TOWARDS A JUST BIOECONOMY

LESSONS FROM EMERGING BIO-BASED VALUE CHAINS IN SPAIN, COLOMBIA AND NAMIBIA

SUSAN VAN DER VEEN

PROPOSITIONS ACCOMPANYING THE DISSERTATION

TOWARDS A JUST BIOECONOMY: LESSONS FROM EMERGING BIO-BASED VALUE CHAINS IN SPAIN, COLOMBIA AND NAMIBIA

BY

SUSAN VAN DER VEEN

1. Inclusive development of bio-based value chains requires not only adapting value chain design to local stakeholders' needs and capabilities, but must also be accompanied by institutional development to enable long-term impact.
   This proposition pertains to this dissertation.

2. Bioeconomy policies should adopt the Capability Approach to assess emerging bio-based value chains, since this perspective reflects the actual opportunities created for stakeholders.
   This proposition pertains to this dissertation.

3. Insisting on comprehensive, inclusive development from the outset of developing bio-based value chains may be unrealistic and could inadvertently leave the most vulnerable behind.
   This proposition pertains to this dissertation.

4. Multi-disciplinary research requires a constant balancing act: as a social scientist, you must make your work accessible to other disciplines without oversimplifying it to the point where its complexity and unique contribution are lost.

5. Even though it is widely known that the social dimension of sustainability is crucial for the transition to a sustainable bioeconomy, companies, policymakers, and researchers don't act accordingly.

6. Incorporating subjective input into Social Life Cycle Assessment (SLCA) is essential, as social impacts are inherently value-laden and context-dependent, and cannot be meaningfully captured through standardized, objective indicators alone.
   This proposition pertains to this dissertation.

7. In field research, adaptability is as important as preparation, since pre-defined plans rarely survive contact with reality.

8. Bioeconomy transitions are more likely than other technological innovations to enable social justice in communities.

9. PhD candidates who have a child during their PhD should receive an additional three-month contract extension to complete their work fairly.

10. A PhD defence is a celebratory milestone; the TU Delft should therefore change its dress code for the PhD candidate to allow for more colorful and festive clothing.

These propositions are regarded as opposable and defendable, and have been approved by the promotors, em. prof. dr. P. Osseweijer and dr. L. Asveld.

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Dissertation

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by

Susan VAN DER VEEN

This dissertation has been approved by the promotors.

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LIST OF ABBREVIATIONS

BR	Basic requirement
BBVC	Bio-based value chain
BoP	Base of the Pyramid
CA	Capability approach
CO_2	Carbon dioxide
COP	Crude olive pomace
CSD	Capability Sensitive Design
DP	Design proposition
EOP	Exhausted olive pomace
FAO	Food and Agriculture Organization
FSC	Forest Stewardship Council
GBEP	Global Bioenergy Partnership
GDP	Gross Domestic Product
HTL	Hydrothermal liquefaction
LCA	Life Cycle Assessment
NGO	Non-governmental organization
SETAC	Society of Environmental Toxicology and Chemistry
SLCA	Social Life Cycle Assessment
SAM	Subcategory Assessment Method
UN	United Nations
UNEP	United Nations Environment Program
VC	Value chain
VSD	Value Sensitive Design

SUMMARY

This dissertation investigates how emerging bio-based value chains (BBVCs) can be developed to account for the needs, knowledge, skills, and values of all relevant actors. Particular attention is given to stakeholders at the beginning of the value chain, who play a critical role yet are often overlooked in the design, development, and improvement of (bio-based) value chains.

The transition to a bioeconomy, where biomass replaces fossil resources to produce energy and materials, is expected not only to contribute significantly to tackling climate change but also to generate socio-economic and environmental benefits in biomass-producing regions. While technological innovation is a key driver of this transition, achieving a sustainable bioeconomy requires a broader societal transformation involving multiple stakeholders who both shape and are affected by how the bioeconomy is developed and governed. Although new BBVCs can create opportunities for producers to diversify income and improve practices, they have also been criticized for negative environmental and social consequences. Ensuring that BBVCs realize their potential, therefore, depends on understanding how they can be developed in ways that are both sustainable and socially equitable. This is especially critical for rural contexts in the Global South, where a large part of the available biomass is produced and where poverty and socio-economic exclusion are widespread, particularly among smallholder farmers.

By studying three diverse cases of prospective BBVCs based on waste biomass - olive oil residues in Spain, coffee and cocoa residues in Colombia, and encroacher bush in Namibia - this research provides insights into the social dynamics that shape the potential for a just bioeconomy transition. The central research question of this dissertation is: *How to develop secure, inclusive, and sustainable bio-based value chains that take into account the needs, knowledge, skills, and values of all relevant actors, with special attention to actors at the beginning of the chain?*

Empirical findings from the three case studies are used to answer the main research question. **Chapter 2** focuses on the early stages of designing new BBVCs and connects these design choices to social justice.

Specific attention is paid to vulnerable, upstream stakeholders such as small-scale farmers and indigenous communities. Existing research often evaluates social justice in established value chains, yet little is known about how to embed these concerns proactively in the creation of new BBVCs. To address this, Capability Sensitive Design (CSD) is introduced as a promising approach for involving vulnerable local stakeholders in the design of new BBVCs. CSD combines Value Sensitive Design (VSD), which integrates human values into design processes, with the Capability Approach (CA), a normative framework emphasizing multiple dimensions of human wellbeing. Applied to the three case studies, CSD illustrates how design choices can strengthen distributive, recognition, and procedural justice by identifying vulnerable stakeholders and providing tools to align design decisions with their needs, knowledge, and capabilities. Beyond including stakeholders in the technical design, however, this research also stresses the importance of considering the broader institutional context.

Chapter 3 broadens the scope by including the perspectives of all stakeholders, upstream and downstream, in the analysis of different pathways towards achieving inclusion. Although inclusive strategies have been widely studied in agri-food systems, their application within the bioeconomy, with its distinct dynamics and complexities, remains limited. This chapter explores how inclusive business, inclusive value chain, and inclusive development strategies can be adapted to new BBVCs. Through a comparative analysis of the three empirical case studies, it examines the contextual and practical barriers to inclusion and highlights what different stakeholders need in order to contribute to positive social impacts and a just transition toward a sustainable bioeconomy. Trade-offs and dilemmas are also identified. The chapter argues that while the ultimate goal is inclusive development, that addresses structural inequalities and ensuring long-term wellbeing for all stakeholders, particularly the most marginalized, this is not always immediately feasible. In such cases, more pragmatic approaches, such as inclusive business models and value chain strategies, can serve as important transitional pathways.

While chapters 2 and 3 examine how BBVCs can be designed and developed to promote social justice and inclusion, **chapter 4** assesses the potential social impacts of a prospective BBVC. To create and ensure sustainable BBVCs, it is essential to understand their potential environ-

mental, economic, and social impacts. This is particularly important in the Global South, where much of the world's biomass is sourced and where vulnerable communities face higher risks of being negatively impacted by the bioeconomy. Gaining deeper insight into the social impacts of new BBVCs is therefore essential. This chapter presents a prospective Social Life Cycle Assessment (SLCA) for a bush-based value chain in Namibia. Using the existing charcoal value chain as a reference, it identifies potential social risks, impacts, and opportunities linked to a prospective value chain for producing marine biofuels from encroacher bush. The case study also serves to reflect on the SLCA methodology. It argues that current SLCA methods often fail to capture critical aspects of the local context and proposes incorporating more context-specific indicators into the risk assessment. Furthermore, stakeholder engagement is highlighted as vital for identifying and evaluating relevant social impact categories, with a call to include local stakeholders' subjective assessments in the process.

Chapter 5 presents an overarching conclusion of the study's results, recognizing limitations and offering recommendations for future research and practice. It synthesizes the results of the three chapters by highlighting key elements of an inclusive process and inclusive outcomes of new BBVCs. A central requirement for developing new BBVCs is the early engagement of all stakeholders, with particular attention to including vulnerable groups from the outset. Co-designing the value chain, by integrating the perspectives, knowledge, needs, and capabilities of diverse actors into key design decisions, can foster outcomes that are both equitable and context-sensitive. The concepts of capabilities and Capability Sensitive Design (CSD) offer valuable frameworks and tools for ensuring that new BBVCs create meaningful opportunities for those involved. Inclusion strategies, however, must be carefully adapted to the specific context. In settings marked by deep-rooted structural inequalities, more modest approaches may serve as practical stepping stones, providing tangible benefits to vulnerable actors while keeping deeper inclusion as a long-term objective. Importantly, the process should remain iterative, grounded in continuous learning and evaluation. Tools such as Social Life Cycle Assessment (SLCA) can support this by assessing the social impacts of existing or emerging BBVCs. When enriched with qualitative insights and stakeholder engagement, SLCA offers a more accurate picture of real-world social outcomes. These approaches help BBVCs grow into systems that are

economically viable, environmentally sustainable, and socially just, offering a better alternative to fossil-based value chains.

SAMENVATTING

Dit proefschrift onderzoekt hoe nieuwe *bio-based* waardeketens kunnen worden ontwikkeld met aandacht voor de behoeften, kennis, vaardigheden en waarden van alle betrokken actoren. Bijzondere aandacht gaat uit naar partijen aan het begin van de keten, die een cruciale rol spelen maar vaak worden vergeten bij het ontwerpen, ontwikkelen en verbeteren van (*bio-based*) waardeketens.

De transitie naar een bio-economie, waarin biomassa fossiele grondstoffen voor energie en materialen vervangt, zal naar verwachting niet alleen aanzienlijk bijdragen aan het aanpakken van klimaatverandering, maar ook sociaal-economische en ecologische voordelen opleveren in regio's waar biomassa wordt geproduceerd. Technologische innovatie is daarbij een belangrijke motor, maar voor een werkelijk duurzame bio-economie is een bredere maatschappelijke transformatie nodig. In deze transitie zijn meerdere actoren betrokken die de ontwikkeling van de bio-economie vormgeven én erdoor worden beïnvloed. Nieuwe *bio-based* waardeketens kunnen producenten van biomassa kansen bieden om hun inkomen te diversifiëren en hun productie praktijken te verbeteren, maar worden ook bekritiseerd vanwege negatieve milieu- en sociale effecten. Het waarborgen van het potentieel van deze waardeketens hangt daarom af van inzicht in hoe zij zó kunnen worden ontwikkeld dat ze zowel duurzaam als sociaal rechtvaardig zijn. Dit is vooral van belang in rurale gebieden in het Mondiale Zuiden, waar een groot deel van de beschikbare biomassa wordt geproduceerd en waar armoede en sociaal-economische uitsluiting wijdverspreid zijn, met name onder kleinschalige boeren.

Dit proefschrift is gebaseerd op drie verschillende casestudy's van potentiële waardeketens op basis van restbiomassa, namelijk restromen van de olijfolie in Spanje, koffie en cacao reststromen in Colombia, en een woekerstruik in Namibië. Met deze casestudy's biedt dit onderzoek inzicht in de sociale dynamiek van de transitie naar een rechtvaardige bio-economie. De centrale onderzoeksvraag van dit proefschrift is: *Hoe kunnen stabiele, inclusieve en duurzame bio-based waardeketens op zo'n manier worden ontwikkeld dat de behoeften, kennis, vaardigheden en waarden van alle relevante actoren worden geïntegreerd, met bijzonder aandacht voor spelers aan het begin van de keten?*

De empirische bevindingen uit de drie casestudy's worden gebruikt om de centrale onderzoeksvraag te beantwoorden. **Hoofdstuk 2** richt zich op de vroege fasen van het ontwerpen van nieuwe *bio-based* waardeketens en verbindt deze ontwerpprocessen met sociale rechtvaardigheid. Daarbij gaat bijzondere aandacht uit naar kwetsbare actoren aan het begin van de keten, zoals kleinschalige boeren en inheemse gemeenschappen. Bestaand onderzoek evalueert sociale rechtvaardigheid vaak in reeds gevestigde waardeketens, terwijl er weinig bekend is over manieren om deze sociale aspecten proactief te verankeren bij het ontwikkelen van nieuwe waardeketens. Om dit vraagstuk te adresseren wordt *Capability Sensitive Design* (CSD) geïntroduceerd als een veelbelovende benadering om kwetsbare lokale belanghebbenden actief te betrekken bij het ontwerp van nieuwe bio-based waardeketens. CSD combineert *Value Sensitive Design*, dat menselijke waarden integreert in ontwerpprocessen, met de *Capability Approach*, een normatief kader dat meerdere dimensies van menselijk welzijn benadrukt. Toegepast op de drie casestudy's laat CSD zien hoe ontwerpkeuzes drie dimensies van rechtvaardigheid, namelijk verdelings-, erkennings- en procedurele rechtvaardigheid, kunnen versterken door kwetsbare actoren te identificeren en handvatten te bieden om ontwerpbeslissingen af te stemmen op hun behoeften, kennis en *capabilities*. Naast het betrekken van belanghebbenden bij het technische ontwerp benadrukt dit onderzoek echter ook het belang van de institutionele context en institutionele ontwikkeling.

Hoofdstuk 3 verbreedt de focus door in de analyse van verschillende strategieën naar inclusie de perspectieven van alle belanghebbenden, zowel aan het begin als het einde van de keten, te betrekken. Hoewel inclusieve strategieën uitgebreid zijn bestudeerd binnen voedselsystemen, blijft hun toepassing in de bio-economie, met een eigen dynamiek en complexiteit, vooralsnog beperkt. Dit hoofdstuk onderzoekt hoe drie strategieën die zijn toegepast in voedselsystemen, namelijk inclusief ondernemen, inclusieve waardeketens en inclusieve ontwikkeling, kunnen worden toegepast in de nieuwe bio-economie. Aan de hand van een vergelijkende analyse van de drie empirische casestudy's worden de contextuele en praktische belemmeringen voor inclusie in kaart gebracht en wordt geanalyseerd wat verschillende actoren nodig hebben om bij te dragen aan positieve sociale effecten en een rechtvaardige transitie naar een duurzame bio-economie. Ook worden afwegingen en dilemma's

geïdentificeerd. Het hoofdstuk stelt dat het uiteindelijke doel inclusieve ontwikkeling is, waarbij structurele ongelijkheden worden aangepakt en het welzijn van alle belanghebbenden, in het bijzonder de meest gemarginaliseerde, op de lange termijn wordt gewaarborgd. Dit is echter niet altijd direct haalbaar. In dergelijke gevallen kunnen meer pragmatische benaderingen, zoals inclusieve bedrijfsmodellen en waardeketenstrategieën, dienen als belangrijke tussenstappen.

Terwijl hoofdstukken 2 en 3 onderzoeken hoe *bio-based* waardeketens kunnen worden ontworpen en ontwikkeld om sociale rechtvaardigheid en inclusie te bevorderen, beoordeelt **hoofdstuk 4** de potentiële sociale effecten van een toekomstige waardeketen. Om duurzame *bio-based* waardeketens te creëren en te waarborgen, is het essentieel om inzicht te krijgen in hun potentiële milieu-, economische en sociale effecten. Dit is met name belangrijk in het Mondiale Zuiden, waar een groot deel van de wereldwijde biomassa wordt gewonnen en kwetsbare gemeenschappen een groter risico lopen negatieve gevolgen van de bio-economie te ondervinden. Het verkrijgen van diepgaander inzicht in de sociale effecten van nieuwe waardeketens is daarom cruciaal. Dit hoofdstuk presenteert een *Social Life Cycle Assessment* (SLCA) voor een waardeketen op basis van woekerstruik in Namibië. Met de bestaande houtskoolwaardeketen als referentie worden potentiële sociale risico's, effecten en kansen in kaart gebracht die samenhangen met een toekomstige waardeketen voor de productie van biobrandstoffen voor de scheepvaart. De casestudy biedt de gelegenheid om te reflecteren op de SLCA-methodologie. Het hoofdstuk betoogt dat huidige SLCA-methoden vaak tekortschieten in het vastleggen van cruciale aspecten van de lokale context en stelt voor om meer context specifieke indicatoren in de risicoanalyse op te nemen. Daarnaast wordt het belang benadrukt van actieve betrokkenheid van belanghebbenden bij het identificeren en evalueren van relevante categorieën van sociale impact, met een oproep om ook de subjectieve beoordelingen van lokale stakeholders in het proces te integreren.

Hoofdstuk 5 presenteert de overkoepelende conclusies van dit onderzoek, erkent de beperkingen en doet aanbevelingen voor toekomstig onderzoek en praktijk. Het hoofdstuk brengt de resultaten van de drie voorafgaande hoofdstukken samen door de belangrijkste elementen te belichten van zowel een inclusief proces als inclusieve uitkomsten bij de

ontwikkeling van nieuwe *bio-based* waardeketens. Een belangrijke voorwaarde voor het ontwikkelen van nieuwe waardeketens is het vroegtijdig betrekken van alle belanghebbenden, met bijzondere aandacht voor de participatie van kwetsbare groepen vanaf het begin. Het gezamenlijk ontwerpen van de waardeketen, waarbij de perspectieven, kennis, behoeften en waarden van diverse actoren worden geïntegreerd in cruciale ontwerpbeslissingen, kan leiden tot resultaten die zowel rechtvaardig als context specifiek zijn. De concepten *capabilities* en *Capability Sensitive Design* (CSD) bieden hierbij waardevolle kaders en instrumenten om ervoor te zorgen dat nieuwe waardeketens betekenisvolle kansen creëren voor alle betrokkenen. De strategieën voor inclusie moeten zorgvuldig worden afgestemd op de specifieke context. In situaties die worden gekenmerkt door diepgewortelde structurele ongelijkheden kunnen meer bescheiden benaderingen fungeren als praktische tussenstappen. Dit biedt tastbare voordelen voor kwetsbare actoren, terwijl diepgaandere vormen van inclusie als lange termijn doel worden nagestreefd. Belangrijk is dat het proces iteratief blijft, gebaseerd op voortdurende reflectie, leren en evaluatie. Instrumenten zoals *Social Life Cycle Assessment* (SLCA) kunnen dit ondersteunen door de sociale effecten van bestaande of opkomende *bio-based* waardeketens te beoordelen. Wanneer deze methode wordt verrijkt met kwalitatieve inzichten en actieve betrokkenheid van belanghebbenden, biedt SLCA een nauwkeuriger beeld van sociale uitkomsten in de praktijk. Dergelijke benaderingen dragen ertoe bij dat de bio-economie zich kan ontwikkelen tot een systeem dat economisch levensvatbaar, ecologisch duurzaam en sociaal rechtvaardig zijn, en zo een beter alternatief vormen voor fossiele brandstoffen.

CHAPTER 1

GENERAL INTRODUCTION

1.1. INTRODUCTION

Climate change is one of the most significant crises humanity currently faces. If not addressed, climate change will lead to increased frequency and intensity of extreme weather events, disruptions to ecosystems, and threats to human health and wellbeing. Consequently, some areas could become unsuitable for habitation, leading to climate-induced migration (IPCC, 2023). It is therefore urgent to reduce greenhouse gas emissions by replacing fossil fuel sources with renewable sources. Moreover, the growing global demand for food, materials, and energy calls for innovative developments in primary sectors. These innovations must focus on developing technologies and methods that use resources more efficiently, while enhancing productivity in agriculture, forestry, and aquaculture, without compromising the planet's ecological limits or biodiversity (Lewandowski, 2018).

The transition to a bioeconomy, where biomass-based resources replace fossil-based energy and materials, is an essential element to achieve global targets set in the Paris Climate Agreement (2015) and the European Green Deal (2021) (Sadeghzadeh et al., 2025). The future bioeconomy is not only expected to play a key role in tackling climate change, but it can also deliver positive socio-economic and environmental benefits in regions that produce biomass. These benefits include emission reduction, improvement of residue management, and additional income for biomass producers (Ladu & Morone, 2021). As a consequence, biomass demand is expected to increase in the next decade (Vargas-Carpintero et al., 2022).

Bio-based value chains (BBVCs) link biomass producers with new markets and actors, potentially creating new opportunities. The global availability of biomass for the bioeconomy is significant, with the potential to cover nearly half of the world's total primary energy demand. However, challenges exist in balancing biomass use for food, feed, and energy, and the need for sustainable production and sourcing of biomass (Popp et al., 2021). Moreover, a large part of the global available biomass is located in the Global South, where many people depend on agriculture for their livelihood. This presents both opportunities and challenges (Lima, 2022). While new BBVCs can provide opportunities for biomass producers to diversify their income and improve production processes, BBVCs have

faced criticism for their adverse environmental and social impacts. Key concerns include the spread of monocultures, investment uncertainties, and unequal distribution of benefits (Balkema & Pols, 2015; Hoffman et al., 2021; Lima, 2022). For new BBVCs to deliver their potential, it is essential to understand how they can be developed in a way that is both sustainable and socially equitable.

While technological advancement and innovation are key drivers of the transition to a bioeconomy, achieving a sustainable bioeconomy also requires broader societal transformation. This involves multiple stakeholders who both shape and are affected by how the bioeconomy is developed and governed (Sadaghzadeh et al., 2025). Even though this social dimension is increasingly recognized as important in bioeconomy literature, it still receives less attention than the economic and environmental aspects of sustainability (Janker & Mann, 2018). Moreover, even though biomass producers play an essential role in the bioeconomy, their perspectives and needs are rarely included in the design and development of the bioeconomy (Asveld et al., 2023). It is therefore essential to include all stakeholders, and most notably stakeholders at the beginning of the value chain, in the design and development of novel BBVCs.

1.2 CLEAN SHIPPING PROJECT

This doctoral thesis is part of the results of the project called 'Clean Shipping: Thermo-chemistry and inclusive supply chains design for sustainable production of biofuels in the marine transport industry'. The project started from the premise that the shipping industry needs to drastically reduce greenhouse gas emissions to meet the goals of the Paris Climate Agreement. The sector has committed to achieving net-zero greenhouse gas emissions by 2050 (IMO, 2025). Biofuels are an important element in the strategy towards greenhouse gas reduction and are currently seen as one of the best viable alternatives in the foreseeable future (Kesieme et al., 2019). However, uptake by the shipping industry has been limited so far. Technical, social, and institutional challenges need to be overcome to deliver a reliable, secure, and sustainable supply of maritime biofuels. This doctoral thesis focuses on the social and institutional challenges of including the perspectives, needs, and knowledge of all stakeholders along novel BBVCs.

The Clean Shipping project researched hydrothermal liquefaction (HTL) as a conversion technology, a technology that still needs further development and optimization. The project aimed to develop the relevant technologies in such a way that they create tangible local social and environmental benefits in the production areas and, at the same time, meet the needs of the shipping industry.

To achieve a secure and large-scale supply of biomass, multiple (smaller-scale) communities can provide biomass to a refinery located at a central location. To avoid food versus fuel debates, this biomass is ideally not in competition with food and could entail, for example, forestry residues, agricultural residues, urban waste, or invasive species. By providing biomass, communities can benefit from extra income and employment opportunities. In addition, by-products from the refinery, such as biochar, could provide valuable services and benefits for the biomass producers, like electricity generation, soil amendment, and water treatment. Other benefits might include support and knowledge sharing on sustainable production practices.

1.3 JUST BIOECONOMY

The transition to a bioeconomy has significant potential for addressing climate change and promoting sustainability, but it also raises important questions of social justice. Bioeconomy initiatives can affect different societal groups in uneven ways (Sadeghzadeh et al., 2025), and their success often depends on social acceptance, which in turn can shape environmental outcomes (Diaconasu et al., 2022; Dietz et al., 2018). Social dimensions must therefore be integrated into the design of novel BBVCs to ensure widespread support and equitable outcomes (Morone & Imbert, 2020). Critical infrastructure and land use changes, such as the development of bioenergy facilities or expansion of biomass production, directly impact local communities' access to resources, livelihoods, and overall quality of life (Gawel et al., 2019; Van De Ven et al., 2021). Investigating social impact is key to identifying potential inequalities and ensuring that the transition is both inclusive and fair (Wilde & Hermans, 2024).

The concept of a 'just transition' has gained prominence within sustainability transitions research (Köhler et al., 2019; Geels et al., 2017). These

transformations often extend beyond technological change, involving shifts in institutions, behaviors, and governance structures that can deeply affect communities (Lima, 2022). The bioeconomy, more than many other governance areas, bridges critical debates around climate, energy, land use, and agriculture, as many bio-based alternatives to fossil fuels are derived from existing forestry and agri-food systems (Lima, 2018). At the same time, and controversially, bioeconomy transitions are more likely than other technological innovations to enable social justice in communities.

Recent literature has emphasized that a just bioeconomy transition must not only address environmental sustainability and biodiversity conservation but also promote social equity and justice (Ramcilovic-Suominen, 2023; Ruml et al., 2025). Despite this, the social dimension of sustainability often receives less attention than its environmental and economic counterparts, both in general sustainability research (Janker & Mann, 2018) and specifically in the bioeconomy literature (Ferreira et al., 2022).

This imbalance is particularly critical in the context of the Global South. While biofuel projects have been promoted as a means to reduce fossil fuel dependence and stimulate socio-economic development (Ahmed, Betey Campion & Gasparatos, 2019; De Gelder & Asveld, 2024), they have often faced significant implementation challenges. These include a lack of local context knowledge, inadequate financial structures, and institutional weaknesses, which can undermine potential benefits for local communities (Balkema & Pols, 2015; Van Eijck et al., 2014; Mudombi et al., 2021; Tagwi & Chipfupa, 2023). Additionally, the globalized nature of biofuel value chains can further complicate efforts to ensure equitable outcomes (De Gelder & Asveld, 2024). In many rural areas across the Global South, where poverty and socio-economic exclusion are widespread, particularly among smallholder farmers, ensuring a just transition is both a moral imperative and a practical necessity (Barbier & Hochard, 2018).

1.4 INCLUSIVE BIO-BASED VALUE CHAINS

Inclusion is essential for developing a sustainable and just transition towards a bioeconomy. Through global value chains, companies, workers, and consumers in different parts of the world are connected

within the global economy (Gereffi and Stark, 2011). In recent years, the integration of poorer, marginalized groups into the global value chains has been promoted as a development strategy. Inclusive value chain development is understood as "positive or desirable change in a value chain to extend or improve productive operations and generate social benefits: poverty reduction, income and employment generation, economic growth, environmental performance, gender equity and other development goals" (UNIDO, 2011). Emphasis is put on those groups that are usually excluded from global value chains. While this can be a successful strategy, inclusive value chain projects also risk reproducing existing inequalities and power imbalances between value chain actors. They may not benefit marginalized groups if not properly designed (Bitzer and Glasbergen, 2015). A farmer-centred approach that recognizes stakeholders' differentiated realities, as well as their knowledge, innovation capacity, and agency, is key to making this process more inclusive (Ros-Tonen et al., 2019).

In this research, inclusion is understood both as a process and an outcome. The 'process dimension' of inclusion is defined as incorporating the needs, perspectives, and capabilities of the most vulnerable groups into the design process of the value chain. A fundamental aspect is how people are included and understood in these processes (Ribeiro et al., 2018). Actively involving stakeholders in the development of bioeconomy initiatives can foster trust and ensure that policies are responsive to the needs and priorities of affected communities (Hasenheit et al., 2016; Szarka et al., 2023). In the long term, meaningful stakeholder engagement is essential to achieving successful and socially sustainable bioeconomy transitions (Wilde & Hermans, 2024; Sadeghzadeh et al., 2025).

In addition, an inclusive process does not automatically lead to inclusive outcomes (Postal et al., 2020). This research will also take into account the 'outcome dimension' of inclusion, which is understood as a fair distribution of risks and benefits along the BBVC, with special attention to the most vulnerable groups.

1.5 RESEARCH QUESTIONS

This thesis consists of three research papers providing answers to the overarching research question: *How to develop secure, inclusive, and sustainable bio-based value chains that take into account the needs,*

knowledge, skills, and values of all relevant actors, with special attention to actors at the beginning of the chain?

This dissertation is based on a case-study research design. Three case studies in different contexts, with the potential to develop novel BBVCs based on waste biomass, are conducted to gather empirical data. By using qualitative methods, stakeholder values, capabilities, and constraints are explored in the case study locations.

A central concept in the Clean Shipping project is the biohub, a concept of secure and sustainable supply of feedstock for biomass that integrates various elements of a socially acceptable, profitable, and sustainable bioeconomy into a modular system that can be adapted to the local context. It refers to an intermediate place where farmers can deliver their by-products, such as residues, to be processed into products that have higher quality and value along the value chain. (EIA, 2024). The biohub is very context-specific, and the scale, type of biomass, variety of benefits, and complexity of technologies can differ in each context. The following infographic illustrates the main elements of a biohub, and was used in the case study locations during interviews and workshop discussions to investigate how an ideal biohub should look in the case study location.

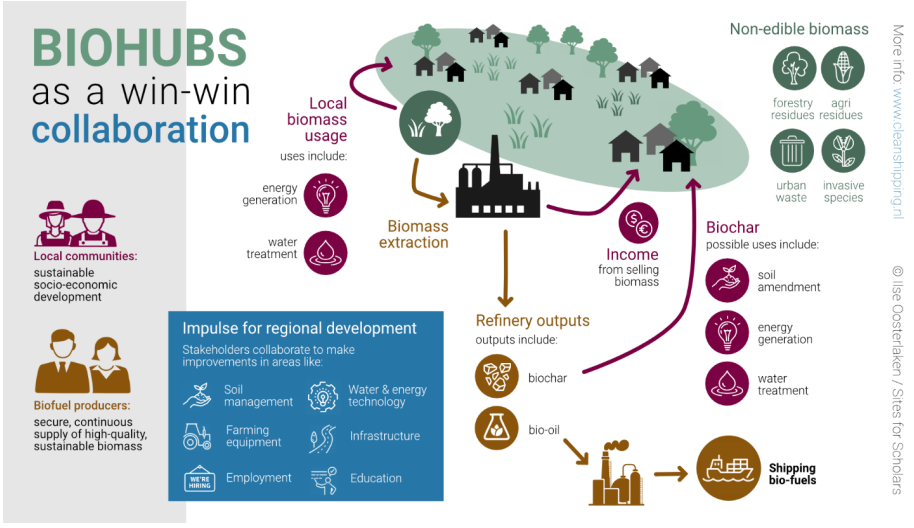

Figure 1.1 – Biohub infographic

Three cases are selected after an iterative process involving project partners who represent key stakeholders within a biofuel value chain, including a shipping company, (bio)fuel producers, a renewable energy platform, and an NGO. Drawing on their input, potential feedstocks and countries were identified, and a set of criteria was developed to guide the selection process. These criteria included biomass availability, potential for utilization, political stability, impacts on small-scale farmers, existing infrastructure, supportive policy environments, and local stakeholder connections. In addition, a set of features was outlined to compare the potential cases, such as the source of feedstock, geographic location, Human Development Index, scale of farming, and current use of the feedstock. Based on these considerations, the partners chose three final cases: 1) Olive oil residues in Spain, 2) Coffee and cocoa residues in Colombia, and 3) Encroacher bush in Namibia.

The cases align with the defined criteria, involve innovative feedstocks, and reflect a range of socio-economic and geographic contexts. Due to COVID-19 restrictions, the first case study was conducted in Europe. In the selected cases, marine biofuel value chains are not yet established. This offers a wide scope for shaping future decisions. Fieldwork focused on insights from existing local and global value chains and stakeholder perspectives on designing a conceptual value chain for marine biofuels. In the field studies, stakeholders that could play a potential role in the new BBVCs, both upstream (at the beginning of the value chain) and downstream (at the end of the value chain), were identified and involved.

Empirical findings from the three case studies are used to answer the main research question. The following chapters comprise research papers that address specific sub-questions. **Chapter 2** is dedicated to analyzing how to make choices in the early stages of designing novel bio-based value chains. The following sub-question is explored: *How can the identification of local stakeholders' skills, needs, and capabilities be used to design scenarios of bio-based value chains for social justice?*

As stressed before, while sustainability and a sustainable transition are high on the research agenda, the social aspect of sustainability receives less attention than the environmental and economic dimensions. Even less attention is paid to issues of social justice. When research does address

Table 1.1 – Comparison of the three case studies

Country	Type of biomass	Context
Spain	Agricultural residue (field and processing)	Region and sector with an established primary agricultural sector with developed infrastructure, organized farmers' cooperatives, logistical expertise to handle residues, traditional residue valorization techniques, and enabling policies. Small-scale production.
Colombia	Agricultural residue (field)	Recognized primary agricultural sector with relatively no current commercial residue valorization expertise, with minimal infrastructure for logistics. Small-scale production.
Namibia	Encroacher bush	Region with abundant biomass, no national petrochemical infrastructure, well-established value chain actors with a high interest in valorizing the biomass. Combination of small- and large-scale production.

social or justice-related issues in (bio-based) value chains, it typically takes a retrospective perspective, focusing on assessing existing systems and practices through methods such as social impact assessments. While this can help formulate lessons learned, we need to better understand how to proactively create novel (bio-based) value chains that are not only sustainable but also socially just. I present Capability Sensitive Design (CSD) as a relevant approach to engage local vulnerable stakeholders in the design of new BBVCs. CSD is a combination of Value Sensitive Design (VSD), an approach to account for human values in a design process, and the Capability Approach (CA), a normative framework that incorporates multiple dimensions of human well-being. By applying CSD to the three case studies, I demonstrate how the design choices made through the CSD process can enhance distributive, recognition, and procedural justice by enabling the identification of locally vulnerable stakeholders and offering tools to align design decisions with their needs, knowledge, and capabilities. Furthermore, I argue that in addition to adapting processes and technical design, attention is needed for the institutional context.

Where chapter 2 focuses on the needs and views of local (upstream) stakeholders, **chapter 3** takes a broader perspective by including the

viewpoints of all stakeholders, upstream and downstream, in the analysis of different pathways towards achieving inclusion. The following sub-research question is addressed: *How can different strategies for inclusive value chains be applied in new bio-based value chains?*

While inclusive strategies have been extensively studied in agri-food systems, their practical application in the bioeconomy, with its own dynamics and complexities, remains underexplored. This chapter investigates how inclusive business, inclusive value chain, and inclusive development strategies can be applied to new bio-based value chains. Drawing on a comparative analysis of the three empirical case studies, I examine the practical and contextual barriers to inclusion and identify what different stakeholders require to engage to create positive social impact and a just transition towards a sustainable bioeconomy. Moreover, trade-offs and dilemmas are identified. I argue that while the ultimate objective is to achieve inclusive development that addresses deep-rooted inequalities and ensures lasting well-being for all stakeholders, especially the most marginalized, this is often not immediately achievable in many contexts. In such instances, practical approaches like inclusive business models and value chain strategies can play a vital transitional role.

In chapters 2 and 3 I have examined how BBVCs can be designed and developed to promote social justice and inclusion. **Chapter 4** assesses the potential social impacts of a prospective BBVC and addresses the following sub-research question: *How can social impact be incorporated into sustainability assessments of bio-based value chains?*

To ensure the sustainable production of bio-based products, it is essential to understand their (potential) environmental, economic, and social impact. Especially in the Global South, where a large part of the world's biomass is produced, vulnerable communities are at higher risk of being negatively affected by the bioeconomy. These risks include food insecurity, monoculture expansion, and unequal wealth distribution. Therefore, it is crucial to understand the social impact of new BBVCs better. In this chapter, a prospective Social Life Cycle Assessment (SLCA) for a bush-based value chain in Namibia is presented. The existing charcoal value chain is used to identify potential social risks, impacts, and opportunities associated with a prospective value chain for producing marine

biofuels from encroacher bush. The case study is used to reflect on the SLCA methodology. I argue that the current methods for SLCA do not adequately capture salient aspects of the local context. Therefore, I propose adding more context-specific indicators to the risk assessment. In addition, stakeholder engagement is crucial for identifying and assessing relevant social impact categories, and I advocate for incorporating local stakeholders' subjective assessments.

Chapter 5 discusses the overall results of this study and answers the main research question. Moreover, limitations and recommendations for future work are discussed.

CHAPTER 2

DESIGNING BIO-BASED VALUE CHAINS FOR SOCIAL JUSTICE: THE POTENTIAL OF CAPABILITY SENSITIVE DESIGN

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2.1 INTRODUCTION

There is an urgent need for a sustainable transition to move away from fossil-based materials and fuels. The bioeconomy is a concept proposed to promote sustainable transitions and generate local socio-economic and environmental benefits (Lewandowski et al., 2018). In the bioeconomy, biomass such as agricultural residues is used to make products previously made from oil, like biofuels. Through bio-based value chains (BBVCs), biomass producers are connected to new actors and markets. This could create opportunities but also impose new risks such as monoculture expansion, uncertain investments, and unequal wealth distribution (Balkema & Pols, 2015; Hoffman et al., 2021). For new BBVCs to deliver their potential, we need to understand how they can be developed in a sustainable *and* socially just way.

