. Therefore, increasing human population growth will continue to strongly drive agricultural expansion and resultant deforestation over the project's fixed baseline period.

Poverty and agricultural dependency

In the reference region, poverty is deeply rooted and its rates are extreme. For example, the Eastern Province, which makes up 88% of the project area, is ranked among the top four poorest provinces in the country; the other provinces being Northern, Western and Luapula. About 50% of the population in these provinces are unable to satisfy their basic food requirements. The poverty incidence in the Eastern Province is at 0.79, meaning 79% of the population live on less than $1.90 a day at the 2011 international prices. This poverty rate is higher than the national average of 60% (De la Fuente *et al*., 2015). Agriculture is the main source of livelihoods, providing more than 80% of household income (Tembo and Sitko, 2013). Alternative livelihoods are very hard to come by, and the few available also largely based on exploitation of forest products, e.g., wood and NTFPs. The high dependence on agriculture means increased demand for agriculture land, resulting in forest clearance.

Rural poverty can be expected to decline but only marginally and very slowly. During the past two decades, there has been significant economic growth in the country; however, rural poverty only declined by 2% in the period 2006-2010; and at the national level, poverty fell by only 2.8% in the same period (De la Fuente *et al*., 2015); and unlike the central parts of the country, which have mining and other industries, the project region does not offer much in terms of alternative jobs to pull the population away from agriculture. Therefore, rural poverty and agricultural dependency are expected to persist in the near to medium term, in particular during the project's fixed baseline period; hence, driving agricultural expansion and associated deforestation.

Poor farming practices

Poor farming practices in the region include burning as part of land clearance, burning of crop residues during cultivation, and limited use of inputs such as organic and in-organic fertilizers, or high yielding seeds. In addition, the traditional practice of long-period fallows that allowed restoration of soil fertility has all but vanished, with the current trend being predominantly permanent conversion of forestlands to agriculture. Following land conversion, farmers plant crops such as maize, cotton, sunflower, tobacco, which are nutrient-mining. The results of poor farming practices are quick exhaustion of the soils and low crop yields. The average yield of maize, for example, is estimated at about 2 tonnes per ha per year, which is far below potential yields (Sitko *et al*., 2011; Tembo and Sitko, 2013).

Poor farming practices are also attributed to the low level of agricultural extension support that farmers receive from the government, and non-governmental entities, i.e., NGOs and commodity trading companies[19]. At the government level, there are simply too few agricultural extension staffs per district to provide extension services to a very large number of farmers; while non-governmental entities only concentrate on their groups of farmers. Due to the widespread poverty, most farmers are not able to afford agricultural inputs or make investments that would increase the productivity of their existing lands. They continue to use poor agricultural practices, leading to soil degradation and ultimately more deforestation – as they move on to clear forests to open new fertile agricultural land. Significant improvements in farming practices and yields are not expected to occur in the near future. This is because funding to the agricultural sector – judged by the government national budget allocation to the sector – is small – averaging 6.8% in 2011-2016; there was even a decline in the 2016 allocation relative to the 2014 and 2015 budget years (Kuteya, 2016). This level of funding is below the Maputo Declaration of 10% of the national budget, required to improve agricultural productivity and bring about sustainable yield improvements. In addition, with poverty remaining stubbornly high and widespread, farmers will not have the capacity to make investments that would increase land productivity. Smallholder farmers lack access to credit, and are an unattractive group for bank credits. With very few government extension staff, and non-governmental entities concentrating only on their contracted/registered farmers, the majority of farmers will continue to receive little or no extension services.

Weak system of forest resource management

This is manifested in terms of weak regulatory and policy environments, lack of institutional capacity to protect, manage, and monitor forests, weak tenure, and a general lack of planning for land use and forest utilisation[20].

The forests in the CFP fall under forests on communal land or “customary forests” and form part of Game Management Areas (GMAs). The traditional authority, i.e., chiefs/chieftainess of the respective chiefdoms, exercises authority over customary forests; while the FD is the statutory

[19] Examples of commodity trading companies include CARGILL, DUNAVANT, and COMACO.

[20] Some local institutions such as CRBs, and chiefdoms, and government entities such as FD have prepared some plans. However, these are few, with such plans made possible in many cases with external support, and they are not effectively implemented.

supervisor. However, the FD is unable to effectively implement its obligations to protect, manage, and monitor forests because it is understaffed, under-funded and in general not effectively engaging the traditional authorities. Information obtained from District Forest offices revealed that they receive very little funding for forest management – equivalent of less than 0.5 ZMW per ha of forest under their management. This converts to less than USD 0.05/ha – yet it is estimated that about USD 12/ha is required to establish sustainable forest management on existing forest areas in the tropics (Köthke, 2014). The traditional authorities also do not have capacity to protect, manage, and monitor forests independently. In addition, a major weakness in the regulatory and policy environments is that no part of the revenues obtained from forest exploitation (e.g. licensed wood harvests) is shared with communities even though the forests are on communal lands. This is a major disincentive for the communities to protect and conserve forests, and a complete contrast to the DNPW operating in the same region, which shares 50% of game hunting proceeds/quotas with surrounding communities through the institution of the CRBs – thus providing a major incentive for wildlife conservation among communities.

Furthermore, both at the governmental and traditional authority levels, there is a general lack of resource use planning such as land use planning or zoning, or forest management plans[21]. Hence, the use and appropriation of forests and associated resources are done in a haphazard manner; for example, the headman, *induna*, or chief/chieftainess can allocate any area for settlement or cultivation as they deem fit since there is no written plan or map to guide them. In some of the chiefdoms, particularly those neighbouring NPs, and GMAs, there are now visible Community Resource Boards (CRBs), who are legally established to support and promote wildlife and forest conservation within the chiefdoms. Nonetheless, similar to the FD, the CRBs do not have the technical and financial capacity to protect, manage, and monitor forests independently.

A positive change can be expected regarding benefit sharing with communities since the new Forests Act (2015) now provides for it. However, a statutory instrument, which is required to operationalise this, has not yet been issued by the government, and it is unknown when it will be. According to consultations, only small positive changes in the current weak system of forest resource management can be expected; for example, a few forest guards are being recruited and deployed by the FD to improve monitoring. In addition, the plan to recruit and deploy honorary forest guards from among members of the community is on-going. However, with no sufficient technical and financial investments being made, no significant improvements in the currently weak system of forest resource management are expected.

4.5.2 Underlying causes of charcoal production

The main factors that drive charcoal production as a major deforestation contributor are: 1) the high dependency of a growing urban population on charcoal as a major source of energy for

[21] With the exceptions of a few CRBs and FDs, where some plans are in draft forms or completed but their implementation remains weak.

cooking and heating; 2) inefficient charcoal production technique; and 3) weak regulatory and institutional system. These factors are discussed in details in the subsequent sections:

High dependency of increasing urban population on charcoal

It is estimated that some 85% of urban households use charcoal as the main source of cooking fuel and heating source (Gumbo *et al*., 2013). This is because alternative energy sources such as electricity, gas, and solar are expensive and not affordable by most people. This situation can be described as “energy poverty”. Even households that have access to electricity in urban areas do not use it much for cooking or heating. Electricity is used primarily for lighting and running appliances such as television sets, fridges, etc. Unsurprisingly, urban centres, where electricity access is high, are the major consumption centres for charcoal. With an estimated urbanisation rate of about 4.4% per year in the country (The World Factbook, 2017), charcoal consumption is set to continue growing in the foreseeable future. A considerable proportion of charcoal produced in the project region is also exported. Efforts to reduce fuelwood consumption – such as the promotion of energy efficient cooking stoves – have also targeted mostly firewood consumption instead of charcoal consumption. Hence, charcoal production will continue to drive deforestation.

