Social Life Cycle Assessment of Marine Biofuels in Namibia:

Insights from the Charcoal Value Chain

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With you guys, its never a little talk,
Always sitting on the piano chairs,
We have shared laughs we have shared tears.
You have made this journey a joyful one,
I am finally finished, thanks for all the fun!

Abstract

The use of encroacher bush in Namibia for the production of sustainable maritime biofuel can play a role in reducing greenhouse gas emissions within the maritime sector. However, it is crucial to ensure that biofuel is produced sustainably, to mitigate any potential negative social, economic and environmental impacts. This thesis focuses on identifying the potential social hotspots for a conceptual biofuel value chain (biohub), by conducting a social life cycle assessment (SLCA) on the existing value chain producing charcoal from encroacher bush. By assessing the social impacts associated with the charcoal value chain, potential challenges and opportunities can be identified and support decision-making processes for the conceptual biohub.

The SLCA was performed by combining participatory stakeholder approaches with the Subcategory Assessment Method (SAM) to evaluate and score the social impacts. A literature screening was used for the initial selection of the context-specific stakeholder categories, social impact subcategories and indicators suggested by the SLCA guidelines. The required data was collected during 36 semi-structured interviews with various stakeholders in Namibia. The most important subcategories for the charcoal value chain were identified by having the stakeholders rank them on importance during a workshop.

The results of the current charcoal value chain show that there are significant negative social impacts associated with encroacher bush harvesting, including the issues related to workers' safe and healthy working conditions, fair remuneration and environmental implications. The local community has issues with limited access to encroacher bush value chains and high unemployment rates. The biohub can address these issues and improve social impacts by implementing better monitoring and control of harvesting practices, creating local employment opportunities, improving working conditions and increasing local community involvement.

Keywords: Social life cycle assessment, Social impacts, Encroacher bush, Charcoal, Marine biofuel

Contents

Abbreviations

BR	Basic requirement
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
HDO	Hydrodeoxygenation
HTL	Hydrothermal Liquefaction
MPI	Multidimensional Poverty Index
NAD	Namibian Dollar
PPE	Personal Protective Equipment
PRP	Performance Reference Point
SAM	Subcategory Assessment Method
SLCA	Social Life Cycle Assessment
USD	U.S. Dollar

Chapter 1

Introduction

The maritime industry contributed 2.89% to the global greenhouse gas emissions in 2018 and this percentage is predicted to increase over time, leading to global warming and climate change (International Marine Organization, 2020). The use of fuels produced from renewable energy sources in the marine industry could help reduce these emissions, such as the use of biofuels. Biofuels can be produced from first-generation feedstocks (crops) or second-generation feedstocks (non-edible biomass) (Naik et al., 2010). It is, however, crucial to ensure that the production of biofuel is conducted in a sustainable manner to mitigate any potential negative social, economic and environmental impacts. One of the potential negative impacts is that biofuel production can lead to an increase in demand for new farmland, which can lead to deforestation and displacement of local communities (Fairley, 2022). In addition, biofuel production can threaten food security by competing with land used for food production (Babcock, 2008). Biofuel production can lead to exploitative labour relations, such as low wages, poor working conditions and other negative impacts on the well-being of local communities (Chingono and Mbohwa, 2015). The Clean Shipping Project aims to tackle these challenges and produce sustainable biofuels by designing biohubs, based on environmental, social and sustainable sourcing of non-edible biomass.

The conceptual biohub is a place where biobased streams and wastes are transformed into marketable products in cooperation with the public and private sectors (see figure 1). The biohub should improve the sustainability of agriculture and biomass uses whilst fulfilling local needs and fairly distributing benefits, risks and opportunities (Oosterlaken, 2021). The biohub uses hydrothermal liquefaction technology (HTL) to convert biomass into biochar and bio-oil, which is then upgraded to biofuel (Clean Shipping Project, n.d.).

The biohub should be designed in a way that is sustainable. Sustainable development is considered to have three pillars; environment, economy and society (Reitinger et al., 2011). In order to evaluate if biofuel is sustainable all three pillars should be taken into consideration during the design of the biohub value chain. This thesis aims to investigate any potential positive and negative social impacts of setting up a biohub value chain by conducting a comprehensive social impact assessment using the Social Life Cycle Assessment (SLCA) methodology and developing strategies to mitigate any negative social consequences.

In this case, the promising biomass investigated is the encroacher bush in Namibia that is replacing the rangeland ecosystems. The encroacher bushes grow at the expense of endemic grasses and plants and reduce the grazing potential, the roaming space of wild animals and livestock and the crop cultivation capacity. Furthermore, the encroacher bushes consume an excessive amount of water compared to the original rangeland ecosystems which depletes the groundwater levels. The removal or thinning of the encroacher bush has positive effects on rangeland restoration and the ability to open up landscapes for wildlife movement (UNIDO, 2019). Thus the encroacher bush is seen as a promising biomass source with potential environmental, social and economic benefits. Therefore, by utilising encroacher bush as a biomass source, it is possible to assess the social impacts using SLCA and design a sustainable supply chain for biomass feedstocks based on the concept of a biohub.

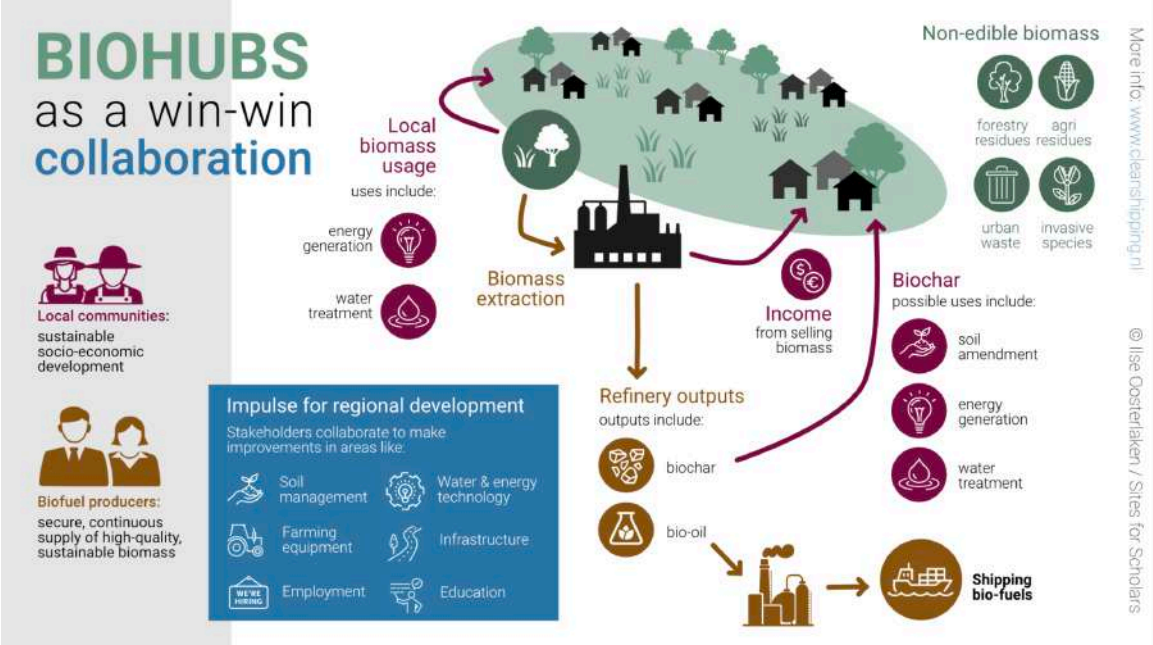


Figure 1: The biohub concept (Oosterlaken, 2021)

Social Life Cycle Assessment

The SLCA methodology consists of four different phases; (i) definition of goal and scope, (ii) life cycle inventory, (iii) life cycle impact assessment and (iv) interpretation (see figure 2). In an SLCA, various stakeholder categories are identified and represent the different people who are directly or indirectly affected by the activities of the value chain. Within each stakeholder category, social impact subcategories are used to capture the specific social issues and concerns that may arise. Each subcategory focuses on a specific aspect of social impact and provides a structured framework for assessment. Within each impact subcategory, a set of indicators is selected to measure and quantify social performance. These indicators act as metrics or parameters that reflect the specific social dimensions under evaluation. The choice of indicators can vary depending on the nature of the impact subcategory and may include both qualitative and quantitative measures. This SLCA approach helps identify and address social risks, challenges, and opportunities throughout the life cycle of a value chain (UNEP, 2020).

Conducting an SLCA, however, does come with a few challenges. Firstly, there is a lack of standardised methodology, making it difficult to compare and ensure consistent and transparent studies. SLCA research frequently differs greatly and faces criticism due to inconsistencies and contradictions in methodological components (Kühnen and Hahn, 2017). Assessments of environmental impacts of a value chain have been standardized into the environmental life cycle assessment with ISO standards (UNEP/SETAC, 2009). However, there is no standardised way yet to perform an SLCA and it is the youngest and least mature method. Guidelines have been written on how to perform a social life cycle assessment in a systematic way but further methodological development is required (Ekener-Petersen, Höglund, and Finnveden, 2014; UNEP, 2020). This thesis also aims to contribute to the standardisation of the SLCA framework.

Secondly, obtaining data on social impacts can be challenging and the quality of available data may vary (Pollok et al., 2021). This challenge is particularly significant in the context of the biohub, as it represents a technology and value chain that is currently non-existent in Namibia. The absence

of an operational biohub makes the collection of reliable data on its social impacts nearly impossible. Given these data challenges, the focus of the assessment is shifted towards the existing value chain of charcoal production from encroacher bush. Both the biohub and charcoal value chains use the same biomass, namely encroacher bush, but different technologies to generate a form of energy. The social challenges related to upstream processing in both value chains, especially harvesting practices are expected to be similar. By analysing the established value chain of charcoal production, which has operational history and available data, it is possible to obtain more comprehensive and reliable social impact data. This ensures a more robust assessment that can be used for informed decision-making processes related to the establishment of the biohub.

Lastly, social impacts are inherently complex and quantifying them poses a challenge (Cadena et al., 2019, Popovic et al., 2018). By focusing on the existing charcoal value chain, which has tangible social interactions and impacts, it becomes more feasible to quantify and assess these impacts.
In this thesis, the social aspects of the charcoal value chain and their possible positive and negative impacts will be assessed to support decision-making for the biohub. The goal of this thesis is to perform and provide a social life cycle assessment framework and quantify the social impacts of the value chain. There are a lot of possible ways to perform these assessments therefore this thesis is aimed at answering various research questions and sub-questions:

- How to perform an integral social life cycle assessment to map the social impacts of an encroacher bush-based value chain in Namibia?
  - Who are the potential stakeholders?
  - What are their context-specific social impact (sub)categories and indicators?
  - How should the reference scales be developed for each indicator and how should these indicators be quantified?
  - Where are the potential positive social impacts and social hotspots throughout the life cycle and what are the risks and opportunities associated with them?
  - How can the social impact of the future biohub improve compared to existing value chains?
  - How can a methodology be developed for social life cycle assessments for future biohubs?

Answering these research questions forms the guiding storyline of this thesis. Initially, the goal and scope for both the biohub and charcoal value chain are established. Subsequently, (site-specific) data is collected and an impact assessment is conducted specifically for the charcoal value chain. The outcomes of this assessment provide insights into the potential social hotspots and positive impacts associated with the charcoal value chain. Within the context of the biohub, the risks and opportunities associated with these findings are examined and strategies for improvement are identified. Based on the lessons learned from analysing the charcoal value chain, the thesis concludes by proposing a framework for future biohub SLCA studies.

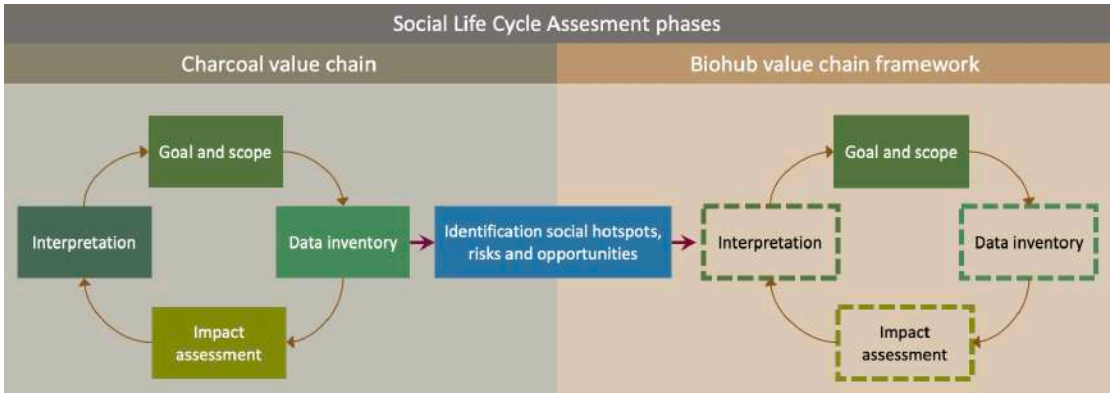


Figure 2: The four iterative phases of an SLCA. For the Charcoal value chain, a full SLCA is conducted and for the biohub the goal and scope and a framework (dashed lines) for the other phases is provided in this thesis.

1.1 Namibian context

Encroacher bush

Bush encroachment is a major problem in Namibia, affecting more than 45 million hectares of land, which is roughly a third of the country (see figure 4a). The annual bush regrowth is 3.4% per year equating to an estimated 412 million tonnes of harvestable biomass that is available (Flesch et al., 2021). The bush encroachment problem is caused by a combination of multiple natural and human factors. The primary determinants of bush encroachment include rainfall, soil and nutrients as prolonged degradation of soils followed by above-average rainfall can cause a mass of tree growth. Other secondary determinants are suppression of veld fires, which were used to maintain a balance between grasses and woody vegetation. However, modern fire suppression policies have reduced controlled burning, leading to the proliferation of woody vegetation. The replacement of game (browsers) with domestic livestock (grazers) plays a significant role, as the livestock overgrazes on grasses, putting pressure on the grass layer and allowing woody plants to dominate the landscape (see figure 3b). Poor land management practices, such as soil degradation and erosion, create favourable conditions for bush encroachment (De Klerk, 2004). Bush thickening can have positive effects on the ecosystem, however, extreme bush thickening is often linked to negative environmental impacts such as loss of open savannas (MEFT, 2022).

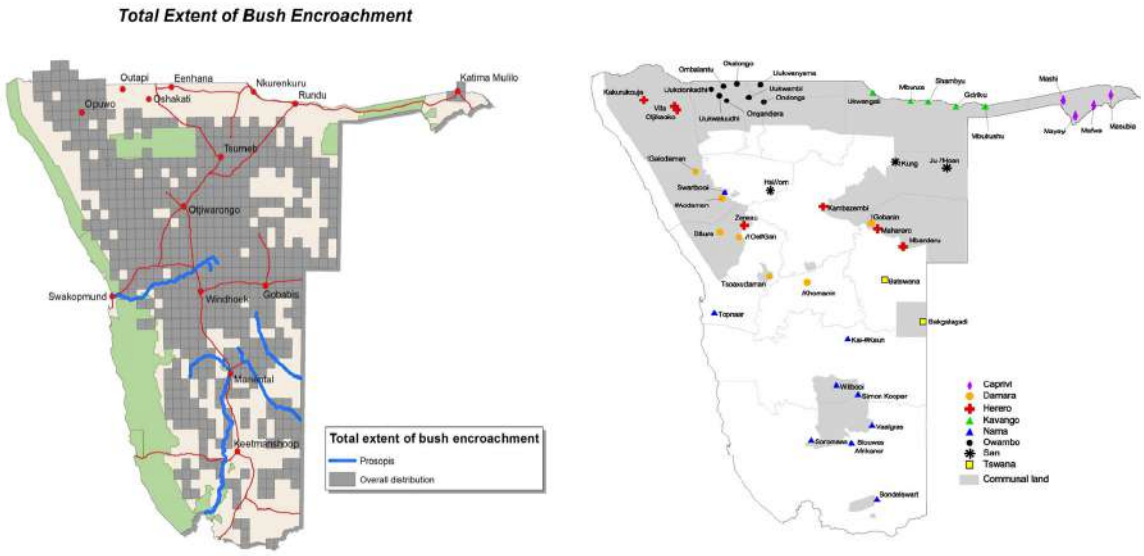
(a) Bush encroachment on a farm near Otjiwarango

(b) Giraffes browsing encroacher bush

Figure 3: Examples of encroacher bush.

The excessive expansion of bush at the expense of other plant species, especially grasses, reduces the productivity of the land and negatively impacts biodiversity, water availability, and soil quality. The loss of open savanna habitat also affects the habitat for animals and plants of the savanna ecosystem (Nghikembua et al., 2023). Bush encroachment also affects tourism as it can undermine wildlife viewing, hunting and the landscapes become less aesthetic. Bush encroachment has also been found to cause significant loss of farm profits due to the reduced carrying capacity of livestock. The stocking rate of large livestock has declined from one livestock per 10 hectares to 1 per 20 or 30 hectares (De Klerk, 2004). The reduced carrying capacity and reduced groundwater levels can lead to food insecurity and poverty due to reduced agricultural output (Lesoli et al., 2013). However, bush encroachment can also be an opportunity for Namibia's economic development, as the biomass produced by bush thinning can be processed in many ways, such as bush feed or charcoal production and is already a source of income for farmers (MITSMED, 2017). Therefore, it is important to remove the encroacher bush to restore the savanna and its biodiversity, improve water conservation efforts, and restore grazing lands (SAIEA, 2016).

The harvesting, or bush control/bush thinning, of encroacher bushes, can generate economic and environmental benefits. However, it is important that bush control happens in a sustainable manner to reduce the number of negative effects. Certain trees are protected and harvesting should be performed in a mosaic pattern, leaving thickets of bushes to maintain biodiversity. The harvesting of encroacher bush in Namibia is regulated by various environmental laws and regulations that must



(a) Bush encroachment in Otjozondjupa (SAIEA, 2016) **(b)** Map of communal lands (Mendelsohn, 2008a)

Figure 4: Maps of Namibia showing the areas bush encroached and the communal lands.

be complied with (see figure 5). These stipulate that a harvesting permit needs to be acquired before starting harvesting, depending on the size of the area an additional Environmental Management Plan or Environmental Impact Assessment needs to be performed before applying for a permit that is valid for 3 months. These are issued after inspection by forestry officers to verify the amount of biomass present on the farm. Also, permits for selling (valid for 3 months), transporting and exporting (valid for 7 days) need to be acquired at the Directorate of Forestry (MAWF, 2017).

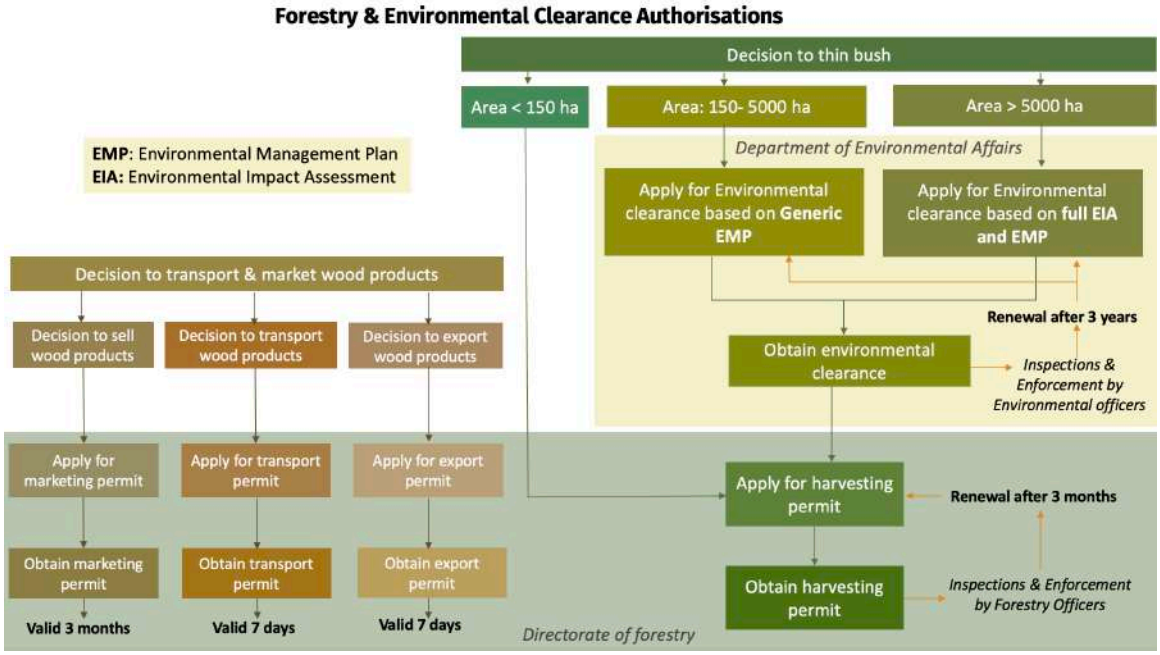


Figure 5: Rules and regulations for harvesting encroacher bush based on MAWF (2017).

Social context of Namibia

In Namibia, different land tenure systems exist, including commercial land, communal land and resettled land as a result of land reform policies implemented after gaining independence. All the farmers face similar environmental challenges such as land degradation, climate change and drought.

Commercial land is privately owned and is used for commercial farming with an average farm size of 5000 hectares. These farms are typically owned by European descendants. Commercial farmers have no barrier to starting bush control and charcoal production on their land, besides requiring the necessary resources for harvesting and obtaining permits (MEFT, 2022).

Communal land, covering a significant portion of Namibia's land (38%) and accommodating half of its population, is owned by the state and managed by traditional authorities following customary laws. It is mainly utilised for subsistence farming and grazing. The land is a common pool resource and the traditional authorities have the power to allocate resources such as land and water and to regulate grazing access (Sato, 2021). There are many different tribes in Namibia each with its own unique characteristics, agricultural practices, beliefs and customs spread out over the communal lands (see figure 4b).

The farmers on communal lands face various additional challenges, such as limited land rights, restricted access to credit and markets, inadequate infrastructure and lack of resources. As well as issues from environmental degradation from overgrazing and deforestation (Mendelsohn, Shixwameni, and Nakamhela, 2012). The communal lands are often exploited due to the absence of individual responsibility and no consideration for long-term consequences or sustainability (De Klerk, 2004). That is why to secure the rights to a harvesting permit, communities have to register as a community forest or cooperative with a Forest Management Plant that outlines sustainable land management (MEFT, 2022, MAWF, 2017).

Resettled land is land from commercial land that has been acquired by the government and is used for the resettlement of previously disadvantaged communities. The farms are divided into smaller plots and allocated on a leasehold agreement (De Villiers et al., 2019). These farmers face similar challenges to communal farmers, however, they do have different land rights and are able to obtain credit and can obtain harvesting permits without barriers.

The overall problem of bush encroachment affects all three land tenure systems, increasing the challenges already faced by farmers in terms of land productivity. Implementing a sustainable biohub whilst addressing the bush encroachment problem can have numerous social, economic and environmental benefits for the different farmers in Namibia.

Chapter 2

Methodology

This chapter provides a comprehensive explanation of the methodologies employed in conducting an SLCA within this thesis. The primary reference for conducting the SLCA in this thesis is the "Guidelines for social life cycle assessment of Products and Organisations 2020" hereinafter referred to as the guidelines developed by the United Nations Environment Programme (UNEP, 2020). These are supplemented by "Methodological Sheets for Subcategories in SLCA" further referred to as the methodological sheets (UNEP, 2021). The guidelines and sheets have been updated and revised from their original version (UNEP/SETAC, 2009, UNEP/SETAC, 2013). In cases where the methodologies used in this thesis deviate from the guidelines, they will be explicitly described. The chapter starts by outlining the objectives and scope of the thesis, including the various subcategories and indicators included in this thesis. Additionally, it elaborates on the data collection processes for this assessment and the impact assessment methodology adopted to establish the reference scales for assessing the subcategories and indicators.

2.1 Goal and Scope

The goal of this thesis is to perform an integral social life cycle assessment to map the social impacts of an encroacher bush-based value chain in Namibia. The absence of tangible data and stakeholder engagement poses challenges in for a conceptual biohub value chain. To overcome these challenges, this SLCA focuses on the well-established charcoal value chain, which also utilises encroacher bush as a feedstock. The charcoal value chain has existing stakeholders who can provide valuable insights and experiences regarding social challenges. By conducting an SLCA of the charcoal value chain, potential social risks and opportunities related to the utilisation of encroacher bush can be identified and addressed. The findings from this assessment can serve as decision-making criteria for the future biohub. Moreover, the thesis establishes the goal and scope of the biohub in the Namibian context, providing a framework for conducting an SLCA once the biohub becomes a reality.