While sustainability and a sustainable transition are high on the research agenda, the social aspect of sustainability receives less attention than the environmental and economic dimensions (Palmeros Parada et al., 2020). Even less attention is paid to issues of social justice (Jabbour et al., 2017). In addition, research on social aspects of sustainability and social justice in global value chains is often backward-looking to evaluate the performance of existing structures and processes through methods such as social impact assessment. While this helps to formulate lessons learned, we need to understand better how to create truly sustainable or socially just value chains (Pagell & Shevchenko, 2014).

One proposed pathway is to include diversified voices with different knowledge, concerns, and objectives to co-design a value chain (Touboulic et al., 2020). We present Capability Sensitive Design (CSD) as a relevant approach to engage local vulnerable stakeholders in the design of new BBVCs. With local vulnerable stakeholders, we refer to stakeholders at the beginning of the value chain, such as small-scale farmers, indigenous communities, and workers, who hold less power than buying firms at the value chains end. While these stakeholders play a crucial role in a value chain, their perspectives and needs have seldom been included in decision-making (Asveld et al., 2023).

CSD is a combination of Value Sensitive Design (VSD), an approach to account for human values in a design process (Friedman, 1996), and the

Capability Approach (CA), a normative framework that incorporates multiple dimensions of human wellbeing (Sen, 2014). The CA evaluates the real opportunities (capabilities) that people have to lead the lives they value. The advantage is the recognition of human diversity in what capabilities are valued and in our ability to achieve them (Robeyns, 2017). Instead of taking moral values as the central goal of a design, as is done in a VSD approach, CSD concentrates on enhancing human capabilities. It provides a framework to normatively assess a design based on whether the design expands capabilities identified as valuable (Jacobs, 2020). CSD is a relatively new approach, and its contribution to designing for social justice in BBVCs remains unexplored. Moreover, there is a need for empirical research focusing on the meaning and interpretation of specific capabilities and how design might enhance those (Oosterlaken, 2013). That leads to the main question of this paper: *How can the identification of local stakeholders' skills, needs, and capabilities be used to design scenarios of bio-based value chains for social justice?*

We argue that CSD can contribute to social justice because it allows identifying local vulnerable stakeholders and provides tools to connect their needs, knowledge, and capabilities to concrete design choices. We present a process of CSD for the context of BBVCs and apply this to three potential VCs for producing marine biofuels from waste biomass in Spain, Colombia, and Namibia. Our work makes academic and practical contributions to social justice and BBVC's debates. We do that by applying CSD prospectively in the methodology and analysis of the cases. This approach is relevant for scholars and practitioners who are involved in the development and design of new value chains.

First, we will outline our theoretical framework, where we define social justice and explain its relevance in the context of the bioeconomy. Then, the concept of CSD is further explained, followed by a description of the methodology. In the results section, design scenarios are presented for the three cases. We then analyze how the process of CSD contributes to distributive, recognition, and procedural justice, the three dimensions of social justice used in this paper. Finally, limitations and trade-offs are discussed.

2.2 SOCIAL JUSTICE IN BIO-BASED VALUE CHAINS

We define social justice using the three dimensions of distributive, recognition, and procedural justice that are often used in the literature on environmental justice (Schlosberg, 2007; Newell et al., 2021) and energy justice (Jenkins et al., 2016; Sovacool et al., 2017). As these fields both relate to the bioeconomy, these justice dimensions also emerge here. We will briefly explain the dimensions and their relevance to the bioeconomy.

Distributive justice concerns the spatial and temporal allocation of benefits and burdens across society (Dillman & Heinonen, 2022). Studies have shown that so far, economic incentives to stimulate the bioeconomy accrue mainly to well-established agribusiness or urban consumers. The burdens, such as monoculture expansion and environmental risks, are disproportionally carried by resource-poor rural populations (Lima, 2022). Additionally, it remains a challenge for smallholders to integrate into and benefit from BBVCs (Balkema & Pols, 2015; Robaey et al., 2022). In the context of the bioeconomy, distributive justice requires prioritizing the needs of local vulnerable stakeholders and a fair allocation of environmental, economic, and social risks (Gupta & Lebel, 2020). While distributive justice is central to social justice, it does not address the root causes of unfair distribution. It needs to be complemented by concepts like recognition and procedural justice (Velasco-Herrejon & Bauwens, 2020).

Whereas distributive justice considers how positive and negative impacts are distributed, recognition justice considers the additional needs and potential harms toward vulnerable groups (Dillman & Heinonen, 2022). It calls to acknowledge the differences rooted in social, cultural, and economic structures that underly unfair distribution (Velasco-Herrejon & Bauwens, 2020). Questions relevant to recognition justice are related to who may be affected and which section of society is under- or misrepresented. Failing to identify and acknowledge the concerns, views, and needs of vulnerable stakeholders has implications for both distributive and procedural justice, as vulnerable rural communities are often left out of value chain governance and the benefits of expanded bio-based production (Lima, 2022).

Apart from distributive and recognition justice, it is crucial to consider the processes leading to fair or unfair distribution (Velasco-Herrejon &

Bauwens, 2020). Procedural justice has to do with participation in the design process and decisions about what kind of future is envisioned (Lima, 2022). When designing new BBVCs, we need to carefully reflect on who is involved in the decision-making process and how decisions are made. By incorporating local stakeholders in the decision-making process, local knowledge is mobilized, which can lead to alternative design choices and views that better represent particular needs and circumstances. In addition to justice claims, the participation of local stakeholders in decision-making processes can also lead to more effective VCs as producers have valuable knowledge of land management and cultivation practices (Asveld et al., 2023). Moreover, participation can enhance social acceptance of new technologies and VCs (Velasco-Herrejon & Bauwens, 2020).

Whereas these concepts are useful for evaluating social justice, there is no concrete approach that actively accounts for social justice in the design of BBVCs. We propose CSD as a relevant approach to designing new BBVCs for social justice.

2.3 DESIGN FOR SOCIAL JUSTICE

Value chain design concerns making decisions about elements such as suppliers, locations, scale, technologies, and contractual arrangements (Battaïa et al., 2023). These choices influence the distribution of burdens and benefits along the chain. Therefore, it is relevant to proactively engage with social justice when making those choices. Approaches to inclusive value chain development, such as inclusive business models or social impact assessment, often focus on the inclusion of smallholders into existing global value chains and improving economic and labor conditions (Ros-Tonen et al., 2019; Lundy et al., 2014). BBVCs are more complex since they are new, often combine various value chains, and involve new and quickly evolving technologies. Therefore, we need an approach that can proactively engage with social justice in the design. Additionally, existing approaches lack a more holistic understanding of the multiple challenges and opportunities for resource-poor farmers in value chains (Asveld et al., 2023; Devaux et al., 2018).

The capability approach (CA) is a useful framework that is relevant in the context of social justice and (value chain) design (Oosterlaken, 2013).

The CA evaluates the real or effective opportunities that people have to lead the life they have reason to value. Capabilities are defined as what people can effectively be and do, for example being healthy or forming meaningful relationships. The central focus of the CA is on increasing the opportunities for people to live a meaningful life. People can exercise their agency and make choices to turn capabilities into so-called 'functionings', realized capabilities (Robeyns, 2017). Instead of focusing on expanding utility or resources, the CA looks at how these resources can enable people to fulfill meaningful activities (Oosterlaken, 2013).

Even though the CA is concerned with inequality and justice, it is not a theory of justice. Social justice concerns the distribution of benefits and burdens and the underlying processes and factors that lead to that distribution. The CA allows to identify capabilities, however it does not answer questions regarding which capabilities matter more, or what constitutes an equal distribution of capabilities (Robeyns, 2017). The CA should be considered an 'open framework' that can be used for several purposes, such as the study of social justice issues (ibid). The CA offers a promising lens to study distributive, procedural, and recognition justice in BBVCs, as we will show in this paper.

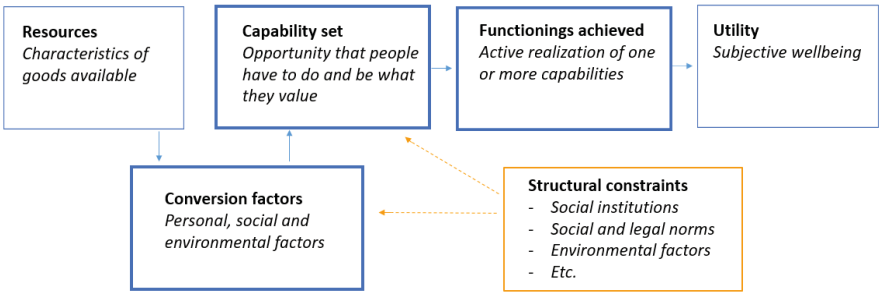


Figure 2.1 – Visualization of CA concepts, based on Robeyns (2017)

The CA accounts for diversity in what we value and in our ability to fulfill those meaningful activities. A relevant concept to identify this diversity is the concept of conversion factors. Conversion factors are internal or external to a person and determine whether a person can transform resources into capabilities. They are classified into three categories. First, personal factors are internal, like physical conditions, skills, or intelligence. Second, social factors come from society, such as

norms, policies, and power relations related to gender or ethnicity. Third, environmental factors arise from the physical environment, like climate, infrastructure stability, or transportation. Additionally, structural constraints like laws and institutions impact people's conversion factors and capabilities (Robeyns, 2017). Conversion factors highlight the differences in access to resources and provide a lens to address these (Asveld et al., 2023). Figure 2.1 shows the relation between the core concepts of the CA.

The CA can be useful in design through CSD, an approach developed by Oosterlaken (2013). CSD is an approach to account for human capabilities in the design of new technologies. It is the combination of value-sensitive design (VSD) and the CA. VSD integrates moral values into technology design, recognizing that engineering is not neutral. Technologies can realize values like privacy, autonomy, and safety, or the opposite, they can embed injustice and insecurity (Friedman, 1996). VSD consists of three phases: 1) Conceptual investigations where stakeholders and their values concerning a certain technology are identified, 2) Empirical investigations in the social context in which the technology is situated, and 3) Technical investigations to translate the investigated values into design outcomes (ibid). Iterations between these investigations can provide better insight into how the technology can support stakeholders' values (Palmeros Parada et al., 2020). While VSD is a valuable approach to addressing the ethics of design, it also faces challenges. Even though VSD uses ethical theories to identify relevant values, there is no explicit commitment to them, and hence no normative guidance to distinguish between values. The CA provides normative guidance by evaluating whether a design enhances stakeholders' capabilities (Jacobs, 2020).

CSD thus combines the method of VSD with the core elements of the CA, namely capabilities and conversion factors. Instead of taking moral values as the central goal of a design, CSD concentrates on enhancing human capabilities. CSD is a promising approach, but still relatively unexplored.

2.4 METHODS

We applied CSD to three cases of early-stage design of marine biofuel value chains out of waste biomass. The choice of a case study approach allows for gaining in-depth knowledge of the complex relationship of real-

life dynamics (Backhouse & Lorenzen, 2021). Cases in different contexts are used to illustrate what design choices would be made when the capabilities of local vulnerable stakeholders are central to the design. We furthermore analyze what this means for social justice in BBVCs.

2.4.1 CASE SELECTION

This research is part of a multi-stakeholder and multi-disciplinary research project to design inclusive and sustainable biofuels for the marine industry, an industry that is actively looking to source more sustainable fuels (IMO, 2025). The cases are selected in an iterative process with project partners who represent stakeholders in a biofuel value chain (shipping company, (bio)fuel producers, renewable energy platform, and an NGO).

Based on input from these partners, potential feedstocks and countries were identified, and a list of criteria was created to filter the options (biomass availability, utilization potential, political stability, impact on small-scale farmers, infrastructure, enabling policies, and local connections). Moreover, a list of features was created to compare the potential cases (source of feedstock, geographical location, Human Development Index, the scale of farming, and current utilization of feedstock). The partners selected the final three cases: 1) Olive oil residues in Spain, 2) Coffee and cocoa residues in Colombia, and 3) Encroacher bush in Namibia. These cases all match the criteria, explore novel feedstocks, and represent a diversity of contexts. Due to COVID-19, we had to conduct our first case study in Europe.

In the selected cases, value chains for marine biofuels do not exist yet. This allows for a broad space for decision-making. The field research focused on learning from existing value chains and perspectives on a conceptual design of a value chain for marine biofuels. As such, we offer a roadmap to parties who are interested in developing a socially just BBVC, such as our consortium partners. Whether they will follow up is still undecided at the time of writing. The partners contributed in cash and in-kind to the consortium but did not directly pay the researchers for any services.

2.4.2 CASE STUDY APPROACH

The case studies are conducted following a CSD approach based on previous studies and adapted to the context of BBVCs (Oosterlaken, 2013; Mink, 2016; Steen, 2016; Asveld et al., 2023). We build on research done by Asveld et al. (2023), who explored the potential of CSD for inclusive BBVCs by applying CSD as an analytical lens in retrospect to existing cases. We contribute to this research by applying CSD from the beginning in the methodology and analysis of the cases. Additionally, we explicitly connect CSD to social justice. The case study protocol can be found in Appendix A.

In the conceptual phase, stakeholders for both the existing value chain and potential BBVC were identified (farmers, logistical companies, technology providers, academia, and governments). Vulnerable stakeholders were identified using power-interest grids based on their position towards the new BBVC. Based on the capabilities list developed by Nussbaum (2011) and methodologies developed by Mink (2016) and Steen (2016), 17 capability cards were prepared and tailored to the context, covering capabilities such as social relationships and care for the environment. These cards were used to guide discussions in the empirical phase. The capabilities were still broadly defined, which allowed for the interpretation of the interviewees.

In the empirical investigation, fieldwork is carried out in the three countries (Spain: 18-10-2021 – 27-11-2021, Colombia: 20-06-2022 – 29-07-2022, Namibia: 16-01-2023 – 17-02-2023). First, interviews were conducted with the identified stakeholders about the current system, challenges, potential role in a new BBVC, as well as opportunities, hurdles, potential harms, and positions on the power-interest grid. In addition, in-depth interviews were conducted with small-scale farmers about the current use of biomass and their challenges. The capability cards were used to identify important capabilities and limiting and enabling conversion factors. Language barriers restricted the possibilities for in-depth interviews with communal farmers in Namibia, therefore, we relied more on interviews with representatives of the different farmer groups.

Next, we organized multi-stakeholder workshops (Spain: 25-04-2022, Colombia: 28-07-2022, Namibia: 16-02-2023) to discuss

different design choices (type of feedstock, feedstock processing and transport, contracts, biomass conversion, biorefinery products, biorefinery ownership, location, and set-up) and necessary policies and local development needs. Participants were asked to choose options for these design choices and come up with an ideal scenario for the BBVC. Participants were then asked to co-create a roadmap to identify necessary steps to achieve the preferred scenario and allocate roles and responsibilities.

Table 2.1 – Overview of interviews and workshop participants

Type of stakeholder	**Spain (S)**		**Colombia (C)**		**Namibia (N)**	
	Interviews	Workshop	Interviews	Workshop	Interviews	Workshop
Farmers (F)	27	2	24	-	8	-
Farmer cooperative/ association (C)	8	8	8	4	1	3
(Farm) workers (W)	-	-	4	-	8	-
Farmer union/ federation (FU)	-	-	4	-	8	-
Secondar industry (I)	1	1	1	1	3	1
Entrepreneurs (E)	-	-	2	1	1	1
Logistics (L)	1	-	3	3	1	-
Government (G)	1	4	4	3	5	5
Technology developers (T)	2	2	-	-	-	-
Academia/ Knowledge institute (A)	3	3	10	7	2	1
NGO (N)	-	-	2	1	3	3
Bioenergy association	1	4	-	-	1	4
Total	**44**	**25**	**63**	**21**	**36**	**20**

**We use abbreviations to refer to interview participants. For example, the code S-F3 refers to farmer #3 in Spain.*

Table 2.1 shows an overview of the interview and workshop participants, and the workshop protocol can be found in Appendix A.

In the technical investigation, information from the conceptual and empirical phases was used to formulate design propositions and develop context-specific value chain design scenarios.

2.4.3 DATA ANALYSIS

Interviews and workshop discussions were recorded with participants' consent, transcribed verbatim, and coded using MAXQDA 2012 software. The thematic analysis combined deductive and inductive coding, with the theoretical framework guiding the main codes (capabilities and conversion factors) and sub-codes emerging from the data. For example, "reluctance to change" was identified and interpreted as a social conversion factor. CSD was then used to create design propositions (DPs) linking capabilities and conversion factors to key design choices. Appendix B provides an overview of the main codes with illustrative quotes and sources.

This paper utilizes qualitative analysis to deeply explore real-life contexts and complex relationships. However, qualitative research has its limitations due to subjective input from stakeholders and interpretation by researchers. To enhance credibility and trustworthiness, several criteria were employed (Guba & Lincoln, 1994). Data is triangulated, using documented in-depth interviews, semi-structured interviews, observations, and a workshop. Staying five to six weeks in the field allowed for prolonged engagement with the research context and participants. Interview and overall project findings were discussed with local partners, such as research institutes and multi-stakeholder platforms. The workshops at the end of the field visit served as a validation of the research findings. The transferability is facilitated by sharing case study protocols for potential replication in similar or different contexts. Detailed case study protocols and transcripts are available upon request.

2.5. THREE CASES

2.5.1 SPAIN

In the province of Jaén, Spain, the cultivation of olives is the most important economic activity and is dominated by small-scale farmers who cultivate

olives in traditional ways. About 30-40% of olive producers depend on olive cultivation for their livelihood. Each year, millions of tons of field and processing residues are either mismanaged or underutilized. Field residues consist of pruning rests, that are chipped and left on the soil or burned in the field. For both methods, farmers are making costs, and burning causes fire risks and environmental damage (La Cal Herrera, 2020). The main processing residue generated at the cooperative-owned olive mills is Crude Olive Pomace (COP) consisting of pulp, pit, peel, and water. This COP is brought to a private secondary mill where it is stored in large open ponds and processed to extract the remaining oil, dry it, and produce Exhausted Olive Pomace (EOP). EOP is used in the same facility as a source of energy and is sold to other industries. In the current scenario, farmers don't receive economic benefits from the production of EOP. Cooperatives are responsible for transporting COP and sometimes need to pay to treat the COP in the secondary mill. So, farmers are making costs to process both field and processing residues (ibid). The large quantities of available residues, coupled with stimulating bioenergy policies and rural development opportunities, make this an interesting case to explore a potential BBVC.

2.5.2 COLOMBIA

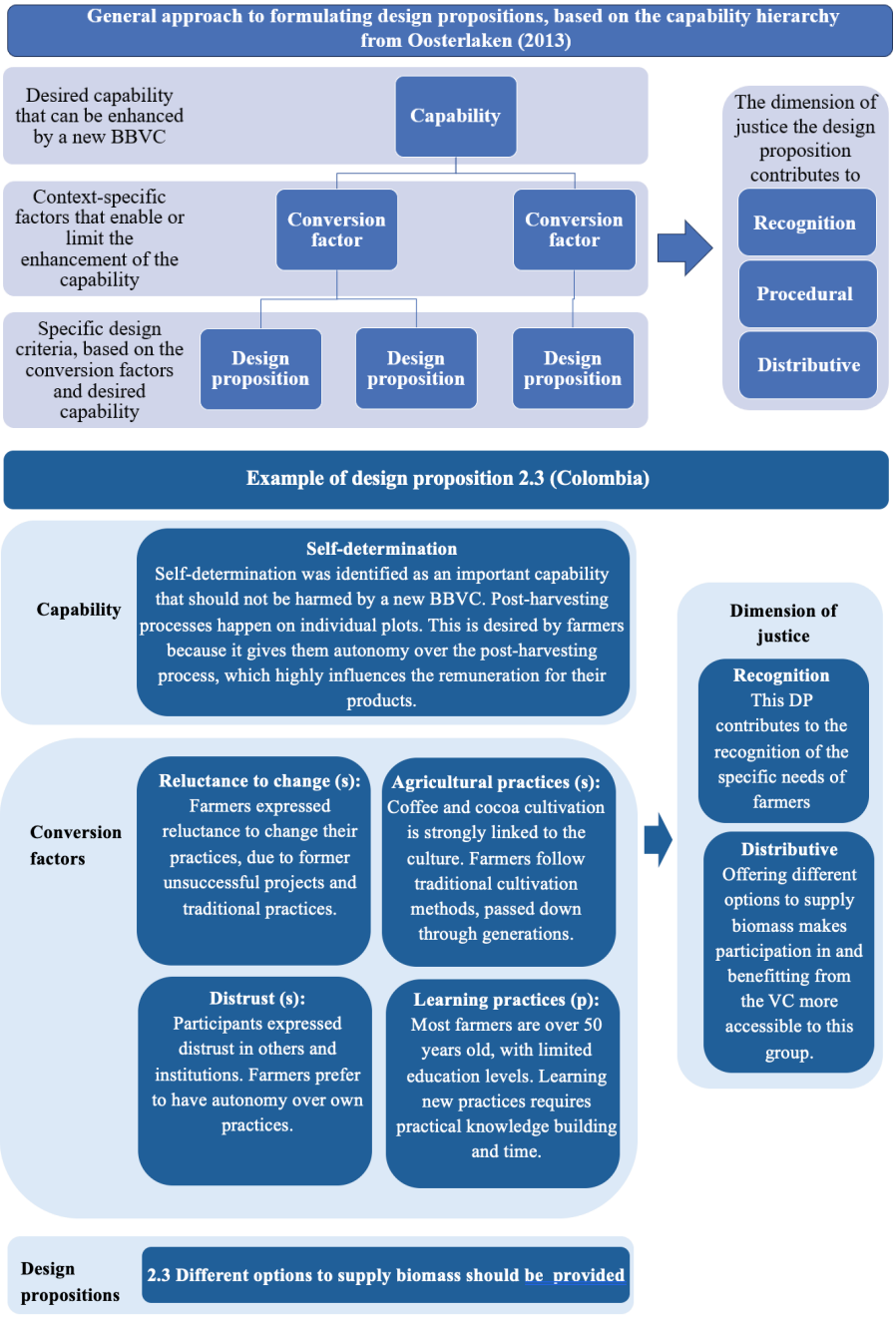
In the coffee axis of Colombia, residues from coffee and cocoa production are identified as potential sources for new BBVCs. Similar to Spain, coffee and cocoa are produced by small-scale farmers who own less than five hectares. Residues such as coffee pulp and cocoa pod husks are generated in the field and are underutilized or mismanaged. They are left on piles on the field, or applied to the soil as a type of compost. Current practices pose environmental risks due to leakages of the residues into water streams. In comparison to the farmers in Spain, most of the farmers in Colombia depend on agriculture for their livelihood. This makes them more vulnerable to price fluctuations, productivity losses, and climate change. These factors currently influence their capability of having economic stability. Farmers diversify their income to cope with that insecurity. Coffee and cocoa are mainly grown in agroforestry systems, where, alongside these crops, bananas and other fruits are cultivated, producing residues like stems, leaves, and pruning. Selling the residues that they generate on their plots can be an additional diversification strategy.

2.5.3 NAMIBIA

Different from Spain and Colombia, the potential biomass source for a new BBVC is not an agricultural residue but an encroacher bush. In Namibia, about 45 million hectares are bush-encroached. This involves the expansion of indigenous bushes, like blackthorn (*Senegalia mellifera*), at the expense of grass vegetation in the Savannah areas. This harms the ecological balance as it causes soil infertility and groundwater depletion (DAS, 2019). Compared to Spain and Colombia, there is a larger diversity of biomass suppliers due to the land ownership structures and historical processes. Firstly, large commercial cattle farmers own on average 7000 hectares. Secondly, communal farmers use land that belongs to the government and share the resources. Finally, resettlement farmers are previously disadvantaged farmers who are placed on land sold by commercial farmers. Each type of farmer has different capabilities, skills, and needs. In addition to negative environmental impact, bush encroachment threatens the livelihoods of people due to the reduced grazing capacity of cattle. More than 70% of the Namibian population depends directly or indirectly on agriculture for their livelihoods as most of them are cattle farmers. Developing new value chains based on encroacher bush can offer opportunities to solve local issues and add value to the bush.

2.6. CAPABILITY SENSITIVE DESIGN FOR SOCIAL JUSTICE

In this section, we show how context-specific design scenarios can be formulated based on the identified capabilities and conversion factors, and what that means for distributive, recognition, and procedural justice. Table 2.2 shows a summary of the design propositions (DPs) for the three cases. Figure 2.2 shows how those DPs were derived from the data. Appendix B shows a more extensive explanation of the DPs and how they were derived from the identified capabilities and conversion factors.


General approach to formulating design propositions, based on the capability hierarchy from Oosterlaken (2013)
Desired capability that can be enhanced by a new BBVC
Capability
Context-specific factors that enable or limit the enhancement of the capability
Conversion factor
Conversion factor
Specific design criteria, based on the conversion factors and desired capability
Design proposition
Design proposition
Design proposition
The dimension of justice the design proposition contributes to
Recognition
Procedural
Distributive
Example of design proposition 2.3 (Colombia)
Capability
Self-determination
Self-determination was identified as an important capability that should not be harmed by a new BBVC. Post-harvesting processes happen on individual plots. This is desired by farmers because it gives them autonomy over the post-harvesting process, which highly influences the remuneration for their products.
Conversion factors
Reluctance to change (s): Farmers expressed reluctance to change their practices, due to former unsuccessful projects and traditional practices.
Agricultural practices (s): Coffee and cocoa cultivation is strongly linked to the culture. Farmers follow traditional cultivation methods, passed down through generations.
Distrust (s): Participants expressed distrust in others and institutions. Farmers prefer to have autonomy over own practices.
Learning practices (p): Most farmers are over 50 years old, with limited education levels. Learning new practices requires practical knowledge building and time.
Dimension of justice
Recognition
This DP contributes to the recognition of the specific needs of farmers
Distributive
Offering different options to supply biomass makes participation in and benefitting from the VC more accessible to this group.
Design propositions
2.3 Different options to supply biomass should be provided

Capabilities and conversion factors are derived from the data (interviews, workshops, observations, and secondary sources). See Appendix B for all codes. Design propositions are based on those context-specific capabilities and conversion factors.

Explanation: In Colombia, post-harvesting processes happen on individual plots, using traditional and manual practices. Centralizing the post-harvesting process would be most efficient but require a big change in practice and a loss of the capability of self-determination, which is undesirable for a large group of farmers. Offering different options to supply biomass would help farmers maintain self-determination and autonomy over their practices. Related conversion factors are a reluctance to change, distrust, agricultural practices, and learning practices that are based on practical learning and require time investments. Applying this design proposition to the VC design would contribute to recognition justice by recognizing the specific needs and concerns of this group of farmers and to distributive justice, by making participation in and benefitting from the new BBVC more accessible to this group of farmers.

Figure 2.2 - Analysis process, based on the capability hierarchy (Oosterlaken, 2013)
** (s) stands for social conversion factor, (p) stands for personal conversion factor, VC stands for value chain*

2.6.1 DESIGN PROPOSITIONS

Table 2.2 shows the main DPs derived from the analysis and how those propositions relate to the desired capabilities and existing social (s), environmental (e), personal (p), and structural (str) conversion factors. In addition, we show how the DPs relate to the dimensions of social justice.

Table 2.2 – Design propositions for Spain, Colombia, and Namibia

1. Design propositions (DPs) Spain	**Related design variable**	**Related capability**	**Related conversion factor**	**Related dimension of social justice**
1.1 Use COP as the main feedstock.	Feedstock	Economic stability, Maintaining traditional system, Self-determination	Reluctance to change (s), Existing infrastructure (e)	Recognition justice, distributive justice
1.2 Use the existing infrastructure of primary and secondary mills.	Feedstock process, biomass conversion	Economic stability	Existing infrastructure (e)	Distributive justice
1.3 Use the existing cooperative structure to organize feedstock collection and benefit sharing.	Feedstock processing	Economic stability, Self-determination	Strong cooperatives (s)	Procedural justice; distributive justice
1.4 The technology should minimize water use.	Conversion technology	Care for the environment	Water scarcity (e)	Distributive justice
1.5 The by-product biochar should be distributed to farmers, to use as soil amendment.	Biorefinery products	Care for the environment	Poor soil quality (e)	Distributive justice, recognition justice

2. Design propositions (DPs) Colombia	Related design variable	Related capability	Related conversion factor	Related dimension of social justice
2.1 The biorefinery should be able to use multiple types of residues.	Feedstock; Biomass conversion	Economic stability, care for the environment	Agroforestry system (e), small volumes (e)	Recognition justice, Distributive justice
2.2 A centralized collection system should be set up, with a standardized post-harvest process.	Feedstock processing	Economic stability	Agricultural practices (s), lacking infrastructure (e)	Distributive justice
2.3 Different options to supply biomass should be provided.	Feedstock processing	Self-determination	Reluctance to change (s), trust (s), learning practices (p), agricultural practices (s)	Recognition justice, distributive justice
2.4 Farmers' associations need to play a central role in collecting biomass.	Feedstock processing	Self-determination	Distrust (s)	Procedural justice
2.5 Biomass should be converted into a decentralized system.	Biomass conversion	Economic stability	Mountainous landscape (e), small volumes (e)	Distributive justice
2.6 An already proven technology is preferred.	Biomass conversion	Economic stability	Lacking knowledge/ experience (str), Reluctance to change (s)	Recognition justice
2.7 The biorefinery should produce products that can be used in the region.	Biorefinery products	Access to energy	Limited electricity access rural areas (e)	Distributive justice, recognition justice
2.8 The new value chain should offer stable job opportunities to youth.	Value chain	Satisfactory work, Meaningful social relations	Entrepreneurial mindset youth (s),	Recognition justice, distributive justice
2.9 Farmers' associations need to be strengthened.	Institutional context	Self-determination	Limited capacity and resources associations (s)	Procedural justice
2.10 Investments are needed in education and knowledge building.	Institutional context		Learning practices (p), reluctance to change (s)	Recognition justice
2.11 A long-term commitment is necessary.	Institutional context		Distrust (s)	Procedural justice

3. Design propositions (DPs) Namibia	Related design variable	Related capability	Related conversion factor	Related dimension of social justice
3.1 The biorefinery should be able to process multiple, problematic species.	Feedstock, biomass conversion	Care for the environment	Multiple problematic species (e)	Distributive justice
3.2 Biomass harvesting and supply methods should be adapted to the capacities of biomass suppliers.	Feedstock, Feedstock processing	Inclusion	Learning practices (p), land ownership (str)	Recognition justice, distributive justice
3.3 Encroacher bush should be harvested according to sustainable harvesting management plans.	Feedstock	Care for the environment	Forest regulation (str), lack of monitoring and implementation (str)	Distributive justice, procedural justice
3.4 Proper harvesting equipment needs to be developed.	Feedstock, Feedstock processing	Economic stability, care for the environment	Hard and thorny bush (e)	Distributive justice
3.5 A pilot needs to be conducted that includes communal areas in the commercial value chain.	Feedstock, feedstock processing	Inclusion	Land ownership (str), communal organization structures (s)	Recognition justice, distributive justice, procedural justice
3.6 Biomass should be converted using a combination of large-scale, high-tech, and small-scale, low-tech hubs.	Biomass conversion	Economic stability, Inclusion	Learning practices (p), lack of access to energy (str), land ownership (str)	Recognition justice, distributive justice
3.7 Biomass conversion and value-adding activities should take place in Namibia.	Biomass conversion	Economic stability, satisfactory work	High unemployment (str)	Distributive justice
3.8 End-products from the biorefinery should first satisfy local demand.	End-product	Access to energy	Dependence on imports (str),	Distributive justice
3.9 Investments are needed in sustainable harvest management and implementation	Institutional context	Care for the environment	Lack of monitoring and implementation (str)	Distributive justice
3.10 Investments are needed in resource management and equitable benefit-sharing structures in communal areas.	Institutional context	Inclusion	Land ownership structure (str), communal organization structures (s)	Procedural justice, distributive justice, recognition justice

Looking at the three cases, we observe clear differences in conversion factors and capabilities of different stakeholders to participate in and benefit from a new BBVC. In comparison, the farmers in Spain are already in a good position, and DPs are mainly related to maintaining the current system and improving economic stability. In Colombia and Namibia, the position of the farmers is more vulnerable, which has consequences for social justice and the interventions needed to achieve social justice via value chain design. In Colombia, limiting factors are environmental factors such as a lack of infrastructure or poor tertiary roads, social factors such as reluctance to change, distrust, and agricultural practices, and personal factors like low education levels and learning practices. While these factors also play a role in Namibia, structural factors like land ownership are limiting the capabilities of especially communal and resettlement farmers. These issues can partially be addressed by adapting the value chain design, such as allowing for both low-tech and high-tech options in Namibia or offering different options to supply biomass in Colombia. Some issues cannot be addressed by adapting the technical design and require investments and interventions in the institutional context, such as knowledge building, developing sustainable harvesting plans, and conducting pilots in communal areas, which requires a multi-stakeholder approach. Below we discuss in more detail how to design for social justice in a BBVC.

2.6.2 DISTRIBUTIVE JUSTICE

Distributive justice concerns the distribution of opportunities and resources as well as imposed risks and harms from a BBVC. CSD contributes to distributive justice by first identifying which capabilities are important to local stakeholders and should be enhanced, or not harmed, by a new BBVC. An added value of CSD is that it allows to identify capabilities apart from economic benefits that are otherwise overlooked, such as the capability to care for one's environment and the capability for self-determination. As such CSD provides a more holistic perspective on distributive justice compared to traditional methods, such as social impact assessment or inclusive business.

In all three cases, the capabilities of enhancing economic stability and care for the environment are identified as relevant to distributive justice, which are also the most obvious capabilities that could be enhanced by a

new BBVC. In the two cases focusing on agricultural residues, self-determination emerged as an important capability that should not be harmed. This was less of an issue in Namibia. Here, there are many inequalities in the distribution of land ownership. This implies that the capability to be included in the new BBVC was important because such inclusion also increases opportunities for stakeholders who do not own land.

In Spain, a motivation for olive farmers to engage in a new BBVC is to improve the capability of economic stability. If this BBVC is designed well, it would contribute to distributive justice because it foresees this need. Currently, a stable income for farmers is threatened due to volatile olive oil prices and fluctuating input prices (structural factors). In addition, few plots are irrigated, which makes them vulnerable to climate change (environmental factor). Engaging in a new BBVC could offer them a more stable income.

Moreover, the desire to enhance the capability to care for the environment was identified by farmers. Currently, COP is stored in open ponds, and water is evaporated in a water-scarce area (environmental factor). The burdens associated with the new technology can be minimized by choosing a technology that minimizes water usage (DP 1.4). At the same time, this design choice can ensure additional benefits for farmers arise since the technology will help them realize the capability to care for the environment.

In Colombia, selling the residues that coffee and cocoa farmers produce in their fields can be an additional strategy to diversify their income and contribute to economic stability. According to a local researcher, this can have economic value as well as cultural: "*We need to think about the uses of those residues for the quality of life of the families that produce cocoa. We need to visualize their production system as more diverse so that they can receive more income, but also more ecosystem services like tourism. Services that sometimes are the last ones that are seen.*" (C-A6). In addition, selling residues can enhance the capability to care for the environment, because currently, the residues pose environmental risks of leaking into water sources.

In Colombia, a new BBVC should offer opportunities to younger farmers specifically (DP 2.8). This is desirable because young generations are migrating out of rural areas due to a lack of stable job opportunities. This has a major impact on families and the sustainability of the coffee and cocoa sectors, integral to the local culture. According to an NGO representative: "*Coffee is part of their culture. There is a family history, and their children don't leave their plots because they don't love coffee. They go because they look for more opportunities. But if there are opportunities, they want to stay. Also, for family reasons, they want to continue with what their parents do*" (C-N3). However, this younger generation does not desire to continue with the traditional practices of the older generations and has a more entrepreneurial mindset.

Beyond the economic, environmental, and social benefits of a new BBVC, participants preferred end-products that can be used locally, like energy, which remains a challenge in some rural areas. A technical advisor of a coffee association says: "*If you can produce gas from the residues and the woman that is cooking doesn't inhale smoke from wood, those are things that improve the quality of life.*" (C-C1). Biofuel for the marine industry might not be the best-suited choice for a biorefinery in this region. From a social justice point of view, at least part of the (by-)products generated in the biorefinery should be distributed and used in the region where biomass is supplied (DP 2.7).

In Namibia, the main motivation for farmers is to restore the rangeland to increase grazing capacity for their cattle. One commercial farmer explains: "*Well, the bush in our eyes is the enemy because he's stealing the water from the grass and the grass is our precious food for the cattle.*" (N-F2). In addition, rangeland restoration can improve conditions for wildlife and also provide more economic stability for farmers.