Inefficient charcoal production technique

Charcoal is produced using earth kilns, which are very inefficient. The conversion efficiency of wood to charcoal in the earth kilns used in Zambia is estimated at 12% at worst, and 20% and 25% at best (Hibajene and Kalumiana 2003 quoted in Gumbo et al., 2013). An improved technique such as *Casamance* kilns could improve efficiency of charcoal conversion to over 30%. The very low efficiency means that for every ton of charcoal produced, 4 to 8 tons of wood is extracted and processed in the earth kilns. Losses during collection, packaging, and transporting are also substantial – at about 20% of the charcoal produced (Gumbo et al., 2013). Presently, there are no noteworthy efforts to improve charcoal production efficiencies[22]. This is compounded by the fact that producers are scattered, making dissemination of improved technology very hard. In addition, as aforementioned, charcoal producers are mobile; others are also seasonal producers, with little to no incentive for investing in improved charcoal production techniques. Thus, in the short to medium term, it is realistic to expect that inefficient charcoal production will persist and continue to drive deforestation.

Weak regulatory and institutional system

There are regulations regarding charcoal production in Zambia, including for licensing of production and trade (see the Forests Act, 2015 for details[23]). However, these are largely not enforced by the FD, which is the responsible institution. As previously mentioned, the FD lacks capacity to protect, manage, and monitor forests because it is understaffed, underfunded, and has not been able to effectively engage with traditional authorities (chiefdoms) where most of

[22]BCP is promoting “eco-charcoal” - with sustainable harvesting techniques and improved kiln efficiency. However, the scope and coverage of this intervention is very small compared to the extent of charcoal production in the region; it is presently restricted to a few areas in Rufunsa district.

[23] The Forests Act, 2015 clearly states that “*a person who, not being a holder of a licence or permit under this Act, manufactures wood into charcoal or offers for sale, sells or removes charcoal in or from any State Land or customary area commits an offence*”.

the forestlands are located. A clear indication of the FD's lack of capacity is the fact that the Zambian national army has now been deployed to control illegal logging – particularly of the *Mukula* tree. The traditional authorities and CRBs who should engage in forest conservation also suffer from the same lack of management capacity plaguing the FD.

Most of the charcoal production occurs without following any legal procedures or sustainability practices. Seasonal producers in particular have no incentive to get license as they produce charcoal only occasionally. Even regular producers dodge getting the FD licenses, claiming it is expensive. Licenses can be obtained at short notice from the FD; but the FD does not ably monitor the licensees. Corruption was also cited as a major problem during FGDs – with claims that licensees either produce more charcoal or transport more volumes than authorized by their licenses, or simply do not get any license; they then bribe law enforcement officers manning the road check points, who allow them to pass instead of arresting them and/or confiscating the charcoal, or at least alerting authorities. Although the FD has recently recruited a few forest guards in an attempt to improve staffing level, the capacity of the FD to effectively protect, manage, and monitor forests is not expected to considerable improve anytime soon.

4.5.3 Underlying causes of firewood extraction

There are two main factors driving deforestation due to firewood extraction: 1) the high dependency of a growing rural population on firewood as a major source of energy for cooking and heating; and 2) inefficient utilisation of firewood. These factors are discussed below:

High dependency of growing rural population on firewood

All rural households use firewood as the primary source of energy for cooking and heating (Gumbo *et al*., 2013). Alternative energy sources such as electricity, gas, and solar are not readily accessible or affordable by most people. Firewood, on the other hand, is readily available and at no cost – except the time spent in collecting it. A substantial amount of firewood is also consumed by institutions including educational institutions, cottage and small-scale businesses, and small to medium-sized industries such as beer breweries. For this group of users, firewood is also readily accessible and cheaper than its alternatives are. The government has made some efforts in rural electrification, but still less than 6% of the rural population of Zambia have access to electricity (World Bank, 2016). Considering that even urban population with high electricity access primarily use charcoal for cooking and heating, rural electrification cannot, therefore, be expected to cause significant reduction in the dependence of rural population on firewood as result of shifting to electricity use for cooking and heating. With a population growth rate between 2 to 4% p.a., firewood extraction is highly likely to continue driving future deforestation for a number of decades to come.

Inefficient utilisation of firewood

Three-stone open-fire is the most common cooking practice in the project region (Figure 7). This practice wastes a lot of wood as the heat is not effectively channelled into cooking and heating purposes, but rather lost to the surrounding.

Figure 7: Three-stone open-fire (L) and an installed efficient wood burning cook stove (R)

Source: Authors

As a comparison, an efficient wood burning stove can reduce firewood consumption by up to 50% if consistently used. This reduction would halve the deforestation attributed to firewood extraction. There have been some efforts to promote efficient wood burning stoves in the region by NGOs and companies. The main efforts have, however, been reliant on the commercialisation and selling of resulting carbon credits in the carbon markets. Such efforts include the cook stove carbon projects of COMACO (partnering with CQuest Capital), and Three Rocks Ltd. These efforts have not resulted into large-scale adoption of the technology because of the cost of the technology, restricted focus of the projects, and other adoption barriers[24]. The sustainability of these efforts is also uncertain as they rely on the unstable carbon markets. In addition, many of the users of efficient stoves continue to concurrently use the three-stone open-fire. With an increasing rural population, the impact of these existing efficient cook stove projects on reduction of fuelwood consumption is very small; hence, inefficient firewood use is highly likely to continue driving future deforestation – particularly during the project's fixed baseline period.

4.5.4 Summary of analysis of underlying causes

The main underlying causes described in the preceding sections are presented as a summary in Figure 8 – showing both current and expected future trends. The future outlooks of most underlying causes described in section 4.5 indicate that they will continue to exert significant influence on and drive future deforestation – even though some slight improvements in the current policy and regulatory environments may occur. Hence, future baseline deforestation is expected to mirror historical deforestation.

[24] About 50,000 cook stoves are reported to have been installed by the COMACO project; while Three Rocks' estimates are about 25,000 to 50,000 cook stoves installed. How many are actually in use is not clear.

AGRICULTURAL EXPANSION

Underlying cause →		Growing rural population	Poverty and agricultural dependency	Poor farming practices	Weak system of forest resource management
Driver ↓	Agent ↓				
Agricultural expansion	Small-scale farmers	↘	→	→	↘

CHARCOAL PRODUCTION

Underlying cause →		High dependency of increasing urban population on charcoal	Inefficient charcoal production technique	Weak regulatory and institutional system
Driver ↓	Agent ↓			
Charcoal production	Charcoal consumers	→	→	→
	Charcoal producers	→	→	↘

FIREWOOD EXTRACTION

Underlying cause →		High dependency of growing rural population on firewood	Inefficient utilisation of firewood
Driver ↓	Agent ↓		
Fuelwood extraction	Firewood consumers	→	→
	Firewood producers	→	→

Current impact of underlying cause on agent

High impact	Medium impact	Low impact

Projected future trend of underlying cause on agent

↗ Increasing impact	→ Business as usual	↘ Decreasing impact

Figure 8: Summary of current and future outlooks of underlying causes of deforestation

Source: Authors

4.6 Chain of events leading to deforestation

Poverty and lack of alternative livelihoods in rural areas cause rural population to depend principally on smallholder agriculture for food and income, and on firewood for cooking and heating. The agriculture practised involves poor farming practices such as burning of cropland and crop residues, and continual cultivation of fertility-mining crops. In urban areas, poverty and low incomes result in high dependence on charcoal for cooking and heating. With increasing population both in rural and urban areas, these situations translate into increased demand for agricultural land, firewood, and charcoal – resulting into forest exploitation and ultimately deforestation. These chains of events are illustrated in Figure 9 below. They are relevant now and for the foreseeable future.