The definition of the goal and scope is where the study's intended purpose, application and methodological framework are outlined with the objective to define its breadth and depth. The scope encompasses the functional unit (quantitative object of study), the product system (all required activities), system boundaries (limits), the type of impact assessment method and the selection of stakeholder impact subcategories and indicators. In addition, the data inventory strategies on how data was collected for this thesis are included. The goal and scope is a crucial part of an SLCA, as it has a significant role in shaping the study and impact on the final results. This phase, as well as the overall SLCA process, was conducted in an iterative manner and revisions were made when new information or limitations were uncovered during the timeline of this thesis (UNEP, 2020).

(a) Senegalia Mellifera (Blackthorn)

(b) Flower of Dichrostachys cinerea (Sickle bush)

Figure 6: Examples of encroacher bushes present in the Otjozondjupa area

2.1.1 Objective of study

Functional unit

The functional unit, which defines the object of the study, in quantiable terms, is a tonne of charcoal produced from encroacher bush. The term encroacher bush is used for invasive and/or thickening aggressive undesired woody species, see figure 6 (De Klerk, 2004). The main species belong to the genus Acacia, which has been reclassied to Senegalia and Vachellia for the African line (see figure 6). All of these trees are indigenous to Namibia and some are protected (MAWF, 2017). One of the main species encroaching in the Otjozondjupa area (see figure 9) is the Senegalia Mellifera, also known as Blackthorn. The protected species and trees wider than 18 cm are not allowed to be harvested. For harvesting to be performed in a sustainable manner it needs to be done selectively and in a mosaic pattern leaving trees. The annual production of charcoal is over 200,000 tonnes of which 99% is exported. To produce one tonne of charcoal three to ve tonnes of solid wood is needed, preferably 10 to 18cm in diameter (MEFT, 2022). Based on the type of wood and type of kilns used, the charcoal yield varies from 20 to 30% wt %. Charcoal has a higher caloric value than wood, giving it a higher energy density for the same weight as wood (Temmerman, 2016).

The farmer receives about roughly 2000 NAD (100USD) per tonne of charcoal produced from the charcoal processors. Out of this amount, around 800/900 NAD is allocated to labour wages, while the remaining portion is utilised to cover various operational costs. The charcoal assessed in this study is Forest Stewardship Council (FSC) certified which means that it is sourced and produced using FSC standards. FSC has environmental and social requirements that the charcoal producers must comply with (FSC, 2019). Around 1.6 million hectares or about 65 per cent of the charcoal exported is FSC-certified, and the number of certificates is rising (Markstein, 2020)

Functional unit biohub

The functional unit, in the biohub case, is one tonne of biofuel produced from encroacher bush which can be used in the maritime industry. The biofuel will therefore have to comply with the maritime industry standards and be tested to check if ships can run on it. The fuel quality should comply with the 18.3 regulations from the MARPOL Annex VI issued by the International Marine Organisation (MEPC, 2021). The biofuel should be a 'drop-in' fuel that is functionally compatible with fossil fuels and has the same functional characteristics such as viscosity, acidity etc. So no additional investment is needed in the modification of ship engines or infrastructure as the existing infrastructure can be used (Hsieh and Felby, 2017). The characteristics of the by-product biochar depend on the HTL conditions and feedstock but the biochar is generally rich in carbon and has a high surface area. Biochar can be used directly without further processing as a fertiliser for soil improvement, as it can

improve water retention, enhance soil structure and increase nutrient availability improving the soil properties (Gollakota, Kishore, and Gu, 2018, Ndoung, Figueiredo, and Ramos, 2021).

2.1.2 Product system

Charcoal value chain

The product system entails all activities in the life cycle of the product. An example of activities in the charcoal production value chain is given in figure 7. The first activity is the harvesting of the bush which can be performed using different methods such as manual, mechanical, and semi-mechanised. The choice of method depends on the farmer's objectives, the landscape and the investment requirements (Rothauge, 2017). Often the farmers divide the farms into 'camps' which is the designated area for harvesting. In order to combat re-infestation of the encroacher bushes aftercare treatments need to be applied post-harvesting, if neglected it could lead to even more aggressive encroachment (De Klerk, 2004). Aftercare options include hand application of arboricides, controlled burning, (mechanical) removal of bush or the introduction of goats for browsing regenerating bush (SAIEA, 2016). After harvesting, the encroacher bush needs to be sorted to remove any unwanted materials such as leaves and twigs. These twigs and leaves are then left on the field as a source of organic matter. The wood is chopped into roughly 20 cm lengths and then sorted by size. The wood is then left to dry for a few weeks to reduce moisture content before it is carbonised. Carbonisation is the process of heating the encroacher bush in a low-oxygen environment to convert it into charcoal. There are different carbonisation techniques that can be used such as metal kilns or retort kilns, which can be either traditional or modern. The retort kilns have an advantage of a larger continuous process and higher yields but require a very high investment and were therefore not a success for farmers in Namibia. The metal kilns require lower investments, have short carbonisation cycles and are more mobile and are more often used (MITSMED, 2017). Therefore the assessment of this study will be based on the use of metal kilns. However, metal kilns do have the disadvantage of high smoke generation and limited lifetime (Temmerman, 2016). It is compulsory for the burning in kilns to happen in central clusters with firebreaks. Once the charcoal is produced, it needs to be cooled down completely for 2 weeks before being packed in bags and delivered to processors for screening, grading and additional packaging. For sorting, the processors use a sand sieve to separate the charcoal from sand and ash and afterwards with a 20/25 mm sieve to remove the fine charcoal which can be used for briquettes. The charcoal is then packaged and transported to Walvis Bay where it is shipped to the final destination (CAON, 2022b).

Figure 7: Production of charcoal using kilns from encroacher bushes.

Biohub product system

The product system of the biohub has a few similar activities to the charcoal value chain at the start of the activities (see figure 8). Firstly is the harvesting of encroacher bush which can be done manually, semi-mechanised or mechanised after which after-care should be provided. After harvesting items such as rocks and sand need to be removed before going to the wood chipper. The wood chipper can use the whole tree, including twigs and leaves to produce wood chips. This

can be performed by a mechanised wood chipper (UNIDO, 2019). The biomass then needs to be transported to the bio-refinery in Otjiwarango for further processing.

The hydro-thermal liquefaction (HTL) technology will be used to convert biomass into biocrude. HTL can use wet biomass which means it does not need to be dried. HTL happens in the presence of water in hydrothermal conditions, with a rough range of temperatures from 250-450 and pressures between 100 and 300 bar (Grande et al., 2021). Generally, the process is first that the biomass is broken up by hydrolysis and then degraded into smaller molecules by dehydration and decarboxylation to yield water-soluble intermediates. Then repolymerization reactions form the water-insoluble products bio-crude and biochar. During the reaction other products are generated, such as a mixture of gases (CO_2, H_2, CH_4 and CO) as well as an aqueous phase with soluble organics such as alcohols, acids and phenols (Castello, Pedersen, and Rosendahl, 2018). Following the separation process, the crude bio-oil undergoes additional upgrading through hydrodeoxygenation (HDO) to transform it into a drop-in biofuel. HDO removes oxygen by a catalytic reaction with hydrogen in the form of water, producing bio-oil. The HDO reaction is performed at high-pressure and moderate temperatures requiring the right catalyst and a supply of hydrogen (Bakhtyari, Makarem, and Rahimpour, 2017; Ramirez, Brown, and Rainey, 2015). The upgrading to bio-fuel can be performed at the same site as the HTL, or at a different refinery in Walvis Bay. Currently, the use of HTL technology using encroacher bush has only been performed at a lab scale, so further technology development is required before it can be used on an industrial scale.

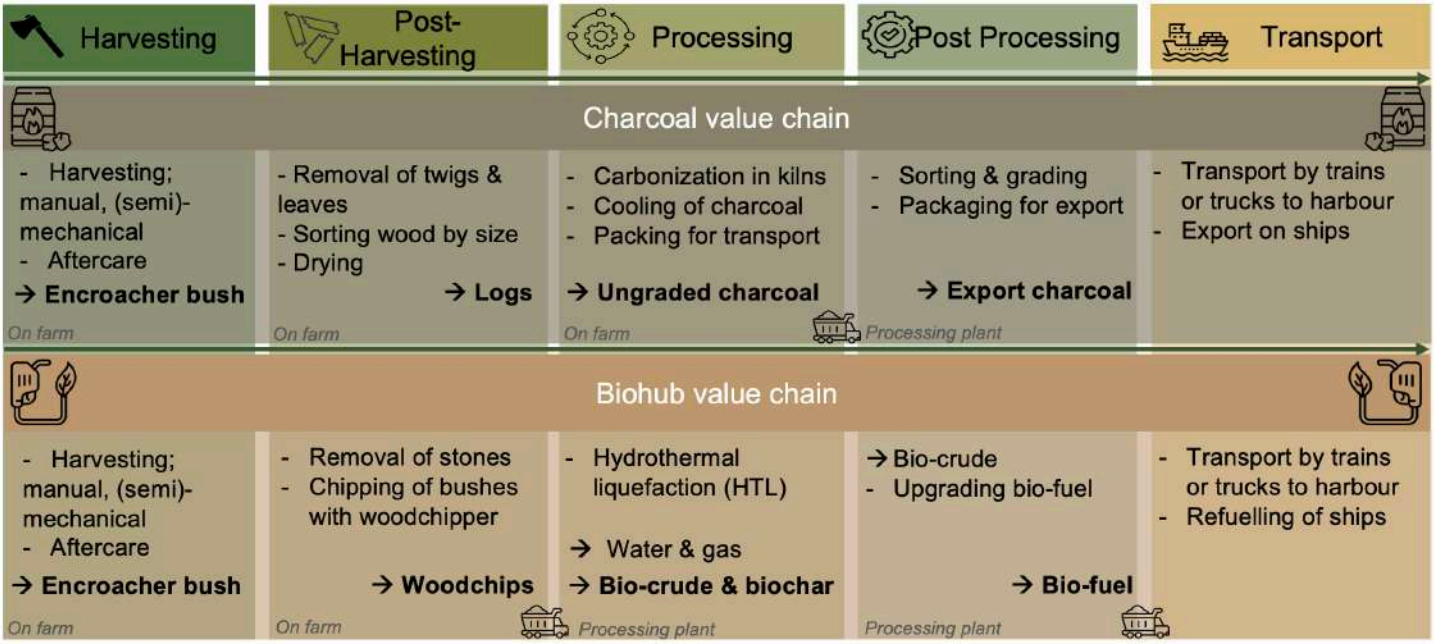


Figure 8: Simplified product system, with the processes required to produce charcoal and bio-fuel from encroacher bush.

2.1.3 System boundaries

The system boundaries define the limits of the product system being assessed and determine the scope of the assessment and the potential social impacts that are considered within the assessment. The system boundary is set at performing a social life cycle assessment of the value chain based on the production of charcoal from encroacher bush in Namibia and setting up an SLCA framework for the biohub. The whole value chain is taken into consideration, however, more focus is put on the upstream processes as those are more similar for both the biohub and charcoal value chains in terms of activities and social issues. Only the technological processes described in the product system are

taken into account in the value chain. Process optimization for the production of charcoal or biofuels is outside the scope of this study. The production and procurement of supporting materials, such as machines and transport vehicles, are also excluded. As well as performing an environmental impact assessment or economic analysis of these value chains, due to time restrictions. The majority of charcoal producers in Namibia are FSC certified and therefore the stakeholders assessed in this study are FSC certified, meaning they have to meet FSC's social and environmental requirements (MEFT, 2022). The direct and indirect stakeholders of the value chain were taken into account, although with an emphasis on those directly involved in the production of charcoal. In order to acquire site-specific data, numerous stakeholders such as charcoal producers and processors were interviewed in January and February 2023.

The province of Otjozondjupa and Windhoek serves as the value chain's physical borders. This is due to Otjozondjupa's significant bush encroachment issue, which affects an estimated 10.5 million hectares of land and has a high bush density of up to 6000 bushes per hectare (Hengari, 2018). The district capital Otjiwarongo is also considered the 'bush capital' of Namibia with stakeholders having experience with bush control, charcoal production and other forms of value addition. The 36 interviews conducted in this study are located within these system boundaries and provided site-specific data for this study, see figure 9. The local communities that will be considered are the ones present in the Otjozondjupa area. For the export of charcoal and in the future biofuel, the products need to be transported from this area to Walvis Bay harbour. The future biohub will be located somewhere within these boundaries, however, the determination of the precise location is out of the scope of this study. Making decisions in this regard might be aided by the assessment used in this study.

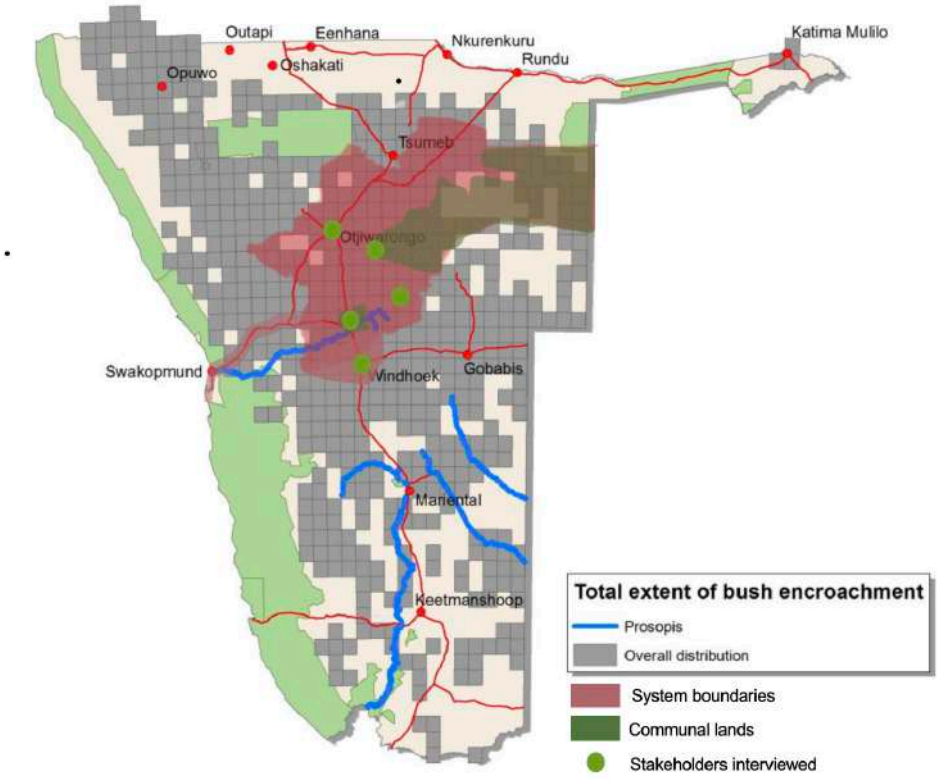


Figure 9: The system boundaries of the value chain and involved stakeholders. The red colour defines system boundaries in the Otjozondjupa area and the green indicates the communal lands within Otjozondjupa. The green dots represent the locations where the interviews took place. Source adapted from SAIEA (2016).

2.1.4 Stakeholders

The stakeholder categories are the type of groups that can be influenced by the activities of organisations involved in the life cycle of a product. The stakeholders involved in the charcoal value chain can be defined in different types; farmers (unions), workers, conservancies, government, private sector, researchers and civil society organisations. The 48 stakeholders interviewed during 36 interviews conducted in Namibia fall under these categories, see table 1. The location where the interviews took place is shown in figure 9. The stakeholders are given a code and number to indicate which group they belong to in order to maintain their anonymity, this code is further used in this thesis to refer to these stakeholders. The stakeholders are divided into four stakeholder group categories; workers, value chain actors, society and the local community according to the guidelines.

The guidelines suggested additional stakeholder categories such as consumers and children but these are not taken into consideration as auxiliary stakeholder categories in this thesis. The stakeholder group consumer and its impact subcategories are merged with the value chain actor group as an end buyer. This is due to the focus on the upstream processes of charcoal production and the social impacts associated with those. The stakeholder group children will not be assessed as they are not part of the decision-making processes and children should have no participation in these value chains. Also, as this is a new stakeholder category suggested by the revised guidelines there is limited data from other SLCA studies or on the indicators for the subcategories (Bouillass, Blanc, and Perez-Lopez, 2021). Furthermore, Namibia has laws and regulations to protect children's rights, such as International Labour Organisation Convention no 138 and 182 for minimum age and worst forms of child labour abuse (ILAB, 2021). However, children can be indirectly impacted by the value chains so the evaluation of these stakeholder groups could also be taken into account in future SLCAs of the biohub. Initially, it was decided to not use the six stakeholder categories but to aggregate the stakeholders into direct and indirect stakeholders of the value chain. However, after conducting the field visit, it was deemed more practical to revert back to the stakeholder group categories for the assessment. The subsequent section provides a characterisation of the stakeholder group categories and describes the inclusion or exclusion of the different stakeholder types per category.

Table 1: Types of stakeholders interviewed during the field visit, categorized into stakeholder groups. In some interviews, there were multiple participants present.

Stakeholder group	Type of stakeholder	Code	No. Interviews	No. Females	No. Males
Workers	Workers	Bush Worker (BW)	6	5	3
		Farm Worker (FW)	2	1	1
Value chain actors	Farmers	Commercial farmers (F)	5	2	4
	Farmers unions	Farmers union (FU)	3	1	2
	Biomass processors	Charcoal producer (CP)	1		1
		Charcoal Processor (CPc)	1		1
		Biomass power station (P)	1		1
	Transport company	Transport (T)	1		1
	Conservancies	Conservancy (C)	1		3
Local community	Communal farmers/leaders	Communal farmers (CF)	4		5
Society	Government	Goverment (G)	4	1	3
		Developmental agency (GIZ)	1	2	
	Researchers	University (U)	2	3	2
	Civil society	Nature conservation (N)	1	1	
		Certification body (Cert)	1	1	
	Investors	Fund management (FM)	1		1
		Bank (B)	1	1	1
		Total	36	18	30

Workers

The stakeholder group "workers" is defined as the people who are involved in the production of charcoal including the employees and temporary workers. In this study, the workers along the value chain, such as the farm workers, bush harvesters, producers, processors and transporters are aggregated together and are assessed as one workers group. There is, however, some differentiation in working conditions, wages, contracts etc. between these groups. In most cases, the workers produce their own charcoal, from harvesting the bush and producing charcoal to packing and loading, hereafter called charcoal workers in this thesis. Then the charcoal is transported and sorted and graded by other workers. The charcoal workers live on the farms in housing provided by the farm owners.

The bulk of the employment of the value chain is in charcoal production compared to charcoal processing (Dieckmann and Muduva, 2010). Specifically, approximately 75% of the workforce is involved in charcoal production, while only 12% of the workforce is engaged in charcoal processing activities (Markstein, 2020). As charcoal production entails different activities it is difficult to separate them into different working groups to analyse and this is one of the reasons they are aggregated. Another reason is the challenge of data collection, as most workers do not have sufficient levels of education and are unable to understand or speak English fluently. Also, during interviews with workers reluctance to express their perceptions and opinions on their working conditions was noticed. The possibility of negative consequences, such as reprisal or dismissal from their employer, may have contributed to a reluctance to engage in open communication. Which could have affected the accuracy and completeness of the data collected. To address this issue, other stakeholders such as representatives of unions and cooperatives were also engaged to gain additional insights into the challenges faced by these workers. Moreover, sources from previous research and reports were used to supplement the data collected during the interviews. By combining multiple sources of data, a more comprehensive understanding of the issues and challenges facing workers was gained.

Local community

The stakeholder group "local community" includes the people who live and work in the area surrounding the production or use of the product and who may be directly impacted by its social and environmental impacts. In this case, the local community is defined as the people living on the communal lands within the system boundary, see figure 9. The communal lands are a common pool resource and are governed by traditional authorities, councils and community-based organisations, which are responsible for allocating the lands and natural resources such as wildlife and wood. Typically the farmers on the communal lands are small-scale farmers (Mendelsohn, Shixwameni, and Nakamhela, 2012). The Herero community occupies the majority of the communal land in Otjozondjupa (see figure 4). They are traditionally pastoralists and make a living from livestock. However, in the Eastern part of Otjozondjupa, there is a high population of San living in what is called the Bushmanland area (Dieckmann, Thiem, and Hays, 2014). The San are still hunter-gatherers and are considered to be one of the most marginalised tribes in Namibia due to the greatest losses of land.

The main challenges of bush control and utilisation of bush in communal lands are issues around uncontrolled and unsustainable harvesting, inclusivity and equitable benefit sharing. That is why the Namibian government placed a moratorium on the commercial harvesting of biomass in communal areas and is charcoal production prohibited as no permits are given (Hindjou, 2021). During the field visit we visited two different communal areas in Otjozondjupa where we performed interviews and spoke to their traditional leaders and councillors, see figure 9.

Value chain actors

The stakeholder group value chain actors refer to the individuals or organisations involved in the creation, production, distribution and consumption of the product. In the charcoal value chain

actors involved are landowners, for the supply of bush and the production of charcoal, processors and distributors, transporters and end-users. Most of the landowners/charcoal producers are commercial farmers with an average size of 5000 hectares (MEFT, 2022). On their farms, they mostly raise livestock and/or game for hunting and tourism. They are often negatively affected by the encroacher bush since it reduces the carrying capacity for livestock on their farms. That is why they produce charcoal, as additional income and in order to increase their carrying capacity. Commercial farmers are included as value chain actors as they do not produce charcoal themselves but employ others to do it for them and are hereafter called charcoal producers.

Society

The society stakeholder group encompasses individuals or organisations that are directly or indirectly impacted by the actions of the value chain. This includes a wide range of stakeholders such as the government, researchers, investors and civil society. The government has an influence on the regulations on operations and policies of the value chain, such as harvesting permits. The researchers study the social and environmental impacts of the value chain and encroacher bush. The investors have a financial stake in the value chain. Environmental and societal issues are being improved through civil society organisations.

Figure 10: Visits to a charcoal processor and a community conservancy.

Stakeholders biohub

In the case of a conceptual biohub in Namibia, certain stakeholders involved in the charcoal value chain may remain the same, while others would not be involved anymore. Specifically, the involvement of charcoal producers or processors would no longer be necessary, while landowners could still play a role as biomass suppliers. Several additional stakeholders would need to be involved in the use of the HTL technology and upgrading of biocrude. For the workers' stakeholder group, the tasks of workers would be altered, shifting from charcoal production and processing to activities such as harvesting and chipping and working in the biorefinery. Within the workers' stakeholder group, their roles and responsibilities would change in the context of a conceptual biohub. Specifically, their tasks would shift from charcoal production and processing to activities such as harvesting and chipping of wood, as well as working within the biorefinery. On the other hand, the stakeholders involved in the categories of the local community and society would likely remain relatively unchanged. Thus, when an SLCA is conducted for the biohub a new identification of the stakeholders involved should be performed. Although, it could be possible to keep a similar stakeholder group categorisation.

2.2 Impact assessment methods

The following section outlines the process of selecting an appropriate impact assessment approach for this thesis. The impact assessment approach determines the potential social impacts and indicators that are considered and the method used for assessment.

Type of impact assessment

The guidelines provide two types of impact assessments: type I, known as the reference scale assessment, and type II, referred to as the impact pathway method. The impact pathway links midpoint and end-point indicators and describes the cause-effect relationship between these points (i.e. the impact pathway). It aims to measure the long-term potential social impacts resulting from the product system, thus adopting a more empirical approach. However, implementing type II assessments can be challenging due to the limited development of causal models within the social sciences (Jørgensen et al., 2008, Tokede and Traverso, 2020).

Type I is a methodology that employs performance reference points to assess inventory data, without establishing a causal relationship. Generally, it uses a multi-level scoring system within the reference scales with benchmarks for assessing the subcategories. These benchmarks, or performance reference points (PRPs) are based on international laws and conventions and serve as a threshold to evaluate the collected data (Haryati et al., 2022). Type I models may avoid the uncertainties of impact pathways, but face the problem of ensuring whether the indicators are relevant for the stakeholders and can lose contextual relevance (Bonilla-Alicea and Fu, 2022). The majority of previous SLCA studies prefer type I more than type II because the scoring system can be created based on the PRPs (Tsalidis and Korevaar, 2019, Wu, Yang, and Chen, 2014). That is also the reason why the type I reference scale assessment is chosen as the method for the impact assessment as it assesses social performance or risks.

Reference scales

For the type I impact assessment reference scales need to be established and it determines the type of data collection that is required. Reference scales can measure positive and negative social performances or the low or high levels of social risks. Social performance is often measured with site-specific data whereas social risk is measured from generic or country-level data. As a result, the term "risk" is frequently used to refer to data that is of lower resolution, making it impossible to assess social performance but instead just pointing out the risk of experiencing negative social impacts. In this thesis, some indicators were assessed as a social risk and others as a social performance depending on data availability (see table 5). Having a social risk assessment allows for contextualisation of the social performance and points out where it is most likely for a social issue to occur (UNEP, 2020). It is necessary to develop two different types of reference scales in order to evaluate a social risk or performance.