A concern in Namibia is sustainable harvesting. There is a monitoring system in place, but monitoring and implementation are lacking due to a lack of resources (structural factor). A government representative states: "*The biggest challenge for monitoring by Forestry is the equipment, the vehicles, internet, computers' that stuff. They hardly have such stuff and it's easy for me to sit here and say they should have been doing this and that. But I mean you come to an office where there's only one person.*

And even the internet to check on Google Earth sometimes lacks." (N-G1). Monitoring and implementation should be strengthened to ensure sustainable harvesting of the bush and prevent environmental harm (DP 3.9).

Another motivation is to enhance inclusion. In Otjozondjupa's communal areas, bush encroachment is worse due to farmers' lack of resources for control. Concerns about overexploitation and unequal benefit sharing have led to strict regulations. Workshop stakeholders emphasized that a new BBVC should include all farmers, especially those on communal lands, who seek new commercial opportunities for bush valorization. A representative of communal farmers explains: *"We are eager for any change and we are ready for any cooperation. We don't want to sit and be fed. Our people are so eager. There is always progress if there is change. There's no progress now."* (N-F5-communal).

In addition, workshop participants stressed the importance of conducting all value-adding activities in Namibia itself, thereby maximizing value addition and job opportunities (DP 3.7). Because the majority of Namibia's fuel demand is imported, biofuel should first satisfy the local demand before being exported (DP 3.8). Additionally, using biomass for electricity in rural areas with limited access could enhance distributive justice.

2.6.3 RECOGNITION JUSTICE

Recognition justice concerns acknowledging the needs and potential harms towards vulnerable and underrepresented groups. CSD offers a relevant lens for identifying those structures and needs using the concepts of capabilities and conversion factors. Social justice can only be achieved when these context-specific factors are identified and recognized in the design.

Local vulnerable stakeholders were identified to align CSD with recognition justice. In Spain, these include small-scale olive farmers with fragmented plots inherited over generations. Despite their small size, farmers can negotiate and participate in decision-making through cooperatives that own the primary mills (social factor). The lens of conversion factors helped to identify and contextualize the concerns of the farmers.

For example, farmers in Jaén showed reluctance to change (social factor). Olive cultivation is integral to Jaén's culture, and farmers wish to preserve their traditional system. Due to fragmented production (environmental factor), mobilizing pruning rests would only be economically viable with more concentrated land management. This conflicts with farmers' conservative attitude, valuing control over their plots and traditional methods.

Building on the desired capability of more economic stability and preserving control and the traditional cultivation system, the design for a new BBVC in Spain should be close to the current system. This is also confirmed by participants in the workshop. This contributes to recognition justice because it acknowledges the specific needs of these local stakeholders. Choosing crude olive pomace (COP) as a main feedstock instead of pruning residues also contributes to maintaining traditional farming practices because many farmers value the current practice of chipping the pruning residues and applying them to the soil (DP 1.1). An olive farmer illustrates: *"I am interested that it stays in the field. Because soil degradation is a problem here, and now my pruning rests are used as compost, it provides benefits to the soil now."* (S-F7).

In addition, bringing by-products from the biorefinery such as biochar back to the plots to enhance the soil quality can also support recognition justice because it makes the bioeconomy more relatable to farmers (DP 1.5). A cooperative representative explains: *"Another thing is that we don't know the technology and the market. If it will generate compost, we can use it so that is familiar to us."* (S-C2).

Unlike in Spain, many conversion factors need to be created or strengthened before small-scale farmers in Colombia can participate in and benefit from a new BBVC. The country lacks experience with biorefineries (structural factor), and biomass transport from plots is challenging due to unpaved tertiary roads in mountainous areas (environmental factors). In Spain, many conversion factors necessary for a new BBVC, such as the existing infrastructure and quality roads, are already present. This differs from the context in Colombia, where coffee and cocoa farmers are identified as vulnerable local stakeholders due to their small scale and dependency on agriculture

The most efficient way would be to centralize the collection of the whole fruit, instead of the green beans or residues (DP 2.2). However, it is important to recognize the current practices and concerns of farmers. In Colombia, post-harvesting processes happen on individual plots, meaning that the coffee pulp and cocoa pod husks are produced and collected in the field (social factor). Current practices are seen as ways to dispose of the residues and are not as highly valued as in Spain, with the pruning rests. A centralized system requires big changes in practices and raises concerns about the remuneration process. Farmers receive prices based on the quality of their products. One farmer and association leader says: *"If I am handing over what belongs to my property, then how do I access and get what I gave from my property? How do I fertilize? What compensation do I have?"* (C-C8). For this system to work, trust needs to be built. In addition, due to the low education levels of especially the older generation farmers, changes require time and practical knowledge building (personal factor).

Building on the identified needs and conversion factors, a design where multiple, smaller-scale hubs supply a larger biorefinery would be best suited for this context (DP 2.5). Farmers should be offered different options to supply biomass (DP 2.3). A representative of an NGO stated in the workshop: *"Not every farmer will be able or willing to change their practices. It is important that they can supply in their preferred way."* Farmers who are more willing to make changes could supply to a centralized location and showcase how this could work. Alternative options should be offered to farmers who are less open to changing their practices. This approach supports recognition justice by allowing farmers autonomy over residue use. A technology that can handle multiple biomass types is also desirable, recognizing the practice of cultivating multiple crops (DP 2.1).

In Namibia, many conversion factors limit farmers' ability to participate in new BBVCs despite large bush availability and stakeholders' interest in its use. Compared to Spain and Colombia, there is a larger diversity of biomass suppliers due to structural factors, where certain groups have been disadvantaged.

From the point of view of commercial farmers, an issue that needs to be recognized is the manual labor that is necessary to harvest the bush, often performed by migrant workers. The bush's hardness makes mechanical harvesting difficult, and providing housing and food for workers is costly and poses challenges like illegal poaching and language barriers. From their point of view, mechanized harvesting is preferred. Because of their large plots, commercial farms could provide a more steady biorefinery supply but require investments in machinery and skills development (DP 3.4).

The capabilities of farmers in communal areas differ from commercial farmers. The land is owned by the government and shared by people living on the land (structural factor), which makes the bush a common-pool resource. This prevents communal farmers currently from taking part in commercial value chains. A condition for participation in commercial value chains from the bush is the establishment of a resource management plan to guarantee a sustainable harvest and equitable benefit sharing (DP 3.3). Several pilots have been carried out, but so far have been unsuccessful. According to a civil society representative involved in this pilot: *"We've been struggling to get that structure in place also with the communal areas because it is, you know, millions of hectares belonging to hundreds of thousands of people equally. Getting a structure in place where one guy does not have a bigger benefit than the other. Other than just the time that he's putting in, it's very difficult."* (N-N2).

Another limiting conversion factor is the education system, which is especially problematic in communal areas (structural factor). Learning new skills requires time (personal factor). Resettlement farmers face similar challenges, as they often have a background as communal farmers and do not have the necessary skills and resources to manage a commercial farm. A representative of resettlement farmers explains: *"The government takes a person from wherever and puts him on a piece of land wherever, expecting him to produce. No orientation, no nothing, at least, they need to be mentored to be productive."* (N-FU2). From the point of view of communal and resettlement farmers, more low-tech and manual harvesting techniques are preferred.

If a BBVC is to benefit all, different farmers need to be involved in diverse ways. Workshop participants proposed a more flexible design that responds to the recognition of the different conversion factors and capabilities of farmers. A central hub with more advanced technologies supplied by larger-scale, commercial farmers can be combined with smaller-scale suppliers using more low-tech harvesting techniques in communal and resettlement areas (DP 3.2).

2.6.4 PROCEDURAL JUSTICE

Procedural justice involves participation in value chain design and decision-making on future visions. When designing a new BBVC, it's crucial to consider who participates in decision-making and how decisions are reached. The CSD process enhances procedural justice by involving local stakeholders in decisions from the early stages on. In addition, we identified important conversion factors that influence the capability for involvement in decision-making, namely the existence of strong cooperatives, trust, and commitment.

An important conversion factor related to procedural justice is farmers' organizations (social factor). Farmers in Spain have a good negotiation position because most of them are organized in cooperatives. Since the cooperatives own the primary mills, where value is added to the olives and the main residue is produced, farmers can influence decision-making in the current and a potential new BBVC. This is different in Colombia, where farmers are organized through the national federation or a smaller-scale association. The position of individual farmers in this system is less powerful than in Spain. The national federation, especially in the coffee sector, has a hierarchical system where decisions are made top-down. One farmer explains: *"Many times, they want to put things on the properties that we don't agree with, like a coffee seed, and we don't want to plant it, and they say, 'Well, you should plant that.' So, I, who manages it and works the property, know what seed I like and what is good for me. They have an idea that they impose on you."* (C-F22). Although this structure provides coffee farmers with important benefits such as guaranteed outlets for their products and capacity building, it limits their negotiation position. Smaller-scale associations are experienced differently. However, associations reported a lack of resources or capacity

and would require strengthening to play an important role in the bioeconomy (DP 2.9).

In addition, in Colombia, the issue of trust was raised. Farmers have faced many projects that promised changes but were discontinued or never materialized, making them reluctant to invest time in new initiatives (social factor). One technical advisor of a coffee association explains: "*People are always sensitive to organizations and to the loss of time and money. Farmers are tired that they come to them and promise a lot of things. That is why some members don't participate in projects like this.*" (C-C1). Therefore, for a new project to work, a longer-term commitment is necessary (DP 2.11).

In Namibia, the position of farmers is more complex and very much dependent on other factors such as land ownership and available resources. Commercial farmers are well-organized in labor unions, while communal farmers face more complex and area-specific organizational structures. As one civil society representative states: "*We don't put enough effort into reaching the people that are not organized and something that we see very little in Namibia are cooperatives. The farmers in the commercial areas got their farmers associations, but you don't have a lot of that in communal areas.*" (N-N1). In communal areas, further investments need to be made in pilot projects to include communal areas in commercial value chains to prevent the reproduction of existing inequalities (DP 3.5). These pilots should build as much as possible on structures that already exist in some areas, such as conservancies and community forests, that manage natural resources.

2.6.5 OPPORTUNITIES AND CHALLENGES

By applying CSD to three cases, we showed that it has added value to social justice. CSD offers a useful approach to identifying the concerns, views, and needs of local vulnerable stakeholders. The CA provides a more holistic view compared to other approaches to develop inclusive and socially just value chains. It allows the identification of capabilities that would otherwise be overlooked, such as care for the environment and self-determination, and the concept of conversion factors helps to identify the context-specific factors that cause differences in access to resources and opportunities. This is highly relevant for recognition and procedural justice.

We showed the differences in conversion factors and the investments needed for smaller-scale actors to participate in a new BBVC. These investments and interventions are higher in areas where conversion factors are limiting the capabilities of local stakeholders, such as in Colombia and Namibia. Building on the recognition of the needs and capabilities of local vulnerable stakeholders, and their participation in decision-making, CSD enables making concrete recommendations for the design of the value chains. That is important since choices in the early stage such as feedstock type, scale of production, and technology determine to a large extent the capability of smaller-scale actors to participate in a value chain. This influences the distribution of opportunities and resources as well as risks and harms. In parallel to the engagement of local stakeholders in technical value chain design choices, investments and developments in necessary conversion factors are needed, especially in contexts where these conversion factors are lacking. CSD helps in identifying those needs.

While CSD is a promising approach, some challenges are identified. One dilemma involves choosing which stakeholders' capabilities to prioritize and dealing with potential conflicts. In the Spanish context, we encountered a dilemma between preserving the traditional practices preferred by the older generation that dominates the sector, or adopting innovations desired by the younger generation. In addition, conflicting needs could arise between stakeholders at different positions in the value chain. The needs and capabilities of stakeholders at the downstream part of the value chain, such as fuel producers or investors, might conflict with the DPs at the local level. An example is contractual arrangements. Downstream actors prioritize supply security and favor longer-term contracts, while farmers, as revealed in workshop discussions, lean towards shorter, more adaptable contract terms. These conflicts cannot entirely be solved by CSD. Similar to the process of VSD, the DPs in this paper are normative, but not prescriptive (Palmeros Parada et al., 2020). They are meant to bring forward the perspectives of local stakeholders and include them in decision-making since these are often overlooked.

Second, studies show that firms are generally less interested in including marginalized stakeholders as co-creators of economic activities (Chowdhury et al., 2024). In the bioeconomy, fossil-dependent companies already face challenges transitioning to sustainability, and engaging local

stakeholders could add complexity. However, identifying local capabilities and needs not only helps in creating social justice outcomes, but it can also increase the security of supply. If a value chain design does not match local skills and knowledge, the project could fail. So CSD could also contribute to the success of the value chain. Moreover, the bioeconomy presents a unique case due to the limited availability and competitive demand for bio-resources. This gives biomass suppliers a stronger position than in industries where suppliers are more abundant, for example, in the garment industry.

Third, the defined DPs raise the question of responsibilities. Who is or should be the main responsible party to realize a socially just value chain design? We formulated some DPs that can be adapted by companies, such as choosing a type of technology, method of biomass collection, or contractual arrangements. But there are also DPs related to the institutional context that are outside the sphere of influence of a company, but vital for social justice. Here, collaborations are needed with governmental and civil society organizations to realize a socially just value chain design.

2.7. DISCUSSION

This paper explored how CSD could enhance social justice in new BBVCs. The insights from this study contribute to the emerging attention for social justice in debates on sustainability and sustainable transition. Given the role of the bioeconomy in this transition, it is crucial to ask where bio-resources come from, under what conditions they are sourced, and who determines those conditions (Lima, 2022). While many studies concentrate on evaluating social justice outcomes in existing value chains, it remains a challenge how to proactively consider social justice issues in the development of new BBVCs. This is particularly relevant since choices made in the early stages determine to a large extent the outcomes in a later stage. CSD offers an approach to proactively engage with social justice issues in the design phase of the value chain. Moreover, we build on research done in the emerging field of CSD (Asveld et al., 2023; Jacobs, 2020; Oosterlaken, 2013). We specifically contribute to this field by applying CSD to three real-life cases of new BBVCs in the methodology and analysis. This has not been done before. In addition, we make an explicit connection between CSD and social justice.

Our work has practical implications by showing how context-specific capabilities and conversion factors can be linked to important value chain design decisions. This can help companies in reaching social justice outcomes and better acceptance and performance of the value chain. Furthermore, our study can contribute to policy decisions. The three cases show that the institutional context is important in achieving more social justice in BBVCs. This is especially true for contexts in the Global South where necessary institutions or conversion factors are lacking. Policy-makers can provide support in strengthening these necessary conversion factors. In addition, this research has social implications by including the voices of stakeholders at the beginning of the value chain who are seldom included in decision-making. We show an approach that connects research and practice and show three cases in underrepresented contexts. Furthermore, we demonstrate the potential for BBVCs to benefit local vulnerable stakeholders, addressing concerns about the adverse social impact of the bioeconomy (Lima, 2022).

Besides the contributions, this research has several limitations. The first limitation is the absence of operational BBVCs in the three contexts. This prevents evaluating their performance or social impact. The scope of this paper is limited to presenting a process that can be followed to reach a more equitable decision-making process and the impact of the value chain. Correspondingly, the DPs in this paper are limited to early-stage design choices. Factors vital to social justice issues, like governance and power dynamics among stakeholders, are excluded from the method due to the challenge of assessing these in prospective value chains. In addition, this paper shows the potential of CSD by using three qualitative case studies. This limits the possibilities of generalization. However, we do show the complex realities in which stakeholders are creating or transforming value chains and present a process that can be replicated in multiple contexts. Last, this paper focuses on the stakeholders at the beginning of the value chain. Including stakeholders in the downstream part of the value chain could have revealed more trade-offs and conflicts.

Future research could build on this approach by applying CSD to other sectors to further explore its potential. In addition, more research can be done on the practical implications of CSD for companies and on dealing with conflicting needs and interests. Last, we found that value chain design

should be done in parallel with institutional development. Further research is needed on how institutions can be developed and strengthened, and who is responsible, especially when operating in contexts in the Global South.

2.8. CONCLUSION

This paper explored the potential of CSD for designing new BBVCs for social justice. We argued that CSD is a relevant framework to guide important early-stage design choices. We show that design choices made via the CSD process can contribute to more distributive, recognition, and procedural justice because it allows the identification of local vulnerable stakeholders and provides tools to connect their needs, knowledge, and capabilities to these choices. We illustrated this by applying CSD to the design of three potential VCs for producing marine biofuels from waste biomass in Spain, Colombia, and Namibia. The CSD process connects with distributive and recognition justice, as it enables the identification of the current distribution of opportunities and resources, as well as the recognition of differences rooted in processes that underlie this distribution. Particularly relevant is the identification of conversion factors that cause differences in access to resources and opportunities, which link with procedural and recognition justice, and underlie the distribution of opportunities and resources. We have also shown that, besides adapting processes and technical design, investments are needed in the institutional context, especially in contexts where necessary conversion factors are lacking.

CHAPTER 3

INCLUSIVE PATHWAYS TO A SUSTAINABLE BIOECONOMY: BALANCING INCLUSION AND ECONOMIC FEASIBILITY IN NEW BIO-BASED VALUE CHAINS

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3.1 INTRODUCTION

The transition to a bioeconomy, where biomass is converted into energy and materials to substitute fossil fuel inputs, is presented as a solution to address global climate change and sustainability challenges (Lewandowski et al., 2018; Cerca et al., 2022; Siegel et al., 2022). Residues from agriculture or forestry are increasingly used as a basis for this substitution (Carus & Dammer, 2018; Gregg et al., 2020; Stegeman et al.,2020). This contributes to the transition towards a circular bioeconomy where biomass is valorized in integrated, multi-output production chains while also making use of residues and wastes and optimizing the value of biomass via cascading (Stegmann et al., 2020, p.5). However, the circular bioeconomy is often criticized for its potential harmful environmental and social impact (Asveld et al., 2015). Through bio-based value chains (BBVCs), different stakeholders are connected to convert renewable biological resources into valuable products. This presents both opportunities and significant complexities. While new BBVCs can drive innovation, they also introduce considerable uncertainties and risks. They involve long-term decisions regarding feedstock, suppliers, and location, and require the coordination of diverse stakeholders from various geographical areas, with different backgrounds, needs, and capabilities. This complicates the transition from a fossil-based economy to a bioeconomy (Asveld & Stemerding, 2017; Sadeghzadeh et al., 2025). A successful and sustainable bioeconomy relies not only on technological innovation but also on its integration into social contexts.

While sustainability is the central promise of the circular bioeconomy, what is understood by sustainability for biomass remains contested and has been the subject of ongoing debate involving a wide range of actors. Especially, aspects related to distributive justice and inclusion must be more clearly defined (Asveld et al., 2015). Recent studies emphasize the importance of a just transition to a bioeconomy and explore how, theoretically, a just bioeconomy should be structured. A just bioeconomy transition must address environmental impacts, biodiversity preservation, and promote social equity (Ramcilovic-Suominen, 2023; Ruml et al., 2025). However, few studies address the practical implications and complexities of transitioning to a sustainable and just bioeconomy.

A key challenge in building a sustainable and circular bioeconomy is that it demands systemic change, requiring the engagement and commitment of all actors along the value chain (Donner et al., 2020). Therefore, new BBVCs must be inclusive and add value to all stakeholders. Different strategies can be followed to improve and promote inclusion in BBVCs. Defining inclusive strategies within the bioeconomy can benefit from lessons learned in agri-food chains. Although existing literature on inclusion in agri-food systems provides valuable insights (Devaux et al., 2017; Ros-Tonen et al., 2019), the bioeconomy presents different dynamics. It is therefore useful to explore how inclusive strategies applied in agri-food chains can be implemented in the context of the bioeconomy. Additionally, there is little empirical research on the practical implications and complexities of establishing inclusive BBVCs for all stakeholders, and more specifically, private actors such as biofuel producers, technology providers, and end consumers. Consequently, this paper addresses the following research question: *How can different strategies for inclusive value chains be applied in new bio-based value chains?*

We explore this question by first reviewing literature on inclusion in agri-food value chains, especially on inclusive business, inclusive value chains, and inclusive development strategies (Ros-Tonen et al., 2019). We then explore the key differences between agri-food chains and BBVCs. Based on our empirical research in three different contexts, we identify complexities for developing inclusive BBVCs. The three cases involve potential value chains for marine biofuels based on waste biomass, namely olive oil residues in Spain, coffee and cocoa residues in Colombia, and encroacher bush in Namibia. The three cases represent potential global value chains, where different segments and activities of the value chain are carried out in different parts of the world (Gereffi & Stark, 2011). The chosen cases are global value chains because the majority of new BBVCs are global in nature, since a large part of the world's available biomass is produced in the Global South (Lima, 2022). This complicates the development of inclusive value chains, because different actors with various backgrounds, needs, and knowledge who are not used to working together are connected (Asveld & Stemerding, 2017).

We build on the study of van der Veen et al. (2024), who identified design requirements based on upstream stakeholders' needs, perspectives,

and capabilities in the three case study locations. In addition, we interviewed downstream stakeholders such as biofuel producers and end-users such as shipping companies. We explore how inclusive business, inclusive value chain, and inclusive development strategies can be shaped in the different contexts to address the identified complexities, and what this requires from the stakeholders involved. We then discuss which strategies are appropriate for specific contexts and reflect on the balance, or trade-offs, between the ideal levels of inclusion and what is practically achievable when establishing new BBVCs.

We conclude that, due to the complexity and diversity of contexts in BBVCs, a range of strategies should be employed. We argue that in contexts where stakeholders are faced with more systemic or structural challenges, it is sometimes more realistic to start with inclusive business strategies, even if ideally the highest form of inclusion (inclusive development) is aimed for. With systemic challenges, we refer to deep-rooted, institutionalized barriers that shape how resources, opportunities, and power are distributed across society. In these contexts, a more modest strategy at least provides some benefits to the most vulnerable stakeholders in the chain. Although inclusive development may not be achievable initially, we argue it should continue to be the long-term objective to provide opportunities for those least well-off.

In the next section, we elaborate on the literature on inclusion in global value chains and present three bodies of literature that conceptualize inclusion in this context (inclusive business, inclusive value chains, and inclusive development). We then address the key differences between agri-food chains and BBVCs. Second, the methodology is presented, including case study descriptions, case study protocols, and analysis. In the following section, the results are presented. We identify five complexities for developing inclusive BBVCs and illustrate these with examples from the case studies. In the discussion section, we elaborate on the trade-offs and reflect on the three bodies of literature.

3.2 INCLUSION

3.2.1 INCLUSION IN GLOBAL VALUE CHAINS

To create a positive social impact, it is important to include all stakeholders in the process and outcomes of developing global value chains (Robaey et al., 2022; Asveld et al., 2023). However, it is not always clear what exactly is meant by inclusion. In a broad sense, we define inclusion as interventions focused on those least well off that aim to increase their opportunity to lead a life worth living (Asveld et al., 2023). Different strategies are possible to address or achieve inclusion in global value chains.

Over the past two decades, a substantial body of literature has emerged on inclusive value chains within agri-food systems (Devaux et al., 2017; Ros-Tonen et al., 2019). A key focus has been on integrating small-scale farmers into global value chains, which is seen as a promising strategy for poverty alleviation, economic development, employment creation, gender equity, and enhanced well-being. Particular attention is paid to smallholders, as they are often the most marginalized and least likely to benefit from participation in global value chains. Ros-Tonen et al. (2019) distinguish three bodies of literature dealing with inclusion in this context: inclusive business, value chains, and development, each with its own strategies and dimensions to enhance inclusive collaboration between value chain actors. Inclusive business is a private-sector approach that integrates smallholders (often including women, poor, or marginalized groups) into value chains in a way that is commercially viable while bringing developmental benefits. Inclusive value chain strategies focus not only on involving smallholders but also on improving the fairness of their participation, in terms of access, power, and environmental and social outcomes. Inclusive development is a broader concept that covers more structural aspects, such as policies, institutions, and norms, and encompasses aspects of social justice, equity, and environmental sustainability. Table 3.1, adopted from Ros-Tonen et al. (2019: 13), shows an overview of how the three bodies of literature define inclusiveness in the context of global value chains.

Both inclusive business and inclusive value chain literature are rooted in sustainability discourses that recognize the role of economic growth and

acknowledge that farmers and companies participate in value chains primarily for economic purposes. Inclusive business literature views inclusiveness as a means to advance business objectives. In contrast, inclusive value chain literature more directly engages with issues of inequality and power asymmetries, aiming to address these challenges through inclusive strategies such as social upgrading and empowerment. Inclusive development theory, however, departs from the growth-oriented neoliberal paradigm altogether. While it shares the normative orientation of inclusive value chain literature, it goes further by critically examining the deeper norms, institutional structures, and discourses that drive exclusion and marginalization (Ros-Tonen et al., 2019).

In all three strands of literature, partnerships between value chain actors and beyond, such as governments, NGOs, and civil society organizations, are crucial. Moreover, most literature on inclusion in global value chains views inclusion as a process, instead of an outcome (Ros-Tonen et al., 2019). It's about the criteria of inclusion on both sides of the chain (Schouten & Vellema, 2019). To create these terms of inclusion in new BBVCs, it is helpful to learn from strategies in agrifood value chains and distinguish between the different strands of literature that deal with inclusion in global value chains. This can contribute to a better understanding of how low-income producers can be included in new (bio-based) value chains and how partnerships among value chain and non-value chain actors could take shape. Table 1 illustrates how inclusion is operationalized across the three bodies of literature. It distinguishes between different dimensions and highlights the distinct strategies each strand presents.

Table 3.1 – Dimensions of inclusive value chain integration, adopted from Ros-Tonen et al. (2019)

Dimensions of inclusive value chain integration as operationalized in the three bodies of literature (P = process; O = outcome)			
Dimension	Inclusive business	Inclusive value chains	Inclusive development
Economic			
Double or triple bottom-line	Combines profitability targets and economic growth with social and environmental goals (P).	Rejects focus on economic growth (P).	
Social			
Concern for wellbeing	Serving the bottom-of-the-pyramid by delivering societal or developmental benefits; include the Base of the Pyramid (BoP)[1] as entrepreneurs or suppliers (P).	Higher incomes (O) through market integration and upgrading (applying quality and sustainability standards) (P).	Multidimensional wellbeing (material, relational, and cognitive-subjective) for poor and marginalized people (O).
Inclusive learning and innovation	Frugal innovations (affordable, simple, and resource-efficient products and services with high use value (O). .	Knowledge co-creation based on recognition of local knowledge, best practices, innovations 'from below' and continual learning through participatory monitoring and evaluation (P)	
Alignment with smallholders' realities	Acknowledge survival entrepreneurs and multiple markets (P).	Sensitive to diversity among farmers in terms of opportunities, constraints, and vulnerabilities; alignment with smallholders' aspirations; accommodating heterogeneity in terms of gender, age, landownership, ethnic/cultural background, and household composition (P).	
Relational			
Empowerment	Improving the human rights and dignity of those at the BoP *(O).*	Strengthening farmers' autonomy, capacity, and agency vis-à-vis companies, NGOs, and donors, through social upgrading (improved rights and working conditions through VC engagement) and labour agency *(P).*	Attention to local political economy and constraining structures; enhance the capacity of the poor and marginalized to exert choice (take control over their own life) and voice (demand equitable rights and fair conditions of VC engagement) *(P).*

Gender equity and responsiveness	Promotes gender aware women's entrepreneurship by recognizing gendered risks and uncertainties in the BoP community and business environment (gender accommodating) *(P)*.	Addresses gendered bottlenecks to and opportunities for participation and benefits by reforming policies and institutions that constrain women ('levelling the playing field') (gender sensitive) *(P)*.	Sensitivity to gender and its intersectionality with age, race, ethnicity, religion, and location, and actively challenging the underlying gender norms, institutional constraints, and power imbalances (gender transformative) *(P)*.
Environmental			
Environmental sustainability	Promotes resource efficiency through frugal innovations (see above) *(P)*.	Upgrading through voluntary certification *(P)*.	Commitment to environmental inclusiveness by avoiding environmental effects; questioning the commitment to growth *(P)*.
Cross-cutting			
Enabling environment	Government and networks create an enabling environment for inclusive businesses and producers in the global South *(P)*.	Political will, local civil society, and producer organizations are essential for creating inclusive VCs *(P)*.	Governments actively protect people's rights and pursue redistributive policies; multilevel governance addresses interconnected global-to-local challenges *(P)*.

[1] *The term 'BoP' is adopted from the paper of Ros-Ronen et al. (2019), who discuss literature on inclusive business. In inclusive business literature, BoP is a frequently used term. In the paper of Ros-Tonen et al. (2019), they refer to BoP as 'Bottom of the Pyramid', which is a more contested term. We chose to refer to BoP as 'Base of the Pyramid' which is more neutral. Nonetheless, there is criticism of this terminology as it is a potentially condescending and oversimplified frame. We chose to still use the term, since it is widely used in inclusive business literature, which we review in the context of bio-based value chains.*

3.2.2 INCLUSION IN BIO-BASED VALUE CHAINS

While we can learn from literature on inclusive agrifood value chains, it is important to address some key differences between agrifood and BBVCs.

First, BBVCs are complex and involve multiple actors who are dispersed across different geographical areas, with different backgrounds, needs, and perspectives. Often, these actors are not used to working together. Moreover, the intended end products are more focused on global markets rather than local (food) markets (Asveld & Stemerding, 2017; Robaey et al., 2020). Second, unlike in many agri-food chains, biomass is not a commodity yet and requires advanced processing. BBVCs are built on new and quickly developing technologies, with a broad spectrum of innovation, ranging from bulk to specialty production. This requires an innovative approach and rapid technological progress, as well as sources of financing (Bröring & Vanecker, 2022; Sliwa & Pink, 2025). Third, creating BBVCs requires systemic changes. Different members of the value chain need to adapt for the new technology to succeed (Donner et al., 2022). Fourth, there is a large degree of interdisciplinarity. It is based on complex knowledge from different fields, including process engineering and local knowledge (Bröring & Vanecker, 2022). Last, BBVCs engage with the part of public opinion and civil society, for which reducing negative environmental impact (and social impact) is a key issue. Civil society organizations play an important role in demanding sustainable BBVC and are often the most critical voices (Asveld et al., 2015; Sliwa & Pink, 2025). These aspects make BBVCs stand out from conventional agri-food chains and therefore require a dedicated, tailored approach to address the specific challenges in new BBVCs. Table 3.2 shows an overview of the key differences between agri-food value chains and BBVCs. In the table, we connect these differences with the relevant dimensions of inclusion as addressed in Table 3.1.

One of the main challenges to transitioning to an inclusive bioeconomy is the lack of value chain collaboration (Dace et al., 2024). The higher the complexity of an exchange of goods or services, the tighter the required coordination among parties involved (Pascucci et al., 2024). Private actors across emerging BBVCs need to organize upstream as well as downstream activities, particularly if they hold an intermediary position, as is often the situation in bioenergy (Berg et al., 2018). Given the difficulty, partnerships

are recognized as crucial for inclusive BBVCs. This addresses the discussion about the roles and responsibilities of various stakeholders, both private and non-private, in ensuring inclusion in new BBVCs. There is a growing expectation for companies to be accountable for the social and environmental consequences of their operations and to actively contribute to societal wellbeing (Scherer & Voegtlin, 2020; De Gelder & Asveld, 2024). However, the specific responsibilities of actors within the bioeconomy remain unclear. This issue is particularly pressing in the context of the bioeconomy, where projects often aim to reduce local poverty (Dawson et al., 2016) but are frequently implemented in regions characterized by deep economic inequalities and cultural diversity (Postal et al., 2020; De Gelder & Asveld, 2024).

Table 3.2 – Overview of the differences between agri-food chains and BBVCs

Agri-food chains	**BBVC**	**Relevant dimensions**
Involve traditional actors like farmers, processors, retailers, and consumers.	Involve a wider range of actors, including farmers, biotechnology companies, and energy providers, who are dispersed among various geographical locations and are not used to working together.	Inclusive learning and innovation (3), Alignment with smallholders' realities (4), Gender equity and responsiveness (6), Enabling environment (8).
Typically involve minimal to moderate processing. Innovation is often incremental.	Biomass is not a commodity yet and requires advanced processing, often built on new and quickly evolving technologies. Innovation is more disruptive and research-intensive.	Double or triple bottom-line (1), Inclusive learning and innovation (3), Enabling environment (8).
Building new agri-food chains requires moderate change.	Building new BBVCs requires systemic change where different value chain actors need to adapt.	Double or triple bottom-line (1), Concern for wellbeing (2), Alignment with smallholders' realities (4), Empowerment (5), Enabling environment (8).
Primarily require knowledge in agriculture, value chain logistics, and food safety.	Built on complex knowledge, characterized by a large degree of interdisciplinarity.	Inclusive learning and innovation (3), Alignment with smallholders' realities (4).
Agri-food chains are mainly influenced by food security, nutrition, and safety guidelines.	Reducing negative environmental impact and preventing societal harm are key issues.	Concern for wellbeing (2), Empowerment (5), Environmental sustainability (7).

**The relevant dimensions are identified according to our own insights*

3.3 METHODOLOGY

To examine which pathways could be followed to achieve inclusive BBVCs and the implications and complexities for the (private) stakeholders involved, we explore three cases of prospective value chains for marine biofuels based on waste biomass. These cases include olive oil residues in Spain, coffee and cocoa residues in Colombia, and encroacher bush in Namibia. The three cases show a diversity in contexts, with different levels of capabilities, experience, and institutional capacities. We build on the work of van der Veen et al. (2024), who identified design requirements based on upstream stakeholders' needs, perspectives, and capabilities in the three case study locations. In addition, we interviewed downstream stakeholders such as biofuel producers and end-users such as shipping companies, located in the Netherlands.

The cases are part of a multi-stakeholder and multi-disciplinary research project to design inclusive and sustainable biofuels for the marine industry, an industry that is actively looking to source more sustainable fuels (IMO, 2025). The cases are selected in an iterative process with project partners who represent stakeholders in a biofuel value chain (shipping company, (bio)fuel producers, renewable energy platform, and an NGO).

3.3.1 CASE DESCRIPTIONS

3.3.1.1 OLIVE OIL RESIDUES IN SPAIN

In Jaén, Spain, olive farming is the main economic activity, largely carried out by small-scale farmers using traditional methods. Around 30-40% of them rely on it for their livelihood. Each year, large amounts of pruning and processing residues are generated, which are poorly managed. Pruning waste is either chipped and left on the field or burned. These are both costly options, with burning posing environmental risks. Olive mills, owned by cooperatives, generate Crude Olive Pomace (COP), made of pulp, pits, peel, and water. COP is currently stored in large open ponds and processed in a secondary industry for further oil extraction and drying into Exhausted Olive Pomace (EOP). EOP is used as energy on-site and sold, but farmers gain no profit from it. In fact, they often bear the cost of transporting and treating COP (La Cal Herrera, 2020). Given the residue

volume and supportive bioenergy policies, this presents a strong case for developing a BBVC.

3.3.1.2 COFFEE AND COCOA RESIDUES IN COLOMBIA

In Colombia's coffee axis, residues from coffee and cocoa, mainly grown by smallholders who own less than five hectares, offer potential for new BBVCs. Coffee pulp and cocoa pod husks are often left in piles in the field or used as compost. Poor management of these residues can pollute waterways. Unlike in Spain, most Colombian farmers rely entirely on agriculture, making them more vulnerable to price shifts, low yields, and climate change. To manage this instability, they diversify their income by cultivating different crops. Apart from coffee or cocoa, they often grow bananas and fruits in agroforestry systems, which generate additional residues. Selling the residues from these products could provide a new income stream and enhance their resilience.

3.3.1.3 ENCROACHER BUSH IN NAMIBIA

Unlike Spain and Colombia, Namibia's potential biomass for a BBVC comes from encroacher bush, not agricultural residues. Around 45 million hectares are bush encroached, which is the expansion of indigenous bushes like blackthorn at the expense of the Savannah lands. This degrades soil, depletes groundwater, and reduces grazing land. This threatens cattle farming, the main livelihood for over 70% of Namibians (DAS, 2019). Biomass supply is more diverse and complex compared to the other two cases due to varied land ownership. Large commercial farms are on average 7000 hectares and predominantly managed by European descendants. Communal lands are owned by the government and governed by traditional authorities following customary laws. Communal land is inhabited by different tribes, who share the land and the resources from that land. Last, resettlement farmers are previously disadvantaged and are placed on land sold by commercial farmers. The challenge of bush encroachment affects all land tenure systems. However, the capabilities and challenges faced are different for the three types of farmers. While small-scale value chains like charcoal exist, they use only 1% of the biomass, leaving major potential for new BBVCs. Turning encroacher bush into value-added products could address environmental issues and support rural livelihoods (van der Veen et al., 2025).

