POLICY BRIEF
GREENHOUSE GAS ASSESSMENT OF BUSH CONTROL AND BIOMASS UTILIZATION IN NAMIBIA

Matthias Seebauer

Alexander Pinkwart

Benjamin Schwarz

Carter Hartz (NNF Namibia)

UNIQUE forestry and land use

Key Messages:

- *Invasion and encroachment of woody plants into grassland and savannas is a global driver of land degradation with significant negative impacts on ecosystem services.*
- *To address the problem it is important to understand the impact of different management options for preventing bush encroachment on mitigation.*
- *A future bush sector can upscale more emission intensive, economically viable bush control activities such charcoal or electricity generation if this is combined with other, more restoration focused activities which increase also soil fertility and resilience through soil carbon sequestration contributing to climate change adaptation.*

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Land degradation by bush encroachment

Invasion and encroachment of woody plants into grassland is a global driver of land degradation and a widespread phenomenon in African savannas with significant negative economic and environmental impacts. It decreases landscape heterogeneity, alters vulnerable habitats and reduces biodiversity (de Klerk, 2004; Sirami et al. 2009; Smit and Prins 2015), and it impacts carbon sequestration and water budgets (Woodward & Lomas 2004; Mitchard & Flintrop 2013). Changing the habitats towards more xerophytic, less productive, palatable, nutritious and resilient grass species encroachment can reduce the “grazing capacity” to less than 10%.

In Namibia, bush encroachment is a major problem: the bush vegetation covers already an estimated 45 million ha of the country’s savannas and reduces livestock productivity significantly (SAIEA 2016). The National Rangeland Management Policy and Strategy estimates the resulting direct economic losses at N$1.4 bn each year. Thus, bush control presents economic opportunities: Restoring encroached areas by sustainably removing and utilizing woody plants will result in improved grass production and enhance the grazing capacity. Targeted management and preventing bush encroachment would provide benefits outweighing by far the costs of management and control: Stafford et al. (2017) estimate the annual value of ecosystem services and tangible benefits from the restoration of bush encroachment in Namibia to USD 5.8 billion.

The Government of Namibia has recognized the importance of the topic for different economic and environmental objectives. Due to the dimension, the management of bush land use will have significant impacts on the country’s GHG emission profile. Active reduction of bush encroachment and restoration can provide meaningfully to Namibia’s Nationally Determined Contributions under the Paris Agreement and enhance the resilience to climate change impacts.

Study objective and design

The objective of this *'greenhouse gas assessment of bush control and biomass utilization'* is to analyze and quantify the mitigation impact of large-scale bush management in Namibia. The selected study area is Otjozondjupa which is representative for Namibia: it has 8.6 Mio ha of encroached areas and represents about 19% of the total encroached area in Namibia.

The study assesses in detail the GHG impacts of

- large-scale bush thinning on Namibian farmland,
- land use or productivity changes after bush thinning, and
- the utilization of the resulting bush biomass.

The study estimates the consequences of bush control in terms of ecosystems impacts, potential future impacts related to GHGs emissions after harvesting (e.g. due to increased livestock stocking), as well as carbon stock changes in the bush biomass pool (considering aftercare) and in soil organic carbon. The study follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, in particular the guidance provided for the AFOLU sector in Volume 4, and consists of three major assessments:

1. A land use impact analysis with an assessment of bush carbon stocks within the landscape and expected carbon stock changes in the different carbon pools after thinning/ harvesting of bush biomass.

2. A value chain GHG assessment of bush utilization from harvesting, processing to the final product of bush biomass for specific value chains related to thermal or energy use (e.g. charcoal, electricity, etc.).