The reference scales developed to assess the social risks are divided into four levels from low risk to high risk. The quantitative data from indices or global performance indicators of countries are used to categorise each level. In appendix B the development of the risk assessment scales is given. The development of reference scales to assess social performance follows a different approach and is explained next.

Subcategory Assessment Method

There is no standardised way yet to develop and classify reference scales with PRPs and assess social performance (Carmo, Margni, and Baptiste, 2017). As a result, establishing the reference scales becomes difficult, and SLCAs are less comparable to one another (Traverzo et al., 2022). Ramirez et al. (2014) defined a framework to establish reference scales, called the Subcategory

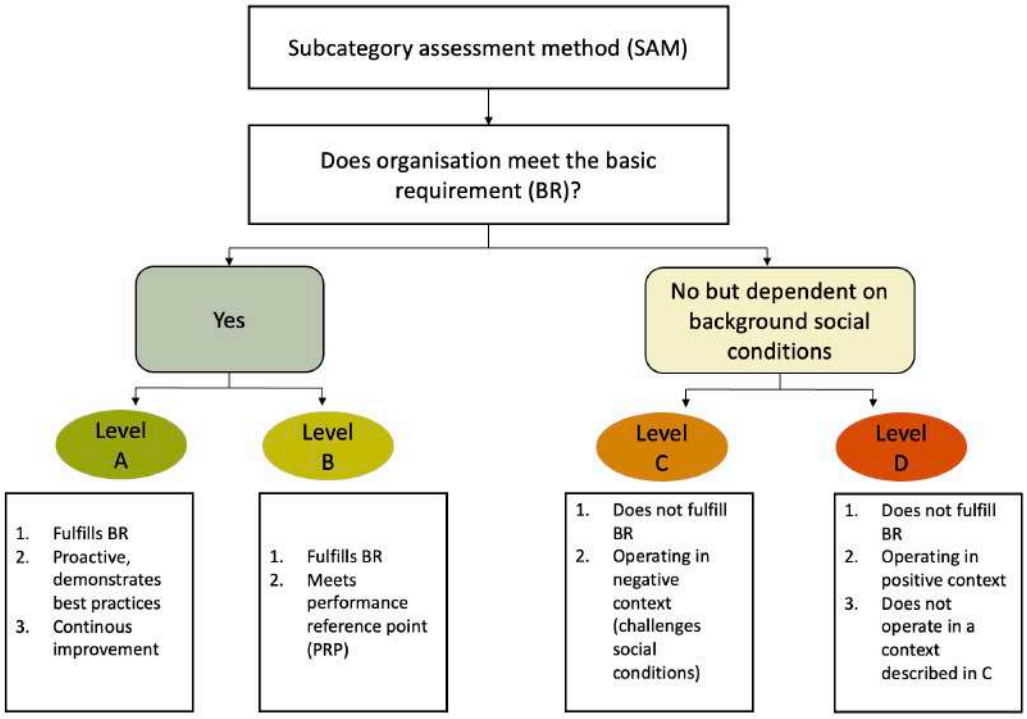


Figure 11: Scoring method of SAM (Ramirez et al., 2014)

Assessment Method (SAM) which was followed in this thesis (see figure 11). The SAM uses basic requirements (BR) defined by PRPs, based on international agreements, existing regulations, SLCA methodological sheets and company management policies to asses social performances. The level definition is based on the fulfilment of the basic requirement (level A or B) or the non-compliance with the BR (level C or D). Levels C and D indicate that the BR has not been met and are based on the background social conditions under which the organisation operates. Level C operates in a negative context, where there is a small possibility of achieving the BR and level D operates in a positive context, meaning that there is a chance the BR can eventually be accomplished (Haryati et al., 2022). In instances where the data for the PRP for levels C and D given by Ramirez et al. (2014) were unavailable for Namibia, the levels were adapted to the data that was available in the Namibian context. For this study level A was specifically defined, since Ramirez et al. (2014) did not provide a definition. The definition is based on that level A is assigned to organisations that fulfil the BR and show proactive behaviour and promote best practices (Rafiaani et al., 2020). The SAM method was originally developed based on the first edition of the methodological sheets (UNEP/SETAC, 2013). However, since then, the guidelines and methodological sheets have been updated with additional subcategories (UNEP, 2021). Hence, reference scales have not yet been developed for these new subcategories. Therefore, new reference scales had to be developed for this study, based on the SAM method approach in the Namibian context. The reference scales were initially developed prior to the field visit but were updated and refined after the visit to more accurately reflect the Namibian context, see appendix C that provides the PRPs that were used to develop the reference scales. Thus, the reference scales used in this study were tailored to the specific context of Namibia, taking into consideration its distinct regulations and requirements.

2.3 Stakeholders social impact subcategories selection

To perform an SLCA, it is necessary to select and prioritise relevant context-specific subcategories and indicators that can accurately measure the social impacts of the value chain. The SLCA guidelines define 37 subcategories, from these the most relevant were selected to assess the value chain (see figure 12). The other less relevant subcategories can be aggregated into one subcategory or can be left out of the assessment. The selection of the subcategories and indicators must not happen just on an intuitive and common sense basis and a standardised approach should be used (Fürtner et al., 2021). Especially as in this first selection of subcategories, the stakeholders were not involved and therefore they could not prioritise and evaluate the subcategories or select the indicators.

The selection of the subcategories is based on the use of literature on the Namibian context and literature from other SLCAs on bio-based systems. Literature used to understand the Namibian context and encroacher bush-based value chains included reports and development plans that cover a wide range of topics relevant to social, economic and sustainable development and the current challenges Namibia faces (NPC, 2019, Kuugongelwa-Amadhila, 2021, NPC, 2020, UNIDO, 2019, Rothauge, 2017). Papers on SLCAs assessing bio-based value chains were also used as an indicator to include or exclude certain subcategories. When considering to include or exclude a subcategory a few questions were considered:

- Is the subcategory relevant to the Namibian or value chain context?
- How would the subcategory be measured or assessed by indicators?

An evaluation of all 37 subcategories was conducted to determine their relevance for the impact assessment. Based on this evaluation, certain subcategories are either be excluded, aggregated with other subcategories, or considered for the impact assessment. After stakeholder engagement, the selection of subcategories was re-evaluated to ensure that the most relevant subcategories were selected for the impact assessment. In Appendix A, the subcategories that were excluded are listed together with the justification for their exclusion. Table 2 shows the subcategories that were excluded from this assessment.

Reclassification and Aggregation

The stakeholder categories value chain actors and consumer are aggregated together in the study to form the category value chain actors. A few of the subcategories can be aggregated to further slim down the number of subcategories and consequently the amount of indicators needed. Appendix A describes the subcategories that are aggregated together and will have the same indicators to assess the subcategory.
A few subcategories have been moved from their original stakeholder category and are assessed in another subcategory. This choice was made after the field trip, during which it was determined that certain subcategories were better suited for another stakeholder category. The context in Namibia is used to illustrate the reason why the reclassification was thought more appropriate, see appendix A. Table 2 shows the reclassification of certain subcategories to another stakeholder group.

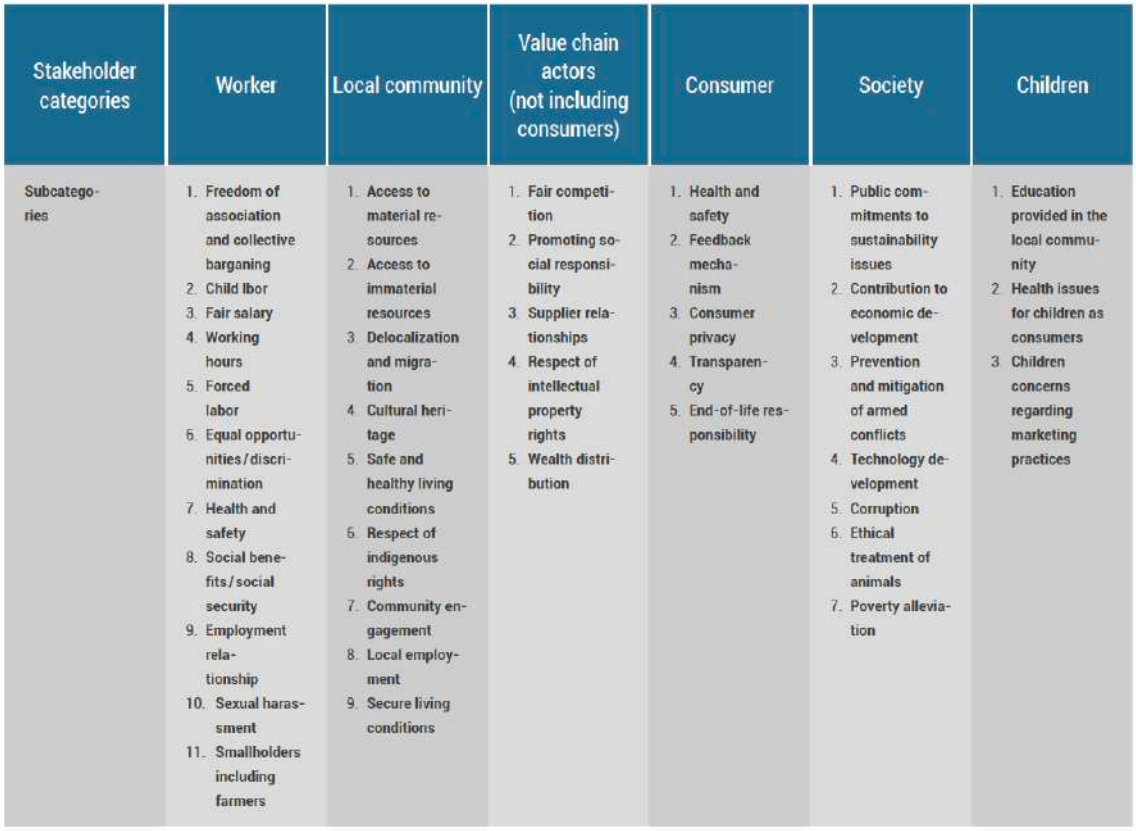


Figure 12: The list of 6 stakeholder categories and 37 impact subcategories (UNEP, 2020)

Table 2: The social impact subcategories excluded in this study and the reclassification of subcategories to a different stakeholder group.

Stakeholder categories	**Worker**	**Local community**	**Value chain actors including consumers**	**Society**
Subcategories excluded	Child labour	Access to immaterial resources	Fair competition	Prevention and mitigation of armed conflicts
	Forced labour	Delocalisation and migration	Respect of intellectual property rights	Ethical treatment of animals
	Sexual harassment	Secure living conditions	Feedback mechanism	
		Health and safety	Consumer privacy	
		End-of-life responsibility		
Reclassification of the subcategory	Safe and healthy living conditions	Smallholder	Local employment	
		Access to material resources	Public commitments to sustainability	

2.3.1 Subcategories selected for further investigation

After exclusion and aggregation 20 subcategories were further investigated and relevant indicators were selected for assessment. The subcategories are listed in table 3, along with a brief explanation of their assessment purpose (UNEP, 2021).

Table 3: The subcategories selected for further investigation and description of what the subcategories will assess (UNEP, 2021).

Stakeholder category	**Subcategory**	**Description of subcategory**
Worker	Freedom of association and collective bargaining	Workers and employers have the right to form and join organisations of their choice, promote and defend their interests and negotiate collectively with others.
	Fair salary	A fair wage is a remuneration that is justifiable and corresponds to the value of a given service, and setting a minimum wage that is fair for such service.
	Working hours	The hours of work comply with applicable laws and industry standards.
	Equal opportunities	Everyone deserves a fair chance and equal opportunities should be offered to workers by the organisation.
	Health and safety	Occupational health should promote worker well-being and prevent work-related health issues.
	Social benefits	Social benefits refer to non-monetary employment compensation.
	Employment relationship	Presence of a formal contract that safeguards workers' rights and outlines their relationship with employers.
Value chain actors	Supplier relationships	Evidence that the organisation is a code of conduct that outlines the ethical standards they and their suppliers must uphold.
	Wealth distribution	Wealth distribution focuses on how the value is distributed among all the actors of the value chain.
	Public commitments to sustainability	A public commitment to sustainability, including transparent product and social responsibility communication.
	Local employment	Local hiring preferences provide important income and training opportunities to community members
	Access to material resources	The sharing, utilisation, and conservation of material resources.
Local community	Cultural heritage	Cultural heritage includes language, social and religious practices, knowledge and traditional craftsmanship, as well as cultural spaces and objects as well as cultural spaces and objects
	Respect of indigenous rights	Respect for communal rights includes the right to lands, resources, cultural identity, self-governance and self-determination.
	Community engagement	Evaluates the organisation's engagement with the community, including involving community stakeholders in decision-making processes.
	Smallholder	Assessing the various characteristics of smallholder farmers, or subsistance farmers and particularly related to food production.
Society	Contribution to economic development	organisations can foster economic development by generating revenue, creating jobs, provide education and training etc.

Technology development	There is development and transfer of technology in the form of sharing and disseminating knowledge, skills, and technologies.
Corruption	Corruption is the misuse of power for personal advantages.
Poverty alleviation	Poverty is a multidimensional phenomenon caused by the lack of opportunity, education, health, and security and the malnutrition of people

2.4 Indicator selection

All the subcategories have numerous quantitative and qualitative indicators that can be used for the impact assessment. There is no standardised way yet to select the indicators and thus the selection of indicators can vary which can already define the results of the study. Consequently, the comparison of social performances of value chains can lead to incomparable assessments (Kühnen and Hahn, 2017). Furthermore, indicators should be chosen for each case study as the stakeholder-specific aspects and context-specific socioeconomic effects can be very different, which makes selecting indicators a complex task. The indicator sets that are established in literature can be too unspecific for a case study and therefore specific indicator sets should be selected for each case (Fürtner et al., 2021). The stakeholders' input was initially not used for the selection of the indicators due to the timing of the field visit, so the first selection of indicators was based on the screening of indicators from literature. This screening was based on SLCAs performed on bio-based value chains as well as the methodological sheets (2013, 2021), which also provide general indicators. Following stakeholder engagement during the field trip, the selection of indicators was re-iterated to finalize a set of indicators relevant to the charcoal value chain. Fürtner et al. (2021) have already reported that by using this multi-methodological approach a balanced set of subcategories and indicators can be obtained.

For the initial screening and reduction of the number of indicators for each subcategory, criteria were used to select the indicators. The indicators were rated by the characteristics of data availability, practicality and relevance with the following definitions (Buchholz, Luzadis, and Volk, 2009, Kamali et al., 2018, Sawaengsak, Assavaruk, and Gheewala, 2015):

- **Data availability**: Is the data is available, reliable and valid? How reproducible are the results?
- **Practicality**: Are there existing reference scales or measurement units? Is data easy, timely and cost-effective to measure?
- **Relevance**: How relevant is the indicator to the value chain? Does its assessment contribute to a better understanding of the social hotspots? Is the indicator prioritised in other bio-based SLCAs.

Table 4: Criteria Rating Scale.

Criteria	Score	Description
Data Availability	High/3	Quantitative data or indexes readily available or data inventory easily obtained in the field or literature.
	Medium/2	Partial availability of data, requiring some effort to obtain or collect the necessary information.
	Low/1	Inventory data not easily found on the indicator.
Practicality	High/3	Indicator is quantitative and can be easily compared with other countries or data can be obtained during stakeholder interviews.
	Medium/2	Indicator requires moderate effort to collect or compare with other countries.
	Low/1	Indicator is difficult to measure or compare practically.
Relevance	High/3	Indicator addresses one of the major challenges faced by the charcoal value chain or Namibia.
	Medium/2	Indicator partially addresses a challenge but may not fully capture its significance.
	Low/1	Indicator has limited relevance to the challenges faced by the charcoal value chain or Namibia.

The results of the scoring and the reasoning behind the scores are given in appendix A and supplementary data (indicator selection). Several indicators were assessed and scored for each subcategory, from which one or two with the highest scores were chosen for further investigation. Certain indicators were selected to evaluate the social risks in Namibia, while others were chosen to evaluate the performance of the charcoal value chain through a respective risk assessment or impact assessment. Despite every effort taken to ensure that the scores were based on factual data, the scoring process was carried out by a single individual, rendering the scores somewhat subjective. The field trip, however, facilitated data triangulation by gathering new data from stakeholders and stakeholder engagement during the workshop and ensured the selection of the most relevant indicators after re-iteration. The final set of indicators, the subcategories to which they belong, along with what they will assess, performance or social risks, is shown in table 5.

Table 5: The subcategories with their corresponding set of indicators and assessment focus; performance of the value chain or social risk

Stakeholder category	Subcategory	Indicator	Kind of assessment
Worker	Freedom of association and collective bargaining	Freedom to join a union	Performance
	Fair salary	Minimum wage	Performance
	Working hours	Working hours	Performance
	Equal opportunities	Policies for equal opportunities	Performance
		Gender gap index	Risk
	Health and safety	Presence of a policy concerning health and safety	Performance
	Social benefits	Social benefits provided to workers	Performance
	Employment relationship	Formal employer contract	Performance
	Safe and healthy living	Standard of living workers	Performance
Value chain actors	Supplier relationships	Code of conduct	Performance
	Wealth distribution	Gini coefficient	Risk
	Public commitments to sustainability	Certifications	Performance
	Local employment	Unemployment statistics	Risk
		Workforce hired locally	Performance
	Access to material resources	Sustainable harvesting	Performance
Local community	Cultural heritage	Traditional way of living	Performance
	Respect of communal rights	Communal rights policy	Performance
	Community engagement	Community engagement	Performance
	Smallholder	Food security	Risk
		Standard of living	Risk
Society	Contribution to economic development	GDP	Risk
		Contribution to economic development	Performance
	Technology development	Technology transfer	Performance
	Corruption	Corruption index	Risk
	Poverty alleviation	Multidimensional poverty index	Risk

2.5 Data inventory

The data inventory phase involves the collection and organisation of qualitative and quantitative data required for the assessment of the social impacts of the value chain. However, gathering social data can be challenging and there can be limitations or gaps in the availability of data which can affect the reliability of the SLCA. Also, there is a lack of a standardised way to collect inventory data for indicators. Moreover, collecting site-specific data is very resource intensive. This is why data collection strategies were developed for the collection of data during the field visit in Namibia to optimise the available resources and data quality (Bamana et al., 2021).

2.5.1 Data collection strategies

Figure 13 shows the data collection strategies used in this thesis. Initially, the selection of subcategories and indicators was based on generic (country) data and literature. This selection was then re-iterated following the collection of site-specific data during the field visit. The following section describes strategies for the collection of site-specific data during the five-week field visit in Namibia.

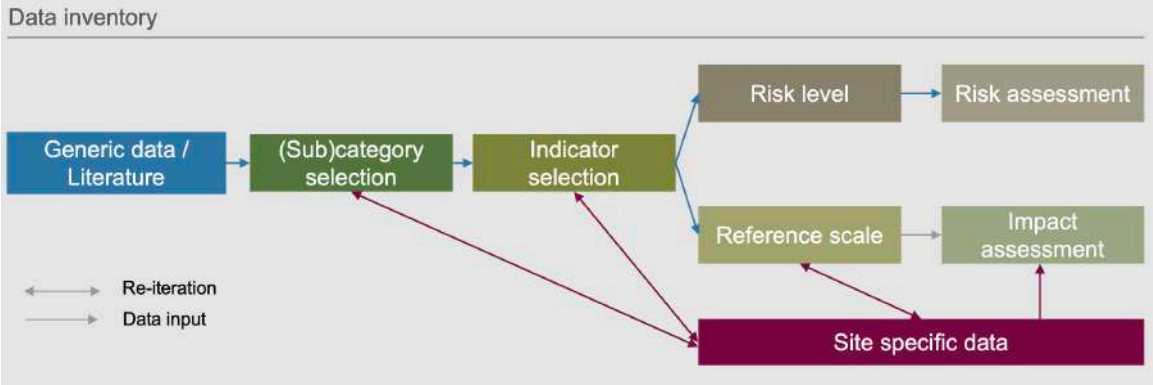


Figure 13: Showing when the two types of data, general and site-specific, were used for the selection of subcategories and indicators as well as for the risk and impact assessments.

2.5.2 Interviews

For the interviews a semi-structured approach was used, that involves a set of pre-determined open questions with the opportunity for the interviewer to delve deeper in certain topics. This also allows for deviation from the pre-determined topics to follow relevant lines of inquiry that may arise during the conversation (Barclay, 2018). Prior to the field visit an interview guide was developed with open questions for the stakeholders in Namibia, see appendix C. The first questions aimed to gather information about the stakeholder and their role and responsibilities within the sector. The following questions were based primarily on the basic requirements and performance reference points, aiming to assess whether or not they were fulfilled. In case the BR would be fulfilled, additional questions were prepared to determine if the organisation showed proactive behaviour and could be assigned to level A. Further questions were prepared if the BR was not fulfilled to understand why and to determine the social conditions. Following that, the stakeholders would be presented with the biohub infographic (see figure 1) and asked questions related to the goals, challenges, benefits and harms of the biohub. Additionally, a power-interest grid was prepared to show to the stakeholders, to ask them to provide feedback on its accuracy and identify missing actors (see figure 22). Finally, the interview would be concluded with any additional remarks, singing of an informed consent form and an invitation to the workshop.

2.5.3 Workshop

At the end of the field trip, a workshop was conducted to gather the input of the stakeholders who had previously participated in the study. The participants were divided into three groups to facilitate focused discussions during the three break-out sessions. In one of the sessions, the stakeholders were asked to envision the ideal scenario for the biohub in 20 years, by choosing the best options for the variable categories. Another session aimed to develop the roadmap to achieve this ideal scenario, based on the necessary steps taken from the current situation and ideal scenario. Then the stakeholders were asked to rank the subcategories and indicators on the basis of their perceived importance. The Mentimeter website was used to gather data on the ranking, as it can gather data quickly and display the results in real-time, see appendix E (Mentimeter, n.d.). The participants were asked to prioritise the subcategories in ascending order of importance, beginning with the most important one as number one and assigning increasing numbers to the other subcategories. Lastly, they were asked if there were any other subcategories they thought should also be assessed.

Figure 14: Stakeholders at the workshop.

Prioritisation calculations

To determine the weightage of each stakeholder's input, a weighting system was employed based on their level of involvement, see table 6. Each stakeholder received a weightage of 3x if they were directly involved, 2x if they were indirectly involved, and 1x if they were not involved in a particular subcategory. This approach ensured that stakeholders with greater expertise and involvement had a stronger influence in their respective areas.

After the points were assigned and weighted, the total points were calculated for each subcategory by summing up the contributions from all stakeholders. Subsequently, the points were categorized into three groups: important (top 33 per cent), neutral and less important (bottom 33 per cent). This method served as the basis for the prioritising calculations, allowing the distinction between subcategories that were deemed more important and those that were comparatively less important.

Table 6: Stakeholders present during workshop and the weighting for the ranking

		Weightage of stakeholders per stakeholder category											
		Workers			Value chain actors			Local community			Society		
Code	**Stakeholders present**	3x	2x	1x	3x	2x	1x	3x	2x	1x	3x	2x	1x
Farmers union (FU)	FU2 FU1	x			x			FU2		FU3		x	
Charcoal producer (CP)	CP1		x		x					x		x	
Conservancy (C)	C1 C2		x		x					x		x	
Communal farmers (CF)	CF5 CF6 CF7	x					x	x				x	
Goverment (G)	G1 G5 G6 G7 G8			x		x			x		x		
Developmental agency (GIZ)	GIZ3			x		x			x		x		
University (U)	U6 U7			x			x			x	x		
Nature conservation (N)	N2			x			x			x	x		
Bank (B)	B1			x		x				x		x	
Industrial Association (IA)	IA1 IA2 IA3 IA4			x	x				x			x	

Chapter 3

Results and discussion

This chapter includes the assessment and evaluation of the social impacts of the charcoal value chain and what the implications of these are for the biohub. First, a social risk assessment was conducted to identify the social risks associated with operating within the specific context of Namibia. Subsequently, an impact assessment is performed to examine the social performance of the charcoal value chain, aiming to identify both positive and negative impacts. Then, during the workshop, a prioritisation exercise involving stakeholders determined the relative importance of subcategories and indicators. By utilising the assessment of the charcoal value chain, it becomes possible to forecast the potential positive and negative social impacts associated with the biohub, providing valuable insights for decision-making processes.

3.1 Risk assessment

The risk assessment helps to provide a broader understanding of the potential social impacts, by identifying and evaluating social risks associated with specific indicators. This provides valuable context for understanding how the charcoal value chain performs within the social context of Namibia. The indicators are assessed using a risk level scale, which ranges from low risk to very high risk to evaluate the social risks. For each indicator a risk level scale is developed and characterised by values from indexes or global performance indicators of countries, see appendix A. This allows for the categorisation of Namibian data into a certain risk level, see table 7. The significance of the indicators and their risk levels in the context of Namibia are subsequently assessed. By doing so, the assessment can identify some of the social and economic challenges facing the country and define the context in which the charcoal value chain has to operate. The risks associated with the current situation in Namibia are also taken into account when considering the development of the biohub, as these risks can impact the project's overall success.