3.3.2 CASE STUDY APPROACH

Field studies have been carried out in the three countries (Spain: 18-10-2021 – 27-11-2021, Colombia: 20-06-2022 – 29-07-2022, Namibia: 16-01-2023 – 17-02-2023) and consisted of semi-structured interviews, observations, and multi-stakeholder workshops. In addition, interviews were carried out with downstream stakeholders in the Netherlands. Figure 3.1 shows an overview of the steps taken in the methodology.

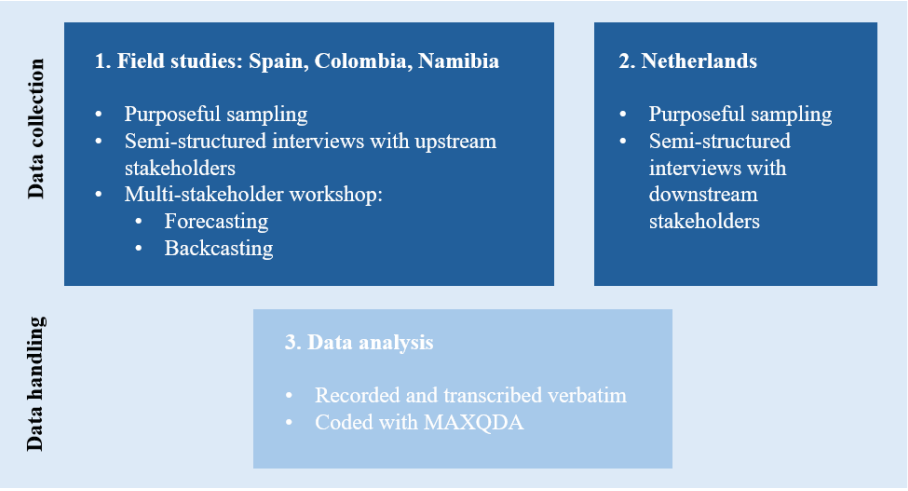

Figure 3.1 – Overview of the steps in the methodology

Interviews were conducted with stakeholders who could play a role in the potential BBVC. Questions were asked about the current system, challenges, potential role in a new BBVC, as well as opportunities, hurdles, potential harms, and their relation to other stakeholders. In addition, in-depth interviews were conducted with small-scale farmers about the current use of biomass and their challenges. Participants were selected using purposeful sampling to select a representative sample of stakeholders with distinct characteristics (age, gender, type of farm, region). The selection of participants was done in close collaboration with our local partners (local universities and a multi-stakeholder platform), who are well-informed about the sector and the relevant stakeholders.

Multi-stakeholder workshops were organized to discuss different design choices and necessary policies, and local development needs. Workshop participants were selected from the interview participants, using

purposeful sampling to ensure representation of all stakeholder groups. Participants were divided into three groups and did a forecasting and backcasting exercise. First, they discussed ideal scenarios for a new BBVC in the region, and made choices on crucial design choices (type of feedstock, feedstock processing and transport, contracts, biomass conversion, biorefinery products, biorefinery ownership, location, and set-up). Next, they made a roadmap and identified necessary steps to be taken in 5, 10, and 20 years to achieve the ideal scenario. More information on the interviews and workshops can be found in the case study protocol in Appendix A.

Downstream stakeholders, such as shipping companies and biofuel suppliers, were interviewed in the Netherlands to understand the drivers and barriers for establishing inclusive BBVCs from their perspectives. These participants were partners in the research project. Table 3 shows an overview of the interview and workshop participants. Interviews and workshop discussions were recorded with participants' consent, transcribed verbatim, and coded using MAXQDA 2012 software. General themes were identified from the data through inductive coding. First, initial labels were created from the data, and then these codes were iteratively redefined and grouped into themes (Chandra & Shang, 2019). The themes were related to challenges and complexities for developing inclusive BBVCs in the three case study locations.

Informed consent was obtained in written form, or in case participants had trouble reading and writing, verbally. Participants were assured confidentiality and data protection. Anonymized data is stored in the data repository of the TU Delft. The fieldwork protocol was approved by the ethics committee of the TU Delft.

Table 3.3 – Overview of interviews and workshop participants

Type of stakeholder	**Spain (S)**		**Colombia (C)**		**Namibia (N)**		**Nether-lands (NL)**
	Interview	*Workshop*	*Interview*	*Workshop*	*Interview*	*Workshop*	*Interview*
Farmers (F)	27	2	24	-	8	-	
Farmer co-operative/ association(C)	8	8	8	4	1	3	
(Farm) workers (W)	-	-	4	-	8	-	
Farmer union/ federation (FU)	2	1	5	2	3	2	
(Secondary) industry (I)	1	1	1	1	3	1	
Entrepreneurs (E)	-	-	2	1	1	1	
Logistics (L)	1	-	3	3	1	-	
Government (G)	1	4	4	3	5	5	
Technology developers (T)	2	2	-	-	-	-	
Academia/ knowledge in-stitute (A)	3	3	10	7	2	1	
NGO (N)	-	-	2	1	3	3	
Bioenergy association (B)	1	4	-	-	1	4	1
Energy com-pany (EC)							1
Biofuel supplier (BS)							2
Shipping com-pany (S)							2
Total	**44**	**25**	**63**	**21**	**36**	**20**	**6**

**We use abbreviations to refer to interview participants. For example, the code S-F3 refers to farmer #3 in Spain.*

3.4 COMPLEXITIES FOR INCLUSIVE BIO-BASED VALUE CHAINS

Based on the three case studies, we identified five complexities for developing inclusive BBVCs. The complexities were derived after inductive coding of the interviews and workshop discussions, and recognizing general themes across the three different cases. The complexities include inequalities, lack of capacity, lack of an intermediary party, logistics, and the importance of maintaining self-determination. In this section, we will present the complexities and explore how the different inclusive value chain strategies from Table 3.1 could be applied in BBVCs to deal with these complexities. We also reflect on what this entails and what the trade-offs are for the different stakeholders. We show that, given the complexity and varied contexts of BBVCs, more modest inclusion strategies, such as those outlined in the inclusive business and inclusive value chain literature, are often the most realistic.

3.4.1 INEQUALITIES

The first complexity is the inequalities between stakeholders in new BBVCs. We discern two types of inequalities: those between different actors in the value chains and those between different biomass producers. Each of these inequalities may have more or less systemic causes. We conclude it is more feasible for private actors to build a truly inclusive value chain if the causes for inequality are not deeply rooted in structural, systemic causes.

First, inequalities exist in the position of the different value chain actors. In Spain and Colombia, small-scale farmers are identified as the most vulnerable stakeholders in the value chain. While the Spanish olive farmers cannot be defined as Base of the Pyramid (BoP) because they are relatively well off and meet their basic needs, the farmers are the most vulnerable actors in the chain because of their small scale and traditional, manual cultivation practices. Farmers reported that they struggle to receive a stable income, and in some years, even produce at a loss, due to fluctuating olive oil prices and input costs. This vulnerability is more severe in Colombia because the majority of the coffee and cocoa farmers depend on agriculture for their livelihoods, making them more vulnerable to price fluctuations and climate change. According to a coffee farmer, coffee production is just enough to make a living: *"I depend on just the coffee. Well, and a little cattle. I have little, so the profits are few. Yes, it is*

enough because, as I work on the property myself, the revenues are for me. But if you have to pay for everything, you have nothing left. Coffee is enough for one to survive, to live, and to survive through time." (C-F22).

Moreover, the average age of the farmers in Colombia is over 50 years old, and the majority of the farmers have only received primary education. These factors also make it more difficult to access and supply to a new BBVC, because it requires (time) investments and changes in practices. An inclusive business case should align with the local needs and realities of small-scale farmers by making it easy and straightforward to participate and build on the existing structures, such as the cooperative system in Spain.

Second, inequalities among biomass producers exist in the biomass production regions, causing differences in opportunities to supply and benefit from the new BBVC. In Colombia, this difference is primarily due to the type of farmers' organization to which they belong. There are significant differences between the level of organization among farmers and the type of services they receive from that organization. Some associations are well-organized and capable of acquiring (international) funds for their projects. An example is a coffee association that set up a centralized collection system for the unprocessed coffee cherries. Post-harvesting processes are carried out centrally, instead of on individual plots, which is the main practice in the area. This makes the post-harvest process more uniform and standardized. This association would be a good starting point for a new BBVC because the coffee pulp is collected in one location. However, this would not increase the access of other farmers to the value chain. More interventions, such as strengthening the farmers' organizations and offering education and capacity building to farmers, are needed to include less well-off farmers as suppliers in the BBVC. So in this case, inclusive value chain strategies may be more appropriate than inclusive business strategies.

In Namibia, inequalities between biomass suppliers are deeper and caused by more structural issues related to land ownership, historical processes, and government policies. While bush encroachment is most severe in communal areas, communal farmers are currently prohibited

from participating in commercial value chains from the bush due to a moratorium placed by the government. This is a result of concerns about unequal benefit sharing in the communal areas and unsustainable harvesting, which would result in even worse bush encroachment (van der Veen et al., 2025). According to a civil society representative in Namibia: *"On the biomass side. It's a lot more difficult in the communal areas. Because you've got, well, a common pool resource, and our government hasn't quite found the right way to manage it because it tends to become elite capture."* (N-N1).

While in Colombia, less organized or less well-off farmers could be included through inclusive value chain strategies, such as capacity building, in Namibia, more structural issues are causing these inequalities. Addressing those requires interventions from many stakeholders, most notably the national and local government and civil society organizations. This requires time and commitment from different actors to set up the required local organizational structures in the communal areas, test them with pilot projects, and change government policies. It is not impossible, however, to establish a new BBVC is already complex for value chain actors. It is even more complex in a context where more structural issues are faced, such as in the case of Namibia. While inclusive development strategies are most desired, in this case, inclusive business strategies might be more feasible and can at least bring some benefits to more marginalized actors, such as communal farmers, by including them as consumers or as workers in the chain. BBVCs could, for example, produce animal feed, which is needed in communal areas. Moreover, communal farmers are currently included in the charcoal value chain as workers. A new BBVC could offer better and cleaner working conditions compared to the charcoal industry. However, this should not be considered the end goal. It could be a first step towards further inclusion.

3.4.2 LACK OF CAPACITY

A second complexity is a lack of capacity, especially of farmers' organizations. Farmers' organizations play a crucial role in strengthening the position of small-scale farmers vis-à-vis other value chain actors. They can also play an essential role in the mobilization of biomass. This is a complex task, especially when involving a large group of diverse, small-scale farmers.

Currently, farmers' organizations lack the capacity to play this role. Even in Spain, the case where farmers' cooperatives are best organized and where value is already added in olive mills owned by cooperatives, the level of professionalization is a major bottleneck. Based on the interviews and workshop discussions, this was identified as one of the main obstacles to establishing new BBVCs from olive oil residues. This is due to the education levels of the cooperative managers and the low (paid) personnel capacity of the cooperatives. As a local researcher explains: *"I think the main challenge we have is to professionalize the sector. In a lot of cooperatives, there are not enough professionals to manage it. In some, there are, but in others no."* (S-A1). They specialize in producing and marketing olive oil, and supplying a biofuel value chain requires different knowledge and skills. For this, more commitment and investments are needed from other actors in the chain and beyond, such as the local government. In Colombia, even more capacity building is needed, especially for less well-organized associations, as described above. In the communal areas of Namibia, some organizational structures exist. They are, however, highly diverse and much less established than the organization of commercial farmers. Moreover, a structure that can organize sustainable harvesting and equal benefit sharing in communal areas is lacking, and pilot projects so far have failed. According to a civil society representative involved in these pilots: *"We've been struggling to get that structure in place, also with the communal areas because it is, you know, millions of hectares belonging to hundreds of thousands of people equally. They all get the same benefit out of the land. Getting a structure in place where one guy does not have a bigger benefit than the other. Other than just the time that he's putting in, is very difficult."* (N-N2).

Failing to address this issue or not strengthening farmers' organizations can hinder effective biomass mobilization (such as in Spain), exclude farmers from less well-organized associations or cooperatives, risking elite capture (such as in Colombia), or risk excluding whole groups from participating or benefiting from the new BBVC (such as in Namibia). So in all three cases, some form of empowerment and capacity building is needed. In comparison, in agri-food chains, strengthening farmers' organizations is also an important strategy to empower small-scale farmers. However. different from agri-food chains are the new knowledge and skills that are

required to supply a bioeconomy, which are out of the scope of the current knowledge present in these farmers' organizations.

3.4.3 LACK OF INTERMEDIARY PARTY

Related to the issue of lacking capacity is the lack of an intermediary party. That intermediary party can be the biorefinery itself or a party between (small-scale) farmers and the biorefinery. In agri-food chains, the link between farmers and processors is much clearer and established. In new BBVCs, especially those value chains based on residual biomass, this connection between biomass suppliers and the biorefinery does not exist. Yet, that intermediary is the most complex position because it needs to organize upstream as well as downstream processes. A representative of a shipping company states: *"A new stakeholder, the biorefinery, comes into place. This is the place where risks are created. For the rest of the value chain, there are not a lot of changes, so they don't increase their risks. The biorefinery is the stakeholder that incurs costs and buys the residues, but is not sure whether it can be sold and sold for enough money to cover all costs. Therefore, they are at risk."* (NL-S1). Biorefinery operators need to be sensitive to the realities and complexities of biomass producers. They also need to respond to market demands to adhere to the required technical specifications, uniform production quality and quantity, and a competitive price. So far, these intermediary parties don't exist, but they are essential for a new bioeconomy. Operating in Global South contexts where other, more structural issues are faced, such as inequalities, a lack of political will or corruption, lower education levels, and a lack of infrastructure, makes establishing a biorefinery even more complex and risky. So far, one of the main bottlenecks identified in field studies and interviews with downstream stakeholders is finding a party that is both able and willing to take on those initial risks.

Farmers' organizations, such as the cooperatives in Spain, are in a good position to play an intermediary role between small-scale farmers and the biorefinery. However, they are in no position to take on the (financial) risks of establishing a new biorefinery or pilot project. The decentralized nature of biomass sourcing adds complexity to the value chain, making risk management and sharing more challenging. According to a representative of a renewable energy platform: *"If you keep your thinking on the linear business cases we have currently, this can't be just*

translated to the new ones we need. This has to do with risk sharing. You need to have far, much more risk sharing in the value chain, and that is the one big challenge we face.'' (NL-B1). The parties that do have the means to take on financial risks, such as oil companies, are reluctant or unwilling to invest in smaller-scale pilot projects. Moreover, while some public funds are available to fund these types of pilot projects, such as from the HORIZON program of the European Union, these funds are limited.

To attract investors, it is important to have one anchor product and a clear market outlet. This was one of the key takeaways from the workshop in Namibia, where a comparable project aimed at sustainably and inclusively valorizing encroacher bush ultimately failed to take off. While multiple factors contributed, a major issue was the project's complexity, trying to achieve too many goals and producing a diversity of products from the bush. Workshop participants concluded that a more effective approach would be to start with a simple, small-scale project focused on a single marketable product, supported by a business model built on a stable supply, and then scale up gradually. In Colombia, similar conclusions were drawn. In these contexts, where the entire value chain, including infrastructure, biorefinery, and logistics, still needs to be developed, it is more realistic and feasible to start with well-established farmers' associations that already have a solid infrastructure in place. While this approach may limit the inclusion of more marginalized stakeholders initially, attempting to achieve full inclusivity from the beginning could undermine the successful establishment of the value chain altogether.

3.4.4 LOGISTICS

Fourth, logistics were identified as a key issue in the three case studies. Logistics are a key aspect of the economic feasibility of the value chain. According to a biofuel supplier: *"Logistics optimization is an important aspect. You need to look into the variables that you have in the process, like which kinds of transport modes you have and where the collection and delivery points are. So then you would mitigate the changes in the transport. You would avoid making too many nodes in the value chain because then you mitigate cost, you reduce the lead time as well."* (NL-BS1). This is a challenge for including smallholders in new BBVCs, especially when the residues are generated in the field. Organizing the mobilization of the residues is a logistical challenge, since it requires

transport in remote, rural areas, sometimes on poor tertiary roads and or steep hills, both are time-consuming and costly. It is also a social challenge as it affects the agricultural practices of the small-scale farmers. The most efficient option is not always the most effective or accepted one.

This is especially true for sectors with more traditional practices, such as olive cultivation and coffee and cocoa production in Colombia. For example, in Spain, olive trees are pruned every two years, and this generates millions of tonnes of field residues, which are currently chipped or burned in the field. Collecting these pruning rests is a logistical challenge because they are spread over multiple smaller-scale plots. Outsourcing pruning, collection, and transportation to a single service provider would be the most efficient approach for handling pruning residues. However, this model is unlikely to gain acceptance among farmers, who are accustomed to their own established practices. Some prefer to carry out pruning themselves, while others rely on trusted employees who perform the task annually. Maintaining control and autonomy over their plots is a priority for them. A previous initiative by a local cooperative to collectively organize on-farm agricultural activities failed for this reason. A similar issue was encountered in Colombia, where the majority of the coffee and cocoa farmers carry out the post-harvesting processes on their individual plots. Although centralizing collection and post-harvest processing would improve efficiency, most farmers are hesitant to adopt new practices due to a lack of trust and a strong preference for familiar methods. A cooperative leader explains: *"With coffee, I think we have a serious problem with cultural individualism. In Colombia, you´ll see at the coffee farms that almost every coffee grower has their own processing plant. Other countries have places where everyone takes their coffee and there, they process it, so it´s easier to manage waste because everything is centralized, processes are standardized, costs are reduced. But here everyone wants to have their own processing plants, even the smallest farms."* (C-F4).

So, logistics are a bottleneck for establishing new BBVCs based on agricultural residues. While economic efficiency is important, logistics must be designed to align with the realities of smallholders to ensure social acceptance.

3.4.5 MAINTAINING SELF-DETERMINATION

The last complexity is the importance of maintaining self-determination. The three cases in this study are based on traditional agricultural sectors, olive oil in Spain, coffee and cocoa in Colombia, and cattle farming in Namibia. Agricultural practices are passed on from generation to generation, and farmers value their known practices. While participation in new BBVCs can bring multiple benefits to them, economic and non-economic, producing for new BBVCs is not their core business. Most farmers identify as olive farmers or coffee farmers, not as bioenergy producers. Supplying new BBVCs means changing their agricultural practices and sometimes interventions that influence the work on their plots. For example, centralizing post-harvesting processes in Colombia or collectively organizing olive tree pruning in Spain, as described above. Another example comes from bush harvesting in Namibia, which is predominantly done manually due to the hard and thorny properties of the bush, making mechanical harvesting a challenge. Manual harvesting requires a group of workers, often migrant workers, to perform the work on the farm. Many commercial farmers expressed reluctance to engage in bush valorization because they don't want a group of workers on their plots that they need to manage. Language and cultural barriers make that more complicated, but also concerns about illegal poaching.

Engaging small-scale farmers as suppliers in a new BBVC requires changes in practices. This can be challenging, especially for producers in more traditional sectors such as the coffee or olive oil sectors. A cooperative leader in Spain states: "*Olive cultivation is not just a business, it is also tradition and culture, in a culture that is very reluctant to change, because they have always done it in a certain way. So in the first place, you'll receive rejection.*" (S-C3). There needs to be a clear benefit for their participation and (time) investments. That is also in the best interest of downstream stakeholders. Making sure (small-scale) farmers are motivated and capable of supplying the BBVC is important for the security of supply. Farmers occupy a different and potentially more influential position in BBVCs compared to conventional agri-food chains. Since supplying biomass to a BBVC is typically not their primary activity, farmers may be in a stronger position to negotiate terms and demand benefits. Their participation is therefore not only valuable but also conditional, making their empowerment and alignment with the BBVC goals a key

factor for success. Balancing efficiency with the desires of many farmers to maintain control over their plots and practices is important. This can sometimes compromise the economic outcomes, but when not addressed or taken seriously, it can result in failed projects.

3.5 DISCUSSION

3.5.1 TRADE-OFFS AND STRATEGIES

The identified complexities are intertwined and show the dilemmas and trade-offs that are encountered when establishing inclusive BBVCs. From our interview and workshop findings, we conclude that for all stakeholders, upstream and downstream, inclusion and adding local value are important, for both normative and instrumental reasons. This value can be economic, social, and/or environmental. However, as demonstrated, building inclusive BBVCs is a complex process that requires carefully balancing inclusion with practical feasibility. Compared to agri-food chains, building new, inclusive value chains is even more complex due to the required technological innovation, new actors, and initial investments and risks that need to be taken, often in a context marked by inequalities and structural issues (Postal et al., 2020; De Gelder & Asveld, 2024). We have addressed several complexities for establishing inclusive BBVCs, drawing on examples from our three case studies, and explored the three inclusive strategies (inclusive business, inclusive value chains, and inclusive development). The three cases studied in this research reflect different contexts. The case in Spain represents a context with a relatively strong enabling environment. In Colombia, more structural issues are experienced by small-scale farmers, and in Namibia, these structural issues are more severe. We conclude that, due to the complexity and diversity of contexts in BBVCs, it is often most realistic to apply more modest strategies towards inclusion, such as those described in inclusive business and inclusive value chain literature. A key bottleneck remains: which party will take up the initial risks of establishing a new value chain? Even though important sectors such as the shipping industry have ambitious targets to become net zero in 2050 (IMO, 2025), and biomass is an important element in achieving those targets, large-scale end users like shipping companies or oil companies are not taking up this role. While smaller-scale start-ups are interested in doing so, they often lack the financial means to take up the initial risks.

While inclusive strategies can strengthen feedstock security by increasing the motivation and engagement of biomass suppliers, they can also give rise to conflicting interests and trade-offs that must be navigated thoughtfully. Moreover, it raises questions about roles and responsibilities, specifically about what type of inclusion is being pursued, what is realistically achievable, and how to manage potential conflicts or trade-offs. In the following section, we reflect on the different dimensions mentioned in Table 3.1 and address potential conflicts and trade-offs.

The first dimension is economic, concerning the extent to which economic growth is prioritized. Rejecting a focus on economic growth, such as in inclusive development literature, is not desirable for establishing new BBVCs. While participation in new BBVCs can have multiple benefits for small-scale farmers, farmers in this study identified receiving more economic stability as one of the main reasons to engage as a supplier in a BBVC. Moreover, to establish the value chain, a robust business model with a secure supply is necessary to attract investors. However, economic growth should not be the primary or only focus of the new BBVC. As demonstrated, a more holistic approach to wellbeing is essential to avoid undermining other important dimensions, such as self-determination, that may at times take precedence over economic efficiency. Next to economic opportunities, environmental sustainability (dimension 7) is the central promise of the bioeconomy. The potential BBVCs in the study all have the potential to positively contribute to environmental sustainability by improving residue management or addressing the ecological issue of bush encroachment, which, in the current situation, causes environmental harm.

Concern for wellbeing (dimension 2) highlights a central tension in developing inclusive BBVCs between improving wellbeing for those least well-off and the practical constraints of setting up new BBVCs. At a minimum, concern for wellbeing entails creating meaningful opportunities for local vulnerable communities to participate in the new value chain, either as suppliers, workers, or consumers (inclusive business). Alignment with smallholders' realities (dimension 4) is vital, accounting for the diversity of farmers and the varying levels of resources and constraints. While inclusive business approaches can support smaller-scale farmers, challenges arise when this diversity is rooted in entrenched structural inequalities that cannot be addressed solely by market actors, at least in

the short term. This also includes gender equity and responsiveness (dimension 6). Market actors can, for example, actively include women's associations, such as those present in Colombia, in their business model, or be sensitive to the specific roles carried out by women in the production process and provide job opportunities for women, as currently done in the charcoal industry in Namibia.

However, in contexts marked by deep-rooted structural inequalities related to land ownership and ethnicity, such as in Namibia, more comprehensive interventions are needed to include the most marginalized farmers. These interventions go beyond market mechanisms and require coordinated efforts from multiple stakeholders, including local and national governments and civil society organizations. Yet, such an inclusive approach could compromise efficiency or reliability of supply, factors that are critical for downstream stakeholders in the chain. While residue valorization and inclusive value chain strategies can lead to higher incomes for smallholders, truly inclusive development is not always feasible. Especially when infrastructure is lacking and farmers' organizations have limited capacity. Attempting to address too many issues simultaneously can be overwhelming and ineffective. Moreover, inclusive development requires commitment and interventions from the state. Addressing structural inequalities exceeds the responsibilities of private actors, and can even be undesirable because outside interference from commercial actors in local political structures may impose external norms on local contexts (De Gelder & Asveld, 2024)

Concern for wellbeing is closely related to the level of empowerment to be aimed for (dimension 5) and the enabling environment (dimension 8). Ideally, there should be attention to the local political economy and constraining structures, and a government that actively protects people's rights and pursues redistributive policies (inclusive development). When this enabling environment is lacking, ideally, a higher level of empowerment is required. This is especially needed in contexts where more structural issues cause inequalities. However, when the government is not able or willing to take up this role, the question remains, who should? This relates to the responsibility of private sector actors to deliver societal goals, 'do good', with their business operations. However, in the context of the emerging bioeconomy, it remains unclear what 'doing good' entails.

De Gelder & Asveld (2024) argue that, at least, companies have the responsibility to offer a perspective on a stable market offtake. The valorization of the residues produced by small-scale farmers is a way to offer more market outlets and can be seen as a type of upgrading, as discussed in inclusive value chain literature. In addition, apart from 'doing good', it is important for companies to 'do no harm'. Voluntary certification schemes can be mechanisms for private actors to avoid doing harm with their operations, especially in contexts where 'hard laws' that protect people's rights are absent (Voegtlin and Scherer, 2015). However, 'soft laws' like voluntary certification schemes can be partially ineffective, especially when monitoring and enforcement capacities are lacking. This was, for example, encountered in the case study in Namibia, where the charcoal value chain is FSC certified. This offers multiple benefits, such as clear policies on workers' conditions, safety, and sustainable harvesting. However, due to a lack of monitoring and enforcement capacities, these policies were not always adhered to. Moreover, certification schemes do not address underlying structural inequalities. To address these, state policies and capacities play a crucial role.

We conclude that in those contexts where this enabling environment is lacking, it is neither feasible nor desirable for value chain actors to simultaneously set up a whole new infrastructure and system, and address structural inequalities. While ideally, a higher form of empowerment is required that can address these structural issues, it may not be achievable in the short term. In these cases, inclusive business strategies that integrate vulnerable groups as consumers can still provide tangible benefits, even if they fall short of full inclusion. A step-by-step approach that recognizes limitations while striving for broader inclusion over time is more realistic and sustainable.

Moreover, what 'doing good' means can differ per context and stakeholder. Therefore, inclusive learning and innovation (dimension 3) is essential. Co-creating solutions with local stakeholders allows for context-sensitive decision-making and ongoing impact assessment. Full inclusivity may not be feasible from the outset, but inclusive innovation can guide incremental progress (Bouchaut & Asveld, 2021). For instance, when establishing a BBVC requiring new infrastructure (e.g., biorefineries), initial efforts may need to focus on relatively better-off farmer groups,

which was a consensus across all three workshops. These groups can participate in pilot projects, forming a foundation for gradually expanding inclusion to more marginalized farmers. Establishing strong multi-stakeholder networks is crucial here. Participating in such multi-stakeholder platforms can accommodate economic as well as non-economic incentives for private actors (Voegtlin & Scherer, 2015). On the economic side, participation can yield indirect benefits such as enhanced reputation, stronger relationships with key stakeholders, and competitive advantages through resource sharing and greater opportunities for innovation through access to broader knowledge networks. Non-economic incentives include the chance to learn from diverse actors, align with institutional or societal expectations, and derive intrinsic satisfaction from contributing to environmental and social well-being. Collaborating with NGOs, in particular, can help companies gain legitimacy, improve product distribution, and access specific markets more effectively (ibid). Table 3.4 shows an overview of the dimensions of inclusion, the trade-offs we encountered, and preferred strategies to deal with them.

Table 3.4 – Summary of trade-offs and preferred strategies

Dimension	Trade-off	Preferred strategy
Economic		
Double or triple line	Balancing economic growth with broader wellbeing.	Stepwise inclusion via inclusive business/value chain models; focus on stable market offtake, not solely on economic growth.
Social		
Concern for well-being	Inclusion vs. feasibility; addressing structural inequalities vs. operational constraints.	Start with modest, realistic inclusive business/value chain strategies; avoid overwhelming scope.
Inclusive learning	Uniform solutions vs. context-sensitive approaches.	Co-creation with local actors; iterative learning and innovation.
Alignment with smallholders' realities	Diversity of farmers vs. market efficiency.	Tailor to smallholder diversity, but acknowledge limits of private actors.
Relational		
Empowerment	High-level empowerment vs. lack of enabling environment.	When state support is weak, adopt incremental empowerment via inclusive business; realistic short-term goals.
Gender equity and responsiveness	Gender inclusion vs. traditional roles/ market priorities.	Proactively include women's groups; recognize and support women's roles in value chains.
Environmental		
Environmental sustainability	Long-term sustainability vs. short-term costs and feasibility.	Focus on residue valorization solutions; emphasize dual ecological-economic value; aim for circularity/ nutrient recycling to guarantee soil maintenance.
Cross-cutting		
Enabling environment	Ambitious inclusion vs. weak governance and infrastructure.	Recognize limitations; avoid burdening private actors with systemic change; advocate for state involvement.

3.5.2 IMPLICATIONS FOR POLICY AND PRACTICE

Besides contributions to the academic debate about the transition towards a sustainable and just bioeconomy, this research also has implications for policy and practice. We have highlighted the complexities of building new and inclusive BBVCs and addressed the trade-offs and dilemmas encountered for the various stakeholders involved. We concluded that the

enabling and institutional environment is important for achieving inclusive development. Policymakers can take specific actions to strengthen this enabling environment. An action they can undertake is de-risking the early investments by allocating public funds for pilot projects that have potential economic, environmental, and social impact. Moreover, policymakers can address the structural barriers towards participation of vulnerable stakeholders, such as the land rights policy in Namibia and the moratorium that is currently preventing communal farmers from participating in commercial bush-based value chains. These actions support the goals of the governments in the Global North and in the Global South, such as the European Green Deal and the bioeconomy strategies of the African Union.

Companies can use the insights from this study by taking a step-wise approach towards deeper levels of inclusion as know-how and infrastructure grow. Moreover, companies can create stability for biomass suppliers by offering a stable market offtake. In addition, they can invest in co-creation and continuous learning to improve inclusive practices in the longer term. Finally, alliances between private, public, and civil society actors can strengthen the inclusion of marginalized stakeholders in new BBVCs.

3.5.3 LIMITATIONS

While this study provides valuable insights into the pathways for developing inclusive BBVCs, several limitations should be acknowledged. First, this research is based on three cases. Although these cases capture diverse contexts, they cannot represent the full range of socio-economic, environmental, and institutional conditions under which new BBVCs can emerge. As such, the findings are exploratory and context-specific and limit the possibilities for generalization. Second, the study relies on purposeful sampling of upstream and downstream stakeholders, conducted in close collaboration with local partners. While this approach ensured access to relevant actors, it may have favored those who are more visible or organized, potentially underrepresenting marginalized groups or informal actors. Furthermore, downstream stakeholders were primarily project partners based in the Netherlands, which may have constrained the diversity of perspectives from the wider shipping and biofuel industries.

3.5.4 RECOMMENDATIONS FOR FUTURE RESEARCH

Future research could build on our work by researching the complexities of establishing new BBVCs in various other contexts. This can contribute to identifying more limiting and enabling factors. In addition, studies can focus on the perspective of companies to gain more insight into the challenges they face in building new BBVCs and what they need to support this transition. Last, future research can build on the trade-offs and strategies we identified and could build decision-making tools for various stakeholders to support the transition towards an inclusive bioeconomy.

4. CONCLUSION

Establishing inclusive BBVCs is a highly complex but essential component of a sustainable and just transition to a bioeconomy. While many studies underscore the importance of balancing environmental impacts, biodiversity preservation, and social equity, few studies address the practical complexities of establishing new BBVCs. We addressed these challenges by studying three cases of potential BBVCs based on waste biomass in different contexts, by interviewing different stakeholders along these potential value chains. Based on the case studies, we identified five complexities for establishing inclusive BBVCs, namely inequalities, lack of capacity, lack of an intermediary party, logistics, and the importance of maintaining self-determination. We then explored different inclusive strategies that can be followed and the trade-offs that are encountered.

We argue that while the ultimate goal for new BBVCs may be inclusive development that addresses structural inequalities and promotes long-term wellbeing for all stakeholders, especially the most marginalized, this is often not immediately feasible in many settings. In such cases, more pragmatic approaches, such as inclusive business and inclusive value chain strategies, can serve as critical stepping stones. These strategies allow for the engagement of upstream stakeholders, particularly smallholder farmers, by offering them tangible benefits and pathways toward greater empowerment, without overwhelming the new value chain with unrealistic expectations. However, the success of even these incremental strategies depends on their alignment with local contexts and the willingness of downstream stakeholders to invest in socially responsible practices.

Ultimately, while inclusive development may not be immediately attainable, it should remain the long-term goal. A phased, flexible approach, grounded in the principles of inclusion and adjusted to local realities, offers a realistic and constructive path forward. Co-creation with local stakeholders, continuous learning, and adaptive governance are crucial to manage trade-offs, build trust, and navigate conflicting interests. As our case studies show, beginning with relatively stronger stakeholder groups and gradually expanding inclusion through iterative learning can provide a more resilient foundation for BBVCs. Such an approach allows BBVCs to evolve over time into systems that are not only economically viable and environmentally sustainable but also socially just, ultimately offering a significantly improved alternative to fossil-based value chains, particularly in terms of their social impact.

CHAPTER 4

STRENGTHENING SOCIAL LIFE CYCLE ASSESSMENT FOR A JUST BIOECONOMY: INSIGHTS FROM NAMIBIA'S BUSH-BASED VALUE CHAINS

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4.1 INTRODUCTION

The bioeconomy is a promising concept to advance sustainable development and a just transition (Lewandowski et al., 2018; Kumar Sarangi et al., 2023). Creating value chains based on biomass from agricultural or forestry residues instead of fossil-based resources can have multiple economic, environmental, and social benefits. These benefits include emission reduction, improvement of residue management, and additional income for biomass producers (Ladu & Morone, 2021; van der Veen et al., 2024). Because of this potential, over 50 countries have developed bioeconomy-related policy strategies to achieve sustainability targets (Zeug et al., 2023). However, introducing new bio-based value chains could also lead to negative instead of positive outcomes (Hoffman et al., 2021).

To ensure the sustainable production of bio-based products, it is essential to understand the potential environmental, economic, and social impacts (Lago-Olveira et al., 2024). Even though the social dimension is equally important to sustainable development, it receives less attention in sustainability literature. Current sustainability assessments focus on the environmental and economic dimensions, and often, the social dimension is left out of the analysis (Janker & Mann, 2018). This is also prominent in the literature on bioeconomy, where the social dimension is the least analyzed sustainability dimension (Ferreira et al., 2022). Moreover, when the social dimension is included, social impact analyses of the bioeconomy mainly focus on employment-related variables, leaving out other important social impact factors (ibid). This is an issue since research has shown that bio-based value chains (BBVCs) could create negative social impacts, especially for populations in the Global South where vulnerable communities are more likely to bear greater proportions of the risks of the growing demand for biomass, such as monoculture expansion, uncertain investments, and unequal wealth distribution (Lima, 2022). Developing new BBVCs should help improve the quality of life for all those affected, or at least not exacerbate or intensify existing social inequalities (van der Veen et al., 2024). Therefore, it is crucial to understand their (potential) social impact.

One of the reasons that the social dimension is less represented in sustainability assessments is the difficulty of understanding and quantifying

social issues (Janker & Mann, 2018; Lago Olveira et al., 2024). One of the most advanced methods to assess the social impacts of products throughout their life cycle is the Social Life Cycle Assessment (SLCA) (Cadena et al., 2019). While the field of SLCA is growing, it is still less advanced than environmental Life Cycle Assessment (LCA) (Lago-Olveira et al., 2024). Even though the SLCA has advanced in recent years, there is no standardized approach yet (Huarachi et al., 2020). The selection of indicators can vary, which can already define the study results. The indicator sets established in the literature can be too unspecific for a case study, and therefore, specific indicator sets should be selected for each case (Fürtner et al., 2021). This complicates the comparison of social performances of value chains (Kühnen & Hahn, 2017). In addition, there is increasing attention to SLCA studies in the bioeconomy field (Macombe et al., 2013; Cadena et al., 2019; Huarachi et al., 2020; Fürtner et al., 2021; Ladu & Morone, 2021), however, the majority have a general focus or focus mainly on the European context (Ferreira et al., 2022). There is a need for SLCA studies on BBVCs in the Global South.