The above deforestation occurs in a weak regulatory and institutional environment: The institutions responsible for protecting, managing, and monitoring forests such as FD, CRBs, and traditional authorities are ineffective due to their meagre staffing, technical/knowledge, and financial capacities. In addition, communities – where most of the forests are found – do not get any part of the revenues obtained from legal harvests of forest products. This breeds indignation, and demoralises communities from dutifully participating in forest conservation. The entire regulatory and institutional environment does not, therefore, effectively protect forest from exploitation for agricultural expansion, firewood extraction or charcoal production.

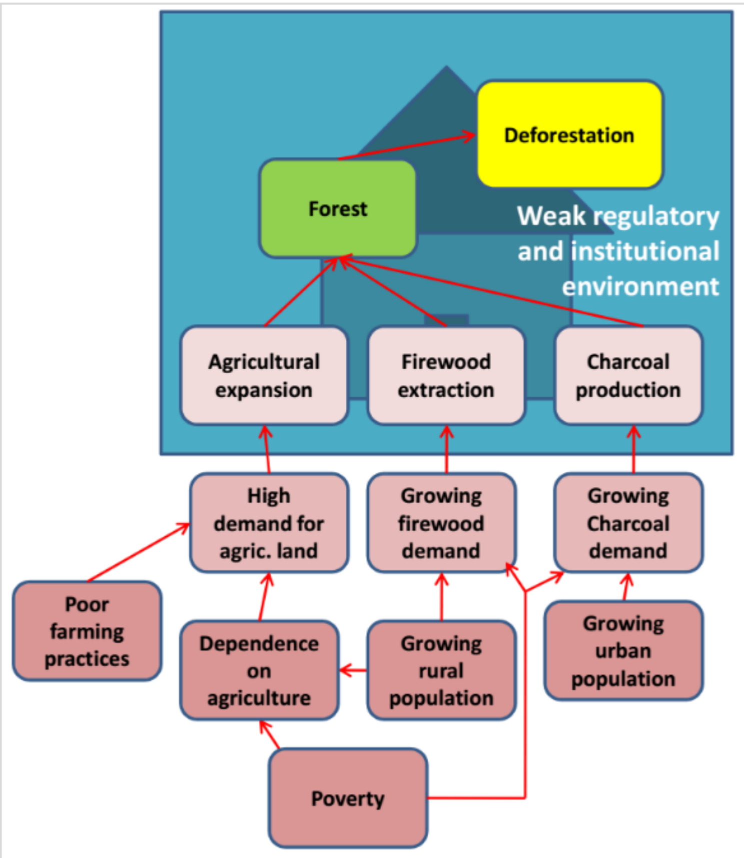

Figure 9: Chains of events leading to deforestation

Source: Authors

4.7 Conclusion

Future deforestation is likely to follow the baseline deforestation trend – where deforestation is primarily driven by agricultural expansion of a subsistence nature with unsustainable land use practices as a well-rooted form of production. This is particularly so due to the region's growing and predominantly rural population, which is heavily dependent on agriculture and forest resources due to lack of alternative economic opportunities. Furthermore, a system of land tenure and poor forest governance that makes unregulated forest clearing and exploitation possible, and growing rural and urban populations that heavily depend on fuelwood will most likely persist for the foreseeable future. Thus, the underlying causes of deforestation detailed in section 4.5 will continue to exist and interact in ways that favour and sustain a high deforestation rate in the reference region.

The main driver variables explaining the quantity and location of deforestation are population density and accessibility to forests, i.e., distance to roads, distance to settlements, and slope. With increase in population and expansion of road infrastructures, both population density and accessibility can be logically expected to increase in the future; while a key underlying cause of deforestation in the region, namely: extreme poverty and high dependency on forest and other natural resources is not expected to improve significantly anytime soon. Therefore, we can make a **conclusive** judgement that deforestation will continue in the reference region and the project area without the proposed project activities – at a rate similar to the baseline deforestation. Thus, future baseline deforestation rates are expected to at least remain **about constant** – in particular during the project's fixed baseline period.

4.8 Effectiveness Index

The Effectiveness Index (EI) is a conservative assumption of the effectiveness of the entire set of project's proposed activities or measures in reducing baseline deforestation. It is expressed as percentage – from 0%, meaning no effectiveness to 100%, meaning full/maximum effectiveness. The project's proposed activities and measures to address deforestation are summarised below; for their detailed descriptions, refer to the project document (PD):

1. Livelihoods development, e.g., honey production, promotion of conservation farming, and market linkages and value chain development for Non-Timber Forest Products (NTFPs).
2. Performance-based forest conservation benefit sharing and impact investments.
3. Sensitisation on value and benefits of conservation.
4. Job creation.
5. Support and promotion of income generating activities.
6. Creating incentives for monitoring, enforcement and compliance.
7. Support to land use planning initiatives, e.g., zoning, Game Management Plans and Fire Management Plans.
8. Strategic partnership with local conservation-compatible enterprises to facilitate access to alternative economic opportunities.

The above proposed project activities/measures are intended to address pertinent issues such as lack of institutional capacity to protect, manage, and monitor forests; low conservation awareness; lack of alternative sustainable livelihoods options; and poor resource governance including weak regulatory and policy environments. BCP is thus using an integrated conservation and development approach to addressing deforestation – centred on improving livelihood systems and an enabling supportive policy framework to alleviate rural poverty, thus reducing over-dependence on forest resources.

The estimation of the project's interventions effectiveness to address deforestation was based on expert evaluations - described in section 3.3. The analysis has been done in an Excel spreadsheet (a separate document). The summary results (Table 5) indicate an overall EI of 85%; see Annex 6 for details.

Table 5: CFP Effectiveness Index

Project year	Effectiveness Index (%)
2016 (project start)	0.0%
2017	14.2%
2018	28.4%
2019	42.6%
2020	56.8%
2021	71.0%
2022	85.2%
2023	85.2%
2024	85.2%
2025	85.2%
2026	85.2%

Source: Authors

The above EI is expected to be achieved by the 6th year since project start– as a result of concerted efforts by BCP working jointly with other project stakeholders. This EI is thus used in the ex-ante estimation of the project's emission reductions in the PD.

4.9 Opportunity cost and co-benefits

4.9.1 Opportunity costs

When forests are converted by smallholder farmers, the resulting land use is crop cultivation. In the case of firewood and charcoal, the resulting land use is a degraded/deforested land. Therefore, opportunity costs have been assessed considering four uses of the forestland, namely:

1. Forest utilisation: costs and benefits from the standing forest;
2. Smallholder agriculture: costs and benefits of cultivation practised on the forestland after conversion/deforestation;
3. Charcoal production: costs and benefits of charcoal production from the forest; and
4. Firewood extraction: costs and benefits of firewood extraction from the forest.