Table 7: Risk assessment.

Stakeholder category	Subcategory	Indicator	Risk level
Workers	Equal opportunities	Gender gap index	Low risk
Value chain actors	Wealth distribution	Gini index	High risk
Local community	Local employment	Unemployment rate	Very high risk
	Smallholders	Food security	No data
Society	Contribution to economic development	Standard of living	No data
		GDP	High risk
	Poverty alleviation	Multidimensional poverty index	Low risk
	Risk of corruption	Corruption index	High risk

Workers - Equal opportunities

Equal opportunities or the principle of non-discrimination highlights the importance of opportunities in education, employment, benefits and other areas to all regardless of age, race, sex, ethnicity or any other characteristics. Providing hard evidence of discrimination can be complex and challenging, requiring a comprehensive analysis of the context and specific work situations (UNEP, 2021). For this reason, the focus of this thesis is on gender inequality rather than the other aspects of non-discrimination due to the availability of data.

The Global Gender Gap Index, for instance, evaluates advancements towards gender parity by comparing gender gaps across four dimensions: economic opportunities, education, health, and political leadership measured by 14 indicators. The index measures gender-based gaps in access to resources and opportunities in countries rather than their development level. The indicators and the index have the highest possible score of 1 (gender equality) and the lowest possible score of 0 (gender inequality). Namibia has a very high score of 0.807, ranking at number 8 in the world, thus classifying it as a low level of risk. Whilst the Global Gap Index provides a tool for cross-country comparison, it does not fully capture the nuances of gender gaps within a certain country. Despite a high index score, there can still be gender inequalities in certain areas not captured by the index. That is why it is important to only use the index as a basis for understanding gender parity in a country and supplement the index with additional sources to understand if it reflects the specific situation correctly.

While the country has achieved high parity in educational attainment and health, there are still gaps in economic participation and political empowerment, particularly in areas such as women's labour force participation, wage equality, and representation in ministerial positions (World Economic Forum, 2022). Namibia still faces various other socio-economic issues such as an increase in gender-based and sexual violence, occasional harmful cultural practices and gender stereotypes (Sioka, 2022). The enduring presence of traditional cultural gender stereotypes regarding gender roles remains prevalent, with women often expected to assume responsibility for household and family care. While the government has made efforts to empower women, the impact of these initiatives has predominantly been experienced by urban women, who have witnessed improvements in their socio-economic status. In contrast, rural women have seen minimal to no change in their circumstances (Hunter, 2004).

Although Namibia's relatively high score on the Global Gender Gap Index indicates progress towards gender parity, improvements still need to be made to include rural women in development and empowerment initiatives. This is particularly significant in the context of the charcoal value chain and biohub, which predominantly operate in rural areas. Therefore, it is important to include rural women in the development of the biohub to have a positive social impact and thereby ensure that rural women are active participants and can also improve their socio-economic status.

Value chain actors - Wealth distribution

The Gini index is a statistical indicator of inequality that is frequently used to represent the distribution of income or wealth in a population (Hayes, 2022). It is quantified as a ratio between 0 and 1, where 0 (0%) represents perfect equality and 1 (100%) represents perfect inequality. The greater the gap between the incomes of the country's richest and poorest citizens is thus indicated by a higher Gini coefficient. Namibia has the second highest Gini coefficient (59,1) classifying it among the most unequal countries in the world and is thus a high social risk (NPC, 2019, World bank, 2015). The disparities in income distribution and access to resources and opportunities fuel poverty and unemployment, with women and youth bearing the brunt of it (Kuugongelwa-Amadhila, 2021).

In order for the biohub to have a positive impact on wealth distribution, it should have policies to promote income equality and reduce income disparities and poverty (Lakner et al., 2022).

Value chain actors - Local employment

The unemployment rate is an indicator that can be used to assess the level of economic activity and employment creation in a country. A high unemployment rate indicates the economy having a lack of capacity to absorb the available people of working age (Namibia Statistics Agency, 2019). The reference scale risk level percentages are based on the World Bank colour scales, which utilises percentages higher than 16.7% to indicate the countries with the highest unemployment rates(The World Bank, 2021). Thus, this percentage is used to classify countries into a very high-risk level. Namibia falls in the category of very high risk with an unemployment rate of 21.27% in 2021 (ILO, 2021). Unemployment in Namibia is caused by different factors such as a lack of education and employment opportunities, corruption, high job requirements for the few open positions, lack of assistance for small to medium enterprises and retrenchment (NPC, 2020). These high levels of unemployment are especially prevalent amongst the youth, 40.1% in 2021, and in rural areas (ILO, 2021). Employment prospects are strongly linked to education levels, with higher levels of unemployment observed among the population with insufficient levels of education (NPC, 2019). This means that the development of the biohub can create a positive impact in reducing unemployment rates in rural areas where it will be located by generating new employment opportunities.

Local community - Smallholder

Food security

Food security can be measured in four dimensions; food availability, access to food, food stability and food utilisation. When one of these dimensions is comprised food insecurity can occur, leading to inadequate access to food, malnutrition and other negative health effects (FAO, 2008). This risk assessment focuses on examining the food security of smallholder farmers living in the communal areas of Otjozondjupa. However, it was challenging to access food security data of the communal areas, as information was only available at the provincial level. The Multidimensional Poverty Index (MPI) already takes into account food security at a national level and at a provincial level the data also includes data from other areas and cities. Thus it does not provide a clear picture of food insecurity amongst smallholder farmers. Consequently, it is not possible to provide a risk assessment scale for food security at a smallholder level due to the lack of available data. This highlights the need for further research to obtain more accurate and detailed data on food security amongst smallholder farmers in communal areas, which can help to provide targeted interventions to address food security in these areas. However, despite the lack of quantitative data a qualitative assessment of the current situation can be made based on interviews and provincial-level data.

Namibia's semi-arid climatic conditions negatively affect the country's food security, as crop production is heavily dependent on sporadic rainfall. Natural conditions such as prolonged droughts threaten crop production and livestock production with increased mortality rates. Other factors such as infertile soil, access to land and limited access to inputs and financing affect the productivity of smallholder farmers (NPC, 2019). The Otjozondjupa communal farmers are predominantly livestock farmers and face additional challenges such as distance to markets, bush encroachment and a lack of skills and knowledge in areas such as vaccinations and pasture management (Mutjavikua, n.d.). All these challenges can lower production, leading to increased vulnerability to food insecurity (NPC, 2017). Otjozondjupa is classified as stressed for food security as the area received better precipitation compared to other areas in Namibia which are classified as in crisis for food security (IPC, 2021). This shows that the smallholder farmers in communal areas are at risk to be food insecure.

The direct impact of the biohub on improving food security in the local community is limited due to restrictions on bush control on communal lands. Bush control on communal lands would have the potential to restore rangelands, increase the carrying capacity and subsequently improve food security (UNIDO, 2019). However, the biohub can contribute indirectly to food security by providing biochar as input to the communities to improve their agricultural productivity (see figure 1). Biochar can be used both as a fertiliser and soil amendment which can increase agricultural yields due to improved soil fertility.

Living standard

The living standards measure access to basic necessities so that good health and well-being can be strived for. A similar challenge of limited available data for assessing the living standards of the smallholders in communal areas was encountered. Available data on the standard of living was only available at a regional or national level, which made it difficult to accurately determine the living standards for the people living in communal areas of Otjozondjupa.

In Otjozondjupa, the people in poverty most often lack basic necessities like transportation assets (38.3%), sanitation (34.6%) and cooking and lighting energy (34.6%) (NSA, 2021). Housing structures in Otjozondjupa are built from various building materials, such as bricks (51.0%) and corrugated iron (33.1%). Corrugated iron is also the most common roofing material used (80.1%). Sanitation is a challenge with 35.1% of the people resorting to the bush for their toilet needs (NSA, 2016). Access to energy is a significant issue in rural areas, with the majority of families lacking electricity. National efforts to address this backlog have been largely unsuccessful (MME, 2021). One interviewee, CF2, shared that their home lacked electricity because it was too expensive to connect their house to the grid in the village. Given how difficult it is to obtain some of the most basic necessities, it is evident that inadequate living conditions can be a potential social risk.

The biohub can possibly play a role in addressing the energy issues in Otjozondjupa by facilitating access to sustainable energy sources (see figure 1). By doing so, the biohub can help improve the communities access to energy and enhance their overall living conditions and welfare.

Society - Contribution to economic development

Gross Domestic Product (GDP) is a measure of the economic activity of a country, which represents the total monetary value of all final goods and services produced within a country's borders in a specific period, typically a year. The GDP is an indicator of a country's economic performance and size. An increasing GDP is a sign of economic strength whilst a negative indicates economic weaknesses (Kramer, 2022).

The GDP of Namibia (12.31 billion) in 2021, placed it in a high-risk category in comparison to other countries (World bank, 2021a). Namibia's economy is also experiencing a low growth environment, primarily due to weak performance in historically significant growth drivers such as construction and wholesale and retail trade (African development bank, 2021). The lingering impact of the COVID-19 pandemic deepened the contraction because of declines in tourism, retail, trade and investments, health and education. In 2021 the economy started recovering with a GDP growth rate of 2.7%, driven by mining, manufacturing and ongoing recovery of services (World bank, 2021b). The ongoing war in Ukraine has also had an impact on growth performance, as rising fertiliser costs, together with draughts and floods, have hampered agricultural production (World bank, 2023).

The economic situation in Namibia can also have implications for the biohub. A low GDP growth can affect the investment climate, which can discourage investors from investing due to a lack of economic opportunities (Bank, 2004). This could pose a challenge for the biohub to secure adequate funding for the development in Namibia.

Society - Poverty alleviation

Multidimensional poverty reflects non-monetary aspects of poverty, considering the many overlapping deprivations experienced by poor people along the dimension of well-being. The global Multidimensional Poverty Index (MPI) measures poverty by constructing a deprivation profile, which monitors deprivations in 10 indicators across three dimensions; health, education and living standards on a scale from 0 to 1 (UNDP, 2022). Namibia's MPI is 0.191, calculated from a headcount ratio of 43.3% and an average intensity of 44.0%. This means 43.3% of Namibia's population is multidimensionally poor, with poor people experiencing 44.0% of the weighted deprivations. The top five indicators that have the highest contribution to multidimensional poverty in Namibia are

Food Security (17.4%), Child Nutrition (15.0%), Transportation Assets (12.0%), Sanitation (11.8%), and Cooking and Lighting Energy (11.7%).

The MPI of Namibia at 0.191 is classified as a low-level risk due to the nature of the scales ranging from 0-1, however, poverty remains a significant challenge in the country. Almost half of the population (43.3%) is multidimensionally poor, with rural areas being more affected (59.4%) (NSA, 2021). As the value chain is operating in a rural area it is important to be aware of deprivations, including lack of access to basic services like education, health, and sanitation, which can have long-term effects on the well-being and economic opportunities of individuals and their communities.

The biohubs commitment to sustainable socio-economic development can help address the poverty challenges by providing employment opportunities, improving access to basic services, promoting inclusive development and improving economic welfare and food security.

Society - Corruption

The Corruption Perceptions Index (CPI) is a global survey conducted by Transparency International that ranks countries and territories based on the perceived level of corruption in the public sector. The index uses a scale of 0 (highly corrupt) to 100 (very clean) and draws on multiple expert assessments and surveys of corruption in order to provide a comprehensive analysis of corruption around the world (Transparancy international, 2021b). Namibia is ranked 58 out of 180 countries, with a score of 49 out of 100, indicating a moderate level of perceived corruption (Transparancy international, 2021a). Yet, there have been high-profile corruption trials involving public officials and private sector actors (BBC, 2023). This means that the possible risk of corruption should be taken into consideration when developing the biohub in Namibia and measures should be taken to mitigate these risks to ensure the integrity of the biohub. The biohub should implement measures such as a culture of compliance and accountability and conduct due diligence reviews to promote transparency and prevent corruption (Wrage, 2020).

Conclusions risk assessment

Indices as tools for measuring progress and identifying areas for improvement are useful. However, there are several limitations when using these, especially the oversimplification of complex social issues which can obscure important differences in context (Das, 2014, World Economic Forum, 2022). This is particularly evident when looking at the contrast between the rural and urban development contexts and the high wealth inequality of Namibia. This must be taken into consideration when assessing the context of the charcoal value chain as it predominantly operates in rural areas. While urban areas have shown advancements towards gender parity and relatively better access to resources and opportunities, rural areas still face challenges across various dimensions. Furthermore, rural areas bear the brunt of income inequality, poverty, and unemployment in Namibia. Food security and living standards are also at present a major concern in rural areas. The semi-arid climatic conditions, coupled with limited access to inputs, financing, and skills, pose significant challenges to smallholder farmers in rural communities. Access to basic necessities like transportation, sanitation, and energy is also more limited in rural areas, affecting the living standards of the population (NSA, 2021).

Overall, the context in which the charcoal value chain operates in Namibia is characterised by rural gender disparities, income inequality, unemployment, food insecurity, low living standards in certain areas and economic challenges. Addressing these issues and promoting inclusive growth, gender equality, poverty alleviation and sustainable development is crucial for the positive impact of the biohub in the country.

3.2 Social performance impact assessment

An impact assessment quantifies and assesses the magnitude and significance of the potential social impacts or performance of a product system. The aim is to analyse and understand the negative and positive social impacts of the charcoal value chain and use this to predict future potential social impacts of the biohub. For the scoring system, the SAM method is used that provides a four-level reference scale (A, BR, C, D) and categorises by the fulfilment of the basic requirements (see figure 11). For each stakeholder category and subcategories, the definition of the reference scales and basic requirements are given, with the colour highlighting which level the subcategory is scored at for the charcoal value chain (see table 8, appendix C).

3.2.1 Workers

The purpose of conducting a social impact assessment on workers in the charcoal industry is to assess and comprehend the social impacts linked to charcoal production and processing (see table 8). The workers are involved in various stages of the charcoal value chain, with the bulk of employment in charcoal production which includes harvesting and are collectively aggregated as "workers" for assessment purposes. Consequently, a single score is assigned to include all the tasks performed by these workers, production and processing within the charcoal value chain. By taking into account the specific context of Namibia the levels are assigned for each indicator and subcategory to reflect the social impact on charcoal workers.

Table 8: Impact assessment stakeholder category workers

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level BR**	**Level C**	**Level D**
Social benefits	The organisation offers more than the legally required amount of social benefits.	As required by Namibian law, the organisation provides the compulsory benefits; Maternity Leave, Sick Leave, and a Death Benefit Fund to all of its employees (Labour act, 2007).	The organisation provides at least 2 social benefits/social security basic requirement	*The organisation does not provide any social benefits/social security basic requirement.*
Working hours	Average weekly hours worked were less than 9 in the day and 45 in the week.	Average weekly hours worked do not exceed than 9 in the day and 45 in the week (Labour act, 2007).	The average weekly hours worked exceed 45 but are less than the average weekly hours worked in the sector/country.	*The average weekly hours worked exceed 45 and exceed the average weekly hours worked in the sector/country.*

Health and safety policy	The organisation implements the health and safety practice beyond the industry standards.	The organisation has a policy related to health and safety and provides a working environment that is without risk to the employees (ILO convention No. 161 & Labour act, 2007).	*No strong health and safety policy in place with evidence of workers not fully complying with obligations on safety practices.*	The organisation has no health and safety policy in place.
Policies for equal opportunities	The organisation proactively implements this policy and ensures equal pay and equal opportunities	*The organisation has a management system, policy or actions to prevent discrimination and promotes equal opportunities for workers, according to ILO Conventions No.100, and No. 111*	There is evidence in the organisation of discrimination and the country where the organisation is located has a Global Gender Gap Index lower than 0.5.	There is evidence in the organisation of discrimination and the country where the organisation is located has a Global Gender Gap Index higher than 0.5.
Formal contract	Formal contract which provides fair and equitable compensation and benefits package	A formal contract is given and the employee is covered by the Labour Act, 2007.	*Contracts are temporary and are not covered by the Labour Act, 2007.*	The employee only has an informal contract with the employer and is not covered by the Labour Act
Minimum wage	The lowest salary is equal to the living wage of the country.	*The lowest salary is equal to or higher than the minimum wage in the sector/country where the organisation is located.*	The lowest salary is below the minimum wage but above the poverty line wage.	The lowest salary is equal to or below the poverty line wage.
Housing standards	The organisation provides a higher standard of housing to employees than the minimum requirements.	*The organisation must provide the employee with adequate housing, including sanitary and water facilities that meet the standards set by the FSC.*	The organisation fails to meet the minimum housing standards.	No housing is provided to the employee.

Freedom to join a union	In the organisation there is evidence of workers belonging to a workers union and it recognises the collective representation of unions in negotiations.	In the organisation there is evidence of workers belonging to a workers union, based on the ILO Convention No.87.	The Global Rights Index score of the country where the organisation's operates has a score between (4-5+).	*The Global Rights Index score of the country where the organisation's operates has a score between (1-3).*

Social benefits

This indicator is assessed as level D, as charcoal workers generally do not receive any social benefits. The charcoal value chain workers are mostly temporary and work on a contract basis for a few months a year (FU3). These workers are treated as independent contractors, which means they are not covered by the Labour Act, 2007 thus not requiring them to receive any social benefits (Republic of Namibia, 2007). Under the Social Security Act 34 of 1994 the benefits; Maternity leave, Sick leave and Death benefit Fund are only mandatory to employees. Specifically, the social security act defines an employee as; any person younger than 65 years other than an independent contractor (Republic of Namibia, 1994). The Generic Charcoal Worker Contract provided by CAON does not outline any provision of social benefits for the workers either (Dege, 2021b). It is important to note, however, that this circumstance does not necessarily apply to all individuals employed in the charcoal industry. For example, charcoal processors are more often considered employees and are eligible to receive social benefits (Cp1). Nonetheless, given that charcoal processors' workers are only a small proportion of the overall workforce, the level for this indicator is still determined as level D (Markstein, 2020).

Working hours

The assessment for this indicator is level D, as on average the hours worked by charcoal producers exceed 45 hours. The workers have flexible hours, allowing them to decide their own schedules. They are employed under a performance-based work structure, where their remuneration is directly linked to the tonnes of charcoal produced. Consequently, the workers have the option to work longer hours to increase their production output and as a result their wages (NCA, 2019). This can result in the workers exceeding the maximum hours allowed under the Labour Act (Republic of Namibia, 2007). According to Dieckmann and Muduva's (2010) study, the majority of the charcoal producers worked for 11 hours per day. Also, a stakeholder (FU3) estimated that the workers put in approximately 60 hours per week. So as the workers are paid based on their performance, there is a lack of monitoring and control over their working hours resulting in long working hours. On the other hand that does mean that they can work in the field when it is cooler, such as early mornings and late afternoons, and rest when it is too hot during the afternoon (F3, FU3).

In contrast, the charcoal processors' workers do comply with the average working week hours. This compliance with the regulations is primarily attributed to the employer undergoing more rigorous auditing processes, which include monitoring working hours. So, charcoal processors are more likely to adhere to standard working hours (Cpc1).

Health and safety

The health and safety subcategory is assessed at level C for several reasons. Firstly, a health and safety policy is in place as this is a requirement for FSC certification. This policy requires the supply of Personal Protective Equipment (PPE) such as overalls, gumboots, hats, gloves and dust masks to the employees. As well as trainings on safety and harvesting techniques and the presence of qualified first aid workers at all times (FSC, 2019). However, while provided with PPE, the workers

(a) Working environment of female charcoal processors

(b) Smoke emitted during the production of charcoal in kilns

Figure 15: Working environment of charcoal processors and charcoal producers.

do not always use it because they are uncomfortable wearing it. The farmers do not have the time to constantly check the workers on PPE usage and adherence to safety regulations. Nevertheless, the farmers are still FSC certified (F3, F4).

Secondly, the working environment is not without risk to the workers. When working in the field they are exposed to snakes, scorpions, other wild animals and thorns from the bushes. The hard physical labour in temperatures from 24-38 degrees can result in physical pain (Dieckmann and Muduva, 2010). Working in such high temperatures has also been found to be hazardous to health and linked to a range of illnesses (Hamerezaee et al., 2020). During the combustion of charcoal, the workers are exposed to potentially poisonous smoke resulting in increased respiratory symptoms such as coughing and decreased pulmonary function (Tzanakis et al., 2001, CP1). Furthermore, the workers in the processing factories are exposed to different health hazards, primarily from charcoal dust, which can cause adverse respiratory problems. The levels of exposure to charcoal dust in most sectors in Namibia, but particularly packing and weighing, exceeded occupational exposure limits (Hamatui, Naidoo, and Kgabi, 2016). Figure 15 gives an example of the working environment of charcoal producers and processors.

Lastly, accidents while operating machinery can also pose a health risk (SAIEA, 2016). For example, a worker (BW2), reported a co-worker losing two fingers due to an accident at work. It is therefore evident that the charcoal workers in Namibia work in an environment that is a risk to their health and safety.

Equal opportunities

The subcategory equal opportunity is assessed as level B, as the organisations within the charcoal value chain have policies to prevent discrimination and promote equal opportunities. This is in the FSC certification requirement, which states that an organisation must promote gender equality in employment practices, training opportunities, awarding of contracts, processes of engagement and management activities (FSC, 2019). Due to the hard physical labour involved with charcoal production, the vast majority of the workers are men. The women active in the industry mainly perform the lighter tasks of gathering wood, sewing charcoal bags and packing charcoal. The charcoal processors employ a higher percentage of women, Cpc1 for example, employed roughly 80% women. Charcoal processing is unskilled work, offering employment opportunities for many uneducated women to level their economic playing field (Cpc1, BW2). Countrywide this number of women working for charcoal processors is about 50%, for the whole charcoal subsector an estimated 14% were women (SAIEA, 2016). Although the charcoal sector is still a male-dominated one, women are taking on greater roles in the charcoal production value chain (Watermeyer, 2021).

Formal contracts

The assessment of level C is given to formal contracts, as charcoal workers are classified as independent contractors and receive a subcontract (Dieckmann and Muduva, 2010). Thereby resulting in them not being covered by the Labour Act 2007 and consequently, they do not receive any social benefits or leave. The contract is based on a performance structure, where the price per tonne of charcoal produced is specified in the contract. This price includes provisions for overtime, Sunday off and leave (Dege, 2021b, FU3, CP1, F3). One of the requirements of the FSC certification is that the employer has to have an employment contract that is signed by both the employer and employee, with a witness signature. The FSC certification also requires payment of wages within 30 days of the transfer of the charcoal product (FSC, 2019). Thus, the workers do have a subcontract that provides them with some degree of protection.

Minimum wage

The basic requirement for this subcategory, the lowest salary is equal to or higher than the minimum wage is met for charcoal workers. The minimum wage for charcoal workers is set at N$ 1500.00 per month or a minimum wage of 35-37% of the selling price of the charcoal (Dege, 2021b, Republic of Namibia, 2011). This comes to roughly about 800 NAD per tonne with a minimum of 2 tonnes per month (NCA, 2019). This is higher than the set minimum cash wage of 972 NAD per month for agricultural employees but lower than the living wage, which is 6400 NAD per month and is the reason why it is not assessed as A (Republic of Namibia, 2021, WageIndicator, 2018).

It is important to note, that even though the charcoal workers receive a higher minimum cash wage than the agricultural workers, they do not receive the same total remuneration package as the agricultural workers. The average charcoal production worker has a monthly salary of 2,550 NAD (Markstein, 2020). The total remuneration package of agricultural employees exists out of two parts; the monetary remuneration part and other employee benefits. The agricultural employees receive additional benefits such as social security contribution and housing (brick 80%) with an average size of 41.77 m^2, with a value of 1002.48 NAD per month (Agricultural Employers Association, 2022). Whereas charcoal workers are not provided with social security and are mostly provided with corrugated iron houses, with a minimal volume per resident of 4 to 5.5 m^2 (FSC, 2019). Similar to charcoal workers, agricultural workers receive an average monthly wage of 2,574.13 NAD dollars, but their overall remuneration package is greater at 3,933.94 NAD a month.

Housing standards

The basic requirement of providing the workers with adequate housing that meets the FSC standards is fulfilled. All the charcoal producers included in the thesis have to fulfil this requirement if they want to be FSC certified. These standards reflect both the ILO requirements and Namibian cultural norms. Traditional or corrugated iron housing must be provided, with at least 4-5.5 m2 of living space per person, with a maximum occupancy of eight per room. For every 15 people, there needs to be a separate washing facility and lavatory for men and women. These are a few examples of the minimum housing requirements, figure 16 shows an example of housing for charcoal workers.

These minimum housing standards are an improvement from previous practices where workers were often living in houses made from black plastic sheeting (Dieckmann and Muduva, 2010). When workers are harvesting in a remote area, far from any permanent structure, the farmers can provide them with tents for intermittent use. On average there are about 20 charcoal workers employed during the charcoal production season, for whom the charcoal producer has to construct housing for. Providing adequate housing is often one of the biggest challenges for charcoal producers as it is very expensive to construct houses and building material is expensive in Namibia (FU3, Cert1).