An advantage of SLCA is that it uses steps and approaches similar to environmental LCA. This makes it feasible to integrate SLCA into an overall sustainability assessment and enables the quantification of potential sustainability impacts. At the same time, quantifying social impact risks losing important qualitative and nuanced information. This paper addresses these issues by answering the following research question: *How can social impact be incorporated into sustainability assessments of bio-based value chains?* In doing so, we contribute to the field of SLCA and address its potential and challenges for assessing social impact in the context of BBVCs in the Global South.

We answer our research question by presenting a real-life case study of a prospective value chain to produce marine biofuels from encroacher bush in Namibia. Encroacher bush affects about 45 million hectares in the country and grows at the expense of Savannah grasslands. This harms the ecological balance and affects people's livelihoods due to reduced grazing capacity for cattle and loss of tourism (MEFT, 2022). Creating new value chains from the bush can have significant environmental, economic, and social benefits (MITSMED, 2017). This offers a unique case to study the potential social impact of a prospective BBVC in a Global South context.

We conducted an SLCA based on the existing charcoal value chain and identified potential social impacts, risks, and opportunities of a new biofuel value chain from the bush. This can help decision-makers and value chain actors in this new value chain to address these potential social risks and impacts and identify opportunities. Apart from the SLCA, we conducted broader qualitative fieldwork, consisting of semi-structured interviews with open-ended questions, observations, and a multi-stakeholder workshop. We use this case study to reflect on the methodology of SLCA by comparing the results of the SLCA with our qualitative fieldwork to identify what the SLCA was able to capture and what was missing from the analysis. We then propose new factors that could be added to the SLCA method to create a more nuanced and realistic assessment of the potential social impacts, risks, and opportunities.

We argue that while SLCA is a good method to quantify some social impacts and to identify social risks in the value chain, the methodology of SLCA currently misses a more nuanced understanding of the context and potential social issues. Even though in our SLCA case study we followed a qualitative and participatory approach, we found that the SLCA did not fully represent the social issues and potential social impact of the value chain based on our interviews, observations, and workshop discussions. Therefore, it is crucial not to rely solely on generic indicators, but to complement them with more fine-grained, context-specific information. Moreover, engagement with local stakeholders during the SLCA process is essential. Not only to receive feedback on the important subcategories, but also to assess and rank those subcategories.

We start this paper with a short literature overview of the research on the social dimension of sustainability and the SLCA. We then present our methodology, followed by a reflection on the results of the SLCA and recommendations.

4.2 SOCIAL DIMENSION OF SUSTAINABILITY

Sustainable development is commonly defined as 'the ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). While this definition strongly focuses on people, most developed concepts, strategies, and measures in this field have an environmental focus. Even

though there is increased attention to social and ethical issues in the bioeconomy literature, social impact is not represented equally in sustainability assessments (Janker & Mann, 2018). Consequently, the extent to which poverty or social inequalities are reduced or exacerbated for those affected remains unknown (Sanz-Hernández et al., 2019; Postal et al., 2020).

Social Life Cycle Assessment (SLCA) is one of the most advanced techniques to assess the social impacts of products throughout their life cycles (Macombe et al., 2013; Huarachi et al., 2020). SLCA was developed as part of the Life Cycle Sustainability Assessment (LCSA) tools. In the guidelines for SLCA, developed by UNEP/SETAC (2009), SLCA is defined as a technique of assessing products' social and socio-economic aspects and their positive and negative (potential) impacts along their life cycles. SLCA is an evaluation method that can be used to compare sectors, industries, or companies. It could also be used within companies or organizations to help decision-making and identify potential positive or negative social impacts (Lago-Olveira et al., 2024). The ultimate goal of conducting an SLCA is to improve a product's social conditions and socio-economic performance throughout its life cycle for all stakeholders involved. SLCA results can be used to stimulate these improvements and dialogue among stakeholders and decision-makers (UNEP/SETAC, 2009). SLCAs are mostly performed to evaluate the social impact of existing value chains (Ferreira et al., 2022). However, it can also identify potential social impacts and risks in new value chains (Yupanqui et al., 2024). This is especially interesting for the bioeconomy since BBVCs are often built on existing ones (Robaey et al., 2022).

Over the past three decades, the literature on SLCA has increased. SLCA has been applied in different contexts and multiple databases, and methodological frameworks for impact assessments were developed (Huarachi et al., 2020). Despite the increased interest in SLCA, it remains less advanced than environmental LCA, and no standardized approach exists (ibid). Various challenges have been identified by researchers who applied SLCA in different fields. First, there is a large number of socio-economic impacts that may arise, and impact categories need to be adapted to individual cases. This makes it difficult to standardize the approach (Fürtner et al., 2021). In addition, proper indicators and consensus over

metrics are lacking, since conceptualization is diverse (Ladu & Morone, 2021; Fürtner et al., 2021). Unlike environmental LCA, cause and effect are difficult to correlate, which makes it hard to select appropriate indicators (Siebert et al., 2018). Data availability is highly diverse (Siebert et al., 2018; Rafiaani et al., 2020), and social assessment is often based on qualitative information, which makes it complicated to express results based on the unit of system output (Rebolleda-Leiva et al., 2023).

One of the main challenges of SLCA is that, compared to the environmental and economic dimensions of sustainability, the social dimension is more open and contested (Lago-Olveira et al., 2024). Social impact is much more value-laden and normative. There is no common understanding of what 'social' means in the context of sustainability. We can use well-established indicators such as CO2 equivalent or Gross Domestic Product (GDP) to determine environmental and economic impact. For social impact, a standardized or generally accepted operationalization is lacking (Reitinger et al., 2011; Huarachi et al., 2020; Lago-Olveira et al., 2024). What is understood as socially sustainable can differ over time and space. Even though these perceptions differ, the social dimension is essential for fulfilling people's needs, which is central to sustainable development. It should therefore not be neglected (Janker & Mann, 2018). Especially in the bioeconomy, there is a need to analyze the social implications of emerging BBVCs (Sanz-Hernández et al., 2019). Moreover, there is a need for studies on the potential impact of the bioeconomy in a Global South context, since a large part of the available biomass is located in the Global South. Here, the bioeconomy presents an important opportunity to contribute to people's livelihoods, since many households depend on agriculture. On the other hand, vulnerable communities are at higher risk of being negatively affected by the bioeconomy (Hoffman et al., 2021; Lima, 2022). More research is needed to help improve existing social sustainability practices and a structure for assessing social impact (Kaur & Sharma, 2017; Janker & Mann, 2018). We contribute to this growing field by reflecting on an SLCA on a bush-based value chain in Namibia and proposing concrete recommendations to strengthen the SLCA methodology.

4.3 METHODS

4.3.1 CASE STUDY NAMIBIA

Namibia is facing the major challenge of bush encroachment, caused by the spread of an indigenous woody species like blackthorn (*Senegalia mellifera*) at the expense of Savannah grassland. It affects about 45 million hectares, roughly a third of the country. This harms the ecological balance as it causes soil infertility, biodiversity loss, and groundwater depletion (MEFT, 2022). In addition, bush encroachment affects people's livelihoods due to the reduced grazing capacity of cattle. More than 70% of the Namibian population directly or indirectly depends on agriculture for their livelihoods, of which most are cattle farmers. The reduced grazing capacity can lead to poverty and food insecurity (Lesoli et al., 2013; MEFT, 2022). The challenge of bush encroachment also presents an opportunity for Namibia's economic development. Creating new value chains based on the bush can offer considerable environmental, economic, and social advantages.

Namibia knows a complex social context, mainly due to the land tenure structure that resulted from land reform policies implemented after independence. First, commercial land is privately owned and used for commercial farming, mostly cattle farming, with an average farm size of 7000 hectares, typically owned by European descendants. Second, communal land is owned by the state and managed by traditional authorities following customary laws. Communal land covers a significant part of the country (38%), accommodating about half of the Namibian population (Beck, 2019). The land is mainly used for subsistence farming and grazing. Different tribes with unique characteristics, agricultural practices, beliefs, and customs inhabit and share the land. This makes the bush that grows on communal land a common pool resource (Sato, 2021). Third, the government has acquired resettlement land from commercial farmers to resettle previously disadvantaged communities. The challenge of bush encroachment affects all land tenure systems. However, the capabilities and challenges faced are different for the three types of farmers.

Several smaller-scale value chains have been set up based on the bush, such as animal feed, fence posts, firewood, and wood chips. With an annual production of over 200.000 tonnes, the most established value

chain is the one for charcoal. Commercial farmers produce charcoal on their land, often using the manual labor of migrant workers, which is then processed and exported to Europe (MEFT, 2022). To date, communal farmers are prohibited from participating in this commercial value chain due to a moratorium placed by the government because of concerns about unequal benefit sharing and overexploitation, which might result in worse bush encroachment (Hindjou, 2021). Several pilots have been conducted in communal areas which so far have been unsuccessful. Even though several value chains have been set up, the current utilization of 1.85 million tonnes of the bush is only 1% of the total available biomass (Heck et al., 2021). So there is a large potential to create more value chains with larger market demand such as biofuels for the shipping sector. However, new value chains could impose new social risks and negative social impacts. Therefore, it is important to understand the potential social implications of this new value chain.

The case study on encroacher bush in Namibia is part of a larger multi-stakeholder and multi-disciplinary research project to design inclusive and sustainable biofuels for the marine industry. Apart from Namibia, two other case studies have been selected in an iterative process with project partners who represent stakeholders in a biofuel value chain (shipping company, (bio)fuel producers, renewable energy platform, and an NGO). The selection was based on criteria to filter the options (e.g. biomass availability, utilization potential, infrastructure, and enabling policies) and features to compare potential cases (e.g. source of feedstock, geographical location, and Human Development Index). The other case studies focus on olive oil residues in Spain and coffee and cocoa residues in Colombia. Only for the Namibian case study, an SLCA was performed.

4.3.2 GOAL AND SCOPE

The goal of the SLCA is to assess the social impacts of a bush-based value chain in Namibia. Because this case study focuses on a potential biofuel value chain, collecting reliable data on its social impact is challenging. Therefore, the SLCA focuses on the existing charcoal value chain. Because the charcoal and biofuel value chains use similar upstream processes, social impact is expected to be similar in the beginning part of the value chain (see Figure 4.1). The charcoal value chain has an operational

history and available data, which ensures a more robust assessment that can be used in decision-making for the prospective biofuel value chain.

The functional unit used in this study is one tonne of charcoal produced from encroacher bush. To produce one tonne of charcoal, three to four tonnes of solid wood is needed (MEFT, 2022). Since the majority of the charcoal is produced for European markets, most charcoal producers are certified with Forest Stewardship Council (FSC). The functional unit of the biofuel value chain is one tonne of biofuel produced from encroacher bush that can be used in the maritime industry. The biofuel must comply with maritime industry standards and be tested in engines. It needs to be a drop-in fuel that can be blended with fossil fuels. The chosen technology for the biofuel value chain is hydrothermal liquefaction (HTL).

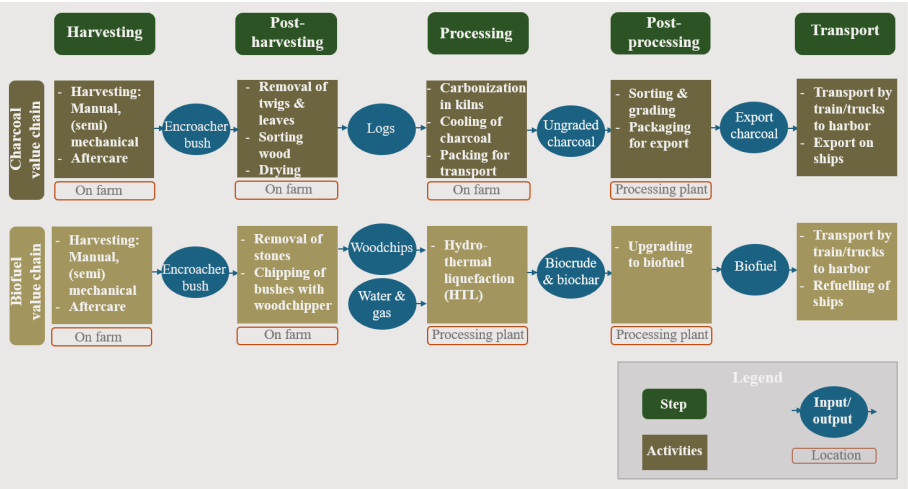

Figure 4.1 – Product system of the charcoal and biofuel value chain

The SLCA considers the whole value chain, but more emphasis is put on the upstream part since this will be more similar for both the charcoal and biofuel value chains regarding activities and social issues. The case study focuses on the provinces of Otjozondjupa and Windhoek, where bush encroachment is most severe (Hengari, 2018).

4.3.3 STAKEHOLDERS

The different stakeholders involved in the charcoal value chain are farmers (unions), workers, conservancies, the government, the private sector, researchers, and civil society organizations. These stakeholders are included through interviews and a multi-stakeholder workshop during the fieldwork of five weeks in January and February 2023. These stakeholders are divided into four groups, following the UN guidelines (UNEP/SETAC, 2013) (Table 4.1).

Table 4.1 – Number of interviews per stakeholder category

Type of stakeholder	**Code**	**Nr. interviews**
Workers		
Workers	Bush workers (BW)	6
	Farmworker (FW)	2
Value chain actors		
Farmers	Commercial farmers (F)	5
Farmers unions	Farmers Union (FU)	3
Biomass processors	Charcoal producer (CP)	1
	Charcoal processor (CPc)	1
	Biomass power station (P)	1
Transport company	Transport (T)	1
Conservancies	Conservancy (C)	1
Local community		
Communal farmers/leaders	Communal farmers (CF)	4
Society		
Government	Government (G)	4
	Developmental Agency (DA)	1
Researchers	University (U)	2
Civil society	Nature conservation (N)	1
	Certification body (Cert)	1
Investors	Fund management (FM)	1
	Bank (B)	1
Total		**36**

4.3.4 IMPACT ASSESSMENT METHOD

In this study, we use a reference scale assessment (UNEP/SETAC, 2013), which is a method that employs performance reference points to assess inventory data without establishing a causal relationship. It uses a multi-level scoring system with benchmarks (basic requirements) to assess the

subcategories. These benchmarks are based on international laws and conventions and serve as a threshold to evaluate the collected data (Haryati et al., 2022).

Reference scales can measure positive and negative social performances or the low or high levels of social risks. There are two types of impact assessments, social performance and social risk. Social performance measures the principles, practices, and outcomes of the relationship between businesses and people, organizations, institutions, communities, and societies. The social performance assessment often uses site-specific data. Social risk is understood as the probability of social effects on stakeholders through a company's activities. Social risk is often assessed from generic country-level data. As a result, the term "risk" is frequently used to refer to data of lower resolution, making it impossible to assess social performance, but instead just pointing out the risk of experiencing negative social impacts. It is useful to do both assessments because it provides more contextual information on social performance (Norris et al., 2020). The indicators are assessed using a risk level scale, ranging from low risk to very high risk. For each indicator, a risk level scale is developed and characterized by values from indexes or global performance indicators of countries (Appendix C, Table C6). For the performance assessment, we followed the Subcategory Assessment Method (SAM) developed by Ramirez et al. (2014), shown in Figure 4.2.

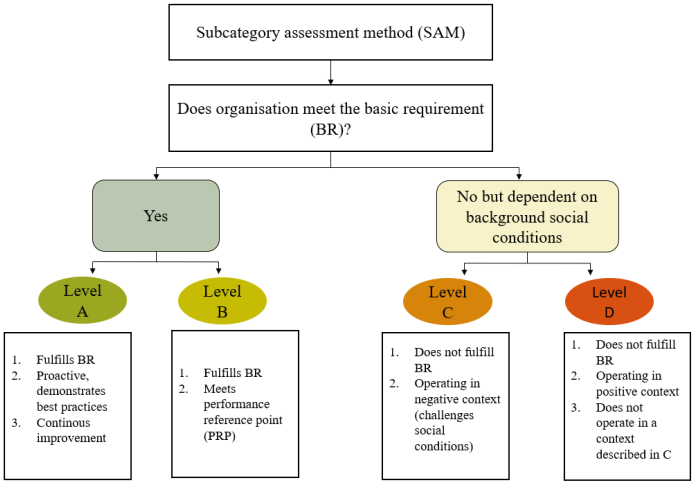

Figure 4.2 – Scoring method of SAM (Ramirez et al., 2014)

The SAM uses basic requirements (BR), based on international agreements, existing regulations, SLCA methodological sheets, and company management policies to assess social performances. The level definition is based on the fulfillment of the BR (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 is based on the social conditions under which the organization 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).

When the data for levels C and D given by Ramirez et al. (2014) were unavailable for Namibia, the levels were adapted to the available data in the Namibian context. For this study level A was specifically defined, since Ramirez et al. (2014) did not provide a definition. Level A is assigned to organizations that fulfill the BR, show proactive behavior, and promote best practices (Rafiaani et al., 2018). The reference scales were initially developed before the field visit and updated and refined after the visit to more accurately reflect the Namibian context (Appendix C, Table C7).

4.3.5 SELECTION OF SUBCATEGORIES

Based on the 37 subcategories provided by the UN guidelines, the most relevant categories for the context of Namibia were selected, using the following criteria: 1) relevance of the subcategory for the Namibian or value chain context, 2) ability to assess and measure the subcategory by indicators. Based on this evaluation, subcategories were included, excluded, aggregated, or considered in the impact assessment. Some subcategories were moved from their original stakeholder category and assessed under another subcategory after fieldwork, since they were found more appropriate for another stakeholder category (Appendix C, Table C1, Table C2, Table C3, Table C4).

The selection of the indicators is done based on an initial screening of indicators in literature, SLCAs performed on bio-based value chains, and the methodological sheets of the UN guidelines. The following criteria were used to select the initial indicators (Buchholz et al., 2009; Sawaengsak et al., 2015; Kamali et al., 2018):

- **Data availability:** is the data 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 for the value chain? Is the indicator prioritized in other bio-based value chain SLCAs?

Since indicators are context-specific, the selection was re-iterated after the fieldwork and engagement with relevant stakeholders (Appendix C, Table C5.1, Table C5.2, Table C5.3). In addition, a choice was made for which type of assessment the indicator would be used, to assess performance or risk. The final set of subcategories and indicators can be found in Table 4.2.

Table 4.2 – Subcategories with their corresponding set of indicators and assessment focus

Stakeholder category	Subcategory	Indicator	Type of assessment
Workers	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 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	Risdk
		Contribution to economic development	Performance
	Technology development	Technology transfer	Performance
	Corruption	Corruption index	Risk
	Poverty alleviation	Multidimensional poverty index	Risk

4.3.6 DATA COLLECTION

Data was collected during fieldwork in January and February 2023 through semi-structured interviews, observations, and a multi-stakeholder workshop. During the interviews, roles and responsibilities were discussed, and questions regarding the basic requirements and performance reference points were asked. Follow-up questions were asked to determine if the organization could be assessed with level A or B, or to find out why the BR was not fulfilled. In addition, participants were shown an infographic of the potential biofuel value chain, and questions were asked about their possible roles, challenges, benefits, and harms (Appendix A, Figure A1). Moreover, a power-interest grid was prepared to ask for feedback on the positions of the stakeholders and to identify missing actors (Appendix C, Figure C8.1). Table 4.1 shows the number of interviews done. The case study protocol can be found in Appendix A and Appendix C.

At the end of the field stay, a multi-stakeholder workshop was organized for stakeholders who participated in the study. The participants were divided into three smaller groups, where different stakeholder groups were mixed, to discuss the following topics:

- Participants were asked to envision the ideal scenario for a new bush-based value chain, choosing the best options for variable choices (such as feedstock type, type of suppliers, harvesting method, biorefinery ownership, contracts, and location) (Appendix A, Figures A4, A5, and A6),
- Participants were asked to rank the subcategories and indicators based on their perceived importance. In addition, they were asked to identify subcategories that were missing. For this, the tool Mentimeter was used (Appendix C, Figures C8.2 and C8.3).
- Based on the ideal scenario identified in the first step, participants were asked to create a roadmap with steps to realize the ideal scenario (Appendix A, Figure A7).

To determine the weightage of each stakeholder's input for the ranking of the subcategories, their input was weighted based on their level of involvement (Table 4.3). Stakeholders received a weightage of three if they were directly involved, two if they were indirectly involved, and one if they were not involved in a particular subcategory. After points were assigned

and weighted, the total points were calculated for each subcategory by summing up the contributions from all stakeholders.

Table 4.3 – Stakeholders present during the workshop and the weighting for the ranking

Stakeholders	**Workers**			**Value chain actors**			**Local community**			**Society**		
	3x	2x	1x	3x	2x	1x	3x	2x	1x	3x	2x	1x
Farmers Union (FU2, FU3)	x			x			x		x		x	
Charcoal producer (CP1)		x		x					x		x	
Conservancy (C1, C2)		x		x					x		x	
Communal farmers (CF5, CF6, CF7)	x					x	x				x	
Government (G1, G5, G6, G7, G8)			x		x			x		x		
Development agency (DA3)			x		x			x		x		
University (U6, U7)			x		x			x		x		
Nature conservation (N2)			x			x			x	x		
Bank (B1)			x			x			x	x		
Industrial Association (IA1, IA2, IA3, IA4)			x		x			x			x	

Interviews were transcribed verbatim, anonymized, and coded using MAXQDA 12 software with the consent of participants. Summaries of the workshop discussions were created. Interview guides and workshop materials can be found in Appendix A. Figure 4.3 represents the process of data collection and interpretation of the data.

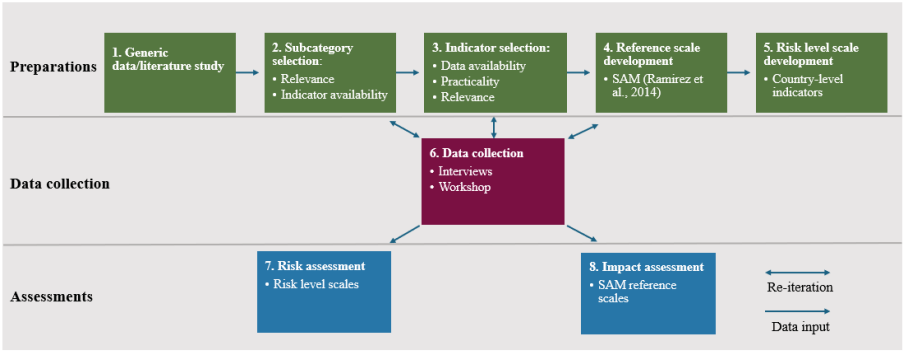

Figure 4.3 – Process of data collection and assessment

4.4 RESULTS

4.4.1 RISK ASSESSMENT

First, a risk assessment was performed based on general indicators, to understand potential social risks in the context of the bio-based value chain (Table 4.4). It shows that the highest social risk is the high unemployment rate, followed by unequal wealth distribution, low GDP, and a high corruption rate. According to this assessment, gender inequality, and multi-dimensional poverty are rated low risk.

Table 4.4 – Risk assessment scores

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

When comparing these results with our interviews, workshop, and other secondary sources, we see that a risk assessment based on general indicators oversimplifies complex issues and does not represent the social risks involved in the specific context of BBVC operating mainly in a rural context.

First, Namibia scores well on the gender gap index. With a score of 0.807, the indicator is assessed with low risk. The country especially scores high on educational attainment and health (World Economic Forum, 2022). Even though Namibia scores well on the gender gap index, it still faces various other socio-economic issues such as an increase in gender-based violence, occasional harmful cultural practices, and gender stereotypes (Sioka, 2022). Moreover, there are still gaps in economic participation and political empowerment of women (World Economic Forum, 2022). The index provides a tool for cross-country comparison but it does not represent the nuances of gender gaps within a country. 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 (Mwetulundila, 2021; Sioka, 2022; Gierse-Arsten, 2024). This was illustrated during an interview with a commercial farmer with a foundation for improving working conditions on farms. She said: *"I realized that a lot of women in this area have no jobs and they prostitute themselves to get a little income here and there. And that made me sad and shocked me because is it really necessary? Can't we find jobs for women that they can also work on farms?"* (F2). In addition to difficulty in finding jobs, women suffer from domestic violence. She continues: *It's also a problem always with abuse when alcohol comes into play. When I came to the farm four years ago, I sat down and wrote some contracts and farm rules. Two of my guys learned that no women are being hit on the farm by getting a final warning, I think still that they obviously deserve a second chance, it's a learning curve. But they just realize that on this farm the women and the children are not getting hit."* (F2).

Second, assessing the multidimensional poverty index (MPI) as low-risk does not represent reality well. Namibia has an MPI of 0.191, with 43.3% of Namibia's population suffering from multidimensional poverty. The top

five factors influencing this number are food security, child nutrition, transportation assets, sanitation, and cooking and lighting energy (NSA, 2021). Even though almost half of the population is multidimensionally poor, it is classified as low-level risk, due to the nature of the scales, which range from 0-1 (Appendix C, Table C6). Even though a high percentage of Namibians are multi-dimensionally poor, Namibia performs relatively well compared to other countries. However, poverty remains a significant challenge, with rural areas most affected (NSA, 2021).

Third, no general indicators were available on food security and living standards in the communal areas to make the assessment. These indicators belong to the stakeholder category of local community, which in this study is defined as the communities living in communal areas within the system boundaries. While country-level statistics on food security are available, no statistics indicate food security in the communal areas specifically. The same is the case for living standards. Based on other sources, we found that in the Otjozondjupa region, food security and living standards are an issue, so leaving these indicators out of the assessment obscures the identification of potential risks. People in poverty most often lack necessities like transportation assets (38.3%), sanitation (34.6%), and cooking and lighting energy (34.6%) (NSA, 2021). Housing structures in Otjozondjupa are quite basic but decent. They are built from various building materials, such as bricks (51.0%) and corrugated iron (33.1%). Sanitation is a challenge with 35.1% of the people resorting to the bush for their toilet needs (ibid). Access to energy is a significant issue in rural areas, with the majority of families lacking electricity. National efforts to address this have been largely unsuccessful (MME, 2021). One communal leader (CF2), shared in an interview that their home lacked electricity because it was too expensive to connect their house to the grid in the village. Another communal leader explains: *"Rural electrification is an issue. It is a very expensive project for rural community households to get electricity from the main grid. In this area, we have more than 80 villages. We have to come one by one. Yeah, but if you have to look at the villages that have electricity, maybe in our area we can count them quickly. Less than 30%."* (CF1). Given how difficult it is to obtain some of the most basic needs, it is evident that inadequate living conditions can be a potential social risk. It was however not possible to assess this risk on a scale due to a lack of data to assess this using general indicators.

To conclude, while the risk assessment highlights some important social risks, it does not represent the social risks in the rural context of Namibia adequately. In this risk assessment, global indicators and scales are based on assessments from international institutions such as the World Bank and World Economic Forum that developed indicators to compare different countries on specific issues. While this is useful, it does not always sufficiently assess the potential context-based social risks. Especially in a rural context, as is the case for a bio-based value chain, country-wide statistics do not always represent the reality in rural areas. Therefore, we recommend complementing the general indicators with other sources to gather a more complete and nuanced picture.

4.4.2 SOCIAL PERFORMANCE IMPACT ASSESSMENT

4.4.2.1 WORKERS

The stakeholder category workers is where the least indicators fulfill the BRs, compared to other stakeholder categories (Table 4.5). According to the impact assessment, workers are most at risk of being negatively impacted by a new bio-based value chain. Workers are involved in various stages of the charcoal value chain, with the majority of workers being employed in the charcoal production phase, including bush harvesting and processing.

The assessment of this stakeholder category is similar to the outcomes of the interviews, observations, and workshop discussions. Most indicators in this stakeholder category are relatively easy to assess on a scale. It is possible to check the type of contracts workers are employed under, how many hours they work a week, and if there is a union. These indicators are representative of the kind of protection workers receive and how they are compensated for their work.

Because charcoal workers perform mostly temporary work on a contract basis for a few months a year, they are treated as independent contractors (FU3). In this type of contract, they are not covered by the Labor Act (2007) and are not required to receive any social benefits (Republic of Namibia, 2007). Because workers are employed under a performance-based work structure where their income is directly linked to

the tonnes of charcoal they produce, they can exceed working hours to increase their output and wages (NCA, 2019). In addition, there are currently no workers unions available for charcoal workers. This is mainly due to the impracticality of doing so, as they move around working on different farms and do not have permanent employment (FU3, CP1, BW2). Even though health and safety policies are in place since this is required for FSC certification, this is often not implemented in practice. The policy requires the supply of personal protective equipment (PPE) such as overalls, gumboots, hats, gloves, and dust masks. In addition, training on health and safety is provided (FSC, 2019). However, while provided to the workers, they do not always wear the PPE because it is uncomfortable. Farmers cannot control this constantly (F3, F4).

The indicator that is more difficult to assess in this stakeholder category is policies for equal opportunities. In this assessment, this indicator focuses only on gender equality, which can be asked about and evaluated. Whereas work in bush harvesting and charcoal production is mainly done by male workers, in charcoal processing a higher percentage of women is employed (CPc1). In addition to gender dynamics, another type of inequality is more prominent in the context of Namibia, and this is inequality based on ethnicity. The population of Namibia has a high ethnic diversity, with European descendants and people who belong to different tribes. Norms and ideas about these ethnic groups play a role in the bio-based value chain. This is illustrated by a commercial farmer who explains why they mainly employ workers from the Oshiwambo and Kavango tribes: *"The work motivation of the Oshiwambo and the Kavango tribe is really not bad. That is just the experience of farmers in this area. The unemployment rate in Namibia is that high, I don't need to motivate people to work, I want people who are motivated already and we just found that also alcoholism is not such a big problem with the Oshiwambo and with the Kavango tribe."* (CF2). Even though these norms related to ethnicity play a role in the social impact of the value chain, this is much more difficult and sensitive to assess based on an indicator.

Table 4.5 – Impact assessment workers

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level B**	**Level C**	**Level D**
Social benefits	The organization offers more than the legally required	As required by Namibian law, the organization provides the compulsory benefits; Maternity Leave, Sick Leave, and a Death Benefit Fund to all of its employees (Labor Act, 2007).	The organization provides at least 2 basic social benefits/ social security requirements.	*The organization does not provide any basic social benefits/social security requirements.*
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 9 in the day and 45 in the week (Labor 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 the average weekly hours worked in the sector/country.*
Health and safety policy	The organization implements health and safety practices beyond the industry standard.	The organization has a policy related to health and safety and provides a working environment that is without risk to the employees (ILO Convention nr. 161 & Labor Act, 2007).	*No strong health and safety policy is in place with evidence of workers not fully complying with obligations on safety practices.*	The organization has no health and safety policy in place.
Policies for equal opportunities	The organization proactively implements this policy and ensures equal pay and equal opportunities.	*The organization has a management system, policy or actions to prevent discrimination and promotes equal opportunities for workers, according to ILO Conventions No.100 and 111.*	There is evidence in the organization of discrimination and the country where the organization is located has a Global Gender Gap Index lower than 0.5.	There is evidence in the organization of discrimination and the country where the organization is located has a Global Gender Gap Index higher than 0.5.
Formal contract	Formal contracts that provide fair and equitable compensation and benefits packages.	A formal contract is given and the employee is covered by the Labor Act (2007).	*Contracts are temporary and are not covered by the Labor Act (2007).*	The employee only has an informal contract with the employer and is not covered by the Labor Act (2007).
Minimum wage	The lowest salary is equal to the living wage of the country.	*The lowest salary is equal to or higher then the minimum wage in the sector/ country where the organization 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 organization provides a higher standard of housing to employees than the minimum requirements.	*The organization must provide employees with adequate housing, incl. sanitary and water facilities that meet the standards set by FSC.*	The organization fails to meet the minimum housing standards.	No housing is provided to the employee.

4.4.2.2 VALUE CHAIN ACTORS

Value chain actors in this study are defined as key participants in the charcoal value chain who can employ people. They include charcoal producers (commercial farmers), processors, transporters, and end consumers. The only indicator that does not fulfill the BR is 'workforce hired locally' (Table 4.6). Similar to the indicators in the stakeholder category of workers, the indicators for value chain actors are quite easy to assess and rank. The assessment of this stakeholder category represents the findings from our interviews, workshop, and observations well. However, there are nuances in two of the indicators.

First, the indicator workforce hired locally is assessed with level C because workers are generally not hired within the system boundaries, even though unemployment levels are high. The majority of the charcoal workers are migrant workers coming from the Kavango and Northern Central regions whose tribal borders span into Angola, with communities living on both sides. These regions are characterized by high poverty and unemployment rates and a poor educational system. The reason that charcoal workers are not employed within the system boundary is that the local population is generally not willing to perform hard physical labor on the land (FU3). This makes it difficult to assess the indicator, because there are opportunities for local employment, but migrant workers are performing the work because the local population does not want to do this type of work. According to a leader of a farmers union, this has to do with the working conditions in the charcoal industry. A new biofuel value chain has the potential to improve working conditions and local employment. He states: *"If it can be a cleaner job, for instance where you use equipment that's not this hard work, then it can be a good alternative that a lot of people will consider. Especially if it need not be with many workers on the farm."* (FU3). This is an issue that was not picked up in the impact assessment.

Second, the indicator of sustainable harvesting is assessed with B because the majority of the charcoal producers are FSC-certified, which requires compliance with environmental, social, and economic standards in forest management (Hindjou, 2021). Charcoal producers must have a forest management plan to address sustainable and selective harvesting because if the wrong species are harvested or too much bush is removed,

the problem will deteriorate (G1). To start producing charcoal, producers need 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 specific species, and desired quantities to be harvested. However, adherence to these guidelines by charcoal producers and workers is not always guaranteed due to a lack of monitoring and enforcement (G3, Cert1, MITSMED, 2017).

Sustainable harvesting was also a key concern that was raised during the workshop discussions and interviews with forestry experts and government officials. A government representative states: "*The biggest challenge for monitoring by Forestry is the equipment, the vehicles, internet, computers' that stuff. They hardly have such stuff and it's easy for me to sit here and say they should have been doing this and that. But I mean you come to an office where there's only one person. And even the internet to check on Google Earth sometimes lacks.*" (G1). In addition, 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. The concern related to sustainable harvesting is not represented in this SLCA due to the definition of the indicator. It assesses whether an internal management system is in place, but does not assess the compliance with that management system.

Table 4.6 – Impact assessment value chain actors

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level B**	**Level C**	**Level D**
Workforce hired locally	The organization can demonstrate that the majority of its employees are hired locally.	There is evidence of equal employment opportunities for local workers.	*The organization is located in a country with an employment-to-population ratio lower than 50.*	The organization is located in a country with an employment-to-population ratio equal or higher than 50.
Certifications	Multiple public commitments to sustainability by the organization, showcasing proactive behavior towards sustainability.	*The evidence of any promise or agreement related to sustainability and social responsibility is disseminated to the public*	There is no record of proven cases that the organization has violated its commitments to sustainability within the last three years.	There is a record of proven cases that the organization has violated its commitments to sustainability within the last three years.
Sustainable harvesting	There is evidence that the organization 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 all encroacher bushes.
Code of conduct	*The organization 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 organization's suppliers.	The organization lacks a code of conduct but does have a supplier relationship.	The organization lacks a code of conduct and has no supplier relationship beyond basic purchasing transactions.

4.4.2.3 LOCAL COMMUNITY

The stakeholder category local community is the most difficult category to assess based on this assessment method. Local community in this context is defined as communities living in communal lands. However, the community lacks access to the overall charcoal value chain as the communal areas are legally restricted from producing charcoal from encroacher bush due to a moratorium from the government. 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.

All indicators in this stakeholder category are assessed with B because FSC certification requires organizations in the charcoal value chain to have a communal rights policy, preserve cultural heritage, maintain positive community relations, and contribute to the social and economic well-being of the local communities near charcoal operations (Table 4.7). This however does not represent the key concerns raised by stakeholders on the inclusion of local communities during our interviews and workshop discussions.