3. A synthesis of the two assessments to develop pre-defined bush management scenarios

To compare potential future bush control management scenarios, a baseline was defined, reflecting the total area under bush encroachment and the current bush control activities occurring throughout the country. This study used the revised 'Bester map' as well as the field knowledge of recognized botanists and bush encroachment experts concluding that 45 million ha of Namibia are bush encroached (SAIEA 2016). Based on updated data from the Baseline Assessment for the De-Bushing Programme in Namibia (GIZ 2014), the main bush control activities and their annual implementation areas are summarized in the table below.

In addition to the study, the team developed an Excel-based bush control accounting model. It allows to flexibly change the different utilization options and bush system strata in order to compare the different results in terms of carbon stocks, carbon stock changes and GHG impacts. In the model, all the default emission factors and values used are listed and together with calculations on how they were derived.

Results

Carbon sequestration in Namibia's bush systems

In total, bushland in the study area results in 123.9 Mio t C sequestered corresponding to an average of 14.5 t C/ha (30.81 t dm/ha expressed in biomass). Additionally, 146.4 Mio t C are stored as soil organic carbon, resulting in an average 17.1 t C/ha. These figures are average values for encroached bushland. The results of the study and the accounting model quantifies carbon stocks for all defined strata and to assess other encroached areas in Namibia.

Table 1: Stratified carbon stock averages

Species strata	% share within the study region	Average biomass carbon stocks (tC/ ha)	Average soil carbon stocks (tC/ ha)
Acacia mellifera	6.9%	17.2	17.1
Acacia reficiens	0.2%	8.6	19.8
Mix	16.2%	11.9	16.6
Mix dominated by *A. mellifera*	63.6%	15.6	19.1
Mix dominated by *C. mopane*	0.4%	9.5	22.2
Terminalia sericea	12.7%	11.1	9.3
Overall weighted average		**14.5**	**17.1**

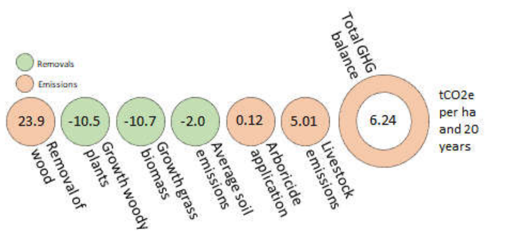
Source: UNIQUE

Typical savanna ecosystems (not encroached) show similar amounts of total stored carbon (34.2 t C/ha), but store more carbon (23.3 t C/ha) in the soil organic carbon pool.

Bush control and utilization scenarios

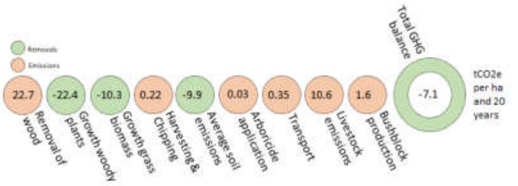
The study developed five harvesting and utilization scenarios reflecting existing and future bush value chains in Namibia. The scenarios calculate all emissions in the value chain as footprint (at the time of bush extraction and utilization) and as a long-term impact over a default IPCC period of 20 years. All scenarios assume that leaf biomass stays on site and that biomass can regrow after harvesting up to the average total biomass per hectare prior to the removal.

GHG scenario 0: Bush chemically controlled with subsequent livestock ranging with increased stocking rate



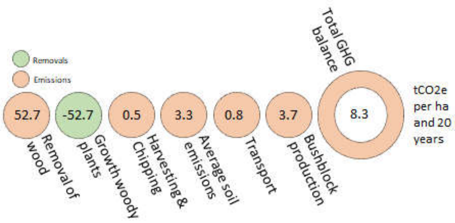
This scenario represents the baseline conditions of chemically controlled bush systems in Namibia. The removal of bush biomass and loss of carbon takes place over time as the standing dead wood is slowly decomposing. Significant sequestration occurs in grass biomass and soil organic carbon.