The opportunity costs compared forest utilisation to the other land uses, resulting into the following:

1. Opportunity cost of smallholder agriculture (Forest → Smallholder agriculture), which indicates the benefits to the deforestation agent that would be foregone for not converting forests to smallholder agriculture.
2. Opportunity cost of charcoal production (Forest → Charcoal agriculture), which indicates the benefits to the deforestation agent that would be foregone for not cutting forests to produce charcoal for sale.
3. Opportunity cost of firewood extraction (Forest →Firewood extraction), which indicates the benefits to the deforestation agent that would be foregone for not cutting forest for sale as firewood.

Details of the procedures, and key figures and assumptions used for the opportunity cost analysis are presented in Annex 3 and Annex 5.

The results of the opportunity cost assessments are presented in Table 6 below. It shows that the smallholder agriculture has the highest and charcoal production the lowest opportunity cost both on per ha basis and per tCO_2. The NPV of forest utilisation, being lower than those of the deforestation drivers, indicates that those deforestation activities are profitable for the deforestation agent; hence, it is economically attractive to deforest – even though those deforestation activities are principally for subsistence.

It is worth pointing out that in estimating opportunity cost/ton of GHG emission (Table 6), both below and above ground biomass carbon and soil carbon are included. The inclusion of the soil carbon, based on a IPCC default value has the impact of lowering the value of the opportunity/ton of GHG emission. When the default soil carbon is excluded (i.e., only biomass carbon is considered), the opportunity cost/ton of GHG emission increases to 8.6, 1.0, and 3.2 USD/tCO_2 for smallholder agriculture, charcoal production, and firewood extraction respectively. Since, the soil carbon is based on IPCC default value, it is deemed to be less reliable compared, for example, to above and below ground biomass carbon, which are based on measurements conducted in the project area. The higher opportunity cost values are also similar to values derived in a separate project study - the Zambia Integrated Forested Landscape Program – conducted in the project region, which reported opportunity cost of USD 15/tCO_2 for small agricultural expansion, and thus may be more realistic.

Table 6: Opportunity costs of deforestation

Variable	**NPV (USD/ha)**	**Above and below ground carbon stock (tCO_2/ha)**	**Soil carbon stock (tCO_2/ha)**	**Total carbon stock (tCO_2/ha)**	**Opportunity cost (USD)**	**Relative opportunity cost – total carbon stock (USD/tCO_2)**	**Relative opportunity cost – biomass carbon stock only (USD/tCO_2)***
Forest utilisation	37	88.3	128.3	216.6	n.a.	n.a.	n.a
Smallholder agriculture	623	20.3	70.7	91.0	587	4.7	8.6
Charcoal production	107	20.3	70.7	91.0	70	0.6	1.0
Firewood extraction	257	20.3	70.7	91.0	220	1.8	3.2

Source: Authors. ***Relative opportunity cost – biomass carbon stock only excludes soil carbon**.

Opportunity cost graphs

Based on the estimate of the contributions of the main drivers to deforestation described in section 4.3.1 to 4.3.3, the quantities of deforestation in the historical reference period was attributed to these drivers as follows:

- Smallholder agricultural expansion – 75%
- Charcoal production – 15%
- Firewood extraction – 10%

The estimates of the deforestation contributions and average carbon stocks/emission factors, presented in Table 6, were combined to produce the opportunity cost graphs for the respective driver (Figure 10). The graphs show opportunity cost per tCO_2e on the Y-axis and total GHG emissions on the X-axis for the respective driver.

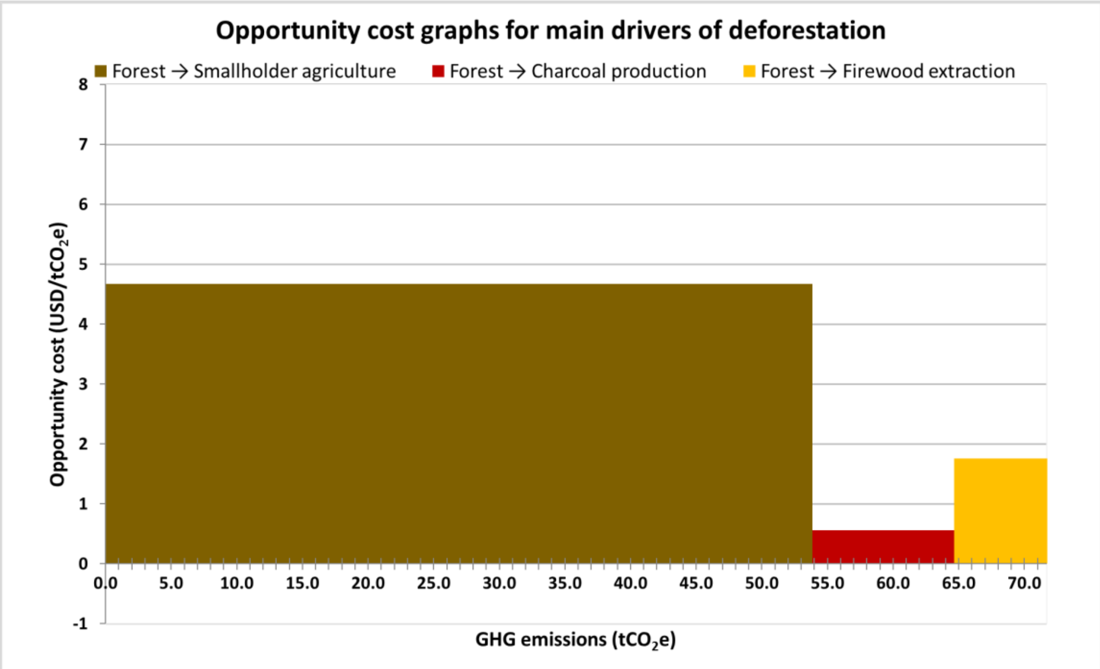

Figure 10: Opportunity cost graphs

Source: Authors

Table 6 and the above opportunity cost graphs show that among the three deforestation drivers, smallholder agricultural expansion has the highest opportunity cost per tCO_2e (USD 4.7/tCO_2e); thus avoiding deforestation and the resulting emission of one tCO_2e from smallholder agricultural expansion has the highest amount of benefits to be foregone by the deforestation agent. The total historical deforestation (571,040 ha) is estimated to generate 71.7 million tCO_2e. Of this GHG emissions, smallholder agricultural expansion is estimated to contribute the largest amount and share, i.e., 53.8 million tCO_2e out of the 71.7 million tCO_2e (Figure 10). Charcoal production, with the lowest opportunity cost, is estimated to generate 10.8 million tCO_2e of GHG emissions, and firewood 7.2 million tCO_2e – from the total deforestation (571,040 ha) estimated to have occurred in the historical reference period.

4.9.2 Co-benefits

There are a number of benefits that the forests in the project region provide – beyond prominent products such as timber, firewood, and other wood products. During FGDs, communities were asked to describe any benefits that they obtain from the forests. The benefits mentioned were mostly physical products, namely:

- Herbs (local medicine);
- Mushrooms;
- Honey production;
- Bush meat from wild animals; and
- Fish from streams/rivers.

These products were mentioned in addition to timber, firewood, charcoal, and construction materials (e.g., poles and fibres), which were the major extracted forest products. Community members were in agreement that everyone among them used or benefited from the forests in one way or another. Besides those physical products, they also stated other non-tangible values/benefits of the forests, namely:

- Bringing rainfall (or negatively affecting rainfall when forests are cut);
- Giving good air for breathing;
- Home (habitat) for wild animals, which are a source of bush meat;
- Protection of homesteads from strong winds (windbreaks);
- Cover and protection of soils; and
- Giving cool weather/climate by reducing heat.