As a result of the government's moratorium on harvesting permits for communal areas, the opportunity to (individually) participate in charcoal production is currently unavailable to local communities. This moratorium was placed by the government due to concerns about over-exploitation, unsustainable harvesting practices, and unequal benefit-sharing within the communities since the bush in these areas is a common pool resource (Hindjou, 2021). However, bush encroachment is most severe in these communal areas due to these harvesting restrictions and a lack of resources. In addition, in communal areas, people suffer more from poverty and unemployment compared to other areas. The history of colonialism and Apartheid makes the dynamic sensitive between commercial charcoal producers, who by the majority are European descendants, and communities in communal areas, who belong to different tribes. Even though people in communal areas are in higher need of bush control, employment opportunities, and additional income sources, their participation in a new bio-based value chain is restricted. One communal representative states: "*We are eager for any change and we are ready for any cooperation. Our people are so eager. There is always progress if there is change. There's no progress now.*" (CF1).

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 et al., 2014). 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). A civil society representative involved in these pilots explains: "*We've been struggling to get that structure in place also with the communal areas because it is, you know, millions of hectares belonging to hundreds of thousands of people equally. They all get the same benefit out of the land. Getting a structure in place where one guy does not have a bigger benefit than the other, other than just the time that he's putting in, it's very difficult.*" (Cert1).

These dynamics are difficult to assess with indicators. In addition, the social impact in this stakeholder category is not directly linked to a company's behavior since it is a result of government regulations. However, the exclusion of communal areas is an important social impact of commercial bush-based value chains. Moreover, it was highlighted by all participants in the workshop that ideally, all different types of farmers should be able to supply the value chain.

Even though companies have communal rights policies in place, local communities do experience social impact from the bush-based value chain, as they lack access to the value chain due to structural factors. An SLCA based on the indicators below alone cannot grasp these dynamics. This highlights the need to gather more context-specific, qualitative information in addition to the indicators and to include factors, such as policies and land ownership, that are out of the direct sphere of influence of companies but that are very important for the social impact of their operations.

Table 4.7 – Impact assessment local community

	Basic requirements fulfilled		Basic requirements not fulfilled	
Indicator	**Level A**	**Level B**	**Level C**	**Level D**
Communal rights policy	The organization has a communal rights policy and engages in regular consultation and engagement with communities and incorporates their feedback into its operations	*The organization 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 way of living	The organization actively promotes the preservation of cultural heritage by promoting the use of traditional products and craftsmanship in their production methods	*The evidence of any promise or agreement related to sustainability and social responsibility is disseminated to the public*	The country where the organization operates has no cultural heritage sites in danger (UNESCO, 2023)	The country where the organization operates does have cultural heritage sites in danger (UNESCO, 2023)
Community engagement	The organization demonstrates proactive efforts to improve the community's environment, health, and welfare and engages the community in decision-making processes	*There is evidence that community environment, health or welfare are of importance to the organization*	There is no record of proven cases that community groups/ members were affected by the actions or products of the organization 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 organization within the last three years

4.4.2.4 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. This stakeholder group thus includes a wide range of actors, such as the government, researchers, and civil society organizations, who can be impacted by the charcoal industry.

The two indicators in this stakeholder category fulfill the BR, with one going above and beyond (Table 4.8). Both indicators are quite easy to assess and rank and are adequate to assess the social impact. The BR for

the indicator technology transfer is fulfilled, as there is evidence of research and development of technology within the charcoal industry that is publicly available. Level A is assigned to 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 ranked among the top ten exporters in the last decade (Markstein, 2020). Beyond its direct economic contribution, the charcoal sector also contributes by bush control and rangeland restoration to the economy. A local fund manager states: *"What you also need to realize is that 70% of Namibians are directly or indirectly linked to agriculture. And if you can have an impact there, you will naturally have an impact on communities."* (FM1). By controlling bush biomass, the industry helps create opportunities for increased livestock production, tourism, groundwater recharge, and biodiversity conservation (De Klerk, 2004).

Table 4.8 – Impact assessment society

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

4.4.3 PRIORITIZATION

In addition to the risk assessment and social impact assessment, a ranking exercise was done with participants in the multi-stakeholder workshop to

identify which subcategories were perceived as more important than others (Table 4.9). This exercise was insightful as it helped to identify the social impacts with the most risks and challenges. This can help decision-makers allocate resources and attention to areas with the greatest potential for improvement.

This ranking exercise provided some new insights that were not identified in the social impact assessment. In the category of value chain actors, sustainable harvesting and local employment were ranked as important. While the social impact assessment did not assess sustainable harvesting as a concern, workshop participants highlighted this as one of the main concerns for this stakeholder category. If the wrong species are harvested, too much bush is removed, or aggressive aftercare is used, this can impact the rangeland negatively. In that way, bush control has a negative environmental impact. This is an issue since one of the key goals of creating bush-based value chains is to control the bush and restore the savannah grasslands. For the stakeholder category of local community, respect for communal rights was prioritized, with the reasoning that communal areas should be included in the value chain. This was not identified in the social impact assessment.

The ranking exercise also confirmed some conclusions from the social impact assessment. In the subcategory of workers, stakeholders prioritized fair salaries and safe and healthy working conditions. This is in line with the social impact assessment, only with the difference that workshop participants emphasized fair salary above working hours and freedom to join a union. They reasoned that when workers are compensated fairly for their work, they don't need to exceed working hours to make a decent income and the need for joining a union is less prominent. Lastly, for society, the contribution to economic development was ranked most important, since Namibia has a relatively low GDP (12.31 billion in 2021) and experiences a low-growth environment (African Development Bank, 2021). The charcoal industry is a major contributor to Namibia's economy and the development of new bush-based value chains could significantly contribute to the country's economy.

In the workshop, participants were also asked to propose subcategories that were missing in their view. Categories that were mentioned

were inequalities related to social identities (ethnicity, gender, religious beliefs), access to join value chains, finance, and benefits, capacity building/skills development for workers, education, law enforcement, and atmosphere for entrepreneurship. These are issues that are not (sufficiently) addressed in the SLCA and are more difficult to assess using indicators but represent important social issues related to the bush-based value chain.

So through the ranking exercise, some social issues and concerns were raised and prioritized that did not come forward in the social impact assessment. This highlights the need for gathering subjective information about how stakeholders experience social impact, in addition to assessing social impact based on the indicators. Because this ranking exercise was insightful in identifying the key concerns within the prospective value chain, this could also be done for the social impact assessment. In addition to the assessment based on indicators definitions, it could be helpful to ask stakeholders to assess the indicators with A, B, C, or D. This could give a more complete and nuanced picture of the actual social impact of the value chain.

Table 4.9 – Prioritization of subcategories

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 for communal rights			
	Community engagement			
	Cultural heritage			
	Standard of living			
	Food security			
Society	Contribution to economic development			
	Poverty alleviation			
	Tranfer of technology			
	Corruption			

The findings of the SLCA and the qualitative field study pointed out several issues that need to be addressed for a prospective biofuel value chain in Namibia. Establishing a biofuel value chain offers promising opportunities for enhancing social impacts compared to the existing charcoal value chain. Therefore it is crucial to acknowledge and address the risks associated with biomass harvesting, especially related to workers' wellbeing and working conditions, and sustainable harvesting.

Additionally, although the involvement of communal farmers is restricted by government policies, it is important to explore alternative avenues to include them in the operations or benefits of the value chain.

4.5 DISCUSSION

4.5.1 RECOMMENDATIONS FOR SLCA

In this study, we have performed an SLCA for a prospective biofuel value chain based on an existing charcoal value chain in Namibia. We reflected on the assessment based on our qualitative fieldwork, which consisted of semi-structured interviews, observations, and workshop discussions. We showed that while the SLCA captured and assessed certain social impact categories well, it also missed some key indicators and concerns raised by local stakeholders.

The SLCA successfully identified labor issues, such as wages, health and safety, and working hours, and assessed whether an organization or company has a certain policy in place or adheres to certification. Those indicators are relatively easy to evaluate on a scale and can be verified and captured under the SLCA framework. However, it is more challenging to assess the more sensitive social issues, such as social norms related to gender and ethnicity, structural factors like policies and land ownership, and the subjective experience of stakeholders. Those factors are crucial for the social impact of a value chain, but are less easy to grasp with an indicator. That is a limitation also identified by Rebolledo-Leiva et al. (2023), who argue that it is needed for SLCA to take a broader focus.

Moreover, the SLCA is often performed from the perspective of a company or organization. This is a limiting focus since the transition towards a bioeconomy involves changes across the value chain and social processes where multiple actors interact, such as farmers, governments, and companies (Rebolleda-Leiva et al., 2023). This limited focus on a company's perspective risks missing potential negative impacts, such as the issue with communal farmers in this case. It can also miss possible positive impacts, as shown by Postal et al. (2020), who evaluate the social impact of sugarcane expansion in Brazil. They conclude that there are differences between global and local perceptions of the sugarcane expansion. While there were global concerns about the negative social impact of sugarcane

expansion, local stakeholders generally perceived this expansion as positive, since it provided them with more economic opportunities. Therefore, it is meaningful to assess the actual opportunities that are created for local stakeholders by the value chain.

Besides the perspective of local stakeholders, a key actor that is not considered a stakeholder in the SLCA is the public sector. According to the UNEP/SETAC guidelines, the State is not proposed as a separate stakeholder category because it is not a dimension in Corporate Social Responsibility (CSR) frameworks and literature (UNEP/SETAC, 2009). However, the bioeconomy involves interactions between different stakeholders, including the State. The State plays a crucial role in promoting the bioeconomy and the institutional environment that influences social and socioeconomic conditions of value chain actors such as farmers (Postal et al., 2020). Therefore, SLCA should pay attention to multiple dimensions in society and factors that influence the transition to a bioeconomy, for instance, government policies, regulatory conditions, human resources, and social acceptance (Rebolleda-Leiva et al., 2023). These factors are currently excluded from the SLCA since they are out of the sphere of influence of a company. That is limiting the assessment of the social impact of a bio-based value chain.

We therefore propose a few changes to the SLCA methodology. First, we recommend broadening the scope of the risk assessment. Currently, the risk assessment utilizes various general country-level indicators. This does not always represent the social risks of the context in which a value chain operates, which is, in the case of the bioeconomy, often a rural context. In addition to country-level indicators, more context-specific sources can be used to make a more realistic risk assessment, and additional relevant indicators should be added. These additional indicators should include more contextual factors that influence the social risks of the value chain, such as land ownership, monitoring and enforcement capacities, education levels, and social norms related to gender, ethnicity, and religion. These indicators can be identified and verified by local stakeholder engagements.

We propose incorporating these contextual factors into the risk assessment to obtain a broader view of the social context and potential

social risks of a (new) bio-based value chain. These factors are mostly beyond the influence of a company and are more associated with social norms and government policies in a certain context. However, they highly influence a value chain's (potential) social impact, risks, and opportunities. For example, in the case of Namibia, the structural factors of land ownership and the government's moratorium influence local communities' access to participate and benefit from a commercial bush-based value chain. These factors cannot always be addressed by a company directly, but a company should be aware of the social context when starting operations like biomass procurement. Through multi-stakeholder collaborations, these risks could be addressed. Moreover, improving the risk assessment will also make the SAM assessment more robust, because the results from the risk assessment are used to determine if the indicator is ranked with level C or D, depending on the context (Ramirez et al., 2014).

In addition to broadening the risk assessment, we suggest complementing the social performance impact assessment based on indicators with a subjective evaluation by local stakeholders. Since the ranking exercise on the subcategories' prioritization provided insights missed in the social performance impact assessment, it could be useful to ask local stakeholders to rank the indicators on the same scale (A, B, C, D). This way, crucial knowledge can be gathered on how social impact categories are experienced by those stakeholders affected, in addition to assessing whether the right policies are in place.

The proposed changes would make the SLCA more subjective and qualitative, which further complicates the standardization of the SLCA method. However, unlike environmental LCA, social impact is more value-laden and normative (Reitinger et al., 2011; Lago-Olveira et al., 2024). As shown in our SLCA case study in Namibia, performing a social impact and risk assessment based on more 'objective' indicators does not always reflect the social reality well. Specific assumptions may be made about the context that do not reflect actual reality, such as the availability of infrastructure and equipment. Therefore, it is imperative to complement the social performance assessment with more subjective information to examine how the social impact is experienced and which social issues are deemed more important to address. Local stakeholders should actively participate in this assessment. We argue that it is undesirable to stand-

ardize the SLCA method in the sense of selecting a general set of indicators that can be applied in multiple contexts, since that will differ per context. The selection and definition of the subcategories and indicators should be tailored to the specific context. Otherwise, the resulting analysis would be less meaningful.

4.5.2 RESEARCH IMPLICATIONS

With the proposed suggestions, SLCA can be an important tool to assess the social impact of bio-based value chains. This is not only promising for evaluating existing value chains but also for identifying potential social impacts and risks of a new bio-based value chain, as we have shown in this paper. Decision-makers can use the results from the SLCA to prioritize which social impact categories need to be improved to prevent potential negative impacts, or where opportunities are for positive social impact. This is especially promising for the bioeconomy since many bio-based value chains build on existing ones (Robaey et al., 2022). This is relevant since choices made in the early stages determine to a large extent the outcomes in a later stage (van der Veen et al., 2024). Apart from bio-based value chains, this method can be used for other value chains or (new) technologies.

Additionally, allowing more stakeholder engagement prevents a 'Western' understanding of which subcategories and indicators are important to consider. Moreover, by only adding subcategories that can be measured quantitatively, important information on (potential) social impact can be missed. This compromises 'data justice' which is the fairness in the way people are made visible and represented in data (Pritchard et al., 2022). What can be standardized is the process of conducting an SLCA, which includes the different steps to be taken. The guidelines of UNEP/SETAC (2009, 2020) provide a good basis for this.

Apart from research implications, our findings also have practical implications. The rising demand for more sustainable alternatives to replace fossil fuels intensifies biofuel production and increases the competition for biomass (Yupanqui et al., 2024). At the same time, biofuel value chains are often scrutinized for their potential negative social impact (Lima, 2022). Conducting an SLCA can help companies evaluate the social impact of their operations and can help in decision-making around

potential new value chains to improve social conditions. A limitation for companies can be that our proposed changes to the SLCA methodology are time- and resource-consuming. Companies can use the existing databases and general indicators when there are time restrictions. However, then they risk missing important social impacts, as we have shown. This does not contribute to adequate decision-making or improvements in the social performance of that value chain. In addition, it can compromise the social acceptance of a new technology or new value chain, which is important for its success (Sanz-Hernández et al., 2019; Velasco-Herrejon & Bauwens, 2020).

In addition, our research has policy implications. Over 50 countries adopted bioeconomy strategies because of their economic, environmental, and social potential (Zeug et al., 2023). For the evaluation of these policies, adequate methodologies are needed to assess the actual (social) impact of the implementation of new bio-based value chains. Our recommendations help in getting a more accurate understanding of the real social impact of the bioeconomy.

4.5.3 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This study also has some limitations. First, our reflection is based on qualitative research. This allows a deeper understanding of real-life contexts and complex relationships. However, qualitative research also has limitations due to subjective input from stakeholders and interpretation by researchers. Data is triangulated using semi-structured interviews, observations, secondary sources, and a workshop to overcome these limitations. Moreover, the research is carried out by a research team, and the interpretation and analysis of the data are discussed among different researchers. In addition, research findings were discussed with local partners, such as research institutes and a multi-stakeholder platform.

Second, this research is based on one case study which limits the possibility of generalizing the results. It does offer in-depth insights into the social impact of a bio-based value chain and the limitations of the SLCA methodology. Even though the findings on the social impact of the bush-based value chains in Namibia cannot be generalized to other contexts,

our reflections and recommendations are relevant for future SLCA studies in the bioeconomy and beyond.

Future research can build on our analysis and implement our suggestions in real-life case studies. In addition, future studies can use this SLCA methodology for decision-making for new (bio-based) value chains. Finally, our study focused specifically on the bioeconomy. Future research can expand the scope and apply this methodology to other types of value chains and (new) technologies.

4.6 CONCLUSION

In this paper, we addressed the issue of including social impact in sustainability assessment. We reflected on an SLCA that we conducted on a bush-based value chain in Namibia and identified its strengths and weaknesses in assessing the social impact of a bio-based value chain. We conclude that while the SLCA can identify and assess certain social issues, such as working hours, health and safety, and contribution to economic development, it is more difficult to assess more sensitive issues like inequality based on ethnicity, social norms, and structural policies and regulations. We, therefore, propose to broaden the risk assessment with more context-specific factors that do not only focus on factors a company can address directly, but that involve multiple stakeholders such as governments, farmers, and local communities. Moreover, we suggest that the social performance impact assessment should be complemented with a more subjective assessment by local stakeholders about how these social impact categories are experienced. This would further complicate the standardization of the SLCA method, but we argue that standardization is not always desirable. A social impact assessment based solely on 'objective' indicators does not represent the social impact in a meaningful way.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This dissertation is set out to examine how emerging bio-based value chains (BBVCs) could be developed in such a way that the needs, knowledge, skills, and values of all relevant actors are taken into account. Special attention was paid to the stakeholders at the beginning of the value chain, since they play a crucial role but are often overlooked in the design, development, and improvement of (bio-based) value chains.

By studying three diverse cases of prospective BBVCs based on waste biomass - olive oil residues in Spain, coffee and cocoa residues in Colombia, and encroacher bush in Namibia - this research provided insights into the social dynamics that shape the potential for a just bioeconomy transition. This chapter recaps the main conclusions that address the central research question: *How to develop secure, inclusive, and sustainable bio-based value chains that take into account the needs, knowledge, skills, and values of all relevant actors, with special attention to actors at the beginning of the chain?* It also discusses the study's limitations and provides recommendations for future research.

Each chapter addressed a specific sub-question aimed at answering the overarching research question. Chapter 2 addressed the choices in the early stages of designing novel BBVCs and connected these design choices to social justice. Specific attention was paid to vulnerable, upstream stakeholders such as small-scale farmers and indigenous communities. In chapter 3, the scope was broadened by incorporating the views of both upstream and downstream actors to analyze various pathways for achieving inclusion. Various complexities and trade-offs were identified based on the three case studies, and preferred strategies were explored. Finally, chapter 4 focused on the social impact assessment of BBVCs, and concrete recommendations to the Social Life Cycle Assessment (SLCA) methodology were provided to better understand the (potential) social impact of BBVCs. Figure 5.1 clarifies the contributions of the three chapters in answering the main question.

Central research question:	*How to develop secure, inclusive, and sustainable bio-based value chains that take into account the needs, knowledge, skills, and values of all relevant actors, with special attention to actors at the beginning of the chain?*		
Case studies	**Olive oil residues, Spain**	**Coffee and cocoa residues, Colombia**	**Encroacher bush, Namibia**
		Focus:	**Context:**
Chapter 2	*How can the identification of local stakeholders' skills, needs, and capabilities be used to design scenarios of bio-based value chains for social justice?*	• Design choices • Social justice • Upstream stakeholders	Spain, Colombia, Namibia
Chapter 3	*How can different strategies for inclusive value chains be applied in new bio-based value chains?*	• Upstream and downstream stakeholders • Strategies towards inclusion • Complexities and trade-offs	Spain, Colombia, Namibia
Chapter 4	*How can social impact be incorporated into sustainability assessments of bio-based value chains?*	• Social impact assessment • Social Life Cycle assessment	Namibia

Figure 5.1 – Overview of chapters and contributions to answering the central research question

5.2 INCLUSION FOR A JUST TRANSITION

This dissertation addresses a just transition towards a sustainable bioeconomy. Central to this thesis is the concept of inclusion in new BBVCs. I started from the premise that for achieving a just bioeconomy, inclusion of all stakeholders, and most notably the most vulnerable stakeholders, into the design, process, and outcomes of new BBVCs is essential. While it is increasingly recognized in sustainability and bioeconomy literature that topics of inclusion and social justice are important, few studies address the practical complexities of developing novel BBVCs. Moreover, often a forward-looking focus is lacking. This is particularly critical in the context of the Global South, where poverty and socio-economic exclusion are widespread, and necessary infrastructure is often lacking. This dissertation aimed to contribute to this debate by examining how to proactively include all stakeholders in the design and development of new BBVCs.

In this dissertation, inclusion is defined as interventions focused on those least well off that aim to increase their opportunity to lead a life worth living (Asveld et al., 2023). Inclusion in (bio-based) value chains can be approached as a process and as an outcome. The three chapters of this dissertation provided insights into how an inclusive process towards building new BBVCs could take place and how inclusive outcomes can be achieved. Below, key themes are highlighted.

5.2.1 INCLUSIVE PROCESS

The *process dimension* of inclusion means integrating the needs and perspectives of vulnerable groups into value chain design. It is key to understand how people are engaged and understood in this process (Ribeiro et al., 2018). In the long run, such meaningful engagement is vital for socially sustainable bioeconomy transitions. This dissertation made contributions to this debate by advancing methodologies for stakeholder engagement in new BBVCs.

5.2.1.1 STAKEHOLDER ENGAGEMENT

First, stakeholder engagement from the early stages on is fundamental to building inclusive, secure, and sustainable BBVCs. As addressed in chapter 3, BBVCs are highly complex systems that involve diverse actors with varying backgrounds, needs, and perspectives, who are not used to working together. Through BBVCs, smallholder farmers are connected to new actors such as biotechnology companies and chemical industry players. For upstream participants, like biomass producers, this requires compliance with novel standards to supply to new BBVCs. For downstream actors, including oil companies, the challenge lies in collaborating with heterogeneous groups of farmers to secure raw materials. Unlike fossil oil, biomass is not a commodity yet and must be cultivated, collected, and processed before being transformed into bio-oil. A key challenge in building a sustainable bioeconomy is that it demands systemic change, requiring the engagement and commitment of all actors along the value chain (Donner et al., 2020). Therefore, partnerships between value chain actors and beyond, such as governments, NGOs, and civil society organizations, are crucial.

While it is increasingly known and recognized that stakeholder engagement is crucial for inclusive BBVCs, it remains under-researched

how this can be realized. This study contributes to this debate by applying a relatively new framework, namely Capability Sensitive Design (CSD) proactively in the methodology and analysis of three diverse cases. The Capability Approach is valuable because it offers a multidimensional perspective on well-being, recognizing the diversity of what people find meaningful in life and their ability to achieve it. CSD is an approach that can connect the context-specific and complex information related to people's capabilities to concrete design choices. However, while it has multiple advantages, applying CSD also presents challenges. First, the Capability Approach is conceptually rich and uses its own terminology, which can take time to grasp, especially for researchers unfamiliar with social sciences. Second, there is a risk of oversimplifying lived experiences and the diversity of people's capabilities by translating them too mechanically into design requirements. CSD enables the identification of complex, context-dependent information about people's experiences, needs, and challenges. To make this information useful for engineers, it must be distilled into clear design requirements. This is both the strength and the difficulty of the approach: how to respect nuance and complexity while providing actionable requirements for engineers working on the value chain. Achieving this balance calls for identifying key patterns in the diverse data, understanding engineers' design processes, and iterating between insights and design choices.

Despite its challenges, CSD is a meaningful and promising approach and can be further developed by applying it to more contexts. In chapter 2, it is shown how CSD can enhance procedural justice. When designing and developing socially just BBVCs, attention must be paid to who participates in decision-making and how these processes are structured. Active involvement of stakeholders fosters trust and strengthens relationships across the value chain. As highlighted in chapter 2, stakeholders' capabilities to engage in decision-making are shaped by several factors. Across the three cases examined, variations in these capabilities were evident. The presence of strong cooperatives or farmers' organizations, a foundation of trust, and longer-term commitment were identified as key elements enhancing procedural justice. Consequently, targeted investments and interventions in these areas are necessary to promote equitable participation. Such efforts are particularly important in contexts where conversion

factors constrain local stakeholders' capabilities, as observed in Colombia and Namibia.

5.2.1.2 RECOGNITION OF VULNERABLE ACTORS

Second, bioeconomy transitions affect various groups in society in different ways. A farmer-centred approach that recognizes stakeholders' differentiated realities, as well as their knowledge, innovation capacity, and agency, is key to making this process more inclusive (Ros-Tonen et al., 2019).

It is essential to identify vulnerable stakeholders as well as the context-specific factors that contribute to their vulnerability. As concluded in chapter 2, Capability Sensitive Design (CSD) provides a valuable framework for uncovering these factors through the concepts of capabilities and conversion factors. Beyond mere identification, this process also requires recognizing different types of knowledge and acknowledging justice concerns, particularly concerning the needs and potential harms experienced by vulnerable and underrepresented groups. By applying the lens of CSD, these structural concerns and limitations can be made visible, thereby enabling value chain designs that take them into account. Moreover, actively identifying and incorporating the specific needs and perspectives of (vulnerable) stakeholders prevents a 'Western' understanding of what is important to consider.

Another challenge in applying CSD is deciding whose capabilities should take priority and how to address potential conflicts, issues that lie beyond what CSD alone can resolve. The design requirements that are formulated based on the CSD approach are meant to be normative but not prescriptive. As discussed in chapter 3, conflicting needs could arise between stakeholders at different positions in the value chain. Moreover, more structural inequalities, like those related to historical processes, ethnicity, and land ownership, are often out of scope for private actors to address fully. However, through CSD, the needs and perspectives of vulnerable stakeholders are identified and brought forward in the decision-making process. This creates opportunities to explore strategies for including these stakeholders and ensuring that they benefit, or at least do not experience harm from the new BBVC. In most cases, partnerships

between private actors, governments, and civil society organizations are essential to achieve deeper levels of inclusion in the longer term.

5.2.1.3 CO-CREATION AND CO-DESIGN

Third, co-designing the BBVC with all stakeholders is a useful approach towards more inclusive BBVCs. Especially since in the early stages of design, decisions must be made about elements such as the scale, type of technology, type of feedstock to be used, and contractual arrangements. Many of these choices will be fixed over time, or at least will be difficult to change. These choices do, however, influence the opportunities of stakeholders to access and benefit from the value chain. Therefore, it is relevant to proactively engage with social justice when making those choices.

As highlighted in chapter 2, design choices made through the CSD process can enhance distributive, recognition, and procedural justice by enabling the identification of vulnerable local stakeholders and by providing tools to align their needs, knowledge, and capabilities with these important design choices. Of particular importance is the identification of conversion factors that shape unequal access to resources and opportunities. These factors are closely tied to procedural and recognition justice and form the basis for how opportunities and resources are distributed. Moreover, we have developed a workshop protocol that can be used to forecast ideal scenarios and involve stakeholders in concrete design choices, as well as to backcast and create a roadmap outlining the steps needed to achieve that scenario. The protocol can be found in Appendix A and can be replicated in other contexts.

5.2.1.4 ITERATIVE LEARNING

Fourth, evaluation and iterative learning are crucial elements in the development of inclusive BBVCs. First of all, to ensure the sustainable production of bio-based products, it is essential to understand the potential environmental, economic, and social impacts. However, social impact assessment methods are still less advanced compared to environmental assessment methods. This can obscure potential negative or positive social impact. As addressed in chapter 4, it is therefore important to advance existing social impact assessment methods. Moreover, following the analysis in chapter 3, achieving deeper levels of inclusion is not always feasible, especially in contexts where enabling conditions are absent or where numerous

conversion factors impose limitations. In such settings, more modest approaches, such as inclusive business or inclusive value chain strategies, may serve as more appropriate stepping-stone strategies.

Iterative learning, combined with continuous impact monitoring, is essential for assessing progress and adapting strategies over time. Drawing from chapter 4, appropriate methods for evaluating the (potential) social impacts of BBVCs are vital to support such processes of iterative learning and adjustment. Social Life Cycle Assessment (SLCA) can be a useful tool to assess the (potential) social impact of new BBVCs and can help in decision-making processes. This is especially promising when the risk assessment is broadened with more context-specific factors that go beyond company-level interventions and engage multiple stakeholders, such as governments, farmers, and local communities. Furthermore, the impact assessment should be complemented by subjective evaluations from local stakeholders, capturing how they experience the social impact categories in practice. While this makes standardization of SLCA more complicated, it does lead to more meaningful findings.

5.2.2 INCLUSIVE OUTCOMES

Apart from an inclusive process, specific attention should be paid to the *outcome dimension* of inclusion, in terms of the social impact of new BBVCs. More specifically, it is important to address a fair distribution of risks and benefits along the BBVC, with special attention to the most vulnerable groups.

5.2.2.1 CAPABILITIES AS CENTRAL GOAL

First, taking the enhancement of stakeholders' capabilities as a central goal in the development of inclusive BBVCs is a useful lens. Capabilities are understood as what individuals are effectively able to be and do. This requires not only acknowledging diverse needs and aspirations but also taking into account the contextual 'conversion factors' that shape how resources can be translated into real opportunities. In that sense, the Capability Approach shifts attention away from the mere expansion of resources or utility toward how these resources enable individuals to engage in meaningful activities (Robeyns, 2017).

As concluded in chapter 2, an added value of the Capability Approach is that it allows for identifying capabilities apart from economic benefits that are otherwise overlooked, such as the capability to care for one's environment and the capability for self-determination. As such CSD provides a more holistic perspective on distributive justice compared to traditional methods, such as social impact assessment. While the method enables the identification of benefits beyond economic stability, it requires in-depth, context-specific research with the relevant stakeholder group to support meaningful conversations about the different aspects of their lives and what wellbeing means to them. This requires time and tools that can help open up conversations. In this research, we have developed an approach using 'capability cards', building on work done by Mink (2016) and Steen (2016), that can be found in Appendix A. An advantage of the CSD approach is that it can identify local complexities and connect these to design choices in concrete ways. Yet, the approach is also complex and requires specific skills and time investments that are not always feasible for companies.

However, ensuring that new BBVCs expand the capabilities of all stakeholders involved is not only important for moral reasons. It can also have instrumental goals. As outlined in chapter 3, engaging small-scale farmers as suppliers in new BBVCs often requires changes in practices, which can be challenging in traditional sectors like coffee or olive oil. Clear benefits are essential to justify their time and investment. This is also in the benefit of downstream stakeholders because ensuring farmers are both motivated and capable is crucial for supply security. Unlike in conventional agri-food chains, farmers in BBVCs may hold stronger bargaining power, as biomass supply is not their primary activity. Their participation is therefore conditional, making empowerment and alignment with BBVC goals critical for success.

5.2.2.2 BALANCING TRADE-OFFS

Second, building inclusive BBVCs is an inherently complex process that requires balancing the trade-offs between inclusion and economic feasibility while ensuring security and sustainability of supply.

As demonstrated in chapter 3, a central tension lies between promoting wellbeing for the least advantaged and managing the practical

constraints of establishing new value chains. While inclusive business models can generate meaningful opportunities for smallholders, as suppliers, workers, or consumers, they don't address more structural inequalities. In settings with entrenched inequalities, such as those linked to land ownership or ethnicity in Namibia, inclusion requires interventions that extend beyond market mechanisms and necessitate coordinated efforts from governments and civil society organizations. Such approaches, however, may compromise the efficiency or reliability of supply, which are critical for downstream actors. Moreover, addressing structural inequalities cannot be the sole responsibility of private actors, as their interventions risk imposing external norms on local contexts. In contexts where an enabling environment is absent, it is neither feasible nor desirable for value chain actors to simultaneously establish new infrastructures and resolve deep-rooted inequalities. Instead, incremental and adaptive approaches that acknowledge limitations, such as integrating vulnerable groups as consumers, may offer tangible benefits and serve as stepping stones toward broader, long-term inclusion.

5.2.2.3 DISTRIBUTION OF RISKS AND BENEFITS

Third, ensuring a fair distribution of risks and benefits of new BBVCs is a central concern. Previous bioeconomy projects have demonstrated an unequal distribution of risks and benefits, where the benefits of the bioeconomy accrued to well-established agri-businesses or urban consumers, and the burdens were disproportionately carried by resource-poor rural populations (Lima, 2022). Therefore, prioritizing the needs of local vulnerable stakeholders and a fair allocation of environmental, economic, and social risks is imperative.

A first step towards a fairer allocation of such risks and benefits is to understand the (potential) social impact. Chapter 4 discussed SLCA as a useful method to use for prospective BBVCs because they are often built on existing ones. Knowing the existing social impacts can help decision-making about a new BBVC. Moreover, tools such as CSD can help in increasing distributive justice in the design of new BBVCs, by connecting stakeholders' capabilities and needs to concrete design choices, as shown in chapter 2.

Regarding the initial risks of establishing new BBVCs, it becomes clear that both upstream and downstream actors need to engage in risk-taking and co-creation for long-term success. However, this risk-taking should be proportional. Small-scale biomass suppliers or cooperatives can invest some of their time by participating in pilot projects and trying new agricultural practices that are required. It is, however, not feasible for farmers' organizations to bear the financial risks of building a new biorefinery. A key bottleneck remains: which party will take up the initial risks of establishing a new BBVC? From interactions in the Clean Shipping project, it was observed that large-scale end users such as shipping and oil companies have not assumed this role, despite the ambitious net-zero targets for 2050 (IMO, 2025) and the vital role of biomass. Smaller start-ups show interest but often lack the financial capacity to bear the initial risks. Here lies a crucial role for governments, and especially governments in the Global North, who have committed to the Paris Climate Agreement and the European Green Deal. They need to incentivise parties, such as start-ups, to take the initial risks of conducting pilots and establishing new biorefineries. In addition, providing more clarity in policies that incentivize biomass use, such as RED III framework of the European Union, can make investing in new BBVCs more attractive. Moreover, creating secure, inclusive, and economically viable business models is vital to enhancing attractiveness for large-scale end-users to invest. A crucial aspect of this business model is to start with a simple, smaller-scale project focused on a single, marketable product, and not to aim for too many goals simultaneously.

5.2.2.4 INSTITUTIONAL DEVELOPMENT

Fourth, institutional development plays a critical role in shaping long-term social outcomes, as structural factors such as land ownership, education systems, and corruption strongly influence opportunities and distributional effects. These dimensions require the involvement of multiple stakeholders, beyond direct value chain actors.

The three cases in this study highlight differences in institutional contexts. In Spain, many conversion factors are already in place, while in Colombia and Namibia, structural barriers constrain small-scale farmers' capabilities to access and benefit from new BBVCs. These barriers, linked to farmers' organizations, local policies, land ownership, contractual

arrangements, and educational systems, can be understood as institutions, defined as the "formal and informal rules and norms that organize social, political, and economic relations" (North, 1990). Some challenges can be mitigated through value chain design, such as offering both low- and high-tech options in Namibia or providing flexible supply models in Colombia. However, other issues extend beyond technical design and require institutional investments, including knowledge building, sustainable harvesting plans, and pilot projects in communal areas. These interventions extend beyond market mechanisms and necessitate coordinated action involving local and national governments as well as civil society actors.

5.3 SUMMARY

In summary, this dissertation addressed the central question of how to develop secure, inclusive, and sustainable bio-based value chains (BBVCs) that account for the needs, knowledge, skills, and values of all relevant actors, with particular attention to those at the beginning of the chain. A key requirement is the early engagement of all stakeholders, with special emphasis on including vulnerable groups in the initial stages of BBVC development. Co-designing the value chain by integrating the perspectives, knowledge, needs, and capabilities of diverse actors in essential design choices helps to foster outcomes that are both equitable and context-sensitive. The concepts of capabilities and Capability Sensitive Design (CSD) provide valuable frameworks and tools for creating new BBVCs that support meaningful opportunities for those involved. Strategies for inclusion must be carefully tailored to the specific context. In settings with deep-rooted structural inequalities, more modest approaches may be most appropriate, serving as stepping stones that deliver at least some tangible benefits to vulnerable actors, while maintaining deeper levels of inclusion as a long-term goal. Crucially, the process must be iterative, involving continuous learning and evaluation. Tools such as Social Life Cycle Assessment (SLCA) can play an important role in assessing the social impacts of existing or new BBVCs, particularly when enriched with qualitative data and stakeholder engagement, thereby offering a more accurate reflection of real-world social outcomes.

5.4 REFLECTIONS ON MULTI-DISCIPLINARY RESEARCH

This dissertation is part of a multi-disciplinary project called 'Clean Shipping', where researchers with technical and social backgrounds

collaborate, together with a consortium of companies and organizations that represent different stakeholders along the marine biofuel value chain. As a social scientist involved in this project at a technical University, I have seen the added value of multi-disciplinary research, as well as its challenges.

One of the main reasons I became involved in this project was its strong multi-disciplinary character and the opportunity it offered to bridge disciplines. Because sustainability challenges are inherently multi-disciplinary, bridging different disciplines is crucial for reaching meaningful solutions. Embedding social science alongside engineering made it possible to contextualize important technological developments, such as the transition to a bioeconomy, and to address the social dimensions of this shift, an aspect often overlooked. Bringing social and technical perspectives together can increase the societal impact of research, yet it also requires significant effort. It is necessary to learn each other's language, methods, and ways of thinking, and to translate complex social concepts into terms that are accessible to colleagues unfamiliar with the social sciences. Such translation inevitably involves some simplification, and striking the right balance is crucial. If concepts are adapted too fully to a technical, solution-oriented framing, they risk losing the nuance that is one of social science's main contributions in multi-disciplinary work. Being the only social scientist in a predominantly technical team also meant I often had to adjust more than my engineering colleagues, who already shared a common language.