GHG scenario 1: Rangeland restoration & bushblok, bush-to-feed or pellet production



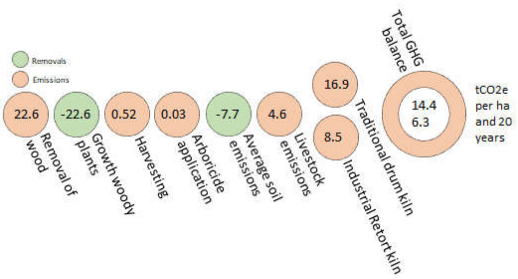
In the savanna restoration scenario bush biomass is used for bushblok, bush-to-feed or pellet production as well as left on-site as organic soil inputs. Aftercare takes place, but not through aerial application of chemicals. This is a plausible restoration scenario for farmers and would have an estimated impact of -7.1 tCO2e per ha over 20 years. The thinning opens up enough area for grasses to re-establish; organic inputs from various sources, including trash lines of some of the harvested bush biomass, will increase site fertility over time.

GHG scenario 2: Bush farming and bushblok production



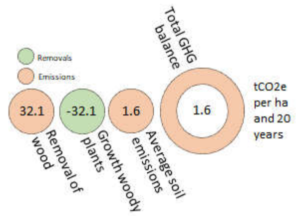
This scenario offers farmers to shift towards becoming "biomass-energy farmers". In contrast to the previous two scenarios, the main objective of this scenario is sustainable production (2 harvesting events) and use of bush biomass. Given the environmental impacts of bush encroachment in view of climate change this option should only be considered in combination with other restoration-focused scenarios.

GHG Scenario 3: Medium-scale charcoal production



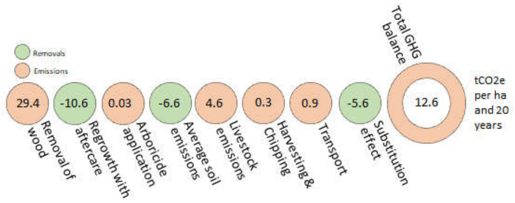
Namibia could export charcoal on a larger scale if advanced kiln technologies replace the traditional steel drum kilns currently used. The charcoal industry is already well established and the sector is growing. This scenario assumes a shift to stationary industrial retort kilns. This could cut the GHG balance over 20 years by more than half: traditional kiln results in 2.83 tCO_2e per ton charcoal over the 20-year period, while retort kilns reduce the emission intensity in the range of 1.87 to 0.85 tCO_2e per ton (emissions from burning charcoal are not considered).

GHG Scenario 4: Use of fire wood



In this scenario, the bush is harvested for fire wood use, especially on community lands subject to smallholder based utilization. This scenario represents a near neutral GHG balance over 20 years. Firewood might be one of the biggest uses for bush biomass. Aftercare is unrealistic because smallholders would most likely use bush biomass as a cheap resource and not want to invest into such measures. However, firewood harvesting is not a strategic control measure against large-scale bush encroachment.

GHG Scenario 5: Electricity generation



A promising project in Namibia is utilization of bush biomass as substitution for imported electricity from the Southern African Power Pool (SAPP). This would reduce Namibia's energy import dependency and enable investment into renewable energies as part of the national climate action agenda.

The strong substitution effect within the Namibian power mix in 2010 could even be further enhanced if Namibia expands its biomass power production and exports electricity to the SAPP. According to the UNFCCC (2018) substituting energy in the SAPP would result in an emission balance of ca -12 tCO2e/ha as compared to -5.6 tCO_2e. A 20 MW biomass power plant would require 106,500 t dry biomass per year (Cirrus Capital 2018). According to the biomass densities in this study, an area of 6,932 ha would need to be harvested every year. For the 20-year period this would amount to 138,645 ha of bush encroached land.