(a) Houses constructed from corrugated iron.

(b) Housing consisting out of a tent.

Figure 16: Examples of housing for charcoal workers.

Freedom to join a union

Level D is assigned to freedom to join a union, as there are currently no workers' unions available for charcoal workers, meaning no members can be members of a union and therefore it does not fulfil the BR. The charcoal workers are not organised into a union due to the impracticality of doing so, as they move around working on different farms and do not have permanent employment (FU3, CP1, BW2). There is an association for the charcoal industry, the Charcoal Association of Namibia (CAoN), that supports charcoal producers (commercial farmers) and processors (CAON, n.d.). They do support the workers for example by defining an acceptable minimum wage and organising trainings (CP1, Dege, 2021b). There is a possibility for the workers to become a member of a farmers union, however, these are mainly focused on different types of farmers (Fu1, FU2, FU3, CP1). This subcategory is classified as level D rather than C, as Namibia has a Global Rights Index score of 2. Indicating that although the country's collective labour rights are weak, it still operates in a positive context (ITUC, 2022).

Conclusion impact assessment workers

In conclusion, the social impact assessment of charcoal workers identifies issues that need to be addressed. The workers generally are hired as subcontractors and do not receive social benefits and frequently work long hours, often exceeding the maximum limit set by the labour laws. Although there are policies in place for health and safety, adherence is lacking, resulting in various risks to the worker's health and safety. The standard of housing and minimum wages meet the basic requirements, but the overall remuneration package falls short of the hard work required to produce charcoal. The charcoal industry remains male-dominated despite efforts to promote equal opportunities. The freedom to join a union is limited, with no specific unions available for charcoal workers. These findings highlight areas in which the charcoal industry requires improvement and emphasises the issues that the biohub should prioritise in order to enhance social conditions.

3.2.2 Value chain actors

To conduct a comprehensive assessment of the social implications of the charcoal value chain, it is important to also evaluate the social impacts associated with the value chain actors involved. The value chain actors are often not taken into included in impact assessments in previous SLCA studies (Tokede and Traverso, 2020). These actors, who are key participants in the charcoal value chain and have the power to hire staff, include charcoal producers (commercial farmers), processors, transporters, and end consumers. Similar to the workers' category, these value chain actors are

evaluated as an aggregated category, with a single score assigned to them (see table 9). The impact assessment addresses the broader social implication of the charcoal value chain associated with the value chain actors.

Table 9: Impact assessment value chain actors

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level BR**	**Level C**	**Level D**
Workforce hired locally	The organisation can demonstrate that the majority of its employees are hired locally.	There is evidence of equal employment opportunities for local workers.	*The organisation is located in a country with an employment to population ratio lower than 50.*	The organisation is located in a country with an employment to population ratio equal or higher than 50.
Certifications	Multiple public commitments to sustainability by the organisation, showcasing proactive behavior towards sustainability.	*The evidence of any promise or agreement related to sustainability and social responsibility, which is disseminated to the public.*	There is no record of proven cases that the organisation has violated its commitments to sustainability within the last three years.	There is a record of proven cases that the organisation has violated its commitments to sustainability within the last three years.
Sustainable harvesting	There is evidence that the organisation implements multiple additional measures to ensure sustainable harvesting	*Presence of an internal management system, such as FSC certification, that is concerned with sustainable and selective harvesting.*	Absence of an internal management system, coupled with unsustainable and unselective harvesting practices	Absence of an internal management system, coupled with harvesting practices removing or killing al encroacher bushes.
Code of conduct	*The organisation that possesses a code of conduct and demonstrates strong supplier relationships.*	The presence of a code of conduct with clearly defined ethical standards that are communicated to the organisation's suppliers.	The organisation lacks a code of conduct and but does have a supplier relationship.	The organisation lacks a code of conduct and has no supplier relationship beyond basic purchasing transactions

Local employment

In the case of local employment, the subcategory has been assessed at level C, as the basic requirement is not met and the workers are not hired locally within the system boundaries. There are a few factors that cause this; first and foremost is that most Namibians are unwilling to do this hard physical work (FU3). The majority of the charcoal workers originate from the Kavango and Northern Central regions whose tribal borders span into Angola, with the community living on both sides, see figure 4 (MITSMED, 2017). There is a deal between the Angolan and Namibian governments, allowing the Angolans to apply for a green card and work in Namibia (Cert1, Cp1). The Kavango region is confronted with a high poverty rate and a lacking an education system, which creates challenges for the local population to secure employment (NSA, 2021,Cert1). The charcoal industry offers them one of the few employment options (Dieckmann and Muduva, 2010). Another explanation is that charcoal production requires considerable physical strength, which is

(a) Rangeland restoration after bush control (Laufs, 2017). **(b)** Results of aerial chemical spraying.

Figure 17: Examples of sustainable and unsustainable methods of bush control.

not necessarily a characteristic of the smaller tribes such as the Nama and the San (FU3). The Oshiwambo and Kavango are considered strong people and hard workers (F2, FU3) and therefore more suitable to work as charcoal producers. Level C is assigned to this subcategory because Namibia's employment-to-population ratio of 47 indicates a negative context as a large share of the population is not directly involved in the labour market (Worldbank, 2022).

Public commitments to sustainability

For this subcategory, the basic requirement is met since obtaining (FSC) certifications represents a public commitment to sustainability. The FSC certification is the most widely used and requires compliance with strict environmental, social and economic standards in forest management (Hindjou, 2021). The FSC-certified charcoal makes up 65% of the total charcoal value exports, whereas about 35% was non-certified in 2019. This is partly linked to the increase in exports to Europe rather than to South Africa. As the majority of the charcoal exported to South Africa is non-certified (Markstein, 2020). The demand for FSC-certified charcoal on the European market has increased in recent years due to consumers' awareness of environmental and social sustainability issues. So many European supermarkets and retail chains only sell FSC-certified charcoal (MITSMED, 2017). Also, FSC-certified charcoal receives at a higher price, providing an incentive to producers to obtain FSC certification (Cp1). Certain supermarkets also demand additional certifications, such as the Business Social Compliance Initiative (BSCI) certification from the charcoal processor Cpc1.

Sustainable harvesting

This subcategory fulfils the basic requirement of having an internal management system that addresses sustainable and selective harvesting, such as FSC certification. Having a forest management plan is a requirement to obtain FSC certification. Also, to start the charcoal production process, producers are required to obtain a harvesting permit from the Directorate of Forestry, where they have to specify biomass density estimates for the area to be thinned, target species and desired quantities to be harvested (see figure 5). A biomass quantification needs to be done to determine how many bushes can be removed from the area (G1). The harvesting permit and FSC standard outline guidelines for the harvesting procedures, including the prohibition of harvesting protected species, restrictions on trees with trunks wider than 18 cm and selective harvesting that maintains a patch of a heterogeneous mix of trees and bushes (MAWF, 2017, FSC, 2019). An example of unsustainable harvesting, which occurs as a result of aerial chemical spraying that kills all the trees, is provided in comparison with an example of sustainable bush control and rangeland restoration, see figure 17.

However, adherence to these guidelines by charcoal producers and workers is not always the case due to a lack of monitoring, control and law enforcement (G3, Cert1, MITSMED, 2017). The first issue arises in inaccurate biomass quantification, which can lead to the incorrect amount of encroacher bushes being harvested (G1). Currently, the rule of thumb uses a formula based on tree equivalents (TEs) and average annual rainfall. A TE is defined as a woody tree or bush of 1,5 meters in height. A bush density (TE/ha) should be maintained at 1.5 times the average annual rainfall depending on soil conditions (MAWF, 2017). A user-friendly model for estimating bush biomass, the Namibia bush biomass quantification tool, was developed to assist charcoal producers and improve the sustainability of the biomass industry (Boys and Smit, 2021). Unfortunately, its utilisation is still low among charcoal producers and forestry officials (G1).

Identification and distinction between protected and non-protected tree species present another challenge because the tree species look very similar. Once the bush has been converted into charcoal, it becomes difficult to determine whether protected species were included. Some charcoal workers harvest trees with tree trunks wider than 18 cm thinking that it will increase their charcoal production and thus income, despite the fact that larger wood pieces do not necessarily contribute to more charcoal production. This misconception has to be addressed through proper training and monitoring of workers, as they are resistant to changing their way of harvesting (CP1, MITSMED, 2017).

A major issue lies in the lack of monitoring and control mechanisms, allowing charcoal producers and workers to partake in unsustainable harvesting practices. Limited vehicles available for forestry officers conducting farm inspections contribute to the monitoring problem, and the FSC auditors only visit annually (Cert1). Due to inadequate law enforcement, unsustainable harvesting practices are not consistently penalized. Although the Directorate of Forestry can revoke harvesting permits and FSC auditors can withdraw FSC certificates, these actions are not always carried out (G1, G3). Charcoal producers also face challenges in establishing effective penalty systems for charcoal workers who partake in improper harvesting practices (CP1). Thus, the absence of robust monitoring and control poses a challenge in ensuring that sustainable harvesting practices are performed consistently everywhere.

Code of conduct

The subcategory supplier relationships is assessed at level A, due to the presence of established codes of conduct for suppliers, as well as strong supplier relationships. The charcoal workers are provided with contracts by the charcoal producers, outlining the expected standards of behavior and conduct regarding harvesting (Dege, 2021b). Similarly, the charcoal producers themselves are required to adhere to a code of conduct in order to obtain the necessary permits for harvesting, transport, and marketing from the Directorate of Forestry (MAWF, 2017, G1, Cert1).

The relationship between charcoal producers and processors involves contractual agreements that outline the required quality, volume, and minimum delivery timelines of charcoal (Dege, 2021a). These contracts are renewed annually, allowing for flexibility in production levels to align with the preferences of charcoal producers. This gives flexibility to the charcoal producer to decide if and how much charcoal he wants to produce that year (Cpc1).

The charcoal processor (Cpc1) enters into contracts with European supermarkets, wherein the terms, including the quality standards, fixed prices and quantities, are typically finalized in September (CAON, 2022c). This leaves a relatively short window for packaging and shipment preparation to export the largest volumes of charcoal by May to Europe in time for their peak summer demand. The supermarkets renew their contracts yearly, which creates uncertainty for the processors regarding the quantity they require to fulfil future orders. Charcoal processors engage in discussions with charcoal producers to establish the desired quantities and delivery schedules to facilitate production planning and meet the market's requirements. Most of the stakeholders within the charcoal sector know each other which strengthens relationships.

Conclusion impact assessment value chain actors

All in all, the impact assessment of the value chain actors identifies both areas of progress and issues that need to be addressed. The findings highlight the need to increase local employment opportunities within the industry, considering factors such as the locals limited interest in the physically demanding work of charcoal production. The industry's commitment to sustainability is evident through the widespread adoption of FSC certification, driven by the rising demand for environmentally and socially responsible sourced charcoal in the European market. However, sustainable harvesting practices require better monitoring, control, and enforcement to ensure adherence to the harvesting guidelines and prevent unsustainable practices. The presence of established codes of conduct and strong supplier relationships demonstrates positive engagement amongst the stakeholders.

3.2.3 Local community

The local community, in the context of this thesis, refers to the community residing within the communal lands (see figure 9). However, the community lacks access to the overall charcoal value chain as the local community is legally restricted from producing charcoal from encroacher bush. Some individuals from the local community are involved in the charcoal value chain as workers. Thus, while the local community as a whole does not have direct participation in the value chain, some of its members are engaged as workers within this industry.

Table 10: Impact assessment local community

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level BR**	**Level C**	**Level D**
Communal rights policy	The organisation has a communal rights policy and engages in regular consultation and engagement with communities and incorporates their feedback into its operations.	*The organisation has a communal rights policy or a commitment to adopt free prior informed consultation in its operations when its operations involve communal lands.*	There is no communal rights policy and there are no cases in the country of discrimination against community members within the last three years.	There is no communal rights policy and there are cases in the country of discrimination against community members within the last three years.
Traditional agricultural practices	The organisation actively promotes the preservation of cultural heritage by promoting the use of traditional products and craftsmanship in their production methods.	*There is evidence that the organisation contributes to the preservation of cultural heritage by example through contributions to traditional agricultural practices.*	The country where the organisation operates has no cultural heritage site in danger (UNESCO, 2023)	The country where the organisation operates does have cultural heritage site in danger (UNESCO, 2023).

Community engagement	The organisation demonstrates proactive efforts to improve the community's environment, health and welfare and engage the community in decision-making processes	*There is evidence that community environment, health or welfare are of importance to the organisation.*	There is no record of proven cases that community groups/ members were affected by the actions or products of the organisation within the last three years.	There is a record of proven cases that community groups/ members were affected by the actions or products of the organisation within the last three years.

Communal rights policy

The subcategory is assessed at level BR as organisations in the value chain have a communal rights policy as it is a requirement from the FSC certification. Its main objective is to uphold the legal and customary rights to ownership, use and management of lands, territories, and resources that are impacted by management operations (FSC, 2019). The local communities have the right to self-government and are their own custodians over their communal lands and have different rights than commercial land (Mendelsohn, 2008b). As a result of the government's moratorium on harvesting permits for local communities, the opportunity to (individually) participate in charcoal production is currently unavailable to them. The charcoal value chain does not operate in these communal lands, so only when a farm is in operation near or adjacent to communal areas or on resettled farms where communities have access rights to the land and its resources, the communal rights policy becomes more important (FSC, 2019).

The moratorium was placed by the government due to over-exploitation of natural resources, unsustainable harvesting practices and no benefit-sharing with the communities (Hindjou, 2021). The land in communal areas is common pool resources and to obtain resource rights the community has to register as a community forest or a cooperative which requires them to have a Forest Management Plan. A Forest Management Committee is elected for the development of the forest management plan, and the subsequent implementation and monitoring of the plan (Benkenstein, Hengari, and Mbongo, 2014). The registration includes resource and boundary mapping, socio-economic needs assessment, development of management plan and equitable benefit sharing plan (Kabajani, 2021). In the community forests, a few small-scale projects such as bush to feed or production of biochar are currently being piloted (CF1). However, previously pilots have failed to work in communal areas due to difficulties in structuring a framework for equitable benefit sharing and various other reasons (Cert1, G4). The only way the government will allow changes to regulations is a successful pilot with a specific framework in place that can ensure the sustainable use of bush biomass (G4, MEFT, 2022).

Cultural heritage

The organisations demonstrate evidence of making an effort to preserve cultural heritage and are therefore assessed as meeting the basic requirement for the subcategory cultural heritage. Compliance with FSC certification requires the identification and protection of sites that are of cultural or spiritual significance for the traditional communities. These sites often include sacred locations, gravesites, historical sites and routes and rock art. By recognising and safeguarding these sites the cultural heritage of the traditional communities can keep on being preserved.

However, it is important to note that no site-specific data was gathered to confirm the degree to which cultural heritage sites are protected by the charcoal value chain because of the nature of the field visit, which was interviewing charcoal producers rather than taking a tour of the farm

Figure 18: Herero women wearing headdresses resembling cows horns (Naughten and Marten, 2013).

and cultural heritage sites. Thus, it is assumed that the FSC standards are being adhered to when making this assessment. Considering that the charcoal industry does not operate on communal lands, it can be concluded that there is no inherent risk of the charcoal industry threatening cultural heritage sites in these areas.

The charcoal industry also indirectly contributes to the preservation of cultural heritage by allowing land users to return to traditional land use through its facilitation of rangeland restoration, which in turn supports livestock farming. This is particularly relevant for the Herero tribe, whose traditional way of life centres around cattle herding and considers cattle ownership as a measure of wealth (F1, CF1, Mendelsohn, 2008b). The importance of cattle for the Herero tribe is also reflected in the traditional dress of the women who wear headdresses that resemble the horns of a cow, see figure 18 (Naughten and Marten, 2013) Many charcoal producers engage in charcoal production as a secondary source of income, utilising the funds generated for rangeland restoration activities aimed at enhancing carrying capacity (MITSMED, 2017). Although the charcoal industry primarily operates outside of communal areas, there are still Herero farm owners and workers involved in cattle farming on commercial farms. Their continued involvement with cattle farming aligns with the cultural practices and traditions of the Herero tribe.

Community engagement

The subcategory of community engagement fulfils the basic requirement as demonstrated by the organisation's recognition of the significance of community environment, health, and welfare. Moreover, adherence to FSC certification requires the maintenance of positive community relations and the contribution to the social and economic well-being of the local communities. Legally the communal areas cannot be engaged in charcoal production. However, several pilot projects have been initiated with the aim of involving the communities in the sustainable utilisation of bush resources (CF4, CF1). The pilot project 'Commercialisation of bush biomass in communal areas through FSC certification' was set up by the charcoal industry stakeholders to test the feasibility of sustainable bush control and utilisation by producing FSC-certified charcoal within communal areas. Additionally, the project aimed to test a model for the equitable distribution of benefits in these areas and improve the inclusiveness of the Namibian charcoal sector (Matthys, 2021, Amutenya, n.d.). Regrettably, the pilot project encountered many challenges and was unsuccessful, partly due to the limited production of charcoal after a few months (G4). The pilot was set up in the Otjozondjupa communal areas and it was observed that there is a tendency among the community members to assume more of an ownership role rather than engaging as workers, which can be attributed to their cultural

background as cattle herders and owners. Consequently, a situation would arise that individuals from other communities would be employed and receive compensation whilst immediate community members would not benefit economically which caused some friction. Hence, proper benefit-sharing structures must be in place for the communities as it remains a criterion for a successful pilot in communal areas (Cert1, CF3).

Conclusion impact assessment local community

To conclude, the assessment indicates that the charcoal industry demonstrates efforts to preserve cultural heritage by recognizing and safeguarding sites of cultural or spiritual significance for traditional communities, as required by FSC certification. In terms of community engagement, the industry recognises the significance of community welfare and has initiated pilot projects to involve communities in the sustainable utilisation of bush resources. However, these pilots have faced challenges, such as limited charcoal production and the need for equitable benefit-sharing structures. To ensure the success of future pilot projects in communal areas, proper frameworks for benefit sharing must be established. The limited engagement of the local community in the charcoal value chain makes it challenging to accurately assess its true social impact. Taking this into consideration, it is crucial to prioritise their inclusion and engagement in the biohub. However, this might prove challenging and further research is needed to explore effective strategies for engaging the local community without relying on their biomass supply.

3.2.4 Society

The assessment of the stakeholder group society focuses on evaluating the broad social and socio-economic effects of the charcoal value chain on society (see table 11). Society includes all individuals or organisations that are directly and indirectly affected by the charcoal value chain. The society stakeholder group thus includes a wide range of actors, such as the government, researchers and civil society organisations, who can be impacted by the charcoal industry.

Table 11: Impact assessment society

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level BR**	**Level C**	**Level D**
Technology transfer	organisation has a higher expenditure on research and development of technologies compared to other organisations within the same sector	The organisation demonstrates participation in joint research and development for efficient and environmentally sound technologies	organisation operates in a country with low research and development expenditure (0-2.35% GDP)	organisation operates in a country with high research and development expenditure (>2.35% GDP)
Contribution to economic development	The organisation demonstrates a higher level of contribution to economic development than other organisations within the same sector	organisation provides a contribution to the economic development of a society	There is a no record of proven cases of the organisation damaging or restraining the economic development of the region within the last three years	There is a record of proven cases of the organisation damaging or restraining the economic development of the region within the last three years

(a) Cluster burning with firebreaks to prevent veld fires

(b) Biochar production plant

Figure 19: Examples of technologies used within the charcoal industry

Technology transfer

The basic requirement for this subcategory is fulfilled, as there is evidence of research and development of technology within the charcoal industry that is publicly available. The Charcoal Association of Namibia (CAON) serves as a knowledge source for the producers and processors for the introduction of new technologies (CAON, n.d.). The CAON also provides shares knowledge on best practices, such as improved burning practices, sustainable harvesting, legislation and certification. For example, the CAON together with the Directorate of Forestry developed instructions for compulsory cluster burning to ensure constant supervision of the kilns and mandatory fire breaks, consequently reducing the number of veld fires started by the charcoal industry, see figure 19 (Otsub, 2021, CP1). Other stakeholders such as the universities, government departments and industry associations frequently work together to research sustainable harvesting practices and make guidelines and develop new technologies such as the biomass quantification tool (G1, Boys and Smit, 2021).

Moreover, practical skill is required for efficient harvesting and charcoal production (CP1). These skills are taught through trainings and through on-the-job capacity transfer (Cert1, Cp1). A majority of the workers do not have any formal training or schooling so learning these skills increases their capacities (BW2, Cp1). Furthermore, the Namibia-Biomass Industry Group (N-Big) conducts various capacity-building programs and developed three Industry Qualification Modules. These modules aim to provide workers with the necessary knowledge and skills for environmentally sustainable bush harvesting and processing, thereby enhancing the overall efficiency and adherence to legal regulations in bush control and processing operations (N-Big, n.d.).

The charcoal industry in Namibia has shown some progress in the development of new technologies, however, there is significant room for improvement to achieve higher production efficiency and cleaner production methods. As Namibia still relies mostly on the use of traditional kilns that have very low conversion ratios and high emissions rates (FAO, 2017). It is worth noting that newer technologies, such as retort kilns, offer promising solutions for more sustainable wood charcoal production. However, the high investment costs form a significant barrier for many producers, preventing widespread adoption and the continued use of traditional kilns (CP1). The industry is however looking more into (by)products that are of higher value such as biochar and wood vinegar and have a wider range of applications such as soil amendments and agricultural insecticides, see figure 19 (Cpc1, Cert1, MITSMED, 2017).

Contribution to economic development

Level A is assigned based on the charcoal industry's contribution to economic development, as it is the largest and most developed subsector in the bush biomass sector. Most of the charcoal is destined for international markets and Namibia consistently ranks among the top ten exporters in the last decade (Markstein, 2020). Namibia has emerged as one of the top ten exporters of charcoal

globally, with consistent growth in production and export volumes over the past decade. In 2020, Namibia produced over 200,000 tonnes of charcoal, valued at approximately 53.8 million US dollars (CAON, 2022a). For years, demand has outpaced supply, and it is anticipated that this trend will continue. There are an estimated 1100 active producers and directly and indirectly, 8.500 people employed in the charcoal sector (MEFT, 2022).

Beyond its direct economic contribution, the charcoal sector also contributes by bush control and rangeland restoration to the economy. By clearing bush biomass, the industry helps create opportunities for increased livestock production, tourism, groundwater recharge and biodiversity conservation, see figure 20 (De Klerk, 2004). It is estimated that if approximately 15.8 million hectares of land undergo bush control measures over a 25-year period, it has the potential to contribute 76 billion NAD of economic benefits to the Namibian economy. These benefits would be derived from various sources, including approximately 6 billion NAD from increased livestock production, 4 billion NAD from charcoal production and approximately 51 NAD billion from enhanced groundwater recharge (Birch et al., 2016). This highlights the significant economic potential linked to the charcoal industry and bush control efforts in Namibia.

(a) Rangeland restoration can improve wildlife viewing **(b)** Increased stocking rates on restored rangeland

Figure 20: Economics benefits from bush control include increased carrying capacity and tourism opportunities.

Conclusion impact assessment society

The charcoal industry has shown progress in technology development and capacity building, but there is still room for improvement in adopting cleaner production methods and newer technologies. The introduction of the biohub presents an opportunity to bring new technology to Namibia and requires capacity building and skills development within the local population. As one of the top global exporters of charcoal, Namibia's charcoal industry contributes significantly to the country's economy, with consistent growth in production and exports. Furthermore, the charcoal industry's efforts in bush control have additional economic benefits, such as livestock production and tourism. The biohub can leverage these indirect economic effects too whilst generating profits from the production of biofuels.

3.3 Prioritisation

Prioritisation within an SLCA can help decision-makers to focus on the most significant social impacts within a product life cycle (Fürtner et al., 2021). By prioritising social impacts, decision-makers can allocate resources and attention to areas that have the greatest potential for improvement or where the highest risks and challenges lie (Scholz, 2023). In this thesis, the workshop participants, representing stakeholders in the charcoal value chain, conducted a ranking exercise to determine the

relative importance of different subcategories (see table 12). The results of the prioritisation process provide insightful information about the subcategories that were deemed to be most important by the stakeholders. These results highlight the areas that should receive heightened attention during the development of the biohub. By focusing on the subcategories that were ranked as most important, the biohub can address the key concerns and effectively meet the needs of the stakeholders involved in the charcoal value chain.