Presenting my findings at social science conferences and summer schools helped me adjust whenever I leaned too far toward a purely technical perspective. A particularly valuable aspect of this project was the close collaboration between the two PhD candidates, an anthropologist and an engineer, who conducted joint fieldwork. Although not planned initially, this collaboration proved essential for embedding social science within the project, fostering mutual understanding, and strengthening the integration of our disciplines.

5.5 MAIN CONTRIBUTIONS

The insights from this study contribute to the growing attention for social justice in debates on sustainability and a transition towards a bioeconomy.

It is increasingly recognized that transitioning to a bioeconomy does not inherently lead to more equitable or just societies and may even produce unintended social consequences (Diaz-Chavez et al., 2016).Given the rising demand for biomass, it is crucial to ask where it comes from, under what conditions it is sourced, and how to distribute risks and benefits more fairly (Vargas-Carpintero et al., 2022, Lima, 2022).

These concerns are increasingly reflected in international governance frameworks addressing the sustainability of bio-based systems. Initiatives such as the Global Bioenergy Partnership (GBEP) provide a global set of indicators to monitor the environmental, economic and social dimensions of bioenergy systems, including land tenure, employment conditions, gendered labour burdens and occupational health (GBEP, 2011). Similarly, international organizations such as the Food and Agriculture Organization (FAO) emphasize that bioeconomy strategies should contribute to inclusive rural development, equitable value distribution and gender-sensitive governance of biomass resources (FAO, 2019; FAO, 2021). Methodological frameworks such as SLCA provide tools to systematically assess social and socio-economic impacts along value chains (UNEP, 2020). However, despite these advances, many policy and regulatory frameworks still struggle to fully capture issues related to social justice, gender relations, and power asymmetries in emerging BBVCs (Diaz-Chavez et al., 2016).

While many studies examine social justice outcomes in existing value chains, how to incorporate these issues proactively into the development of new BBVCs remains unresolved. This study contributes to this academic debate by exploring three real-life cases of prospective BBVCs and by proactively applying a design approach (CSD) that can enhance social justice. In addition, this study addressed the practical complexities of building inclusive value chains by engaging all relevant stakeholders and incorporating their views, needs, concerns, and capabilities in the strategies towards more inclusive BBVCs. Last, this study contributed to the literature on social impact assessments of BBVCs by applying SLCA to a prospective BBVC and offering concrete recommendations.

Beyond its theoretical contributions, this work bridges research and practice through empirical fieldwork across three continents. By applying

tools such as CSD and SLCA, it demonstrates concrete approaches for integrating vulnerable stakeholders into the design, development, and evaluation of BBVCs. These approaches can support companies in decision-making that leads to more inclusive, socially just, and secure outcomes, while also enhancing the acceptance and performance of the value chain. In addition, this research has social implications by including the voices of stakeholders at the beginning of the value chain who are seldom included in decision-making. Moreover, this research is relevant for policymakers. More than 50 countries have adopted bioeconomy strategies in light of their economic, environmental, and social potential (Zeug et al., 2023). Evaluating these strategies requires robust methodologies to assess the actual social impacts of implementing new BBVCs. The recommendations in this study contribute to a more accurate understanding of the bioeconomy's real social effects, which can lead to more effective policies.

5.6 LIMITATIONS

This research also has its limitations. First, it is based on empirical fieldwork in three case studies. These case studies were conducted using qualitative research methods, which allow for a deeper understanding of real-life contexts and complex relationships. At the same time, qualitative research has limitations, as it relies on stakeholders' subjective input and researchers' interpretations. To address these challenges, data were triangulated through semi-structured interviews, observations, secondary sources, and a workshop. The research was conducted by a team, with data interpretation and analysis discussed collaboratively among researchers. Findings were also validated through discussions with local partners, including research institutes and a multi-stakeholder platform.

Moreover, relying on three case studies limits the possibilities of generalization. While three cases with distinct characteristics were chosen, the number of cases is still too small to draw general conclusions. The realities and contexts are specific to the included regions in Spain, Colombia, and Namibia. However, we do show the complex realities in which stakeholders are creating or transforming value chains and present processes (CSD and SLCA) that can be replicated in multiple contexts.

Last, this study focused on three cases of potential BBVCs, these value chains do not exist yet. This absence of operational BBVCs prevents evaluating their performance or social impact. Therefore, the scope of this dissertation is limited to approaches that can be followed to reach a more equitable decision-making process in the early stages of the design and development. Other factors that are vital to social justice, such as governance or power dynamics among stakeholders, are excluded due to the complexity of studying this in prospective value chains.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH AND PRACTICE

Future research can build on this dissertation in several ways. First, future studies can apply CSD and SLCA to different contexts and industries to further develop and strengthen the approaches and understand the different dynamics in other contexts. Moreover, exploring how the Capability Approach could strengthen SLCA is an interesting avenue for future research. Second, communities of practice can be formed in contexts of emerging BBVCs, and more longitudinal research could enhance the understanding of the dynamics and impact beyond the early stages. Third, as institutional development was found to be an important aspect in building more inclusive BBVCs, future research could focus on how institutions can be developed to strengthen the inclusive development of BBVCs, and what the roles and responsibilities are of the different stakeholders in developing these institutions.

Looking ahead, achieving inclusive and sustainable BBVCs will require collaboration, co-creation, and a willingness to embrace iterative learning. Policymakers must create enabling environments that incentivize risk-sharing and protect vulnerable stakeholders. Companies need to invest in understanding the context of biomass-producing regions and engage more deeply with local communities and civil society. Researchers can play a critical role in facilitating dialogue, monitoring impacts, and refining strategies that adapt to changing conditions.

As bio-based industries continue to reshape production and consumption systems, ensuring that these transitions are socially just and inclusive will be as important as achieving technical efficiency or environmental performance.

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APPENDIX A – CASE STUDY PROTOCOL

**A sample of the interview and workshop materials is shown. The full case study protocol, including workshop outcomes, can be shared upon request.*

**In Spain and Colombia, interview and workshop materials were translated into Spanish*

General interview guide stakeholders

1. Introduction	a. Personal introduction b. Personal introduction, introduction to the organization, to confirm the role c. Current role in the organization and activities involved with d. Sector introduction e. Explanation of the current system in place f. Purpose behind the current practice g. What are the biggest challenges and issues faced in the current system? h. If improvement can be made, what are the suggested measures or focal points?
2. Sustainability	a. Present and expected challenges regarding sustainability b. Current projects/activities related to improving sustainability (e.g. trainings, certification, organic fertilisers etc.)
3. Impact (goals, challenges, benefits, and harms) of new bio-based supply chain in the region *(show biohub infographic)*	Impact a. Interest to play a role in a new bio-based supply chain? b. Identify their foreseen role in the supply chain and elaborate c. Possible benefits for the organization from the new supply chain d. Reason for participating in a new supply chain e. Why is that important? Hurdles a. What is preventing them currently in doing so (lack of capacity, funding, policies, infrastructure, trade agreements, knowledge, partnership etc.) Harms a. What could threaten the existence/operation of a new bio-based supply chain? b. What are the disruptions that will happen in the sector and for the sectors associated?
4. Stakeholder analysis (*show power-interest grid)*	a. Which actors do you think should be included in a new bio-based supply chain? b. Which actors are missing in the power-interest grid? c. What do you think of the positions on the power interest grid?
5. Sector specific questions	
6. Closing	a. Summarize and ask if there is nothing more to say b. Follow-up contact c. Confirm agreements on records, publication d. Willingness to participate in the workshop

Interview materials

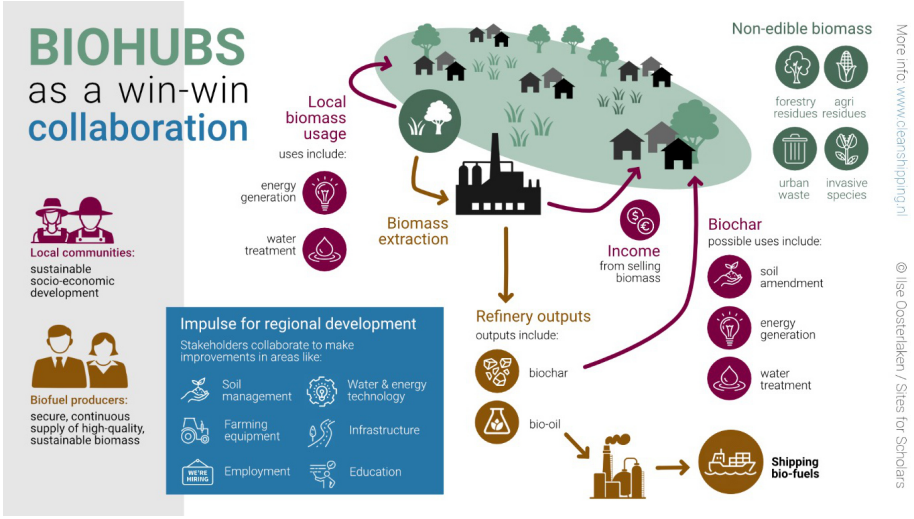

Figure A1 – Infographic of a potential biohub/new bio-based value chain

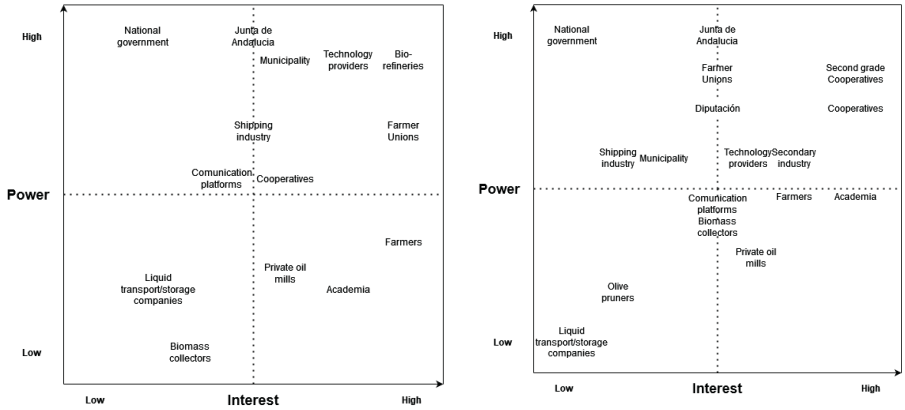

Figure A2 – Example of the power-interest grid from Spain, before and after feedback from participants

Interview guide in-depth interviews farmers

1. Introduction
2. Open-ended questions about different aspects of their lives, to understand their daily lives, perspectives and make them think about these aspects. (Living, activities, possessions, person, health, relationships)
3. Ranking of capability cards that represent different aspects of life. We discussed the cards one by one and asked them what those meant to them and to rank the card as most important (!!!!!!) to least important (!) for their wellbeing. In addition, we discussed factors that limit or enable the expansion of these capabilities.
4. Specific questions about their agricultural practices, how they handle their residues, if they are open to selling the residues, and under what conditions. We showed a (simplified) picture of the biohub concept we are working with.

Figure A3 – Sample of capability cards

**All capability cards categories: Social relations, education and knowledge, self-determination, mobility, public participation, nutrition, security, physical health, mental health, satisfactory work, free time and play, care for the environment, housing, and 4 blank cards.*

Workshop protocol

- Break up in 3 smaller groups, representing a mix of stakeholders
- Break-out session 1 - Forecasting: Discuss an ideal scenario for +20 years. Participants can choose options for the different variables of the supply chain. The following tools are used:
  - Empty biohub scenario where participants can fill in their ideal choices (figure A4).
  - Poster representing different variables of the biohub, to be filled with post-its (figure A5).
  - Table with options to choose from for each variable (figure A6).
- Break-out session 2 - Backcasting: Create a roadmap for how to achieve the ideal scenario. Identify steps for what is needed in +5 and +10 years to achieve the ideal scenario. Discuss roles, responsibilities, and challenges. Tools:
  - Poster of a roadmap, to be filled with post-its (figure A7).

Workshop materials

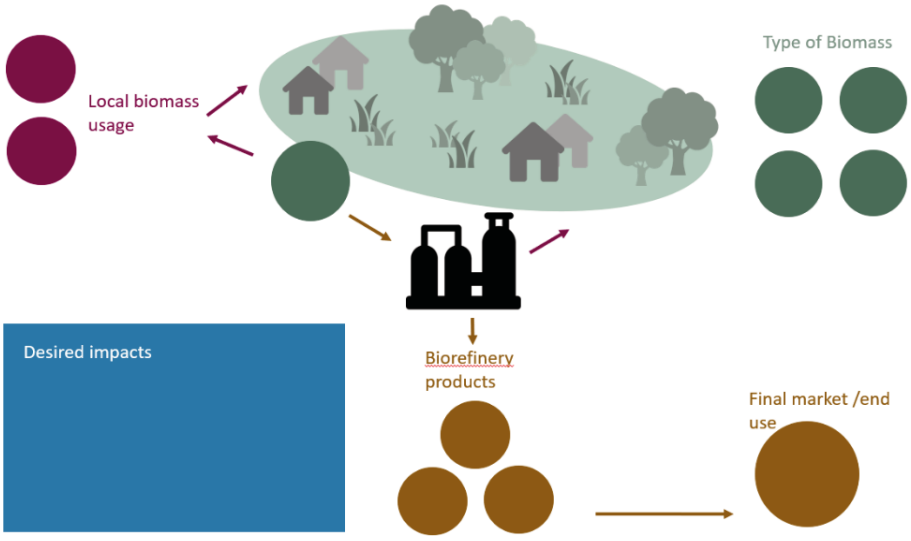

Figure A4 – Empty biohub scenario

Feedstock	**Feedstock providers**	**Feedstock harvesting method**	**Feedstock processing (ownership)**
Feedstock transport	**Feedstock purchasing (contracts)**	**Biohub products**	**Biorefinery ownership**
Biorefinery location	**Policies**	**Potential contribution of Biohub to local development needs**	**Development needed in region**

Figure A5 – Example of variables poster from Namibia

Variable category	**Variable options**
Feedstock	• Acacia Mellifera • Sickle bush • Mixed species
Feedstock harvesting method	• Manual • Semi-manual • Roller • Other
Feedstock providers	• Commercial farmers • Resettlement farmers • Communal farmers • Mix
Feedstock processing (incl. cleaning and chipping if necessary) (Ownership)	• Individual farmers • Centralized facility (Co-operative/Association) • Specialized company/SME • Biorefinery
Feedstock transport (ownership)	• Farmers • Association/co-operatives • Specialized company/SME • Biorefineries
Feedstock purchasing contractual environment	• Flexible • Short term • Long term commitment • Right to deliver • Combination

Figure A6 – Sample of variable categories and options from Namibia (under category feedstock)

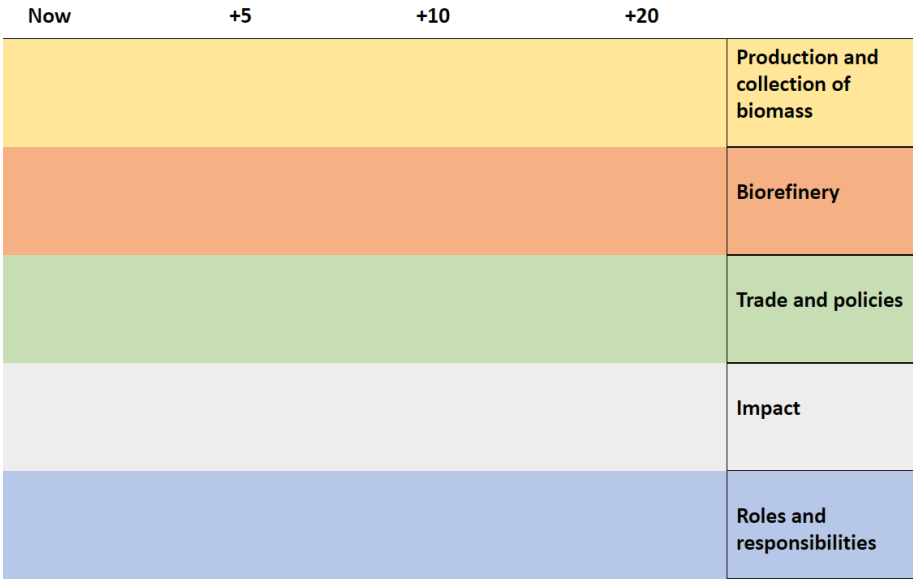

Figure A7 – Poster of the roadmap

APPENDIX B – SUPPLEMENTARY INFORMATION TO CHAPTER 2

B1 - Coding scheme

Table B1 – Coding scheme

1. Spain			
Main code	**Subcode**	**Illustrative quotes**	**Sources**
Important capabilities	*Economic stability*	"There are difficulties, especially related to the prices. We don't have a stable perspective, and every person who will enter the sector, and especially young people need to have the perspective that they can live from it." (S-FU1) "It's complicated. Right now, I live well. Not very well, but I live well. But when I have a family, I will need my partner. If I have children, I will need an increase in income." (S-F18)	Interviews, workshop
	Care for the environment	"What we eat, all come from our fields. And if we put poison in the field, we all eat poison. So we need to maintain the natural environment. We need to take care of our residues and bring it to the right place. We need to look after it." (S-F20) "It is very important. Furthermore, it is our livelihood. We are worried, very worried. Actually, let's see, I go now to nature and see a dried swamp and I get sad." (S-F22)	Interviews, workshop
	Self-determination	"I decided to be a farmer so nobody could tell me what to do, to be my own boss. That is for me the most important thing." (S-F20) "What are appearing are service companies for the application of phytosanitary products, for pruning, to collect firewood, to chop up the pruning remains, and for the olive harvest. That is what we are headed for and that is why service companies are emerging. But I do not want to let a service company do my work." (S-F12)	Interviews
	Maintain traditional system	"It is also a culture here, it is difficult to replace an olive tree over 100 years old, that you have been taking care of for many years. They don't see it just as an olive business, it is also a culture. So it takes a lot of work and time to make that transformation." (S-C2) "I strongly believe that people should bet on farming, on our lands, on our roots, on our identity. Therefore I left my previous work and I bet 100% to the farming life, including all of what it implies." (S-F24)	Interviews, workshop
	Stable employment	"The rural areas are depopulating because there are fewer opportunities for employment and development. The important thing is that more opportunities are generated for people to stay in the territory." (S-G1) "But here it is difficult for younger people because there are not that many opportunities, people go somewhere else. They leave the villages." (S-F27)	Interviews, workshop

Structural conversion factors	*Volatile olive oil price*	"If there is no production, I don't earn anything. And the prices, that's another thing, we suffer from that. People say the prices are better now, yes that is true, but the costs are also higher." (S-F17) "I see the sector as very bad, especially because the prices of the olives are very uncertain, it changes a lot. It was the case for many years that the price of olives was below the cost." (S-F14)	Interviews, secondary sources
	CAP policy	"Thanks to CAP, they oblige us to have certain conditions in the field. For example, you cannot burn the fields before sowing. And you can also not stir the ground in areas with slopes/hilly areas, because that will cause erosion." (S-F27) "In the new CAP, they want to have a more sustainable focus, and to leave cover crops, for example by chipping the pruning rests and leaving it on the soil, that is something they will stimulate." (S-FU1)	Interviews, secondary sources
Environmental conversion factors	*Water scarcity*	"Here in Andalucía, in Jaén, it rains very little, it rains very little. Every year it rains less, and we are noticing it a lot. We depend a lot on water; water is very, very important." (S-F18) "Here, irrigation is very limited. It is a shame because it is very difficult to keep the competitiveness in dryland crops in Andalucía due to the weather conditions. But I also see that there is bad water management. Water is badly distributed, and there are irrigated areas and dry land areas." (S-C3)	Interviews, secondary sources, observations
	Mountainous landscape	"Here it is difficult to mechanize, because of the terrain we have. That is much easier in flatter areas, they use more machines. We need to do the things the way they did it in the past. For us, it takes more time to harvest, it is more difficult in the mountains." (S-F6) "Especially here, because if you are in the area of Jaén it is full of slopes, and it is far more laborious. There are places where tractors or cars cannot get in, and you have to carry yourself the olives." (S-F25)	Interviews, workshop, observations
	Small scale plots	"One characteristic of Jaen is the average size of the farms, about 5 hectares. Because what happened here is that these 5 hectares are divided, because your parents have 5 hectares, but 3 children, so when they die, the land is divided into 3." (S-A1) "Especially the subdivision of land in very small plots is a problem. There are many owners with small plots, which makes things complicated. The project could fail if the price is not right. If the collection of pruning waste is not profitable." (S-C6)	Interviews, workshop, observations
	Poor soil quality	"Here, a problem that we have is a lack of organic material in the soil. It is very low, so the people have learned that it is really important to have organic material in the soil and so they leave the chopped pruning rests on the soil to decompose." (S-C4) "Chemicals are used on the soil, because the olive tree uses a lot of nitrogen, phosphor and potassium, the soil that we have are not the best soils for the olive trees, so they need a little help." (S-C2)	Interviews, workshop

	Existing infrastructure	"The cooperatives have patios, they have physical space to store biomass, and are located where the farmers are located. So they will have a lot of interest." (S-I1) "The secondary mills are located in the countryside, that can also be beneficial to the project. It could be serving as centres to store the biomass, because they all have central locations." (S-I1)	Interviews, workshop, observations
Social conversion factors	*Strong cooperative system*	"Cooperativism started around 1920, as a reaction to the low prices that the people who owned olive mills in the villages. So the producers formed cooperatives to improve their position. In Jaen are about 220 cooperatives that produce around 70% of the total production in Jaen." (S-A1) "They take the strategic decisions. Then there is an assembly that consists of all the members. Some cooperatives have 2000 members, some have 300 members. In most of the cooperatives, the rule is one person, one vote, regardless of the size of the farm." (S-A1)	Interviews, workshop
	Traditional practices	"I don't know how to explain that, since I was born, I learned it. All I know since I was little, is this. My father always took me to the fields, I always went to the fields. I know how to navigate. It's like how a small child learns to walk, who teaches him? He just learns it. The countryside is the same, I learned it, by living it." (S-F17) "Here, the majority, it is manual. We, small farmers, we are mechanized but basic. We have tractors and use hand vibrators that run on gasoline. We don't have big exploitations that have big machines that shake the whole tree." (S-F14)	Interviews, workshop
	Reluctance to change	"Another thing is that we don't know the technology and we don't know the market. If it will generate compost, well we can use it, so that is familiar to us. So the members can invest in it, they know that they can use that amount of compost, then they are willing. But if we need to search for a market for the product, and the sale of the product is not in our sector/market, it is more difficult." (S-C2). "It is not just a business, it is also tradition and culture, in a culture that is very reluctant to change, because they have always done it in a certain way. So in the first place, you'll receive rejection." (S-C3)	Interviews, workshop
Personal conversion factors	*Aging farming population*	"One problem here as well is that people are getting older, they can't dedicate themselves to working on the field, but their children are working somewhere else." (S-A1) "Another one is the aging of the farmers, among the younger generation there is not a lot of interest, because of the low profitability." (S-C2)	Interviews

2. Colombia			
Main code	**Subcode**	**Illustrative quotes**	**Sources**
Important capabilities	*Economic stability*	Producing coffee nowadays is on a loss, because of the price of the dollar, the price of agrochemicals, the workforce. Since it´s very cheap to collect coffee, it´s very badly paid." (C-G1) "We need to think especially about the uses of those residues for the quality of life of the families that produce cocoa. Of course, it will benefit the environment. But we need to visualize their production system as a more diverse production system so that they can receive more income, but also more ecosystem services." (C-A6).	Interviews, workshop
	Care for the environment	"For me, taking care of the environment is everything. Because if I want to live nicely, I need to feed myself properly and breathe properly. Then… I have to drink good water. So I depend on it. I depend on the environment." (C-F10) "The benefit to the environment that is being made, to the reduction of waste, is fundamental." (C-C7)	Interviews, workshop
	Meaningful social relations	"Coffee is part of their culture, a small-scale coffee grower often has been that for whole their lives. There is a family history. Their children don't leave their plots because they don't love coffee. They go because they look for more opportunities. But if there are opportunities, they want to stay, also for family reasons, they want to continue with what their parents do" (C-N3) "If it turns the coffee system into a more productive one, it involves fostering it so that the tradition is not lost, more important because we are at the heart of the coffee cultural landscape." (C-G1)	Interviews, workshop
	Self-determination	"With coffee, I think we have a serious problem with cultural individualism. In Colombia you´ll see at the coffee farms that almost every coffee grower has their own processing plant. Other countries have places where everyone takes their coffee and there, they process it, so it´s easier to manage waste because everything is centralized, processes are standardized, costs are reduced, but here everyone wants to have their own processing plants, even the smallest farms." (C-F4) "The second largest challenge, knowing cocoa farming culture… No, knowing Colombian culture, is the resistance to associating. That is a big issue. Because when people associate, things are way easier. But given the culture of ours, we don't have the tendency to associating." (C-I5)	Interviews, workshop
	Stable employment	"Dignified working conditions, if there are good opportunities here, then I want to stay because here I have my family, my friends. I think that the actions of the association are generating dignified employment opportunities, that they learn to do the tasting, barista, all those other things. It is not only growing coffee, it is much more." (C-C1) "Our parents said "Leave because the field doesn´t work. Opportunities are in the city, opportunities are somewhere else." But here there are also opportunities, one can live from this happily without the need of separating families." (C-F3).	Interviews, workshop

	Access to energy	"Here, in this area, the properties have general services; There are areas of the country where the properties do not have this service, they do not even have water. There are times when they don't have electricity." (C-FU4) "Yes, if an estate can produce gas, that will improve the situation of the people that make the food. That they don't inhale the gases that are produced by the wood. It has big opportunities." (C-C1)	Interviews, workshop
Structural conversion factors	*Corruption*	"And also the municipalities. The resources from the municipalities are more difficult than the resources from the national government. Because it happens that the person in charge of the resources maybe is not very much in favour of the association, and is friends with certain intermediaries, so it is difficult that the resources reach the association and the producers." (C-C1) "The rurality in Colombia has no connectivity. This government stole the money. A minister disappeared the money that we had to connect rural zones to the internet, all the money went with corruption." (C-A2)	Interviews
	No existing knowledge and experience biorefinery	"In Colombia the field of finding a company that really is capable of producing these biofuels from these residues is hard, precisely because there are no… that machinery that allows for the economic viability of that plant." (C-A10) "No, nothing. About biorefineries, not here. When I worked at the university, I learned about a process on pelletization for guadua pellets, for energy generation. But that was from the university. From here? No. From the municipality, nothing. Zero. Nothing, nothing." (C-G4)	Interviews, workshop
Environmental conversion factors	*Mountainous landscape*	"I worked at Genova. Genova is the most mountainous part of Quindio. I got to the school by motorcycle. From there on I put on my boots, backpack, a hat and walked 2 hours up there, and there are families there. They use mules for everything. It is not the same to transport the raw materials to commercialize a product than for a subproduct." (C-A2)	Interviews, observations
	Poor tertiary roads	"Here in Colombia we have huge problems of rural infrastructure, which is where the raw materials that you need is produced. But it´s not that with pavement this will be solved, because our topography is very difficult, and coffee grows on mountains." (C-A2) "And in general, the logistics issue is more difficult. The producers are in very distant sectors. Thus, many times, it is difficult to bring all these products from there to here." (C-L1)	Interviews, workshop, observations
	Small plots	"And another challenge is that we don't have very large plots, about 96% of the coffee growers has an average of less than 5 hectares. Every time, we are more and more small." (C-N1) "And the scale need to be small-scale, because the whole harvest is divided in a lot of small parts." (C-A13)	Interviews, workshop, observations

	Agroforestry systems	**"**Cocoa and its system because remember that cacao is not a monoculture, cocoa is a system. So, the idea is to take advantage not only of cacao, but also of the accompanying species, such as agroforestry, trees, or fruits."(C-A1) **"**There is a lot of focus on cocoa, and very little technical assistance for the cultivation of plantains. They don't pay attention to the families that also have other cultivation, like mais, beans, rice, they only focus on cocoa. 95% of the cocoa production happens in an agroforestry system, because of the climate conditions." (C- A6)	Interviews, workshop, observations
Social conversion factors	*Distrust*	"It is a cultural thing, we do not trust others, "I want to handle it myself, because if not someone will steal it", it is difficult to do a cluster, but we are making progress, someday we´ll get there." (C-F4) "If I am handing over what belongs to my property, then how do I access and get what I gave from my property? How do I fertilize? What compensation do I have?" (C-C8)	Interviews, workshop
	Hierarchical federation	"Fedecafe is an organization financed with money from the coffee growers: per pound of exported coffee, we need to pay a fee that I think right now is of 6 cents of a dollar. With that we pay the functioning of Fedecafe." (C-F4) "Many times, they want to put things on the properties that we don't agree with, like maybe a coffee seed, and we don't want to plant it, and they say, 'Well, you should plant that.' So, I, who manages it and works the property, know what seed I like and what is good for me. They have an idea that they impose on you." (C-F22)	Interviews
	Small scale associations	"The association was born from a necessity of the producers. To look for better prices, better quality of life, and that´s how the association began." (C-F3) "Well, the association was also created looking at that, that the farmer realized that coffee is not only a bean, the seed of hope, as they call it, but that it comes with some other by-products." (C-C6)	Interviews, workshop
	Limited capacity and resources associations	"Everything depends on the economic part, and what we are doing now is knocking on doors, knocking on doors with our allies. Right now, we are with the Government, with the Secretary of Agriculture, with the Ministry of Agriculture. Currently, we are one of the blessed associations, let's say it this way, because due to the good judgment that the association has had up to now. A productive alliance was made." (C-C5) "And very important, the strengthening of associativity. Strengthen associations so that they can improve their processes and that finally materializes. That new products or services can really come out of this initiative, that can really strengthen associations, that bring them more income, that people commit, become passionate." (C-C7)	Interviews, workshop

	Entrepreneurial mindset youth	"Well, the youth committee. What is sought by the youth committee is to create an overlap with our parents, with our uncles, with the producers that have been doing it for years. It is now about replacing but creating an overlap. It is old knowledge plus new knowledge, and try to bring added value to everything that has been done." (C-F10) "The young people that do want to continue in the cocoa sector, want to do that in a different way than their parents. They want to focus on added value of cocoa and the principal idea in these communities is to make chocolate, or cocoa liquor, but there is not enough institutional support to support these young people in this development." (C-A6)	Interviews, workshop
	Reluctance to change	"There is a challenge in changing this focus on the production of cocoa, that apart from cocoa, we want to produce energy, or bioproducts different from cocoa. That is a big challenge to amplify this sensibilization for producers and institutions in general." (C-A6) "People are always sensitive to organizations and to the loss of time and money. The farmer is tired that they come to them and promise a lot of things. That is why some members don't participate in projects like this. They need space and resources, and also technical capacity." (C-C1).	Interviews, workshop
	Tradition	"I am the son of a coffee grower, yes. My dad is a coffee grower, my family has been a coffee grower for many generations. My grandfather was a coffee grower. We currently live on a coffee property, which is where my grandparents lived, and they cultivated the same coffee plantation for many years. So yes, coffee is in our veins, in our DNA." (C-C7) "There can be exceptions, but within the values of small-scale farmers, coffee is part of their culture, a small-scale coffee grower often has been that for whole their lives, because they did not have other opportunities. Here, I think there is all the history, this is where I was born, there is a family history, it is related to our story, experience." (C-N1)	Interviews, workshop
	Agricultural practices	"Coffee grower´s culture is very basic. Coffee growers still use processes from 100 years ago and hasn´t changed precisely because their culture level has not allowed them to evolve. What we need is that the culture level of the owners increases, but also that they stay." (C-A2) "Due to tradition, this happens from generation to generation. I do what my dad did, and then that is actually inherited. For instance, I did not have access to the university to study. Therefore, it is a matter of culture." (C-C6)	Interviews, workshop, observations
Personal conversion factors	*Aging farming population*	"The problem in Colombia, in the countryside, is that there is no generational change. Young people no longer want to be in the field. So, for that reason, you go to the properties, and you see all adults, who are 60, 70. Thus, basically, we are very few young people." (C-W1) "In the coffee-growing union we have an average of people aged 58, over 50 years old, 56-58 years old, who are already of retirement age." (C-C6)	Interviews, workshop

	Education levels	"So I want to say that, the fathers of those young people, who are taking care of that work, those are people who didn't have access to education, who only have primary school, there are farmers that don't know how to write. That is normal here in the rural areas of Colombia." (C-C1) "But there is also a difference in the profession of the person or in their knowledge. The traditional coffee growers, most of them, are old farmers that didn´t study, they learned empirically, and they have a bit of trouble moving out of their comfort zone." (C-G1)	Interviews
	Learning practices	"We use a scheme of technical assistance, some are farmers that you only need to tell once and they start doing it because they are motivated. Those are only a few, but they are a reference point for other coffee producers. Others first want to see how others are doing, before they will adapt. And then there is the big mass, that waits for those few farmers to see how it is going." (C-N3) "All my life I have worked with coffee, my dad has been a coffee grower and let´s say that I grew up in the world of coffee since I was a small child. I don´t know how to do anything else that is not producing coffee. I am the generational replacement of my father, out of 5 brothers 2 of us are coffee growers. I come from a traditional coffee culture, traditional means that we know about the coffee, collecting it, pulping it, giving it a fermentation, washing it, and selling it and that´s it." (C-F3)	Interviews, workshop

3. Namibia			
Main code	**Subcode**	**Illustrative quotes**	**Sources**
Important capabilities	*Care for the environment*	"Well, the bush in our eyes is the enemy because he's stealing the water from the grass and the grass is our precious food for the cattle." (N-F2-commercial). "But when it comes to bush encroachment. It's throughout the year a challenge. Where they were supposed to grow grass it's bushes. So animals for grazing, there's not enough space. They are not running around, there's bush everywhere." (N-F5-communal).	Interviews, workshop, secondary sources
	Economic stability	"But what you also need to realize is that 70% of Namibians are directly, indirectly linked to agriculture. And if you can have an impact there, you will naturally have an impact on communities." (N-I2) "They thought in the beginning, but the benefit you get is you get rangeland restoration, but we've seen if you don't pay the farmer, they said no. Then I don't want you on my farm. It's my bush and I want to sell them. So even if you get the big machine that harvests it. If I don't get the direct benefit from it, I won't participate." (N-FU3)	Interviews, workshop

	Healthy working conditions	"If it can be a cleaner job, for instance, where you use equipment that's not this hard work, then the physical work of the charcoal production, then it can be a good alternative which a lot of people will definitely consider especially if it need not be with many workers on the farm." (N-FU3) "Now if you go to the charcoal, the central burning spot, the dust is coming up. I have a problem with that because they don't wear masks." (N-F4)	Interviews, workshop, observations
	Inclusion	"We are eager for any change and we are ready for any cooperation. We don't want to sit and to be fed. You know, nowadays they say it's better to teach someone to catch a fish himself instead of catching fish for him and cooking it for him and then give him to eat and. So our people are so eager. There is always progress if there is change. There's no progress now, so." (N-F5-communal) "They're not gonna let you use their land if it's not 100% to their benefits. And that I've had personal meetings with the councillors of the communal areas where we did the pilot projects and all of them said it's fine. Let's get this thing up and running but it has to be 100% community owned, 100% benefiting them, 100% of the processing done there." (N-N2)	Interviews, workshop
Structural conversion factors	*Land ownership - commercial*	"The average size of farms. It varies from the Northern parts where the rainfall is much higher than from the South, but on average the average farming unit is between 7000 and 8000 hectares." (N-FU3) "OK, the vast majority are livestock farmers so. Cattle in the North. And then if you go South, it's more sheep, sheep, goats. People are trying different modes of income also on the farms, like the charcoal." (N-FU3)	Interviews, workshop, secondary sources
	Land ownership - communal	"And then we have communal areas. So those are the ones that you can class with either subsistence, or those are the small scale producers, whereas the commercial ones that are massively producing, who are commission trained and so forth. But they have different needs and challenges." (N-I1) "On the biomass side. It's a lot more difficult. Because you've got, well, a common pool resource, and our government hasn't quite found the right way to manage it because it tends to become elite capture." (N-N1)	Interviews, workshop, secondary sources
	Land ownership - resettlement	"People in the resettlement program are those that are the previously disadvantaged farmers, before independence they did not have the right to acquire land, due to the Apartheid structure that we had. So black farmers could not acquire fixed property." (N-FU2) "The government, they take a person from wherever and put him on a piece of land wherever, expecting him to produce. No orientation, no nothing, at least, they need to be mentored to be productive." (N-FU2).	Interviews, workshop, secondary sources