Therefore, in addition to published literature (e.g., Huntington et al., 2016; Turpie et al., 2015; Mofya-Mukuka and Simoloka, 2015), and a series of Participatory Rural Appraisals (PRAs) undertaken by BCP in the region, many benefits of forests that communities recognize and value were identified, and are further described:

Non-Wood Forest Products

These include the following:

1. Mushrooms
2. Honey
3. Herbal medicine
4. Fruits
5. Bush meat
6. Fish
7. Edible caterpillar/worms
8. Grasses
9. Pasture/Fodder
10. Reeds and fibres

Edible mushrooms are collected mostly by women in the rainy season. The harvests are consumed by the collecting household or sold or exchanged for another good with a neighbour. Wild honey is harvested from the forests – though the practice often involves cutting or injury of the trees. In addition, bee-keeping is commonly practised inside the forests, with beehives hung under tree shade. The surrounding trees provide pollen and nectar, and cool shade for successful honey production. Herbal medicines are obtained from herbs, shrubs, and trees. Examples include false sesame (*Ceratotheca sesamoides*), Baobab (*Adasonia digitata*), and wild custard apple (*Annona senegalesis*), which are used for treating stomach disorders, diarrhoea, and stomach pains respectively (Mofya-Mukuka and Simoloka, 2015). Fruit trees include *Uapaca kirkiana*, Baobab (*Adasonia digitata*), Tamarind (*Tamarindus indica*) and *Piliostigma thonningii* (Mofya-Mukuka and Simoloka, 2015; Gumbo et al., 2013). A number of wild animals are hunted for bush meat including antelopes, warthogs, and birds such as guinea fowls. Fishing occurs in and around areas having permanent water sources. However, both hunting and fishing are regulated, with the former being even more controlled by the DNPW; hence, some community members either do these activities illegally (poaching), or benefit from the share of hunting quotas, which are annually issued to communities surrounding GMAs by the DNPW. Hunting of edible mice, a local delicacy in the region is, however, free and open to communities.

Edible caterpillars are harvested from the forests seasonally. These worms are in fact the larval form of the *mopane* emperor moth (*Gonimbrasia belina*). They are consumed by many communities in Zambia, Zimbabwe, Botswana and northern Namibia.

Forests also provide grasses, which are cut and used for thatching of houses. In addition, they are a source of pasture; hence, providing food for livestock through open grazing. Reeds and fibres and obtained from the forests for various uses – including making of mats and other crafts, which are sold, and for ropes, which are used for tying goods, and in house constructions.

Ecosystems regulation

The provision of regulatory services provided by forests, which were recognised and expressly stated by communities during FGDs included:

- Rainfall formation;
- Moderation of weather/local climate; and
- Protection from strong winds.

These values are also reported in the published literature, e.g., Huntington et al., 2016 and Turpie et al., 2015. In addition, there are a number of other regulatory roles that the forests play, which are documented in the literature, including:

- Climate regulation through carbon sequestration;
- Regulation of hydrological flows including enhancing water infiltration, and flood attenuation;
- Erosion control and trapping of sediments;
- Amelioration of water quality; and
- Providing habitats and refuge for organisms threatened with extinction and those useful in controlling populations of crop pests (Turpie et al., 2015).

Biodiversity

Both in the FGDs, and in the literature, forests were recognised as critical for biodiversity conservation. Forests contain a variety of both plants and animals. Those of particular conservation concerns in the region include the locally threatened *Pterocarpus chrysothrix*, a highly valuable timber tree species, and a variety of animals including the endangered African wild dogs. During FGDs, communities clearly asserted that forest loss was resulting into disappearance of wild animals, some of which they highly valued for bush meat.

Related to biodiversity is the aesthetic and tourism value of forests: The National Parks and GMAs present in the regions are all forested landscapes. The natural forests create scenic landscapes that attract tourists to the area in addition to the appeal of seeing wild animals. The South Lwangua, North Lwangua, and Lukusi NPs all demonstrate the aesthetic and tourism benefits of forested landscapes. This is greatly valued by the communities and the tourism sector at large– as a source of incomes for the communities, government, and the private sector. In and around NPs and GMAs, a few community members were reportedly employed in the tourism sector – besides relying on the predominant farming and charcoal production livelihoods.

Spiritual and cultural value

Forests and trees have known spiritual and cultural significance for communities in the region. In rural areas, graveyards (cemeteries) are typically covered by trees/forests. Since graveyards are associated with the spirits of the ancestors, they are covered in trees as a sign of respect for the dead ancestors and to provide them shade. In addition, a number of rituals and ceremonies involve either using forest products or are performed in the forests or both. One of those is the renowned *N'cwala* traditional ceremony of the Ngoni tribe. The materials used, including wild animal skins and wooden artefacts, come from the forests.

As a summary, we present the list of forest co-benefits identified from FGDs, BCP PRAs, and in the literature in Table 7.

Table 7: Summary of co-benefits of forests in the project region

Categorisation	Product or service	Source of information
Non-Timber Forest Products	• Mushrooms • Honey • Herbal medicine • Fruits • Bush meat • Fish • Edible caterpillar/worms • Grasses • Pasture/Fodder • Reeds and fibres	FGDs and expert consultations in this study; BCP PRA; Huntington et al., 2016; Turpie et al., 2015; Mofya-Mukuka and Simoloka, 2015; Gumbo et al., 2013
Ecosystems regulation	• Rainfall formation • Moderation of weather/local climate • Protection from strong winds • Climate regulation through carbon sequestration • Regulation of hydrological flows (enhancing water infiltration, and flood attenuation • Erosion control and trapping of sediments • Amelioration of water quality • Providing habitats and refuge	FGDs and expert consultations in this study; BCP PRA; Huntington et al., 2016; Turpie et al., 2015
Biodiversity	• Habitat for variety of species • Aesthetic value • Tourism	FGDs and expert consultations in this study; BCP PRA; Huntington et al., 2016; Turpie et al., 2015
Spiritual and cultural	• Rituals & ceremonies • Graveyard shade	FGDs and expert consultations in this study; Turpie et al., 2015

Source: see third column of the table.

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6 ANNEX

Annex 1: Guiding Questions

BCP Community Forests Program Drivers Study

A. Expert Consultations/Focus Group Discussions Guiding Questions

Changes in forest cover

- Changes in forest cover seen over the past 5-10 years?

(Probe: increase or decrease in forest cover)
(Probe: illustrate with map of forest cover loss)

- What are the causes/reasons for the observed changes?
- What changes in forest cover do you expect to see in the next 5-10 years?
- What are the reasons/causes for those expected changes?
- What commonly happens to piece of forestland over time (10 years) when converted to agriculture

(Probe: continuous cultivation or fallow; if fallow; how long?)
(Probe: 1 or 2 crops mostly grown on the cleared land)
(Probe: Yield/lima of the crops)
Note there will be separate interviews of farmers on costs and benefits of crop cultivation following forest conversion.

- What commonly happens to piece of forestland over time (10 years) after cutting for charcoal production

(Probe: left to regenerate; taken over by crop cultivation; left bare?)
Note: there will be separate interviews of charcoal producer on costs and benefits of charcoal making.

Benefits

- Of what value/benefit, if any, is the forest to them?