Table 12: Prioritisation of subcategories per stakeholder category

Stakeholder category	Subcategory/Indicator	Less Important	Neutral	Important
Workers	Working hours			
	Safe and healthy living conditions			
	Fair salary			
	Social benefits			
	Safe and healthy working conditions			
	Equal opportunities			
	Freedom to join a union			
Value chain actors	Sustainable harvesting of biomass			
	Local employment			
	Wealth distribution			
	Feedback mechanism			
	Contractual relationships			
	Public commitments to sustainability			
	Sustainable use of water			
Local community	Respect of communal rights			
	Community engagement			
	Cultural heritage			
	Standard of living			
	Food security			
Society	Contribution to economic development			
	Povety alleviation			
	Tranfer of technology			
	Corruption			

Among the stakeholder category of workers, fair salary and safe and healthy working conditions were ranked as the most important subcategories. This is due to the challenging nature of charcoal work, characterised by physically demanding labour, unfavourable working conditions and relatively low wages. Due to the extremely hard work, it has been likened to a form of slavery (Trede, 2015). These findings correspond with a study conducted by Dieckmann et al. (2010), which identified low payment rates per tonne and labour-intensive work and health-related issues as the major challenges faced by workers in the industry. The subcategories of working hours and freedom to join a union were ranked lower in importance. Working hours were deemed less significant as workers have autonomy in determining their own schedules and thus determine how much they work themselves. Similarly, the freedom to join a union was not viewed as important, because it would be difficult for charcoal workers to organise and participate in a union given their mobility.

The sustainable harvesting of biomass is considered important since, if not done correctly, it might result in even worse bush encroachment, defeating the purpose of producing charcoal and controlling bush encroachment. Part of the underlying problem is the lacking monitoring and control mechanisms necessary to ensure sustainable harvesting, both from the side of charcoal producers and the government. Local employment has also been prioritised, given that the locals are not being employed despite the high unemployment rate. This is partially caused by locals' reluctance to work in the sector, necessitating the recruitment of workers from other regions and Angola. This represents a missed opportunity to address unemployment within the local population. The subcategories of feedback mechanism and sustainable use of water were deemed not important to the stakeholders due to the limited involvement of the charcoal value chain in these aspects. This resulted in the exclusion of these subcategories from further impact assessments.

For the local community, respect for communal rights was ranked as the most important subcategory. This prioritisation stems from the perception that communal areas lack participation opportunities and equitable access to the value chain, despite them also having the issue of bush encroachment on their land. Thus the potential of utilising biomass on their land as a resource remains untapped until a different legal framework and regulations are implemented in the future. The standard of living was not prioritised, since individuals in these communities often construct their own houses using available resources.

From the stakeholder category society, the contribution to economic development was prioritised, given its potential to generate job opportunities and alleviate poverty. Corruption was not identified as a problem within the charcoal value chain at present, and therefore not prioritised.

There are certain limitations associated with the prioritisation exercise conducted during the workshop by the stakeholders. Firstly, not all the stakeholders were able to attend the workshop, particularly those from the private sector, who faced work-related constraints. Consequently, the workshop did not represent all the stakeholders involved in the value chain. Despite the absence of certain stakeholders, it should be noted that generally, the participants of the workshop were very experienced with different aspects of the charcoal value chain. It is also worth mentioning that the prioritised subcategories are in line with what was expected following the interviews and the challenges mentioned by the stakeholders.

Following the prioritisation exercise the subcategories feedback mechanism and indicator access to water, were excluded from further assessment. This choice was based on their perceived lower importance and the limited availability of site-specific data on these aspects. Because of this, they are included in this section of the thesis but are not further discussed or analysed in other sections.

Conclusion from prioritisation

Overall, these stakeholder rankings shed light on the perceived importance of specific subcategories and key concerns within the charcoal value chain. This prioritization can be used as a foundation for decision-making and pinpointing areas that need improvement within the industry. Within the current context, significant concerns revolve around unfavourable and unhealthy working conditions and inadequate remuneration for labour-intensive work. Additionally, ensuring sustainable harvesting practices is essential to mitigate any negative environmental impacts. Enhancing local employment opportunities becomes crucial for lowering unemployment rates within the local communities. Local communities' limited access to the value chains hinders their ability to benefit from bush encroachment. By addressing these concerns, the charcoal industry or the biohub could have positive social impacts.

3.4 Challenges and opportunities for the biohub

The charcoal value chain impact assessment and stakeholder rankings provide insights into the social risks, social performance, and priorities within the industry. The assessment helps identify potential challenges and opportunities associated with the utilisation of encroacher bush, while stakeholder rankings highlight key concerns and areas for improvement. This will be used to provide a framework for the biohub to address social concerns and create positive social impacts if it is ever implemented. The biohub envisions a region where both public and private actors work together to:

1. Source biobased streams and convert them into marketable products
2. Improve sustainability of traditional biomass use
3. Fulfil local needs
4. Fairly distributing the costs, benefits, risks and opportunities

Based on this vision the challenges and opportunities will be discussed associated with the biohub (Clean Shipping Project, n.d.). Additionally, the biohubs potential social impacts are compared to the existing charcoal value chain, as shown in table 13. It is important to note that the specific social impacts of the biohub will depend on its operational setup and business model. The highlighted scores in yellow indicate areas where the biohub has the potential for improvement, particularly if it adopts different approaches compared to the charcoal value chain. Subsequently, the following section discusses the anticipated social impacts in the Namibian context, based on the envisioned vision of the biohub.

3.4.1 Sourcing biomass

The availability of bio-based streams in Namibia is abundant, with approximately 10 million hectares of bush encroached land that can be utilised for bush control and rangeland restoration in Otjozondjupa alone. However, the actual sourcing or harvesting of biomass poses significant challenges. (Semi)mechanised harvesting is capital intensive, requires regular maintenance, and difficulties arise in procuring spare parts from other countries, leading to operational disruptions. However, the output is a lot higher than manual harvesting. On the other hand, manual harvesting requires lower input costs but is very labour-intensive which presents its own set of challenges. From a landowner's perspective, employing extra workers for manual harvesting introduces concerns such as poaching and cattle theft as well as increased costs of providing housing.

The Workers prioritise fair wages and safe and healthy working conditions (see table 12). While the biohub cannot eliminate the physical labour of manually harvesting bushes, it presents an opportunity to improve mechanisation and improve worker health and safety (see 21). The biohub's wood chipping operations could offer a healthier working environment, as unlike charcoal production, it does not involve the production of hazardous smoke, charcoal dust, and exposure to intense heat from burning kilns. Thus workers would be less exposed to occupational health threats, besides using mechanised equipment and therefore could potentially be scored at level BR instead of C (see table 13). Additionally, the higher value of biofuels compared to charcoal provides the potential for better wealth distribution along the value chain. Which could possibly enable the provision of better wages to the workers. If the wages are higher, working in the sector could be more attractive to local workers thus increasing the percentage of the local workforce. Also, assuming that the biohub will generate employment possibilities and favour local hiring, it may have a positive social impact on local employment (level BR instead of C).

(a) Process of chipping encroacher bushes **(b)** Woodchips from encroacher bushes

Figure 21: The chipping of encroacher bushes.

Another potential improvement the biohub could make is by offering workers full-time employment contracts instead of subcontracts, as it would entitle workers to social benefits. However, the feasibility of this approach depends on the specific setup of the biohub business and its contractual

agreements and length of contract with suppliers. In the charcoal sector, supplier contracts of the charcoal producer haretypically renewed annually, making long-term employee hiring impractical. Ohorongo Cement, a company in Otjozondjupa that uses woodchips, purchases woodchips directly from the harvesters and not the landowners. These landowners typically let the harvesters perform bush control free of charge (Brown et al., 2018). If these contracts are a few years, it can give harvesters a chance to set up small to medium enterprises (SMEs) and invest in machinery (P1). Thus the nature of supplier contracts and the consequent impacts varies based on whether the biohub engages harvesters/SME businesses or purchases from land owners who undertake the harvesting and chipping processes themselves. So, if it aligns with the economic model, the biohub could have a significant positive impact, especially for the harvesters, by offering full-time contracts with the associated social benefits. But, if this cannot be accomplished, the biohub will operate in a similar context as the value chain for charcoal, having negative social impacts.

Under the assumption that the biohub adopts a payment system based on the tonnes of woodchips supplied, it is anticipated that the working hours for the harvesters will exceed the standard working week. In this model, increased production of woodchips would directly correspond to higher earnings, incentivizing harvesters to work long hours. This is also based on the fact that most workers take time off during the wet season to go back home and therefore opt to work intensively for a period. The freedom to join a union for the biohub is also a potential negative social impact due to the unlikelihood of a union that will be established for harvesters. Particularly given that, excluding agricultural unions, this has not yet occurred in the developed charcoal value chain.

3.4.2 Sustainability of biomass use

Ensuring the sustainable harvesting of encroacher bush is essential to restore rangelands and mitigate negative environmental impacts. However, achieving proper adherence to sustainable harvesting practices presents a significant challenge. Despite the availability of tools and guidelines for biomass quantification and sustainable harvesting of the encroacher bush, these are not always properly implemented. The first essential step in improving the practices is ensuring that the harvesters receive proper training and understand and implement the guidelines set by the Directorate of Forestry and FSC. Obtaining FSC certifications provides incentives to landowners to prioritise sustainable harvesting practices, as landowners can increase their earnings by being FSC certified due to higher rates. However, the effectiveness of such certifications and permits depends on adequate monitoring and control mechanisms, which are currently deficient from both governmental and landowners' sides. This lack of monitoring, control and enforcement, reduces the likelihood of detection and penalization when unsustainable harvesting practices occur, thus supporting these mispractices.

In the context of a biohub, additional certifications can offer an opportunity to impose supplementary criteria and enhance monitoring and control measures. An example of a certification that addresses key aspects of biofuel use is the Sustainable Biomass Program (SBP), which is aligned with the REDII objectives. The SBP certification aims to minimise the risk of unsustainable harvesting and mitigate negative impacts on forest carbon stocks. The FSC certification is often considered a prerequisite to obtaining SBP certification, enabling the integration of both schemes. This certification scheme was proposed by the Biomass Industry Park (BIP), and although never realised in Namibia, the ideas and lessons learned from its conceptualisation remain valuable for the biohub initiative (Heck, 2021). However, there are many other biomass certification schemes that could also be suitable, such as Roundtable on Sustainable Biomaterials (RSB) (RSB, 2017). Even better would be establishing a dedicated Namibian certification body, in collaboration with industry stakeholders, which would further enhance monitoring and control efforts, tailor standards to local requirements, and encourage sustainable harvesting practices (G1). However, implementation would still need to be monitored, which will probably still be an issue. Another challenge is the time and costs associated with obtaining (additional) certification, creating barriers for organisations to become certified.

3.4.3 Local needs

Engaging the local community in ways beyond employment opportunities and rural development will pose a significant challenge for the biohub. As currently, the government has a moratorium placed on harvesting in communal lands and it is unlikely this policy will change in the near future. The only way to change this is for the biohub to establish a pilot project within the communal areas and successfully demonstrate the feasibility of sustainable harvesting and a framework for equitable benefit sharing within the community. Only after the completion of a successful pilot will the government consider changing its policies to allow harvesting on communal lands (G3). However, given the history of failed pilot projects in communal areas, this achievement may take several years to complete. Consequently, the biohub cannot directly involve the local community in the communal areas as biomass suppliers.

Alternatively, the biohub could focus on engaging formerly disadvantaged farmers on resettled land. These farmers were previously communal farmers but have been allocated land from former commercial farms by the government. However, these resettled farms often face challenges of low productivity and degradation of natural resources due to the farmers' limited skills and resources (Rothauge, 2007). By involving these farmers in the biohub activities, they can benefit from additional income sources that can support their existing farming activities (P1).

The biohub can create new opportunities for the local community and contribute to rural development. By offering local employment opportunities, the biohub can contribute to increased workforce participation, particularly among women, within the biomass sector. The increased employment can have positive ripple effects on local businesses, due to the increased income and purchasing power of employees. Thus the biohub can help foster positive socio-economic development in the area that can benefit the local community (Flesch et al., 2021).

Additionally, the biohub can provide a domestic energy source to a country that currently relies on mostly imported energy sources (Brown et al., 2018). The biochar produced can be returned to the community and used as a fertiliser for soil improvement. So, while direct involvement of the local community in communal areas is not feasible, on shorter notice, the biohub can still have a positive social impact on the community.

3.4.4 Fair distribution of costs, benefits, risks and opportunities

Namibia has a large wealth disparity, as shown by its high Gini coefficient, which highlights the importance of establishing a biohub with a fair distribution of costs, benefits, risks, and opportunities. This equitable distribution becomes essential for guaranteeing that all actors involved, especially the disadvantaged, receive equitable benefits. Therefore, establishing a partnership with multiple stakeholders becomes essential to establish a fair and inclusive biohub, where potential socio-economic risks are shared, and long-term operational efficiency is achieved.

The risks can be distributed fairly amongst the stakeholders, by developing strategies to identify and mitigate the risks to prevent one from bearing a disproportionate burden. For instance, by working with different suppliers of woodchips, the danger of insufficient supply can be reduced and volume fluctuations from the suppliers can be accommodated. The biohub may face supply issues, especially during the rainy season, due to staff shortages and problematic transportation on bad roads. However, caution should be exercised not to involve too many stakeholders which may lead to conflicting interests and hinder effective decision-making. One of the reasons failure of the establishment of BIP was the inclusion of too many stakeholders with diverse objectives making the decision-making processes highly complex and eventually unfeasible (IA1). This was highlighted at the workshop that, for example, the government's role in the biohub should be to focus on regulatory monitoring and offering guidance, rather than being directly involved. So a robust partnership model should be in place to ensure the success of the project (Heck, 2021).

Table 13: Foreseen social impacts of the biohub compared to the charcoal value chain based on the Subcategory Assessment Method reference scores.

		Charcoal value chain	Biohub
Stakeholder category	**Subcategory**	**Social impact score**	**Potential social impact score**
Worker	Freedom of association and collective bargaining	D	D
	Fair salary	BR	BR - A
	Working hours	D	D
	Equal opportunities	BR	BR - A
	Health and safety	C	BR
	Social benefits	D	D - BR
	Employment relationship	C	C - BR
Value chain actors	Supplier relationships	A	A
	Wealth distribution	-	-
	Public commitments to sustainability	BR	A
	Local employment	C	BR
	Access to material resources	BR	BR
Local community	Cultural heritage	BR	BR
	Respect of communal rights	BR	BR
	Community engagement	BR	A
	Smallholder	-	-
Society	Contribution to economic development	A	A
	Technology development	BR	A
	Corruption	-	-
	Poverty alleviation	-	-

In conclusion, the establishment of a biohub in Namibia offers promising opportunities for enhancing social impacts in comparison to the existing charcoal value chain. However, it is crucial for the biohub to acknowledge and address the risks associated with biomass harvesting, including the concerns related to workers' well-being and working conditions and environmental implications. Safeguarding the welfare of workers and sustainable harvesting should be a priority for the biohub's operations. Furthermore, although the involvement of the local community is hindered by governmental policies, it is important for the biohub to explore alternative avenues to include the local community.

Chapter 4

Conclusion

This thesis addressed the main research question of performing an integral SCLA to map the social impacts of an encroacher bush-based value chain. Specifically, the social impacts of the charcoal value chain were assessed to determine social hotspots associated with an encroacher bush-based value chain, which were used to identify the opportunities and challenges for the conceptual biohub.

In the first phase of the SLCA, the goal and scope were defined for both the charcoal and biohub encroacher bush-based value chains. This involved determining the functional unit, which was set as one tonne of charcoal or biofuel, and identifying the specific activities required to produce this quantity. This was used to define the system boundaries, which were focused on the upstream processes and the stakeholders involved in those activities within the Otjozondjupa region. The stakeholder groups workers, value chain actors, society and the local community were selected for their impact subcategories to be assessed in this thesis. After a literature screening and further refinement after the fieldwork was conducted, 20 social impact subcategories were considered relevant for the assessment. A multi-criteria analysis was performed to select the most relevant and appropriate indicators to assess these subcategories.

In order to quantify the selected indicators, four-level reference scales were developed for each indicator based on the SAM method. The basic requirement is linked to a performance reference point and was used to score the indicators to a level. In this assessment, the basic requirements and reference scales were adjusted to fit the Namibian context, incorporating both existing SAM reference scales and newly developed reference scales.

The assessment of the charcoal value chain against the reference scales revealed both positive and negative social impacts which were used for identifying the opportunities and challenges for a conceptual biohub. The negative impacts primarily revolved around the working conditions of charcoal workers, including unsafe and unhealthy environments, the absence of social benefits and long working hours. Additionally, concerns were raised regarding fair remuneration for workers, the lack of local employment opportunities and inadequate monitoring and control of harvesting practices, which could result in negative environmental implications. The assessment also identified potential areas for the biohub to improve social impacts compared to the charcoal value chain. Key opportunities include the improvement of working conditions and welfare for the workers as well as the creation of local employment opportunities. Additionally, the biohub should actively try to involve the local community in the biohub's activities. Currently, the local community is does not have access to and is not actively involved with the charcoal value chains. In conclusion, by recognising and addressing the identified challenges and the opportunities for improvement, a socially sustainable biohub can be developed in the future.

4.1 Future recommendations

In this section, the limitations will be discussed and the sub-question answered of how a methodology can be developed for SLCAs for future biohubs after a reflection of current methods used in this SLCA of the charcoal value chain. This thesis can contribute to the still ongoing development of the standardisation of SLCA (Huarachi et al., 2020). As far as current knowledge indicates, this thesis is the first SLCA performed in a Namibian context. The lessons learned and methodology established in this thesis can serve as a reference and benchmark for future SLCA studies conducted in Namibia.

4.2 Recommendations framework future biohub SLCA

Lessons learned from conducting an SLCA on the charcoal value chain in Namibia provide valuable insights for future studies. The experience gained in this thesis will be used to give recommendations for conducting future SLCAs on biohubs.

4.2.1 Goal and scope

The first phase in the SLCA is the definition of goal and scope which includes describing the goal, functional unit, system boundaries, categorisation of stakeholders, impact assessment method and impact subcategories and indicators. An SLCA can be conducted on a similar biobased value chain, like in this thesis, if the biohub is still in the conceptual stage. Or a comparative SLCA of different potential suppliers for the biohub with the goal of using the SLCAs for the selection processes can be performed (Carmo, Margni, and Baptiste, 2017). An early definition of the goal in the SLCA facilitates decision-making during the subsequent stages of the assessment process.

Stakeholder categorisation

Regarding stakeholder categorisation, the groups directly or indirectly affected by the product or organisation should be considered. The guidelines suggest stakeholder categories including workers, consumers, local communities, society, children, and other value chain actors. Initially, due to perceived practicality, the stakeholders were separated into direct and indirect categories, with direct stakeholders representing value chain actors and indirect stakeholders comprising government, the private sector, universities, civil society organizations, and competitors. However, using an alternative method of stakeholder categorisation and aggregation posed challenges in conducting impact assessments on the subcategories. As it became unclear which data from which stakeholder should be utilised for the assessment. Consequently, reverting back to the original stakeholder categories was deemed more practical to conduct the impact assessment. After conducting the field visit, the categorisation of stakeholders into stakeholder groups became more straightforward due to a better understanding of the context in which they operated. Therefore, a future recommendation is to adhere to the predefined stakeholder categories and establish clear assignments of stakeholders to specific categories from the beginning even though it can be challenging.

Stakeholder impact subcategories

After a literature screening, decisions were made regarding the inclusion and exclusion of various stakeholder subcategories based on their relevance to the Namibian context. Indicators for these subcategories were selected based on screening indicators from the literature, considering different criteria. These selections were revised after the field study to ensure their relevance. However, a future approach may benefit from consulting stakeholders at an earlier stage, as stakeholder input can help in selecting and prioritising a final set of context-specific subcategories and indicators that are the most socially relevant. Indicators established in literature can be too unspecific for a

case study, so involving stakeholders early on can help ensure the relevance and legitimacy of the assessment (Fürtner et al., 2021). A framework that could be followed in the future is one that uses a participatory approach for the identification and prioritisation of impact subcategories (Bouillass, Blanc, and Perez-Lopez, 2021). This collaborative approach could reduce the time required for screening and selecting relevant subcategories and indicators. As one of the main challenges with the guidelines lies in the methodological selection, normalisation, aggregation, and weighting of social indicators, which can limit data gathering and identification of social impacts (Bonilla-Alicea and Fu, 2022, Tokede and Traverso, 2020).

Indicator selection

Before selecting indicators, the type of impact assessment and reference scale used should also be selected. In this thesis, screening and selection of indicators were performed before a decision was made on how the reference scales would be developed to assess the indicators. After further research and consultation, the SAM method was chosen as a subcategory impact assessment to evaluate the social indicators. The basic requirement level in the SAM is defined by international agreements or indicators concerning organization management (Ramirez et al., 2014). The use of SAM required a re-iteration of the selection of indicators. The definition of the basic requirements of SAM can be used to define the performance reference points, from which indicators can be selected to collect the relevant data (Haryati et al., 2022). Using this approach immediately to select indicators would have most probably proven more time-effective than the approach used in this thesis and is, therefore, the recommended approach.

Reference scale development

During this thesis adjustments were made to the reference scales, to fit the Namibian context as the SAM method is based more on European reference points for the establishment of the basic requirements. Additionally, new reference scales had to be developed since new subcategories were added to the guidelines since the development of the SAM. Defining the basic requirement to be used in the evaluation of the subcategories proved to be a challenging part of developing reference scales, so selecting indicators that can be assessed by performance reference points can facilitate the development of new reference scales (Ramirez et al., 2016). Although the new reference scales cannot be compared to other studies yet, the use of a baseline scale in the SAM method should make the reference scales more comparable. Currently, the absence of established reference scales limits the comparability of studies not using the SAM method. The results are hard to compare if every study redefines the reference scales using its own performance indicators. The use of a standard baseline scale in future studies can increase the comparability of SLCA results (Traverzo et al., 2022). Thus, the use of the SAM framework to develop reference scales is a recommended approach, as it is beneficial for the standardisation of reference scales.

4.2.2 Data inventory

The collection of site-specific data required to conduct an SLCA is time-consuming and resource-heavy, posting limitations of data collection. A proposed list of stakeholders to interview was sent to the local partners so that they could arrange meetings with the stakeholders. This approach worked well and nearly all the stakeholders were able to be reached and engaged. During field visit in Namibia, 36 interviews were conducted, with on average 3 interviews a day. In Namibia, scheduling appointments with stakeholders did not require significant advance notice. The local partner contacted the stakeholders a few days or even a day ahead and the stakeholders were generally accommodating and willing to make time for an appointment. The presence of a local partner with an established network was crucial for setting up meetings and gaining introductions. In particular in accessing key individuals within the charcoal value chain and government. So engaging a local partner would definitely be a recommended approach to engaging key stakeholders, as well as

taking into consideration national holidays and distances to ensure the availability of stakeholders for interviews.

During the interviews, it was not always possible to collect data on all the indicators for a stakeholder category due to the semi-structured nature and time constraints of the interviews. Conducting interviews with multiple stakeholders helps with comprehensive data collection and duplication. Therefore, if time permits, it is advisable to review collected data after each interview and identify if any data needs to be collected in subsequent interviews. Furthermore, a suggestion would be to introduce the SLCA approach to stakeholders, in addition to the biohub and Clean Shipping project, so that they understand why questions are being asked about social issues.

The prioritisation exercise during the workshop was successful with the Mentimeter tool to rank the subcategories (Mentimeter, n.d.). As it was simple for the stakeholders to fill in their rankings and real-time data was shown on the screen which allowed for immediate discussion of the results. However, not all participants filled in the complete rankings, leading to missing data. To mitigate this, it is recommended to highlight the importance of completing the rankings accurately and monitor participants progress to ensure proper completion of the rankings. Afterwards, the results from Mentimeter could be exported to Excel making it easy to perform further analyses and weighting. Mentimeter is thus a recommended tool because it is user-friendly for all stakeholders and facilitates straightforward data analysis in Excel.

4.2.3 Results

Risk assessment

For the social risk assessment, the indicators and risk levels were specifically selected and developed for this thesis. Alternatively, online databases such as the Social Hotspots Database Product (SHBD) and Social Impact Life Cycle Assessment (PSILCA) can be utilised, although they require a license or subscription (UNEP, 2020). These databases offer extensive social data on risks or opportunities at the sector or country level for certain product systems. This high level of aggregation in country-specific sectors can present challenges when looking at specific product systems. As data for these databases is frequently retrieved from international statistics agencies that only cover country-level data (Indrane, 2019). Also, these databases also have other limitations, SHBD for instance does not cover all countries (Tsalidis et al., 2020). Nonetheless, utilising these databases can serve as an initial screening to identify social risks prior to an in-depth study such as SAM. The results derived from these databases at both the sector and country levels can enhance understanding of the organisational performance. Future research could explore integrating the use of one of these databases for screening social risks and subsequently using the SAM method for performance assessment (Tragnone et al., 2023).