National baseline and bush utilization scenarios

The results were used to estimate GHG emissions and removals at the national level under current (baseline) conditions of bush control and for selected future utilization scenarios. The results are shown in a 20 years timeframe, implying that bush control activities are implemented annually on specified areas. In addition to the GHG balances of the bush utilization scenarios, carbon sequestration as a result of new annual encroachment is also considered based on an annual bush encroachment rate until 2035 of 0.43 Mio ha and an assumed growth rate of 0.61 tCO2e/ha/year. Since no additional growth of already encroached bush areas is assumed, this is a conservative assumption for the carbon sequestration capacity of bush biomass in Namibia. The baseline scenario shown in Figurer 1 assumes an annual implementation of bush control on 198,510 ha.

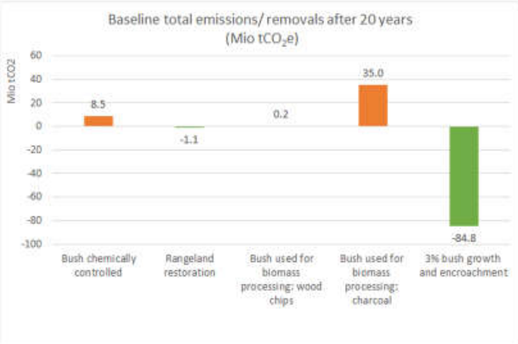


Figure 1: Baseline of emissions and removals after 20 years (in Mio tCO_2)

To compare the baseline emission of bush control, we calculated the average annual emissions of the different baseline activities (i.e. removal of biomass and biomass utilization processes). For this, we used the activity data of the latest NIR 3 report and combined it with the accounting tool developed for this study. In total, the average annual emissions of the different baseline activities amount to 7.4 Mio t CO_2e – significantly above the annualized emissions in the baseline scenario that also considers biomass regrowth and sequestration in soils over this timeframe.

A significant mitigation potential exists if chemical bush control is replaced by rangeland restoration: Implemented on 68,000 ha annually provides a mitigation potential of 9.7 Mio tCO_2e over 20 years. Increased soil organic carbon contributes also to climate change adaptation as the soils will be more resilient and productive. In addition, the establishment of a 20 MW power plant is also considered under this future scenario, which requires annually 6,932 ha for biomass supply.

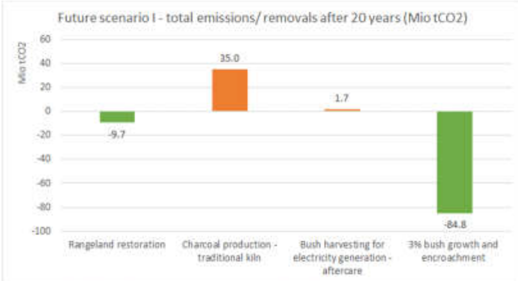


Figure 2: Future scenario I: emissions & removals in a rangeland restoration scenario (20 yrs., in Mio tCO_2)

Finally, an alternative future scenario is presented for upscaled large-scale bush control expecting an increase in charcoal production to 320,000 ha per annum of which 270,000 ha of bush are utilized with the traditional kiln technology while another 50,000 ha is implemented with an advanced stationary retort kiln technology. 130,000 ha annually are successfully restored by consequently implementing aftercare. The biomass is used for different uses, such as bushbloks, bush-to-feed applications and, if realistic, pellet production. In order to show options for future developments the requirements and impacts of 170 MW extra biomass power (based on Stafford et al. 2016) are modelled here, using the assumption to use 58,924 ha annually.

Figure 3: Future scenario II – emissions and removals of bush control activities (after 20 yrs., in Mio tCO_2)

In total, all utilizations and harvest options in the future scenario would require the biomass of around 0.5 Mio ha per year. The largest emission source would still be the traditional charcoal sector followed by electricity generation and charcoal produced with advanced kiln technology.

Factoring in the 3% bush growth and encroachment, the net GHG result of this scenario would almost result in a carbon neutral situation with a sink of annually -0.2 Mio tCO_2e. Electricity generation, even though it represents an emission scenario in total, would also include a substitution (mitigation) effect of -6.6 Mio tCO_2e over 20 years or -0.3 Mio tCO_2e annually.