(Probe: Tangible and intangible values of forests)

(Probe: Will loss of forests produce overall negative or

B. Cost and benefits of smallholder agriculture - smallholder farmer

1. Crops grown most frequently (each year) on the cleared forest land?
2. After clearing for agric., and commencing cultivation, is there fallow?
3. If fallow applies, in which year after initial clearing does fallow commonly occur? Range and average?
4. What happens on the land during fallow period?
5. How long (years) is the fallow period?

Costs /*lima* for the crop most frequently grown

Activity/item	Cost	Frequency
Clearing land		
Tilling land		
Seed cost		
Planting		

Fertilizer cost per application		
Weeding/hoeing		
Weeding/chemical		
Pesticide per application		
Harvesting		
Shelling		
Packaging		
Packing materials		

Revenues /*lima*

Activity/item	**Value**	**Note**
Yield		
Price/unit (farm-gate)		

C. Cost and benefits of charcoal production – charcoal producer

1. Which species of trees are used for charcoal production?
2. From cutting trees over one lima, how many heaps/kilns of charcoal do you get? Range and average?
3. How many bags of charcoal do you get from one heap/ kiln? Range and average?
4. What is the price per bag on site? Range and average?
5. What is the price per bag on the roadside? Range and average?
6. What happens afterwards to the cleared site?
7. Distance to the roadside where selling takes place? Range and average?
8. Is their return to the once-cleared-for-charcoal site?
9. If there is return to the site, after how long (years)? Range and average?

Costs/activity

Activity/item	**Cost**
Felling the trees per tree/over one lima	
Cutting felled trees into pieces – per tree/over one lima	
Heaping per kiln	
Burning per kiln	
Packaging per kiln/bag	
Packing material/bag	
Transport to roadside per bag	
Other cost	

D. Cost and benefits of forest utilization – DFO

1. How many hectares of state forests are there in the district?
2. How many hectares of customary forests are there in the district?

3. Which main forest products are actually being legally harvested from forests under FD?
4. Which main forests products are actually being legally harvested from forests on customary land?
5. What are the main timber species, which are actually harvested in the district?
6. What quantities of forest products were legally harvested last year in the district?

Name of product	**Total quantity of forest product harvest last year**	**Total value (ZMW)**

Examples of forest products: timber, charcoal, firewood, stones, sand, etc.

7. What was the annual budget of the FD office (in ZMW) for the whole of last year?
8. What was the actual expenditure of the FD office (in ZMW) for the whole of last year?
9. How much of the revenues generated from forestland utilization last year was shared with local communities in the district?
10. Is there a regulation or plan to share revenues generated from forestland utilization with local communities in the district?
11. If yes, what % of revenues generated from forestland utilization is/will be shared with local communities?

Annex 2: Fieldwork activities

Date	Activity and place
1st October 2017	Arrival; Brief introductory meet with Paul (Chief of Party);Travel to Rufunsa
2nd October 2017	Community meetings (FGDs) with: 1) Kamwesha community, 2) Mulamba community Rufunsa district
3rd October 2017	Expert consultations/meeting with GRZ Rufunsa; Travel to Nyimba; Expert consultations/meeting with GRZ Nyimba
4th October 2017	Community meetings (FGDs) with: 1) Chief Nyalugwe, 2) Nyalugwe community, Nyimba district
5th October 2017	Travel to Lundazi; Expert consultations/meeting with GRZ Lundazi
6th October 2017	Travel to Mambwe; Expert consultations/meeting with GRZ Mambwe
7th October 2017	Community meetings (FGDs) with: 1) Mkasanga community, 2) Mukwera community, Lundazi district
8th October 2017	Day-off. Notes.
9th October 2017	Community meetings (FGDs) with: 1) Chipako community, 2) Pendwe community, Mambwe district
10th October 2017	Travel to Chipata; Expert consultations workshop in Chipata; Return flight to Lusaka, then return flight to Uganda

Note GRZ include: District Forestry Officer, District Planning Officer, Representative of DNPW, Representative of Chiefs and Traditional Affairs, and District Agricultural Coordinator/Officer.

Annex 3: One-hectare models

Each one hectare (1-ha) land use model estimates the costs incurred and benefits in terms of revenues from sale of products generated by one hectare of the forest or when the forest is deforested/degraded by the activity (driver). The net benefit of the forest is compared with that of the deforesting or forest degrading activity (driver). Three drivers were considered: small-holder agricultural expansion, charcoal production and firewood extraction. Hence, four 1-ha models were developed, including one for forest utilisation.

The steps applied were as follows:

a) The costs of the activities and materials required to undertake the land use activity (e.g., clearing the land and producing crops on it) were estimated based on local data/statistics, interviews, and published literature.
b) The costs were then annualized according to annual routines of the expenditures on the activities/materials.
c) Benefits from products, e.g., crops, were estimated from known or expected yields and prices obtained from local data/statistics, interviews, and published literature. Prices used for forest products were taken from the Forestry Department royalty rates/price list.
d) Where costs of production or prices of products were taken from past reports/studies, the values were adjusted for inflation to reflect current prices according to the formula:

   $$Current\ price\ = Price\ in\ year\ t * (1\ +\ Inflation\ rate\ \%\ in\ year\ t)$$

   The annual inflation figures were obtained from the World Bank World Development Indicators database, and are shown below:

Year	2010	2011	2012	2013	2014	2015	2016	Average of last 5 years
Inflation (%)	14.0	11.1	7.0	9.7	5.4	6.7	6.4	7.1

Source: World Bank, 2017.

e) Both cost and benefits were annualised according to the routine of the production of the goods.
f) All values reported in ZMW were converted to USD using an exchange rate of USD 1 = 11.25 ZMW.
g) Annual cash flows were then calculated as the difference between total annual costs and total annual revenues.
h) NPVs were estimated over 10-year period (corresponding to the fixed baseline period of the project as per the methodology). The Excel NPV function was used, applying a real discount rate of 8.5%, derived from the online World Bank World Development Indicators database[25].

The key figures and the specific assumptions/approach used for the individual models are further described:

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[25] World Bank, 2017. Accessed here.

Smallholder agricultural expansion

Maize is the predominant crop grown in the region on newly cleared forestlands. Hence, for the purpose of NPV analysis and opportunity cost assessment, we assumed the farmers would grow maize on the deforested land. The costs of production, farm-gate price, and yields were obtained from interviews conducted with farmers, and published literature and previous studies, e.g., Sitko *et al*., 2011; and Chapoto and Zulu-Mbata, 2016. Average yield was estimated at about 2.4 tonnes/ha/year. Farm gate price was estimated from FGDs as varying from 50, 90, 100, up to 160 ZMW for a 50-kg bag of maize depending on the time after harvests. Hence, an average value of 90 ZMW per 50-kg bag was used in the NPV calculation. See the table below for the summary of the key figures used. The cash-flow analyses resulted into NPV of USD 623/ha over 10 years.