Social performance impact assessment

For the impact assessment, the process of assessing site-specific data against reference scales proved a complex task due to the aggregation of multiple stakeholders into one stakeholder group. This aggregation is due to limitations in data collection, resulting in the need to combine different stakeholders into one category, such as combining the workers employed in charcoal production and processing into the category workers. This can make assessing an indicator complex if there are different working conditions and situations for both types of workers. Due to time constraints, it was not possible to interview charcoal processor workers, otherwise, it could have been possible to separate these workers and perform another SLCA. As a result, aggregation can lead to a loss of information. To address this limitation, it is important to provide not only the score but also a nuanced description explaining the rationale behind the given score for each subcategory and indicator. Just assigning a score fails to provide insights into the actual situation and the context of social performance (Ramirez et al., 2016). In future studies aiming to conduct informative SLCAs, avoiding aggregation would be recommended to prevent the loss of information. However, if the goal

is a comparative type of analysis, aggregation can be beneficial for the comparison amongst different production systems (Bonilla-Alicea and Fu, 2022).

The search for standardisation within the field of SLCA still continues and significant progress needs to be made before it reaches a level of standardisation comparable to the LCA. As no standardised approach is yet available, it is important for further research and to develop a robust framework for SLCA that incorporates both qualitative and quantitative data to assess social performance (Haryati et al., 2022). As a start to standardize a framework for SLCA, databases such as SHDB or PSILCA can be used for identifying social hotspots. For evaluating social performance, the SAM can be used as an impact assessment framework (Huarachi et al., 2020). In combination with the guidelines and methodological sheets, these methodologies could pave the way to establish a more standardised approach for conducting an SLCA.

To conclude, the recommendations for conducting future SLCAs are:

- Follow guidelines and sheets for goal and scope definition
- After literature screening engage stakeholders in a participatory approach for the identification and prioritisation of impact subcategories
- When conducting an informative SLCA avoid aggregation of categories
- Use SAM impact assessment framework. The basic requirements of the reference scales aid in identifying performance reference points and indicators necessary for data collection
- For social hotspot identification use online databases (SHDB/PSILCA)
- Collaborate with local partners to engage stakeholders
- Impact assessment results should provide scoring and rationale behind the score

4.2.4 Limitations

The SLCA is a useful tool for assessing social impacts, however, it is important to recognise its and this thesis's limitations:

Subjectivity

Performing an SLCA involves incorporating subjective input from stakeholders, which produces potential biases in the results. To ensure the data quality, multiple stakeholders were interviewed and data was also validated by using additional literary sources. Although the multitude of stakeholders involved also makes it challenging to capture the full range of social impacts accurately due to the complexity of social issues. Also, diverse interpretations can arise about social issues during interviews. Especially during the interviews a lot of "reading between the lines" was required to grasp the real context. Which highlights the importance of discussing the results with multiple people.

Data availability

A significant limitation of this thesis was the limited data availability. This is mostly due to not being able to collect comprehensive site-specific data on all stakeholders. Engaging charcoal workers was particularly difficult, partly because of the language barrier, they could not grasp the questions being asked. To compensate, other stakeholders were asked questions regarding workers for supplementary data. Also, engaging the local community was challenging due to cultural limitations that required obtaining permission from the traditional authorities first before conducting interviews with any member of the community. To increase the credibility and robustness of the SLCA on the charcoal

value chain it would have been beneficial to interview more stakeholders to gain a broader perspective and to avoid aggregation of stakeholder groups. The aggregation of data across stakeholder groups simplified the results and could have resulted in the loss of nuances and context-specific information. Nonetheless, the data obtained from the field study and used in the SLCA still serves the purpose to aid in decision-making processes.

Lack of standardisation

The lack of a standardized framework for conducting an SLCA contributes to variations in methodologies, selection of impact categories and indicators and interpretation. Consequently, it will be challenging to directly compare this case study with other studies if a different methodological framework is used. However, the lack of standardization and comparability in SLCA remains an inherent challenge, enhanced by the different contexts in which SLCA studies are conducted. As far as we know there has been no SLCA conducted before in Namibia, so this study cannot be compared to another SLCA in the same context.

Addressing a part of these limitations will require further research and development of SLCA methodologies and standardisation. In order to ensure the data quality of this thesis, one approach could be conducting a sensitivity analysis to assess to what extent the conclusions of this SLCA may have been influenced by the assumptions and choices made in scope definition, inventory and impact assessment. Alternatively, an independent critical review of this SLCA could be conducted to enhance its overall quality and credibility.

4.3 Future research recommendations

The next step for the Clean Shipping project in Namibia is to perform additional environmental assessments and develop an inclusive business case that addresses the needs of local stakeholders and aims to ensure a fair distribution of wealth within the value chain. Extra investigations would be needed to find a way to engage the local community on communal lands and explore ways to benefit them beyond employment and the supply of biochar. Furthermore, the development of a pilot plant using HTL technology in Namibia could be beneficial. As a pilot plant would serve as a demonstration of the technology's readiness and showcase its feasibility within the Namibian context, thereby garnering support from the local stakeholders and fostering confidence in its implementation.

One promising avenue for research is exploring collaboration and possible integration between the Clean Shipping project and the planned Green Hydrogen project in Namibia. This project aims to use renewable energy sources in Namibia to produce green hydrogen and its derivatives and supply industrial centres (Ministry of Mines and Energy, 2022). Combining these two projects could combine solving the bush encroachment problem, whilst using green electricity to produce biofuels.

Another research area worth investigating is if the bio hub could utilise carbon credits or emission trading systems as a possible additional economic revenue stream. However, for Namibia, further research will be needed before this is possible. First of all, there have been significant scientific debates on the carbon sequestration potential of bush-encroached land and rangeland ecosystems. Especially regarding the effect of bush control on soil organic carbon levels, which is linked to soil fertility and carbon sequestration. Evidence suggests that rangelands have higher levels of carbon storage, due to increased soil organic carbon content, which can help offset emissions resulting from biomass removal (MEFT, 2022, Brown et al., 2018, Archer et al., 2017). So, further detailed studies on the impact of bush control on soil organic carbon would be needed. In addition, Namibia still needs to develop the key building blocks such as a carbon market policy framework and Carbon Market operations that are required to set up the emission trading systems (UNDP, 2022).

Furthermore, advancements in technology can play a crucial role in optimising the harvesting process and biomass quantification. Developing machines capable of withstanding the toughness of encroacher wood and prolonging their operational lifespan is essential for (semi) mechanised

harvesting. The biomass quantification tools could be optimised to reduce manual input and farm visits required and improve the accuracy and time efficiency of the estimations. For example, further development of biomass quantification tools with machine learning and computer vision to differentiate between trees and identify areas for harvesting could be investigated (Marggraff and Venter, 2020).

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Appendix A

Aggregation, reclassification and exclusion subcategories

A.1 Reclassification and aggregation of subcategories

Aggregation

The stakeholder categories value chain actors and consumer are aggregated together in the study to form the category value chain actors. A few of the subcategories can be aggregated to further slim down the number of subcategories and consequently the amount of indicators needed. The next part describes the subcategories that will be aggregated together and will have the same indicators to assess the subcategory.

Public commitments to sustainability
The subcategories transparency (stakeholder category consumers) and public commitment to sustainable issues (stakeholder category society) will be evaluated as one subcategory. The transparency subcategory evaluates whether the organisation communicates about all issues regarding its products and social responsibility in a transparent way. On the other hand, public commitment refers to an organisation's promise to its customers, shareholders, local community, or the general public that can be demonstrated transparently. Obtaining certification standards is a way to simultaneously provide information about the company's performance concerning social responsibility and commitment to sustainability. thereforee, these two subcategories will be aggregated and assessed through the acquisition of certifications.

Reclassification of subcategories to different stakeholder groups

A few subcategories have been moved from their original stakeholder category and are assessed in another subcategory. This choice was made after the field trip, during which it was determined that certain subcategories were better suited for another stakeholder category. The context in Namibia is used to illustrate the reason why the reclassification was thought more appropriate.

Smallholders: In the guidelines, the smallholder subcategory were assessed under the stakeholder category workers. However, due to the fact that most people living in the communal areas are smallholder farmers, the subcategory will be moved to the stakeholder category local community for assessment. Between 60% and 70% of the Namibian population practice subsistence farming on communal land, which means that smallholders are an integral part of the local community (NPC, 2019). It should be noted that the workers within the value chain often have ties to smallholder

farming, as many return to their family plots during leave and are involved with farming activities (BW1, FU3).

Safe and healthy living conditions: Originally, the safe and healthy living conditions subcategory was included within the local community category. However, it has since been incorporated into the worker's category. This shift in categorization is due to the fact that the housing that the workers live in during charcoal production is provided by the farmers. The housing for the workers was frequently substandard, with housing constructed from plastic sheets and overcrowding being common occurrences (FU3). In addition, issues with a lack of access to proper sanitation and potable water have been mentioned (Dieckmann and Muduva, 2010, Cert1). Given that workers are obliged to reside in these conditions, it seemed more appropriate to assess this subcategory as part of the worker's category.

Local employment: The subcategory local employment was initially included in the local community category, however, it has since been moved to the value chain actors category. This reclassification was done as the value chain actors are the ones who can employ people from the local community and have influence over the hiring process.

Access to material resources: Originally this subcategory was assessed under the local community to assess how communities and organisations share the use of material resources. The methodological sheets suggest that organisations should conduct a risk assessment for potential conflicts over material resources and engage with the local community for sustainable resource sharing. Additionally, they should establish risk management plans to prevent environmental damage, including sustainable use of natural resources. In this case, the encroacher bush is widely available on the lands of the local community, providing them with sufficient access to the material resource. However, the community is legally not permitted to use the encroacher bush for charcoal production due to past unsustainable use and harvesting practices. thereforee, since the community currently lacks access to the utilisation of the encroacher bush, the subcategory will be evaluated based on the value chain actors who are permitted to use it.

Respect for indigenous rights will be assessed under the same stakeholder category local community. The people living in communal areas have distinct forms of self-governance and rules and regulations, differentiating their rights from the rest of the country (Republic of Namibia, 2002). However, the term "communal" will be used instead of "indigenous", as the Namibian government prefers not to use the term indigenous as it is in reference to European colonialism and therefore not deemed appropriate to use in this thesis (FSC, 2019).

A.2 Exclusion of subcategories

The following subcategories will not be included in the analysis for the case study as they are not considered relevant in the Namibian or value chain context. Another reason for emission can be due to the challenge of assessing a subcategory due to difficulty of data-collection. The challenge can be in the availability of data or sensitivity of the topic.

Workers

Sexual Harassment subcategory assesses whether under working conditions sexual harassment is tolerated or occurs. Sexual harassment is considered a widespread issue in Namibian workplaces. The consensus is that it arises from power imbalances, cultural factors, and a lack of consequences (Adel-Sheehama, 2019). Despite being a prevalent issue, it is significantly under-reported. A study by den Adel-Shehama (2019) focusing on harassment reported difficulty in obtaining data as it often involves sensitive, personal and traumatic topics. Fear of retaliation or victim blaming may have also deterred disclosure from respondents. Due to the difficult nature of collecting accurate data for this subcategory, it will be omitted from assessment in this case study.

Child labour subcategory examines if employment prevents children from experiencing childhood, reaching their full potential and is harmful to their physical and mental development. Very few children were found working in the production of charcoal in Namibia. However, a concern can be that children are often present at the worksite, which can pose a health risk to them and prevent them from receiving an education (Dieckmann and Muduva, 2010). This could be assessed in the future if children are also considered a stakeholder in the value chain. Namibia has recorded a total of ten child labour cases between 2015 and 2021 and the Labour Act prohibits the appointment of a child under the age of 14 for employment purposes (Matthys, 2022). This subcategory will be omitted from the evaluation as child labour does not appear to occur frequently in Namibia.

Forced labour assess if anyone is forced to work involuntarily under threat for an organisation. Namibia has taken steps to combat forced labour by ratifying the Forced labour protocol in 2014 and aims to end forced labour for good, which was pervasive under colonial rule (ILO, 2017). No formal allegations of forced or compulsory labour were reported, however, the government did not effectively enforce the law and resources and inspections were inadequate (United States Department of State, 2017). As Namibia has laws prohibiting forced labour and no formal cases of forced labour have been reported, this subcategory will be excluded from the assessment as it is not relevant.

Local community

Secure living conditions assesses how organisations contribute to insecure living conditions, community tensions and regional conflicts. As Namibia is a conflict-free country it should not be necessary for the employment of security forces to protect employees of the value chain (HIIK, 2022).

Access to immaterial resources assesses an organisation's respect for community services, intellectual property rights, freedom of expression and access to information. Since the charcoal value chain does not involve advanced technologies and other and other SLCAs on biobased value chains hardly cover this subcategory, it is chosen to exclude the subcategory for this assessment (Fürtner et al., 2021, Marting Vidaurre et al., 2020).

Delocalization and migration is a subcategory that examines whether organisations contribute to involuntary resettlement, migration, or delocalization within communities. In the charcoal industry, seasonal workers are predominantly employed in short-term contracts and they live on-site at the farm (Dieckmann and Muduva, 2010). However, the workers do not permanently relocate to the area where harvesting takes place but rather return to their family homes when on leave (FU3, F2, Cp1). As this only involves the temporary resettlement of workers, this subcategory will be omitted from the assessment.

Value chain actors and consumers

Promoting social responsibility evaluates if an organisation considers the interests of its stakeholders and creates shared value. Since numerous activities that promote social responsibility, such as supplier code of conduct, contractual agreements and environmental responsibilities, are evaluated in other subcategories it has been excluded from this assessment. Moreover, this subcategory is also one of the least assessed subcategories in biobased value chains (Marting Vidaurre et al., 2020).

Respect of intellectual rights checks if the creation of value of intellectual goods and services is safeguarded through patents, copyrights and trademarks. In the charcoal value chain established technologies for harvesting and production are used. While it may be a possibility that in the future an improved or new technology could be developed and possibly patented, it is currently not yet relevant.

Health and safety of consumer refers to the right of the consumer to be protected against products or services that may be hazardous to their health. When charcoal is used for grilling food, the fumes emitted could be a potential health hazard due to inhalation, dermal contact exposure or ingestion. Exposure can however depend on time spent grilling, distance kept from the grill, wind direction etc. Currently, there are no legal regulations regarding emissions or health risks associated

with exposure to pollutants from grilling, except for occupational exposure (Badyda et al., 2022). Due to difficulty obtaining data on health risks associated with charcoal grilling per consumer, as various factors can affect exposure and lack of legal restrictions this subcategory will be excluded from this assessment.

End-of-life responsibility considers the recycling, disposal or re-use of a product. Charcoal is a one-time-use product, as most of it is consumed during grilling. Once the charcoal has been burned, it turns into ash and can be disposed of in the trash or can be re-used as a fertiliser in the garden for example (Benett, 2015). The end-of-life responsibility subcategory will be excluded from the assessment due to the limited relevance and practicability of gathering data for all end-of-life scenarios throughout the timeframe of this case study.

Fair competition assesses whether an organisation's competitive operations are carried out fairly and in accordance with laws that forbid anti-competitive, anti-trust, or monopolistic practices. A limitation of this subcategory is that even if an organisation commits to refrain from engaging in or being complicit in anti-competitive behaviour, it is difficult to obtain information about possible violations (UNEP, 2021. Due to time constraints in collecting data and data availability limitations, this subcategory will be excluded from the assessment.

Consumer privacy assesses whether an organisation can safeguard its consumer's privacy. Given that the value chain is not involved in activities that require personal information from its consumers, this issue is considered not relevant and can thus be left out of the assessment.

Society

Prevention and mitigation of armed conflicts considers how an organisation acts in conflict zones. Namibia is considered a peaceful country ranking 68 out of 168 countries on the Global Peace Index (Global Peace Index, 2022). There are also no conflicts reported in Namibia in 2021 (HIIK, 2022). Therefore it can be concluded that the value chain does not need to operate in a conflict zone and that this subcategory can be excluded from the assessment.

Ethical treatment of animals assesses how animals might be affected by the product system. In the case of the charcoal value chain, animals are not involved in the production process. Nonetheless, there is an indirect impact, as charcoal production can lead to rangeland restoration post-harvesting, which can lead to an increase in the availability of grasses for animal grazing. This is also the main reason why farmers produce charcoal, to increase the carrying capacity of their land and increase livestock production (De Klerk, 2004). However, as this is an indirect impact, it will not be taken into account for this case study but should be taken into account in future assessments concerning encroacher bush.

A.3 Indicator selection

The initial selection of indicators using a multi-criteria analysis is given in the supplementary data sheet called indicator selection. The score (1/2/3) for each criterion, data availability, practicality and relevance, is given after each indicator. The indicator per subcategory with the highest score was then selected for further investigation. The selection of indicators was re-iterated after the field study and therefore what is selected in the sheets may not be the indicator selected for the final assessment.

Appendix B

Risk assessment

The risk level scale is divided into four levels: low risk, medium risk, high risk or very high risk. Each level is categorised by numerical values from indexes or global performance indicators of countries. Specifically, the best-performing indexes are categorised as low risk, while the worst-performing indexes are classified as high risk. The remaining indexes with values falling between these two extremes are classified as medium risk. Table 14 provides an overview of how various indexes are categorised according to their associated risk levels and what the Namibian score is with the associated risk level. For the unemployment rate global performance indicators are used instead of an index. The reference scale risk level percentages are based on the World Bank colour scales, which utilises percentages higher than 16.7% to indicate the countries with the highest unemployment rates(The World Bank, 2021). Thus, this percentage is used to classify countries into a very high-risk level. The other levels are calculated based on that it takes three levels to reach higher than 16.7%. The nominal GDP is used in order to compare Namibia's GDP to those of other countries. This involves converting each country's GDP value into US dollars to enable a direct comparison (Callen, n.d.). To give an indication of where Namibia ranks compared to other countries, the GDP is categorised into reference scales to assess the risk level. The countries with the lowest 50 GDPs are categorised under the very high-risk level. The next 50 countries with slightly higher GDPs are categorised under the high-risk level. The countries with the highest GDPs are categorised under the low-risk level. This categorization will provide a clearer picture of Namibia's GDP in comparison to other countries. Due to data limitations in more recent years, the comparative analysis of all countries is based on the most recently available data from 2021 (World bank, 2021a).

Table 14: Generic data was used to perform a risk assessment of indicators, categorizing the risk levels using characterization levels of indexes or global performance indicators of countries. The score for Namibia is given and the associated risk level highlighted.

Stakeholder category	Subcategory	Indicator	Risk level	Level characterization	Namibia score	Reference
Workers	Equal opportunities	Gender gap index	Very high risk	0-0.25		
			High risk	0.25-0.5		World Economic Forum, 2022
			Medium risk	0.5-0.75		
			Low risk	*0.75-1*	0.80	
Value chain actors	Wealth distribution	Gini index	Very high risk	75-100		
			High risk	*50-75*	59.1	World bank, 2015
			Medium risk	25-50		
			Low risk	0-25		
	Local employment	Unemployment rate	*Very high risk*	*>16.7%*	21.3%	
			High risk	11-16.7%		ILO, 2021
			Medium risk	5.5-11%		
			Low risk	0-5.5%		
Local community	Smallholders	Food security	No data	No data	No data	
		Standard of living	No data	No data	No data	
Society	Contribution to economic development	GDP	Very high risk	<8.41 bill		
			High risk	*8.41-28.73 bill*	12.31 bill	World bank, 2021a
			Medium risk	28.73 bill -223.24 bill		
			Low risk	>223.24 bill		
	Poverty alleviation	Multidemnsional poverty index	Very high risk	0.75-1		
			High risk	0.5-0.75		NSA, 2021
			Medium risk	0.25-0.5		
			Low risk	*0-0.25*	0.19	
	Risk of corruption	Corruption index	Very high risk	0-25		
			High risk	*25-50*	49	Transparancy international, 2021a
			Medium risk	50-75		
			Low risk	75-100		

Appendix C

Reference scale development

The development of the reference scales in this thesis is based on the Subcategory Assessment Method (SAM) developed by Ramirez et al. (2014), further referred to as the SAM method.

C.1 Reference scales workers

Social benefits

For the subcategory social benefits, the BR is defined when the organisation provides the mandatory social benefits under the Social Security Act 34 of 1994; Maternity leave, Sick leave and Death benefit Fund (Republic of Namibia, 1994). organisations that offer their workers at least 2 of the listed social benefits are assigned a Level C assessment, while those that provide no social benefits receive a Level D assessment. Level A is given when the organisation offers more social benefits than is legally necessary.

Working hours

For the subcategory of working hours, the BR is specified as the average number of hours worked per week by employees, which should not exceed 9 hours per day and 45 hours per week, in accordance with the Labour Act, 2007 (no. 11 of 2007). An organisation is given a level C assessment when the average number of hours worked per week is below the sector/country average. If the average number of hours worked per week exceeds the sector/country average, the organisation is assessed at level D.

Freedom to join a union

The basic requirement for the subcategory freedom of association and collective bargaining is that the organisation provides evidence that its employees are members of a union (ILO, 1948). Level A is given if the employees are members of one or more unions and the organisation recognizes the collective representation of unions in negotiations. The SAM method defined levels C and D based on the Workers Rights Score in the country where the organisation was located from the CIRI Humans Rights Dataset. However, this dataset was updated annually from 1981 to 2011 and is therefore outdated (Cingranelli and Richards, 2014). That is why the Global Rights Index is used instead, which assesses the violations of collective labour rights by governments and employers. The methodology is based on established standards of fundamental labour rights, in particular civil liberties, the right to establish and join unions, trade union activities, the right to collective bargaining and the right to strike. These are evaluated based on 97 indicators that are derived from ILO conventions and jurisprudence. The countries are rated on a scale from 1 (best) to 5+ (worst) (ITUC, 2022). Therefore, an organisation that does not meet the BR in a country with a high score

(1-3) is assessed at level D (positive context). Otherwise, it is assessed at level C (3-5+) under a negative context.

Formal contract

The Basic Requirement for the subcategory of the employment relationship is determined by the type of contract provided to employees. When a formal contract is given and the employee is covered by the Labour Act 2007, the Basic Requirement is met. As the Labour Act 2007 establishes a labour law for all employers and employees. It seeks to protect fundamental labour rights, regulate basic terms and conditions of employment, ensure the health, safety and welfare of employees and protect them from unfair labour practices. The organisations are assessed as level C when they offer a temporary contract since, employees, as independent contractors, are not protected by the Labour Act (Republic of Namibia, 2007). Level D, is given when an informal employment contract is given as this is not legally binding or enforceable and does not provide the employee with any protection (ILO, n.d.). Level A is assigned when the organisation has fulfilled the basic requirement and also provides a fair and equitable compensation and benefits package. This indicates the organisation's commitment towards enhancing its work environment and showing appreciation and acknowledgement for employees' work (Dutta, 2023).

Fair salary

The Basic requirement for a Fair salary is that the lowest salary is equal to or higher than the minimum wage of the sector/country. Currently, the minimum wage set for the agricultural sector is 5.40 NAD per hour, which amounts to 972 NAD per month for a 45-hour work week (Republic of Namibia, 2021). The organisation is defined at level A if the lowest salary is equal to the living wage, which signifies an income level that is capable of fulfilling a person's basic needs and maintaining a decent standard of living. The living wage in Namibia is 6,400 NAD per month, which is significantly higher than the minimum wage (Traverzo et al., 2022). Consequently, the difference between level C and level D assessment will be based on the poverty line wage instead of the living wage (Traverzo et al., 2022). Level C is thus given if the lowest salary is below the minimum wage but above the poverty line (breadline) wage. Level D is given if the lowest salary is equal to or below the poverty line wage, which is 21 NAD dollars per day (World Bank, 2021).

Health and safety

The basic requirement for this subcategory is that the organisation should have a policy related to health and safety and provide a working environment that is without risk to the employees based on ILO convention No.161 and Labour Act, 2007 (ILO, 1985, Republic of Namibia, 2007). While SAM defines levels C and D based on the rates of fatal and occupational injuries, that data is not available for the charcoal sector in Namibia. So a revised definition will be used, where Level C will be assigned if there is no strong health and safety policy in place with evidence of workers not fully complying with obligations on safety practices. If there is no health and safety policy in place Level D will be assigned. Level A will be assigned if the organisation implements the health and safety practice beyond the industry standards (Traverzo et al., 2022).

Equal opportunities

When analysing the subcategory equal opportunities, the basic requirement is defined as the organisation has a management system, policy or actions in place to prevent discrimination and promotion of equal opportunities for workers, in accordance with ILO Conventions No.100, and No. 111. These are the ILO conventions ratified by Namibia and concern equal remuneration and discrimination (ILO, n.d.). Level A is assigned when the organisation proactively implements this policy and ensures equal pay and equal opportunities. The SAM method used the Gender Equity Index to differentiate between levels C and D, however, since this index is only available for Europe, the Global

Gender Gap Index will be used for this thesis. By comparing gender gaps across four dimensions: economic opportunities, education, health, and political leadership the Global Gender Gap Index evaluates advancements toward gender equality. The index does not measure the country's level of development but rather measures gender-based gaps in access to resources and opportunities. The indicators and the index have a maximum score of 1 (gender equality) and a minimum score of 0 (gender inequality) (World Economic Forum, 2022). Using a similar method to SAM, countries were ranked in two levels: those who scored from 0-0.49 (lowest levels of equality) and those that scored above 0.50 (higher levels of equality). An organisation that does not fulfil the Basic Requirement and operates in a country with higher levels of equality is assessed as level D. Otherwise, it is assessed as level C, operating in a country with high inequality.