Conclusion

The GHG balances show potential mitigation options. When directly comparing the bush control scenarios over a default period of 20 years, it can be concluded that the highest emissions are caused in charcoal production when using a traditional Namibian steel drum kiln. If charcoal is produced in industrial retort kilns, emissions drop to levels below the ones of bush farming. Despite the substitution effect of electricity generation from bush biomass, this scenario also results in GHG emissions over 20 years.

One of the most important factors considering bush encroachment and bush control is the effect on soil organic carbon, which is closely linked to soil fertility, due to the ability of SOC and SOM (soil organic matter) to bind water and nutrients. Increased bush biomass creates sufficient organic inputs, but alters soil microbial communities and therefore reduces decomposition ratios, thus SOC and ultimately soil fertility in bush encroached areas (Buyer et al., 2016). Due to the expected reduced rainfall and strong bush growth, SOC and fertility are expected to decrease in the future; soil erosion is expected to increase due to bare areas between bushes, which are prone to wind erosion (Manjoro et al., 2012).

Bush control can have various impacts on soil fertility. Harvesting intensity and aftercare are key management tools. They determine restoration success or failure, due to the amount of bare areas or the successful re-introduction of a grass layer. If no sustainable management is implemented the areas will further degrade, with lower biomass growth (wood) and no establishment of perennial and palatable grasses (Zimmermann et al., 2017). The soil modelling confirms that only under the assumption of aftercare and savanna restoration success SOC is increasing (sequestration), and the highest SOC increase is under a moderate harvesting of 50% bush biomass leading to 0.44 tCO2e sequestered per year and ha.

Water provision is a vital ecosystem service, in particular for very arid conditions as those in Namibia. Bush encroachment impacts all water related ecosystem services due to interception: interception is increasing; climate change and changing rainfall patterns with high interception rates will reduce groundwater recharge as well as overall soil moisture. Less bush reduces interception, and more water can percolate and contribute to groundwater re-charge. As under climate change precipitation is expected to decrease, groundwater may not necessarily benefit – even if rangelands are restored – but impacts will be less negative compared to bush farming or even encroachment. The water use efficiency under a rangeland restoration scenario is increased while under encroachment water gets scarce. Rangeland restoration has also positive impacts on biodiversity.

In general, all bush control scenarios which actively increase soil fertility through soil carbon sequestration should be promoted on a national level. This should be combined with wetland restoration to establish more diverse conditions in favor of grasses. It can be concluded that despite uncertainties rangeland restoration at landscape scale will increase the adaptive capacity of the ecosystem, benefit biodiversity, groundwater, and soil fertility. Bush-to-feed systems should be assessed more in terms of potential emission reductions of the livestock sector.

Given the importance of the topic the authors see a strong need for a national paradigm shift in the bush management sector and propose the following measures as next steps:

- The accounting logic of this study should be combined with the bush information system study to develop a National Bush Management and Information System. This system should allow to combine spatial information on bush encroachment on a national level with activity data on bush control activities and emission factors along their different value chains.
- The mitigation potential of shifting from chemical bush control to rangeland restoration should be further assessed regarding a carbon crediting scheme for the voluntary carbon market. The VCS (Verra) Standard for example allows accounting for emission reductions in agricultural landscapes (bush systems in Namibia are not defined as forests).
- With a view to the high vulnerability of Namibia and the importance of the bush sector, a detailed climate change adaptation study should assess the vulnerability and impacts, in line with the IPCC Climate Risk and Vulnerability Assessment Framework.
- The study findings should be further scrutinized in a thorough economic assessment.

The closing of these knowledge gaps and the monitoring data allow for developing tailored measures at different jurisdictional levels. It enables the sector to be 'ready' to integrate the accounting in the wider national GHG inventory (as well as other national reporting requirements) and the future enhanced transparency framework under the UNFCCC. Beyond mitigation, this system could also be used to monitor other ecosystem services and biodiversity.