Summary of key figures for smallholder agricultural expansion

Item	Cost/price	Remarks
Cost figures		
Clearing (forest) land	600 ZMW/ha	Cost incurred in year 1 only.
Tilling land	667 ZMW/ha	
Seed cost	100 ZMW/ha	Recycled seeds are used
Planting	560 ZMW/ha	
Fertilizer cost per application	0	Commonly not applied
Weeding/hoeing	840 ZMW/ha	Done twice per crop season on average
Weeding/chemical	0	Commonly not applied
Pesticide per application	0	Commonly not applied
Harvesting	400 ZMW/ha	
Transportation from field to home	200 ZMW/ha	
Shelling	400 ZMW/ha	
Revenue figures		
Yield of maize	2,400kg/ha	Authors' estimate
Farm gate price of maize	90 ZMW/50-kg bag	Authors' estimate

Charcoal production

Charcoal is produced in earth kilns, with varying conversion efficiencies – from 12%, 20% to 25% (Gumbo et al., 2013); we used an average of 20% in the analysis. Average standing volume of the harvested forest was taken as 55 m^3/ha – taken from Forestry Department ILUA II inventory data. Harvesting is assumed to occur once over the 10-year analysis period; hence, no additional benefits accrue from the land from charcoal production during this time. Average wood density was taken as 0.73 tonne per m^3 (Kamelarczyk, 2009). The cost of production per 50-kg bag was estimated at 10,500 ZMK[26] (Gumbo et al., 2013), and the farm-gate price (charcoal at production site) was estimated at an average of 30 ZMW per 50-kg bag. See table below, summarising all the cost and revenue figures used.

[26]ZMK is the old Zambia currency used since 2012, now replaced by ZMW; 10,500 ZMK converts to about 2 USD.

Summary of key figures for charcoal production

Item	Cost/price	Source of data
Cost figures		
Cost of production	10,500 ZMK per 50-kg bag (= USD 2.0)	Gumbo et al., 2013.
Revenues figures		
Harvested volume	55.0 m^3/ha	Forestry Department ILUA II inventory data. Harvested once over 10-year period.
Wood density	0.73 tonnes/m^3	Kamelarczyk, 2009
Farm gate price of charcoal	30 ZMW per 50-kg bag	Authors' interviews for this study

The cash-flow analysis done using the above figures resulted into NPV of USD 107/ha over 10 years.

Firewood extraction

Firewood extraction is considered to involve clear-cutting of trees, and the harvested firewood is sold at 90 ZMW per m^3 – according to figures from District Forest office. Average standing volume of the harvested forest was taken as 55 m^3/ha – taken from Forestry Department ILUA II inventory data. Harvesting is assumed to occur once over the 10-year analysis period; hence, no additional benefits from firewood harvests accrue from the land to the deforestation agent during this time. The cost of production of wood and NWFPs is estimated in various studies as being 20, 40, and 50% of the product value (Reichhuber and Requate, 2007). In this analysis, we assumed the average of those estimates, i.e., 36.6% of the product value as the cost of production. The cost and revenue figures used are summarised in the table below:

Summary of key figures for firewood extraction

Item	Cost/price	Source of data
Cost figures		
Cost of harvesting firewood	36.6% of product value	Averaged value from Reichhuber and Requate, 2007.
Revenues figures		
Harvested volume	55.0 m^3/ha	Forestry Department ILUA II inventory data. Harvested once over the 10-year period.
Farm gate price of firewood	90 ZMW/m^3	District Forest Offices in the region

The cash-flow analysis done using the above figures resulted into NPV of USD 257/ha over 10 years.

Forest utilisation

The forest would be undisturbed (except for fires) if it were not converted to agriculture land use or used for charcoal production or firewood extraction. The main products harvested from the forest would be NTFPs. Turpie *et al*., (2015) estimated the value of NTFPs from Zambian forests at about USD 135.8 million per annum. Assuming this value is obtained primarily from undisturbed forests, which makes up 33.1% of the 49.9 million hectares of forests in Zambia, the average value of NTFPs per ha of forest was calculated as USD 8.2/ha in 2015; adjusted with 5-year (2012-2016) average inflation (7.1%), resulted in USD 8.8/ha in 2017.

Harvesting of timber and other wood products yield additional revenues. Statistics obtained from DFO showed the following are the main products that are legally harvested from the forest: timber, firewood, charcoal, bamboo canes, and bush (construction) poles. An example for Lundazi district is shown below for the year 2016.

Products harvested from forests in 2016 in Lundazi district

Name of Product	Total quantity harvested in 2016	Total value (ZMW)
Timber (hardwood)	7 cubic meters	2,625
Timber (softwood)	5 cubic meters	1,012
Charcoal (production)	1025 bags of 50 bags	13,838
Charcoal conveyance)	1021 bags of 50 bags	13,784
Firewood (cords)	96.5	26,055
Firewood (cubic metres)	4.66	420
Bush poles	285	5,130

Source: District Forest Office Lundazi

Based on the forest revenues data obtained from DFO offices of Rufunsa, Lundazi, and Mambwe district, the revenue from timber and other wood products were estimated at 0.2 ZWM/ha in 2016, which is less than USD 0.1/ha/year. However, both the DFO officials and other stakeholders consulted acknowledged that some forest products are harvested illegally and, therefore, were missing from the DFO books. Thus, a value of USD 0.1/ha was assumed as the annual revenue obtained from harvesting timber and other wood products – in addition to the NFTPs above. The cost of production of NTFPs was taken as 36.6% of the product value – derived from the average production cost of wood and NTFPs reported in Reichhuber and Requate, 2007. The cost of managing the forest, which is borne by the FD, was estimated at about 0.5 ZMW/ha – obtained from dividing annual expenditures from District Forest offices in the region by the total forest area under their management. The table below presents a summary of the cost and revenues figures used.

Summary of key figures for forest utilisation

Item	Cost/price	Source of data
Cost figures		
Cost of production of timber and NTFPs	36.6% of product value	Averaged value from Reichhuber and Requate, 2007.
Cost of managing the forest	0.5 ZMW/ha/year	Authors' estimate
Revenues figures		
Value of NTFPs annually harvested	8.8 USD/ha/year	Estimate based on value reported in Turpie et al., 2015
Price of timber	375 ZMW/m^3	District Forest Offices in the region& Government of Zambia, Statutory Instrument No. 52 of 2013.
Annual revenues from timber and other wood products	USD 0.1 /ha/year	Estimate based on 2016 data from District Forest Offices

With the above cost and revenue figures, the cash-flow analysis for forest utilisation resulted in NPV of USD 37/ha over 10 years.

Annex 4: Net Present Value

Net present value (NPV) is an economic profitability index used to estimate the profitability of a land use over a certain period of time. NPV takes into account the time-value of money. Since waiting for profits is less attractive than obtaining profits now, the “value” of future profits is discounted by a specific percentage rate, often ranging between 2-20%. Within a multi-year analysis, the NPV is a discounted stream of profits (revenues minus costs of capital, land and labour inputs) as shown in the equation below:

$$NPV = \sum_{1=t}^{T} \frac{\Pi_t}{(1+r)^t}$$

Where t = year, T = length of time horizon, π = annual profits of a land use ($/ha), r = discount rate. The major assumptions introduced at the stage of NPV calculation are the discount rate (r) and the time horizon (T).

For discount rates, NPV analyses typically use loan interest rates, which are set by a national bank or the government. The interest rate reflects the opportunity cost of obtaining profits - not now - but in the future.

High discount rates can dramatically reduce the viability and attractiveness of long-term investments. The context of high discount rates creates incentives to generate profits and benefits in the short term, since waiting for the long term is nearly worthless. For example, the use of high discount rates challenges this view of conservationists who consider current and future values of biodiversity to be high. Therefore, in order to value ecosystem services, lower (social) discount rates could be more justifiable than higher discount rates used in a risky (private) business environment.