Safe and healthy living conditions

The basic requirement is that the organisation must provide the employee with adequate housing including sanitary and water facilities set by the FSC standards and Labour Act 2007 to ensure safe and healthy living conditions for the employee. Level C is assigned if the organisation fails to meet the minimum housing standards, while Level D is assigned when no accommodation is provided to workers. When an organisation provides a higher standard of housing to the employees than the minimum housing requirements, it is granted a Level A assessment.

C.1.1 Reference scales value chain actors

Local employment

The basic requirement for local employment is that there is evidence of the organisation's local hiring preferences, with at least 50% of the entire workforce being hired locally. The SAM method differentiates levels C and D by the employment-to-population ratio of the country where the organisation is located. It measures the number of people employed against the total working-age population, which can be used as a general indicator for labour unemployment (Estevez, 2022). Level C is assigned when the ratio is lower than 50, indicating that a large share of the population is not directly involved in the labour market. Level D is assigned when the country has a ratio higher than 50, meaning that a large population of the country is employed. Level A is assigned when the organisation can demonstrate that the majority of its employees are hired locally.

Public commitments to sustainability

In the case of the subcategory public commitments to sustainability, the basic requirement is the evidence of any promise or agreement related to sustainability and social responsibility, which is disseminated to the public, for example by obtaining certifications. The SAM method distinction between a C-level and a D-level assessment depends on the presence or absence of proven cases that the organisation has violated commitments to sustainability. It refers to any issue related to the organisation that could harm society environmentally, socially, or economically. Level D is assigned when the organisation has a history of proven cases of violations to commitments of sustainability in the last three years. The cut-off criterion of three years was established by the SAM method. If there is no evidence of such violations, it is assessed at level C. Level A is assigned when there are multiple public commitments to sustainability by the organisation, showcasing proactive behaviour toward sustainability.

Access to material resources

For this subcategory, the reference levels have been made more specific to the Namibian context and specifically concerning the sustainable harvesting of encroacher bush. The basic requirement will be the presence of an internal management system, such as FSC certification, that is concerned with sustainable and selective harvesting. This specific requirement has been chosen to align with the

FSC standards which for example prohibit the harvesting of protected trees and emphasize patch harvesting to maintain spatial heterogeneity (FSC, 2019, De Klerk, 2004). Level A is given when there is evidence that the organisation implements multiple additional measures to ensure sustainable harvesting such as biomass quantification, sustainable and selective harvesting and continuous aftercare rangeland restoration. A level C will be given in the absence of an internal management system, coupled with unsustainable and unselective harvesting practices. Examples of such practices include the harvesting of protected species or trees with trunks broader than 18 cm, which is environmentally harmful. Level D is given for cases of over-harvesting where all bushes are eliminated or killed, which can have negative impacts on the ecosystem and lead to heavy re-infestation (Markstein, 2020).

Supplier relationships

For assessing the subcategory of supplier relationships, the presence of a code of conduct with clearly defined ethical standards that are communicated to the organisation's suppliers is the basic requirement. To differentiate between levels C and D, the SAM method typically uses a supplier satisfaction survey. However, an alternative distinction will be used, due to the practical challenges of conducting such a survey within the time frame of this thesis. Specifically, level D will be assigned when the organisation lacks a code of conduct and has no supplier relationship beyond basic purchasing transactions. Level C will be given if a supplier relationship exists, despite the absence of a code of conduct. An example of this is a sense of commitment to the supplier, giving adequate lead time and allowing for volume fluctuations (UNEP, 2021). Finally, level A will be assigned to an organisation that possesses a code of conduct and demonstrates strong supplier relationships.

Respect of communal rights

The reference scales are based on the SAM method with the basic requirement being that there is evidence that the organisation has a communal rights policy or a commitment to adopt free prior consultation. The word "indigenous" has been changed to "communal" to be more culturally appropriate. Levels C and D are assigned if the basic requirement is not met and there is documented evidence of discrimination against the community in the past three years. Level A will be given when the organisation shows proactive behaviour regarding communal rights policy and commitments to implement free prior informed consultation when operating on communal lands. The organisation also engages in regular consultation and engagement with communities and incorporates their feedback into its operations.

Cultural heritage

Cultural spaces and objects, social and religious practices, knowledge, and traditional craftsmanship are all included in cultural heritage. Traditional craftsmanship can also include agricultural production methods, which is relevant in the Namibian context. That is why when analysing the subcategory cultural heritage, the basic requirement is that there is evidence that the organisation contributes to the preservation of cultural heritage through contributions to traditional agricultural practices. Level A will be assigned when the organisation actively promotes the preservation of cultural heritage by promoting the use of traditional products and craftsmanship in their production methods (UNEP, 2021). In the SAM method, the assessment levels C and D are determined by the risk of cultural heritage disappearing in the country where the organisation operates. The assessment uses the UNESCO list of world heritage sites in danger (UNESCO, 2023). If the country has a cultural heritage site listed as endangered, the organisation is assigned level D. Otherwise, if the organisation operates in a country without any heritage sites in danger, it receives level C.

Community engagement

The basic requirement for the subcategory community engagement is evidence that the organisation recognizes the importance of the environment, welfare, or health of the community. This could be demonstrated by the implementation of an environmental management system, risk analysis or community initiatives. Level A will be assigned when the organisation demonstrates proactive efforts to improve the community's environment, health and welfare and engage the community in decision-making processes (UNEP, 2021). The SAM method differentiates between levels C and D based on the presence or absence of records of proven cases where community groups/members have been affected by the organisation. When an organisation does not meet the BR and has documented cases of the organisation negatively affecting the community in the last three years it is assessed at level D. If the cases are not documented, it is assessed as level C.

C.1.2 Society

Contribution to economic development

When analysing this subcategory, the basic requirement is met when the organisation provides a contribution to the economic development of a society. Economic development can be fostered in many ways, for example by revenue generation, value addition, job creation and providing education and training (UNEP, 2021). Level A is assigned to the organisation when it demonstrates a higher level of economic development contribution in comparison to other organisations within the same sector. Level D is assigned when there is a record of proven cases of the organisation damaging or restraining the economic development of the region within the last three years. If there are no records of proven cases, level C is assigned. The differentiation between levels C and D is based on the SAM method.

Technology development

Technology development and transfer can encompass various elements such as capacity-building, enabling environments, technology needs and information and financial and institutional mechanisms. That is why for the subcategory technology development, the basic requirement will be fulfilled if the organisation demonstrates participation in joint research and development for efficient and environmentally sound technologies (UNEP, 2021). when an organisation has a higher expenditure on research and development of technologies compared to other organisations within the same sector, it is scored as Level A. The SAM method differentiates levels C and D based on the level of investment in technology development by country, which is measured by the research and development expenditure relative to the GDP. This gives a perspective on how a country is building its capabilities in science and technology to improve its national economy and society (Boroush and Guci, 2022. If an organisation operates in a country with high research and development expenditure ($>$ 2.35 % GDP) and does not meet the basic requirement, it is assessed as level D (positive conditions). Otherwise, if the organisation operates in a country with low research and development expenditure (0-2.35% GDP), it is assessed as level C (World bank, n.d.).

Appendix D

Interview guide

D.1 Introduction

1. Personal Introduction
   (a) Provide a personal introduction, introduce the organisation, and confirm the interviewee's role.
   (b) Discuss their current role in the organisation and the activities they are involved in.
2. Sector Introduction
   (a) Explain the current system in place.
   (b) Discuss the purpose behind the current practice.
   (c) Explore the biggest challenges and issues faced in the current system.
   (d) Ask for suggested measures or focal points for improvement.

D.1.1 Sustainability

1. Discuss present and expected challenges regarding sustainability.
2. Inquire about current projects/activities related to improving sustainability (e.g., trainings, certification, organic fertilizers, etc.).

D.1.2 Previous Experience

1. Explore the interviewee's experience with bioenergy projects.
2. Discuss the challenges and opportunities encountered in previous projects.

D.1.3 Impact of New Bio-based Value Chain

1. Present the biohub infographic.
2. Discuss the impact (goals, challenges, benefits, and harms) of a new bio-based value chain in the region.
3. Inquire about the interviewee's interest in playing a role in the new value chain.
4. Identify their foreseen role in the value chain and ask for elaboration.

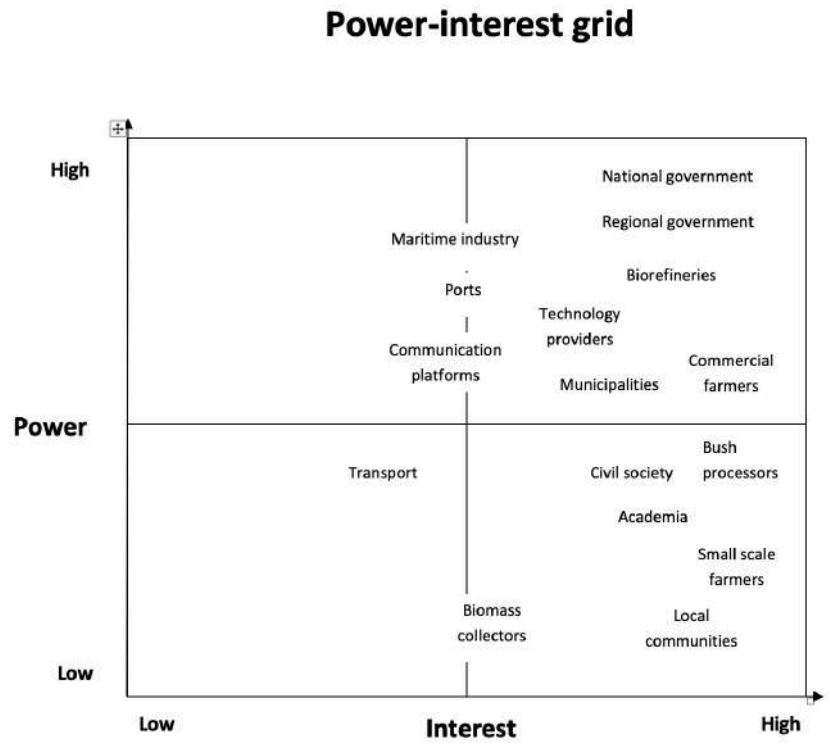

Figure 22: Stakeholder power-interest grid

5. Discuss the possible benefits for the organisation from the new value chain.
   (a) Explore the reasons for participating in a new value chain (e.g., employment opportunity, economic benefits, transitioning the sector, ensuring the use of renewables, expanding market reach, etc.).
   (b) Inquire about the importance of these reasons.
6. Discuss the hurdles preventing their participation in the new value chain (e.g., lack of capacity, funding, policies, infrastructure, trade agreements, knowledge, partnerships, etc.).
7. Inquire about potential harms that could threaten the existence/operation of a new bio-based value chain.
8. Discuss the disruptions that may occur in the sector and associated sectors.

D.1.4 Stakeholder Analysis

1. Discuss which actors the interviewee thinks should be included in a new bio-based value chain.
2. Inquire about any missing actors in the power-interest grid (see figure 22).
3. Seek their opinion on the positions on the power-interest grid.

D.2 Stakeholder Specific Questions

The questions will be shown in the next section per stakeholder category.

D.2.1 Closing

1. Summarize the key points discussed and ask if there is anything else the interviewee would like to add.
2. Discuss the possibility of follow-up contact.
3. Confirm agreements regarding records and publication.
4. Inquire about their willingness to participate in a workshop.

D.3 Questions for workers

1. What type of contracts used? Flexible fixed?
   (a) If not flexible: NO: Why is there no contract flexibility? Is this standard practice for the industry?
   (b) If flexible: YES: Is there (continuous) communication about the contract & code of conduct with adjustments made?
2. Pricing biomass
   (a) Is there a set price that is paid for the biomass?
   (b) How much value is added in the process to the biomass?
   (c) How much do the farmers receive?
3. What percentage of staff hired locally? Do the locals have the same chance/opportunity to receive a job offer if they apply for the same job compared to non-locals?
   (a) Does the company prefer to hire locally?
   (b) Does the company employ youth?
   (c) What is the men/women ratio of the staff?
4. By Namibian law, the maximum working hours are 45 hours a week and 9 hours a day. Do the employees/workers work more or less than these hours?
   (a) Does everyone in the bush sector work these overtime hours? Do they get paid for overtime? Do they have formal contracts?
   (b) Do they work part-time? Do they have formal contracts?
   (c) Do they have to stay out on the farms for the harvest? Is it seasonal work?
5. The minimum wage is 1653 NAD per month. Is this similar to the minimum salaries paid to the workers? Do they receive any extra compensation?
   (a) Would the minimum wage be able to cover all their and their families (basic) needs? Is any other compensation given, such as food or housing?
   (b) Do they feel that they receive a wage that is able to cover their and their families living costs? A living wage?

6. The social benefits that are mandatory by Namibian law are maternity leave, sick leave, and death benefit funds. What social benefits are provided to the employees? (Are the mandatory benefits provided?)
   (a) What social benefits would be most essential for a company to provide?
7. Does the company have a policy/guidelines related to health and safety? Are trainings given on how to safely use the equipment?
   (a) Have any accidents occurred? Do they happen more often in this company compared to others in the bush harvesting sector?
   (b) Does someone check if everybody is adhering to the safety measures?
8. Equal opportunities:
   (a) Are there policies for equal opportunities and prevention of discrimination in the company? If so, what are they?
   (b) If there are no policies: Do the employees of the farm reflect the ethnicity (tribal) and sex frequency of the community? Are an equal number of men and women employed?
   (c) If there are policies: How are equal opportunities promoted and discrimination prevented on the farm?
9. Freedom of assembly:
   i. Do workers belong to or have the freedom to join a farmers union?
   ii. If they do not belong to a union: Have others (employees) also not joined a union? Why?
   iii. If they belong to a union: Does the company negotiate with the unions?
10. Sustainability:
    a. Present and expected challenges regarding sustainability.
    b. Internal management systems that ensure sustainable use of natural resources.
       i. If there are no internal management systems: How do others in the sector perform resource extraction? Do they control it?
       ii. If there are internal management systems: How is resource extraction managed in a way that prevents resource depletion, waste, or pollution?
    c. Is the company's water use controlled to prevent drought/groundwater depletion?

D.4 Questions for value chain actors

1. Supplier relationships:
   (a) What type of contracts are used? Flexible or fixed?
   (b) If not flexible: Why is there no contract flexibility? Is this standard practice for the industry?
   (c) If flexible: Is there continuous communication about the contract and code of conduct with adjustments made?
2. Value distribution:
   (a) Is there a policy on how the value is distributed among the actors?
   (b) If there is no policy: Are value chain actors still getting a fair price for their products?

(c) If there is a policy: How is this information disseminated on websites or through certifications?

(d) Is there a set price that is paid for the biomass?

(e) How much value is added in the process to the biomass?

(f) How much do the farmers receive?

3. Joint research and development:

   (a) Is there joint research and development for environmental technologies that is shared via the organisation's website, promotional material, or with other companies/general public?

   (b) If yes: Is joint research one of the main properties of the organisation?

4. Employment:

   (a) What percentage of staff is hired locally? Do locals have the same chance/opportunity to receive a job offer for the same job compared to non-locals?

   (b) Does the company prefer to hire locally?

   (c) Does the company employ youth?

   (d) What is the men/women ratio of the staff?

5. Sustainability:

   (a) Present and expected challenges regarding sustainability.

   (b) Internal management systems that ensure sustainable use of natural resources.

      i. If there are no internal management systems: How do others in the sector perform resource extraction? Do they control it?

      ii. If there are internal management systems: How is resource extraction managed in a way that prevents resource depletion, waste, or pollution?

   (c) Is the company's water use controlled to prevent drought/groundwater depletion?

      i. If there is no control: What is the water usage of this company compared to other companies?

      ii. If there is control: Is the water reused/recycled in the process?

   (d) Public commitments to sustainability or social responsibility:

      i. If there are no public commitments/certifications: Why does the company not have public commitments/certifications? Does the company act in a sustainable and socially responsible way?

      ii. If there are public commitments/certifications: What certifications are there? How often are reports made or the validity of the certification checked?

   (e) Contribution to community health:

      i. If there are efforts to strengthen community health: How does the farm contribute to the health and safety of the community?

   (f) Contribution to regional economic development:

      i. If there is no contribution: Does the company extract resources and then export them with the revenue going to a foreign country?

      ii. If there is a contribution: Does the organisation provide a large contribution to the economy, in the form of employment, value addition, or reinvestment, compared to similar companies in the same sector?

      iii. Would it not be better to generate electricity for their own country as they are importing it from South Africa?

   (g) Current projects/activities related to improving sustainability:

      i. Are there any current projects or activities related to improving sustainability, such as trainings, certification, organic fertilizers, etc.?

D.5 Questions for Local community

1. Do the companies consider the rights of the indigenous people? Are the indigenous people consulted or do the companies have policies?
    i. If there is no consideration: How are the indigenous treated in the country? Do they have the same rights and opportunities as everyone else?
    ii. If there is consideration: How are the indigenous people consulted or involved?
    iii. Are there any involvement or activities on indigenous land?
2. Does the organisation make an effort to strengthen community health?
    i. Are there policies in place to communicate its effect on the health and safety of the community?
    ii. Are there environmental risk systems in place to contribute to the health and safety of the community?
3. How does the organisation involve the local community? Are meetings being held with representatives from the community?
    i. If there are no meetings: Is the local community affected by the company, and how is the relationship with the community?
    ii. If there are meetings: Are the community's input being used for decision making?
4. What are the living conditions of the community? Does everyone have access to the basic necessities?
5. Is there always enough food? What does the community do if there is a drought?

D.6 Questions for society stakeholders

1. Is there joint research and development for environmental technologies that is shared via the organisation's website, promotional material, or other companies/general public?
    i. If there is joint research and development: Is (joint) research one of the main properties of the organisation?
2. Has the company created job opportunities, value addition, or reinvested that has contributed to regional economic development? Is the revenue from exported goods reinvested in Namibia?
    i. If the company has not contributed to regional economic development: Does the company extract resources and then export these with the revenue going to a foreign country?
    ii. If the company has contributed to regional economic development: Does the organisation provide a large contribution to the economy, in the form of employment, value addition, or reinvestment, compared to similar companies in the same sector?
3. Sustainability:
    i. Present and expected challenges regarding sustainability
    ii. Current projects/activities related to improving sustainability (e.g., trainings, certification, organic fertilizers, etc.)

Appendix E

Workshop

The comprehensive results of all the rankings can be found in the supplementary data, in the Excel sheet called Workshop. Also, the functionality and implementation of the Mentimeter tool are shown in figure 24, showcasing the process of how the rankings for different subcategories were selected by the stakeholders. Participants engaged in the ranking exercise using their mobile devices and the results were subsequently presented on a laptop, enabling a discussion regarding the rationale behind their rankings (see figure 23).

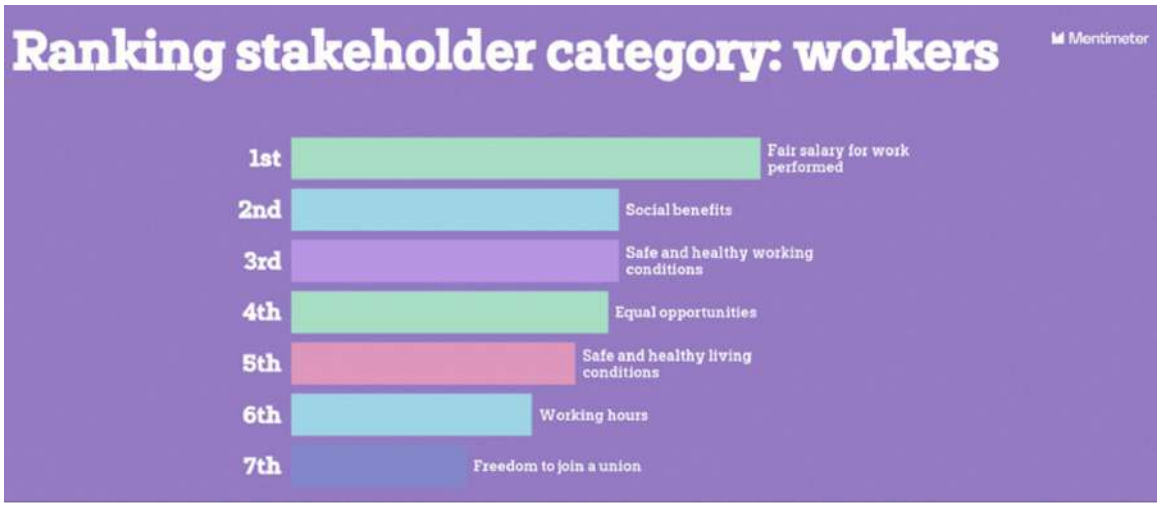

Figure 23: Example of ranking results of the worker subcategories from one of the three groups during the workshop.

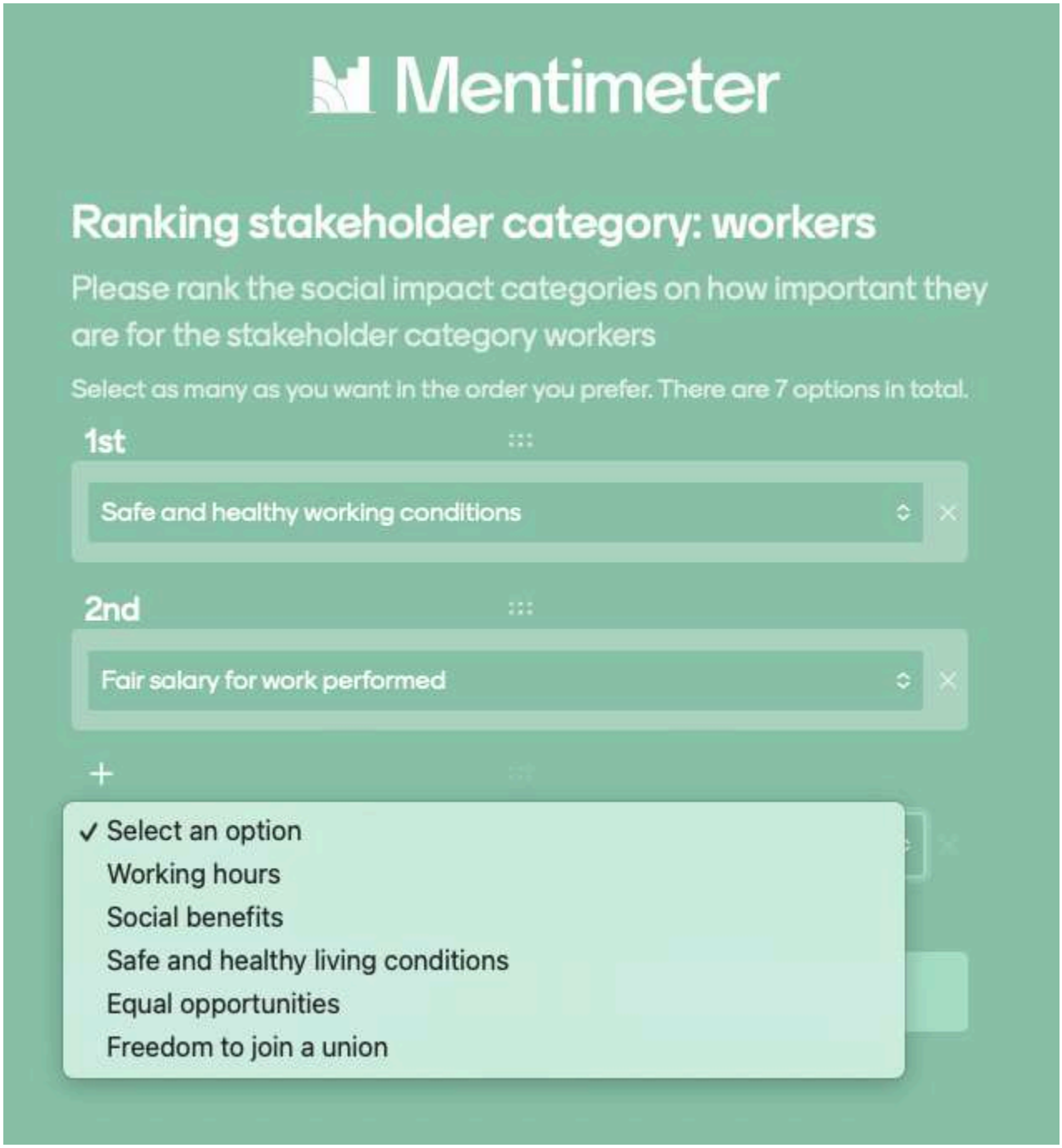

Figure 24: Mentimeter tool used for choosing the ranks of subcategories.