Source: World Bank, 2011 (p. 6-29)

Annex 5: Opportunity cost in absolute and relative terms

Opportunity costs are net benefits foregone when considering alternative activities such as producing crops, or any other activity that could have been carried out on the same land. REDD+ opportunity costs are precisely the difference in net benefits from maintaining or enhancing forest cover and the net benefits from converting these forests and (if feasible) using the land for alternative purposes (e.g. small-scale agriculture). Opportunity costs can be presented on a per hectare basis – absolute term, or per tonne of tCO_2e of emissions avoided – relative term. Opportunity cost analysis is an economic approach to monetize profits from these land uses, based on the calculation of the Net Present Value (NPV). The NPV is the result of a discounted cash flow analysis of the costs and benefits for a certain land use over a defined period of time (see Annex 4). Comparing the NPVs ($/ha) of various land uses indicates the most profitable land uses (e.g. profits from forest, agriculture, etc.). The difference between the NPV of a land use type A and that of land use type B is the opportunity cost, indicating the foregone monetized value the land user has to incur when opting for land use A.

Each land use is characterized by a typical time average carbon stock (tCO_2/ha). Since each land use type is also characterized by distinct NPV ($/ha), both parameters can be linked, resulting in opportunity cost estimates per ha (absolute term), and per tCO_2e (relative term).

The Figure below is a simple illustration to explain this:

- The total carbon stock of a natural forest is 217 tCO_2/ha, while agricultural land use carbon stock is 91 tCO_2/ha.
- The NPV of forest is 37 $/ha, that of agriculture is 623 $/ha.

Conserving the forest in its current state instead of converting it to agriculture would result in opportunity costs of 587 $/ha (difference between 623$/ha and 37$/ha), while the carbon conserved amounts to 126 tCO_2/ha (difference between 217 tCO_2/ha and 91 tCO_2/ha). Hence, the opportunity cost per tCO_2 due to forest conservation amounts to 4.7 $/$tCO_2$.

The carbon stocks used in for calculating relative opportunity costs in this study were obtained from Forestry Department ILUA II inventory data for biomass carbon - above and below ground, and IPCC 2006 for soil carbon:

Main category	**Land use class**	**Biomass carbon - above and below ground (tCO2/ha)**	**Soil carbon (tCO2/ha)**	**Total carbon (tCO2/ha)**
Forest	Forest utilisation	88.3	128.3	216.6
Non-forest (post-deforestation class)	Smallholder agriculture	20.3	70.7	91.0
	Charcoal production	20.3	70.7	91.0
	Firewood extraction	20.3	70.7	91.0

Note: For forest soil carbon, a default value from IPCC 2006 (35 tC/ha) was used, and for land converted from forest to non-forest the value was estimated as follows: Average carbon stocks after forest conversion were estimated using IPCC default reference soil organic carbon (SOC_{REF}) for mineral soils (Table 2.3 of IPCC, 2006), and relative soil stock change factors for land use, management regime, and level of inputs listed in Table 5.5 of IPCC (2006). The project area's climate is classified as tropical dry, and the soils are both High Activity Mineral (HAC), and Low Activity Mineral (LAC). To be conservative, we used SOC_{REF} for LAC (35 tC/ha as opposed to 38 tC/ha for HAC). The farming system has been defined as cropland continuously managed for more than 20 years, to predominantly annual crops, with low input, and full tillage. The following equation of the IPCC has been used for the calculation:

$$SOC = SOC_{REF} * F_{LU} * F_{MG} * F_{I}$$

Where:

SOC = soil organic carbon stock, tons C ha^{-1}

SOC_{REF} = the reference carbon stock, tons C ha^{-1} (value used: 35; Source: IPCC, 2006[27], Table 2.3)

F_{LU} = stock change factor for land use or land-use change type; dimensionless (value used: 0.58; Source: IPCC, 2006[28], Table 5.5)

F_{MG} = stock change factor for management regime, dimensionless (value used: 1.00; Source: IPCC, 2006, Table 5.5)

F_{I} = stock change factor for input of organic matter, dimensionless (value used: 0.95; Source: IPCC, 2006, Table 5.5).

The above calculation resulted in soil carbon stocks of 70.7 tCO_2/ha used uniformly across all non-forest classes.

A graphical illustration of the opportunity cost is presented in the figure below. The opportunity costs presented in section 4.9 includes both the absolute and relative terms.

[27] IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Accessed here.
[28] IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Accessed here

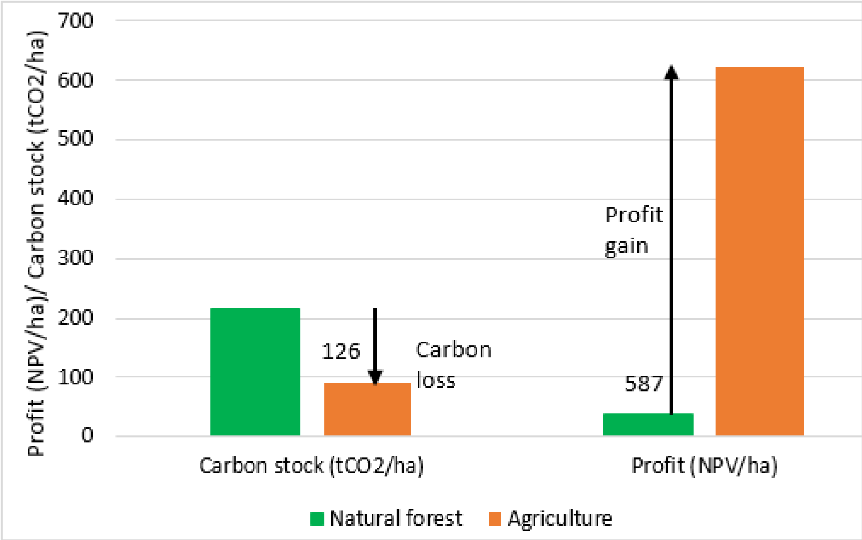

Illustration of opportunity cost

Source: Authors

Annex 6: Project Effectiveness Index Tables

Project intervention effectiveness to reduce deforestation

Driver	Relative importance of driver (% deforestation contribution)	Project interventions							
		Livelihood development	Performance-based forest conservation & impact investments	Sensitisation	Job creation	Income generating activities	Incentives for monitoring, enforcement and compliance	Support to land use planning	Partnership with local conservation-compatible enterprises
Agricultural expansion	75.0%	20%	10%	5%	20%	10%	30%	30%	10%
Charcoal production	15.0%	30%	20%	5%	30%	40%	20%	30%	20%
Fuelwood extraction	10.0%	3%	3%	5%	7%	7%	20%	40%	30%
Settlement & housing	0.0%	0%	0%	10%	3%	0%	30%	50%	20%
Illegal timber extraction	0.0%	0%	0%	0%	20%	30%	40%	30%	30%
Mining	0.0%	0%	0%	0%	0%	0%	3%	10%	0%
Road infrastructure	0.0%	0%	0%	0%	0%	0%	0%	10%	0%
Forest fires	0.0%	0%	0%	10%	3%	0%	7%	7%	10%

Cumulative effectiveness during fixed baseline period

Driver	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Agricultural expansion	10.1%	20.3%	30.4%	40.5%	50.6%	60.8%
Charcoal production	2.9%	5.9%	8.8%	11.7%	14.6%	17.6%
Fuelwood extraction	1.2%	2.3%	3.5%	4.6%	5.8%	6.9%
Settlement & housing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Illegal timber extraction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Road infrastructure	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Forest fires	14.2%	28.4%	42.6%	56.8%	71.0%	85.2%

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