	Corruption	"So you have a lot of farmers that are not productive now, because you know, some of these things are done politically. If you are my comrade, I put you there, so you can produce. But just to apiece you, so I can secure a vote from you. So, that's the landscape that we are operating." (N-FU2) "Every government project in Namibia is a disaster because they don't have that commercial story sorted out. They want to do a project to create jobs. You do a project to service a market demand, and in the process, you obviously create jobs. But you can't start something without it being a black hole for money." (N-I2)	Interviews
	Forest regulation	"So now it has to go through some structures where every community or communal area should have a community forest that is gazetted by the government. So it's like more of a formal structure that will now monitor these activities of bush harvesting. But then, the challenge remains that the grazing areas have lost value and are heavily encroached. And for them to act, they have to wait for this whole process to be recognized as community forest to be able to have access." (N-I1) "But in communal areas we don't, we never allowed land clearing for charcoal production because it's a commonage and everyone is using the only areas. We are regulating charcoal in which encroachment is in communal areas." (N-G4)	Interviews, secondary sources
	Finding workforce	"But staff to do the harvest had been a big issue. It's the same with the chipping crew. This is hard work, nasty work, and it's hard to find people who are reliable to do it." (N-B1) "A lot of people in this area do charcoal, and it's a very stressful business for those people who have to motivate the employees chopping the bush. Now you have 30 people working for you, for example. You have to make sure that they eat enough so they are productive enough and you need to check that they don't go out and poach when you don't supply them with enough food in that sense, it's a difficult one." (N-F2-commercial)	Interviews, workshop
	Lack of monitoring and implementation	"The biggest challenge for monitoring by Forestry is the vehicles. The equipment, the vehicles, internet, computers, printers, that stuff. They hardly have such stuff and it's easy for me to sit down here and say they should have been doing that. But I mean you come to an office where there's only one person, so. And even the internet to check on Google Earth sometimes lacks." (N-G1) "And then you see that there was a lot of delays in inspecting these areas, which leads also to the illegal activities. Most of the harvesters don't follow the guidelines of what size of trees to be harvested. We only allow trees of diameter less than 18 centimeters." (N-G4)	Interviews, workshop
	High unemployment	"There is a lot of unemployment in the communal areas, but it was difficult to find workers because some of them do have some cattle they look after, they have to walk very far to get to that area." (N-N2)	Interviews, secondary sources

	Lack of access to energy	"Rural electrification is an issue. For rural community households to get electricity from the main grid is a very expensive project. In this area, we have more than 80 villages. We have to come one by one. Yeah, but if you have to look at the villages that have electricity, maybe in our area we can counter them quickly. Less than 30%." (N-F5-communal) "We have a problem here with electricity, I am a bit further from the village, I don't have electricity in my home." (N-F8-communal)	Interviews, workshop
	Dependence on electricity imports	"Namibia remains dependent on electricity imports from neighbouring countries, which met about 60% of total demand in 2020. The majority of electricity imports are sourced from South Africa." (GIZ, 2022)	Interviews, workshop, secondary sources
Environmental conversion factors	*Drought*	"If it wasn't the drought then the charcoal industry would have been 1/3 smaller than currently. But the drought forced us to look at other ways of income." (N-F2-commercial) "Then we saw that a lot of farmers are in need of cash. They've moved to charcoal, so the charcoal has been a growing industry over the past three to four years every year." (N-FU3)	Interviews, secondary sources
	Lacking infrastructure	"The biggest challenge with this would be the logistics of moving the biomass around. Transport is super expensive, fuel is super expensive. There's a limited radius where you can move biomass before it's just too expensive to use it. It's normally 75 to 100 kilometres based on the other projects that I've worked on." (N-N2) "And it may sound cynical, but you can't commercialize a project in the communal areas. I mean, the model is there. You have to have a community Forest Gazette, they can manage their resources how they see fit and you can build something there, so they could be a supplier. But you have to think about the logistics and the power, and they have neither of those." (N-I2)	Interviews, workshop, observations
	High volume of bush	"I think the bush encroachment is big enough. And what we've seen is the charcoal has perhaps the ability to do only 10%, you know. Getting rid of bushes or 10% contribution to rangeland creation. (N-FU3) Yeah, but it doesn't look like Namibia is going to solve this problem very quickly because I mean even if it was not sustainable. There will still be regrowth. But I mean the biomass for us it's, it's here to stay regardless if you have a sustainable or unsustainable." (N-G1)	Interviews, workshop, observations
	Hard and thorny bush	"Senegalia mellifera is a thorny bush. So you'd always need to wear protective clothing. It was a bit problematic for the workers. The equipment you think it would be particularly durable, but that bush is very strong." (N-U1)	Interviews, workshop, observations
	Multiple problematic species of bush	"A total of 30 woody species (bushes and shrubs) were recorded in the survey of the woody plants and they were broadly divided into three groups: 1) Scarce and/or desirable species not to be targeted for removal/harvesting, 2) Potentially problematic species that may thicken under specific conditions, but with a low biomass potential, 3) Potentially problematic species that may thicken under specific conditions and which have a high biomass potential." (GIZ, 2015)	Interviews, workshop, observations, secondary sources

Social conversion factors	*Egalitarian culture communal areas*	"And also the clash of 1 being the owner and one being the worker. You know in the same community where people should have the same rights was difficult. Not all of them wanted to do that." (N-N2)	Interviews
	Communal organization structures	"We've been struggling to get that structure in place also with the communal areas because it is, you know, millions of hectares belonging to hundreds of thousands of people equally. They all get the same benefit out of the land. Getting a structure in place where one guy does not have a bigger benefit than the other. Other than just the time that he's putting in, it's very difficult." (N-N2). "We don't put enough effort into reaching the people that are not organized and conservancies and something that we for example, see very little in Namibia is we have very little cooperatives for example. In sort of the commercial areas where you do have, a lot of farmers here German by the way, got their farmers associations, but you don't have a lot of that in communal areas and there's they're trying to strengthen their presence again." (N-N1)	Interviews, workshop
	Migrant labour	"Namibia is one of the most unequal countries in the world and we're very well aware of that. Sad reality is that most of our charcoal workers are not even Namibian. They come in from Angola, so it must be worse there." (N-I2) "The other thing also more than 13,000 workforce on these different farms who are doing harvesting, most of them are also not having documents to prove that they are national. But currently now we are dealing with an issue where we need to come with immigration to give them temporal kind of permission so that they are legal on the farms." (N-G4)	Interviews, workshop, observations
Personal conversion factors	*Low education levels*	"Knowledge in these areas, you know the education in these areas. A very big percentage of the people living in the communal areas do not have any education." (N-N2) "The other problem is education. There's no control, I mean the headmasters get appointed on political grounds rather than they are qualified for the job. At the end, the poor farm children go to school. Grade one, they fail. Then they go to grade 2 to they fail. Then you see that poor old guys cannot even write and read after attending school for five years." (N-FU3)	Interviews
	Language barriers	"We worked with a translator, and we had no problems. They understood everything. But when I worked with my guide, they couldn't understand me. And I only did what I saw what the translator did and tried to do other stuff. But they were checking me. They were laughing at me. They couldn't understand why. I never could have told them that I don't need a full pot. I need the quality that's inside the charcoal." (N-F4-commercial)	Interviews

	Learning practices	"So we have our Northern populations, they come in, they're really good at swinging an axe. But you can't train them to use a chainsaw. They don't have the capacity, so you have 60 people on the farm swinging axes instead of 20 using chainsaws." (N-N2) "The type of harvesting method is manual. I bought 10 chainsaws but the people don't want to use this chainsaw. We were trying to teach these people, to help them, to convince them. But he stays with the axe. Ask him now, why do you do this? They are used to working with the axe. It's a learning curve. It would take a while." (N-F4-commercial)	Interviews, workshop

B2 – Design propositions including explanation

Table B2 – Elaborate design propositions

1. Spain					
Design proposition (DP)	**Related design variable**	**Related capability**	**Related conversion factor**	**Related dimension of social justice**	**Explanation**
1.1 Use COP as the main feedstock.	Feedstock	Economic stability, Maintaining traditional system, Self-determination	Reluctance to change (s), Existing infrastructure (e)	Recognition justice, distributive justice	*Choosing COP as the main feedstock will contribute to the capability of maintaining the traditional system and self-determination because it does not require big changes in practices for farmers (reluctance to change). In addition, it contributes to economic stability since farmers currently do not receive economic benefits from the COP. The existing infrastructure of the primary and secondary mills can be used to collect and transport the COP more easily. This DP can lead to recognition justice by acknowledging the desires of a large group of farmers to maintain the traditional system, and distributive justice since it will generate economic benefits, which can be distributed via the cooperatives.*
1.2 Use the existing infrastructure of primary and secondary mills.	Feedstock process, biomass conversion	Economic stability	Existing infrastructure (e)	Distributive justice	*Using the existing infrastructure of the primary and secondary mills will reduce the needed investment costs, leading to more economic revenues, which can be distributed via the cooperative system.*
1.3 Use the existing cooperative structure to organize feedstock collection and benefit sharing.	Feedstock processing	Economic stability, Self-determination	Strong cooperatives (s)	Procedural justice; distributive justice	*When existing cooperatives play an important role in organizing feedstock collection and benefit sharing, more economic stability can be generated for farmers, leading to more distributive justice. It will also increase their capability of self-determination because individual farmers can influence decision-making in the cooperatives, which strengthens procedural justice.*

1.4 The technology should minimize water use.	Conversion technology	Care for the environment	Water scarcity €	Distributive justice	*Because of the dry climate in the area, the technology should minimize water use to strengthen the capability to care for the environment and reduce potential harm from the new BBVC, leading to more distributive justice.*
1.5 The by-product biochar should be distributed to farmers, to use as soil amendment.	Biorefinery products	Care for the environment	Poor soil quality (e)	Distributive justice, recognition justice	*Distributing biochar to the farmers as a soil amendment will enable farmers to better care for the environment since plots are characterized by poor soil quality. Applying this DP leads to more distributive justice, since benefits generated from the BBVC are directly distributed to farmers and recognition justice, by making the BBVC more relatable to them.*

2. Colombia					
Design proposition (DP)	**Related design variable**	**Related capability**	**Related conversion factor**	**Related dimension of social justice**	**Explanation**
2.1 The biorefinery should be able to use multiple types of residues.	Feedstock Biomass conversion	Economic stability, care for the environment	Agroforestry system (e), small volumes (e)	Recognition justice, Distributive justice	*This DP can enhance the capability of economic stability because it makes the BBVC more economically viable since this would increase the total volume of biomass generated at the (small-scale) farms. It will enhance the capability to care for the environment because different types of residues at the farms pose environmental risks. This DP contributes to recognition justice by recognizing the practices of cultivating multiple crops on the farms, and to distributive justice by making the BBVC more economically viable.*
2.2 A centralized collection system should be set up, with a standardized post-harvest process.	Feedstock processing	Economic stability	Agricultural practices (s), lacking infrastructure (e)	Distributive justice	*Centralizing the collection of biomass as much as possible, instead of on individual plots which is currently the agricultural practice, will make the BBVC more economically viable, leading to more distributive justice. This system needs to be set up since it does not exist yet and the necessary infrastructure is lacking.*

2.3 Different options to supply biomass should be provided.	Feedstock processing	Self-determination	Reluctance to change (s), trust (s), learning practices (p), agricultural practices (s)	Recognition justice, distributive justice	*Post-harvesting processes happen on individual plots, using traditional practices. While centralizing this process would be more efficient, it requires a big change which is undesirable for a large group of farmers due to reluctance to change, distrust, and learning practices. This DP contributes to recognition justice by recognizing the specific needs of this group and to distributive justice by making participation in the new BBVC more accessible to them.*
2.4 Farmers' associations need to play a central role in collecting biomass.	Feedstock processing	Self-determination	Distrust (s)	Procedural justice	*Assigning a central role for associations will generate more trust among individual farmers. It will increase the capability of self-determination since farmers can influence decision-making, which contributes to procedural justice.*
2.5 Biomass should be converted into a decentralized system.	Biomass conversion	Economic stability	Mountainous landscape (e), small volumes (e)	Distributive justice	*Due to the mountainous landscape and small volumes generated at individual farms, a decentralized system is preferred to reduce transport costs. This will enhance the capability of economic stability since more economic revenues can be distributed.*
2.6 An already proven technology is preferred.	Biomass conversion	Economic stability	Lacking knowledge/ experience (str), Reluctance to change (s)	Recognition justice	*Since there is no existing experience with biorefineries yet in the area and stakeholders express reluctance to change, a technology that is already proven is preferred. Adapting to the concerns of stakeholders contributes to recognition justice. This DP also contributes to more economic stability since it is less risky.*
2.7 The biorefinery should produce products that can be used in the region.	Biorefinery products	Access to energy	Limited electricity access rural areas (e)	Distributive justice, recognition justice	*Producing products that are needed in the region, such as energy production, will contribute to distributive justice since the benefits of the BBVC can be directly distributed to people in the region. It also contributes to recognition justice, by recognizing the specific needs of local stakeholders.*

2.8 The new supply chain should offer stable job opportunities to youth.	Supply chain	Satisfactory work, Meaningful social relations	Entrepreneurial mindset youth (s),	Recognition justice, distributive justice	*The new BBVC should specifically offer opportunities to young farmers, who are more open to change and look for more stable opportunities. This allows them to continue to work in the coffee and cocoa sector, which is closely connected to the culture and family relations in this area. This DP contributes to recognition justice by recognizing the specific skills and needs of this group and to distributive justice by providing opportunities to the groups that need them.*
2.9 Farmers' associations need to be strengthened.	Institutional context	Self-determination	Limited capacity and resources associations (s)	Procedural justice	*Associations currently lack the capacity and resources to play a central role. By strengthening these associations, the capability of self-determination will be enhanced because farmers can influence decision-making. This also contributes to procedural justice.*
2.10 Investments are needed in education and knowledge building.	Institutional context		Learning practices (p), reluctance to change (s)	Recognition justice	*Awareness raising and knowledge transfer are needed before farmers can participate in a new BBVC, due to practical learning practices and a reluctance to change. Investing in this will contribute to recognition justice by adapting to their specific skills.*
2.11 A long-term commitment is necessary.	Institutional context		Distrust (s)	Procedural justice	*Since farmers expressed distrust towards new projects, a long-term commitment is necessary to build that trust and to strengthen procedural justice by continuing to involve farmers in the process.*

3. Namibia					
Design proposition (DP)	**Related design variable**	**Related capability**	**Related conversion factor**	**Related dimension of social justice**	**Explanation**
3.1 The biorefinery should be able to process multiple, problematic species.	Feedstock, biomass conversion	Care for the environment	Multiple problematic species (e)	Distributive justice	*Multiple species of bush are problematic. When the biorefinery is flexible enough to process multiple species, this can positively influence the capability to care for the environment. This contributes to distributive justice, since this is a desired benefit from the new BBVC by local stakeholders.*
3.2 Biomass harvesting and supply methods should be adapted to the capacities of biomass suppliers.	Feedstock, Feedstock processing	Inclusion	Learning practices (p), land ownership (str)	Recognition justice, distributive justice	*It is desired to include all types of farmers in the new BBVC. Adapting to the specific needs, skills, and land ownership structures of the different farmers enhances the capability to be included in the new BBVC. This contributes to recognition justice by acknowledging the different skills and needs and distributive justice by making the BBVC more accessible to different types of farmers.*
3.3 Encroacher bush should be harvested according to sustainable harvesting management plans.	Feedstock	Care for the environment	Forest regulation (str), lack of monitoring and implementation (str)	Distributive justice, procedural justice	*Enhancing the capability to care for the environment by controlling the bush is a central goal of the new BBVC. Therefore, harvesting should be done sustainably, following existing regulations. This is especially needed in communal areas, where the bush is a common pool resource. Applying this DP contributes to distributive justice by preventing environmental harm from the new BBVC and to procedural justice, especially in communal areas, where communities can influence harvesting and benefit distribution.*

3.4 Proper harvesting equipment needs to be developed.	Feedstock, Feedstock processing	Economic stability, care for the environment	Hard and thorny bush (e)	Distributive justice	*Due to the physical characteristics of the bush, manual harvesting is hard and physical labour. By developing harvesting equipment that can selectively harvest bush, harvesting can be done more efficiently. This increases the economic return and the capability to care for the environment, since selective harvesting is more sustainable than rollers that crush all the bush. This results in more economic return that can be distributed to farmers.*
3.5 A pilot needs to be conducted that includes communal areas in the commercial supply chain.	Feedstock, feedstock processing	Inclusion	Land ownership (str), communal organization structures (s)	Recognition justice, distributive justice, procedural justice	*All stakeholders stressed the importance of including all types of farmers in the new BBVC. This is challenging due to land ownership structures and communal organization structures that are sometimes lacking and are egalitarian, meaning that everyone in the community should benefit. Conducting pilots in these areas contributes to recognition justice by addressing the specific circumstances and needs of communal farmers, and to distributive justice by making the BBVC, or at least its benefits, more accessible to this group. It contributes to procedural justice by including communal farmers in the process and decision-making.*
3.6 Biomass should be converted using a combination of large-scale, high-tech, and small-scale, low-tech hubs.	Biomass conversion	Economic stability, Inclusion	Learning practices (p), lack of access to energy (str), land ownership (str)	Recognition justice, distributive justice	*Allowing for both high-tech and low-tech options leads to more inclusion and more economic stability for different types of farmers, which contributes to distributive justice. Because of the different skill levels, available resources, and land ownership structures, it is more desirable for some farmers to use low-tech solutions, while for others, more mechanized practices are preferred. Applying this DP leads to recognition justice by addressing these different skills and needs.*

3.7 Biomass conversion and value-adding activities should take place in Namibia.	Biomass conversion	Economic stability, satisfactory work	High unemployment (str)	Distributive justice	*Carrying out all value-adding activities in Namibia leads to maximum job creation and value-addition in the region, leading to more distributive justice. This is desirable because of the high unemployment rate.*
3.8 End-products from the biorefinery should first satisfy local demand.	End-product	Access to energy	Dependence on imports (str),	Distributive justice	*Since Namibia is for a large part dependent on energy import, it is desired to first satisfy local demand, before energy products are exported. This DP leads to distributive justice by distributing the benefits directly to the region.*
3.9 Investments are needed in sustainable harvest management and implementation	Institutional context	Care for the environment	Lack of monitoring and implementation (str)	Distributive justice	*Improvements are needed in monitoring and implementation of sustainable harvesting regulations, which are currently a challenge. This is especially needed in communal areas, where the bush is a common pool resource. Applying this DP contributes to distributive justice, by preventing environmental harm from the new BBVC.*
3.10 Investments are needed in resource management and equitable benefit-sharing structures in communal areas.	Institutional context	Inclusion	Land ownership structure (str), communal organization structures (s)	Procedural justice, distributive justice, recognition justice	*Due to the land ownership and communal organization structures, that are sometimes lacking, it is needed to invest in resource management and equitable benefit-sharing structures in communal areas, to ensure distributive justice by preventing elite capture, procedural justice by including communal farmers in decision-making and recognition justice by acknowledging the specific circumstances and needs of communal farmers.*

APPENDIX C – SUPPLEMENTARY INFORMATION TO CHAPTER 4

C1 - Aggregation of subcategories

The stakeholder categories value chain actors and consumers 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 are aggregated together and have the same indicators to assess the subcategory.

Table C1 - Aggregation of subcategories

Subcategory	Explanation
Public commitments to sustainability	The subcategories transparency (stakeholder category consumers) and public commitment to sustainability issues (stakeholder category society) is evaluated as one subcategory. The transparency subcategory evaluates whether the organization communicates about all issues regarding its products and social responsibility transparently. On the other hand, public commitment refers to an organization'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. Therefore, these two subcategories are aggregated and assessed through the acquisition of certifications.

C2 - Reclassification of subcategories

A few subcategories have been moved from their original stakeholder category and are assessed in another subcategory. This choice was made after the field study, 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.

Table C2 - Reclassification of subcategories

Subcategory	Explanation
Smallholders	In the UNEP guidelines, the smallholder subcategory is assessed under the stakeholder category workers. However, because most people living in the communal areas are smallholder farmers, the subcategory is 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 since the housing that the workers live in during charcoal production is provided by the farmers. The housing for the workers has been 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 & 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 organizations share the use of material resources. The methodological sheets suggest that organizations 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 material resources. However, the community is legally not permitted to use the encroacher bush for charcoal production due to past unsustainable use and harvesting practices. Therefore, since the community currently lacks access to the utilization of the encroacher bush, the subcategory is evaluated based on the value chain actors who are permitted to use it.
Respect for indigenous rights	This subcategory is 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" is 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 study (FSC, 2019).

C3 -Exclusion of subcategories

The following subcategories are not 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 the difficulty of data collection. The challenge can be in the availability of data or the sensitivity of the topic.

Table C3 – Exclusion of subcategories

Subcategory	Explanation
Workers	
Sexual Harassment	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 underreported. 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 is omitted from the assessment in this case study.
Child labor	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 & 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 labor cases between 2015 and 2021 and the Labor Act prohibits the appointment of a child under the age of 14 for employment purposes (Matthys, 2022). This subcategory is omitted from the evaluation as child labor does not appear to occur frequently in Namibia.
Forced labor	assesses if anyone is forced to work involuntarily under threat for an organization. Namibia has taken steps to combat forced labor by ratifying the Forced labor protocol in 2014 and aims to end forced labor for good, which was pervasive under colonial rule (ILO, 2017). No formal allegations of forced or compulsory labor 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 labor and no formal cases of forced labor have been reported, this subcategory is excluded from the assessment as it is not relevant.
Local community	
Secure living conditions	assesses how organizations 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 organization'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	a subcategory that examines whether organizations 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 & 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 is omitted from the assessment.
Value chain actors and consumers	
Promoting social responsibility	evaluates if an organization considers the interests of its stakeholders and creates shared value. Since numerous activities that promote social responsibility, such as supplier codes 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 consumers	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 is 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 fertilizer in the garden for example (Benett, 2015). The end-of-life responsibility subcategory is 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 organization'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 organization commits to refrain from engaging in or being complicit in anti-competitive behavior, it is difficult to obtain information about possible violations (UNEP, 2021. Due to time constraints in collecting data and data availability limitations, this subcategory is excluded from the assessment.
Consumer privacy	assesses whether an organization 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 organization 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 is 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 is not taken into account for this case study but should be taken into account in future assessments concerning encroacher bush.

C4 - Subcategory definitions

Table C4 - Subcategory definitions

Stakeholder category	Subcategory	Description of subcategory
Worker	Freedom of association and collective bargaining	Workers and employers have the right to form and join organizations 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 wellbeing and prevent work-related health issues.
	Social benefits	Social benefits refer to non-monetary employment compensation.
	Employment relationship	The presence of a formal contract that safeguards workers' rights and outlines their relationship with employers.
	Safe and healthy living conditions	The impact of an organization on community safety and health.
Value chain actors	Supplier relationships	Evidence that the organization 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 for community members
	Access to material resources	The sharing, utilization, 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 organization's engagement with the community, including involving community stakeholders in decision-making processes.
	Smallholder	Assessing the various characteristics of smallholder farmers or subsistence farmers particularly related to food production.
Society	Contribution to economic development	Organisations can foster economic development by generating revenue, creating jobs, providing education and training etc.
	Technology development	There is the 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 advantage.
	Poverty alleviation	Poverty is a multidimensional phenomenon caused by the lack of opportunity, education, health, and security and the malnutrition of people

C5 - Indicator selection

The initial selection of indicators is based on a multi-criteria analysis where the score 1, 2, or 3 is given for each criterion (data availability, practicality, and relevance) per indicator. The description of the score is provided in Table S5. The indicator per subcategory with the highest score was considered for further investigation. For practicality, preference was given to indicators utilized in the SAM method, as reference scales for these had already been developed. The field trip 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. Fürtner et al. (2021) have already reported that by using this multi-methodological approach a balanced set of subcategories and indicators can be obtained.

Table C5.1 – Criteria rating scale

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

Table C5.2 – Criteria rating per indicator

Low *Medium* *High* *No data*

Subcategories	Indicator	Unit	Data availability	Practicality	Relevance	Score
Supplier relationships	Absence of coercive communication with suppliers	yes/no				*3*
	Sufficient lead time	yes/no				*3*
	Reasonable volume fluctuations // contract flexibility	yes/no				***7***
	Payments on time to suppliers	yes/no				*4*
Wealth distribution	**Gini coefficient**	%				***8***
	Fair price	$/ yes/no				*7*
	Contractual agreements	yes/no				*3*
Fair salary /income	**Living wages**	$				***8***
	Minimum wage	$				*7*
	Lowest wage compared minimum wage	%				*7*
Equal opportunities	Women in the labor force	%				*7*
	Gender gap index	0-1				***9***
	Prevalence of discrimination	yes/no				***7***
	Gender wage gap	%				***8***
Health and safety	**Presence of a formal policy concerning health and safety**	yes/no				***7***
	Occupational accident rate	%				*3*
Social benefits	**Social benefits provided to workers**					***7***
	Percentage of permanent workers receiving paid time off	%				*4*
Safe and healthy living conditions	Burden of Disease by Country					*8*
	Pollution Levels by country					***9***
	Organizational efforts to strengthen community health	yes/no				*3*

Subcategories	Indicator	Unit	Data availability	Practicality	Relevance	Score
Access to material resources	**Levels of industrial water use**	Volume /y				***8***
	Extraction of material resources	Volume /y				***9***
	Does the organization have certified environmental management system	yes/no				*7*
Local employment	**Unemployment statistics**	%				***8***
	Percentage of workforce hired locally	%				***8***
	Percentage of spending on locally based suppliers	%				*6*
Working conditions	Percentage (estimate) of forced labor by region	%				*5*
	Percentage of children working by country and sector	%				*4*
	Working hours					***7***
Consumer privacy	Number of consumer complaints related to breach of privacy or loss of data within the last year					*3*
	Strength of internal management system to protect consumer privacy	Level				***4***
Feedback mechanism	Presence of a mechanism for customers to provide feedback	yes/no				*6*
	Management measures to improve feedback mechanisms	yes/no				*6*
Community engagement	**Freedom of Peaceful Assembly and association**	yes/no				***6***
	Transparency of Government Policymaking	Level				*4*
	Public trust of politicians	Yes/no				*3*
	Diversity of community stakeholder groups that engage with the organization					*6*
	Number and quality of meetings with community stakeholders					***6***
	Strength of written policies on community engagement					*4*

Subcategories	Indicator	Unit	Data availability	Practicality	Relevance	Score
Cultural heritage	**Presence of organizational program to include cultural heritage expression production**	yes/no				***4***
	Strength of Policies in place to protect cultural heritage	Level				*3*
Respect of indigenous rights	Human Rights Issues faced by indigenous peoples	yes/no				*5*
	Indigenous land rights claims/conflicts	ye/no				***6***
Transparency	Publication of a sustainability report	yes/no				*4*
	Certifications for products	yes/no				***8***
Smallholders	**Standard of living**					***7***
	Food security					***7***
Total indicators						**22**

Table C5.3 – Final set of indicators after re-iteration in the field

Subcategory	Indicator	Description
Workers		
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 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

C6 - Risk assessment

The risk level scale is divided into four levels: low risk, medium risk, high risk, or very high risk. Each level is categorized by numerical values from indexes or global performance indicators of countries. Specifically, the best-performing indexes are categorized 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 B.1 provides an overview of how various indexes are categorized 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 color scales, which utilize 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 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 indicate where Namibia ranks compared to other countries, the GDP is categorized into reference scales to assess the risk level. The countries with the lowest 50 GDPs are categorized under the very high-risk level. The next 50 countries with slightly higher GDPs are categorized under the high-risk level. The countries with the highest GDPs are categorized 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 C6 – Risk assessment

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 is highlighted.

Stakeholder category	Subcategory	Indicator
Workers	Equal opportunities	Gender gap index
Value chain actors	Wealth distribution	Gini index
	Local employment	Unemployment rate
Local community	Smallholders	Food security
		Standard of living
Society	Contribution to economic development	GDP
	Poverty alleviation	Multidemnsional poverty index
	Risk of corruption	Corruption index

Risk level	Level characterization	Namibia score	Reference
Very high risk	0-0.25		World Economic Forum, 2022
High risk	0.25-0.5		
Medium risk	0.5-0.75		
Low risk	*0.75-1*	0.80	
Very high risk	75-100		World bank, 2015
High risk	*50-75*	59.1	
Medium risk	25-50		
Low risk	0-25		
Very high risk	*>16.7%*	21.3%	ILO, 2021
High risk	11-16.7%		
Medium risk	5.5-11%		
Low risk	0-5.5%		
No data	No data	No data	
No data	No data	No data	
Very high risk	<8.41 bill		World bank, 2021a
High risk	*8.41-28.73 bill*	12.31 bill	
Medium risk	28.73 bill -223.24 bill		
Low risk	>223.24 bill		
Very high risk	0.75-1		NSA, 2021
High risk	0.5-0.75		
Medium risk	0.25-0.5		
Low risk	*0-0.25*	0.19	
Very high risk	0-25		Transparancy international, 2021a
High risk	*25-50*	49	
Medium risk	50-75		
Low risk	75-100		

C7 - Reference scale development

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

Table C7 – Reference scales

Sub-category	Reference scale
Workers	
Social benefits	For the subcategory social benefits, the BR is defined when the organization 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). Organizations 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 organization 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, by the Labor Act, 2007 (no. 11 of 2007). An organization 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 organization is assessed at level D.
Freedom to join a union	The BR for the subcategory freedom of association and collective bargaining is that the organization 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 organization 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 organization was located from the CIRI Humans Rights Dataset. However, this dataset was updated annually from 1981 to 2011 and is therefore outdated (Cingranelli & Richards, 2014). That is why the Global Rights Index is used instead, which assesses the violations of collective labor rights by governments and employers. The methodology is based on established standards of fundamental labor 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 organization 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.
Employment relationship	The BR 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 Labor Act 2007, the BR is met. The Labor Act 2007 establishes a labor law for all employers and employees. It seeks to protect fundamental labor rights, regulate basic terms and conditions of employment, ensure the health, safety, and welfare of employees, and protect them from unfair labor practices. The organizations are assessed as level C when they offer a temporary contract since, employees, as independent contractors, are not protected by the Labor 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 organization has fulfilled the BR and also provides a fair and equitable compensation and benefits package. This indicates the organization's commitment to enhancing its work environment and showing appreciation and acknowledgment for employees' work.

Fair salary	The BR 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 organization 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 is 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 BR for this subcategory is that the organization 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 Labor 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 is used, where Level C is 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 is assigned. Level A is assigned if the organization implements the health and safety practices beyond the industry standards (Traverzo et al., 2022).
Equal opportunities	When analyzing the subcategory equal opportunities, the BR is defined as the organization has a management system, policy, or actions in place to prevent discrimination and promotion of equal opportunities for workers, following 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 organization 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 is used for this study. 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 who scored above 0.50 (higher levels of equality). An organization that does not fulfill the BR 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 BR is that the organization must provide the employee with adequate housing including sanitary and water facilities set by the FSC standards and Labor Act 2007 to ensure safe and healthy living conditions for the employee. Level C is assigned if the organization fails to meet the minimum housing standards, while Level D is assigned when no accommodation is provided to workers. When an organization provides a higher standard of housing to the employees than the minimum housing requirements, it is granted a Level A assessment.

Value chain actors	
Local employment	The BR for local employment is that there is evidence of the organization'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 organization is located. It measures the number of people employed against the total working-age population, which can be used as a general indicator for labor 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 labor 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 organization 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 BR 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 organization has violated commitments to sustainability. It refers to any issue related to the organization that could harm society environmentally, socially, or economically. Level D is assigned when the organization 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 organization, showcasing proactive behavior 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 BR is 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 organization implements multiple additional measures to ensure sustainable harvesting such as biomass quantification, sustainable and selective harvesting, and continuous aftercare rangeland restoration. A level C is 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 organization's suppliers is the BR. To differentiate between levels C and D, the SAM method typically uses a supplier satisfaction survey. However, an alternative distinction is used, due to the practical challenges of conducting such a survey within the time frame of this study. Specifically, level D is assigned when the organization lacks a code of conduct and has no supplier relationship beyond basic purchasing transactions. Level C is 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 is assigned to an organization that possesses a code of conduct and demonstrates strong supplier relationships.

Local community	
Respect of communal rights	The reference scales are based on the SAM method with the BR being that there is evidence that the organization 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 BR is not met and there is documented evidence of discrimination against the community in the past three years. Level A is given when the organization shows proactive behavior regarding communal rights policy and commitments to implement free prior informed consultation when operating on communal lands. The organization 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 analyzing the subcategory cultural heritage, the BR is that there is evidence that the organization contributes to the preservation of cultural heritage through contributions to traditional agricultural practices. Level A is assigned when the organization 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 organization 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 organization is assigned level D. Otherwise, if the organization operates in a country without any heritage sites in danger, it receives.
Community engagement	The BR for the subcategory community engagement is evidence that the organization 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 is assigned when the organization 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 organization. When an organization does not meet the BR and has documented cases of the organization 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.
Society	
Contribution to economic development	When analyzing this subcategory, the BR is met when the organization contributes 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 organization when it demonstrates a higher level of economic development contribution in comparison to other organizations within the same sector. Level D is assigned when there is a record of proven cases of the organization 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 BR is fulfilled if the organization demonstrates participation in joint research and development for efficient and environmentally sound technologies (UNEP, 2021). when an organization has a higher expenditure on research and development of technologies compared to other organizations 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 & Ledia, 2022). If an organization operates in a country with high research and development expenditure (> 2.35% GDP) and does not meet the BR, it is assessed as level D (positive conditions). Otherwise, if the organization operates in a country with low research and development expenditure (0-2.35% GDP), it is assessed as level C (World Bank, n.d.).

C8 - Case study protocol

In addition to the case study protocol as presented in appendix A:

Stakeholder specific questions – 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:
    a. Do workers belong to or have the freedom to join a farmers union?
    b. If they do not belong to a union: Have others (employees) also not joined a union? Why?
    c. If they belong to a union: Does the company negotiate with the unions?

Stakeholder specific questions – 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?
        1. If there is no policy: Are value chain actors still getting a fair price for their products?
        2. If there is a policy: How is this information disseminated on websites or through certifications?
    b. Is there a set price that is paid for the biomass?
    c. How much value is added in the process to the biomass?
    d. 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 organization's website, promotional material, or with other companies/general public?
        1. If yes: Is joint research one of the main properties of the organization?
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. lPresent and expected challenges regarding sustainability.
    b. Internal management systems that ensure sustainable use of natural resources.
        1. If there are no internal management systems: How do others in the sector perform resource extraction? Do they control it?

2. 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?
   1. If there is no control: What is the water usage of this company compared to other companies?
   2. If there is control: Is the water reused/recycled in the process?

d. Public commitments to sustainability or social responsibility:
   1. 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?
   2. 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:
   1. 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:
   1. If there is no contribution: Does the company extract resources and then export them with the revenue going to a foreign country?
   2. If there is a contribution: Does the organization provide a large contribution to the economy, in the form of employment, value addition, or reinvestment, compared to similar companies in the same sector?

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

6. Current projects/activities related to improving sustainability:
   a. Are there any current projects or activities related to improving sustainability, such as trainings, certification, organic fertilizers, etc.?

Stakeholder specific questions – local community

1. Do the companies consider the rights of the people in communal areas? Are the local communities consulted or do the companies have policies?
    a. If there is no consideration: How are the indigenous treated in the country? Do they have the same rights and opportunities as everyone else?
    b. If there is consideration: How are the people in communal areas consulted or involved?
    c. lAre there any involvement or activities on indigenous land?
2. lDoes the organization make an effort to strengthen community health?
    a. Are there policies in place to communicate its effect on the health and safety of the community?
    b. Are there environmental risk systems in place to contribute to the health and safety of the community?
3. How does the organization involve the local community? Are meetings being held with representatives from the community?
    a. If there are no meetings: Is the local community affected by the company, and how is the relationship with the community?
    b. 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?

Stakeholder specific questions – society

1. Is there joint research and development for environmental technologies that is shared via the organization's website, promotional material, or other companies/general public?
    a. If there is joint research and development: Is (joint) research one of the main properties of the organization?
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?
    a. 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?

b If the company has contributed to regional economic development: Does the organization provide a large contribution to the economy, in the form of employment, value addition, or reinvestment, compared to similar companies in the same sector?

Interview materials

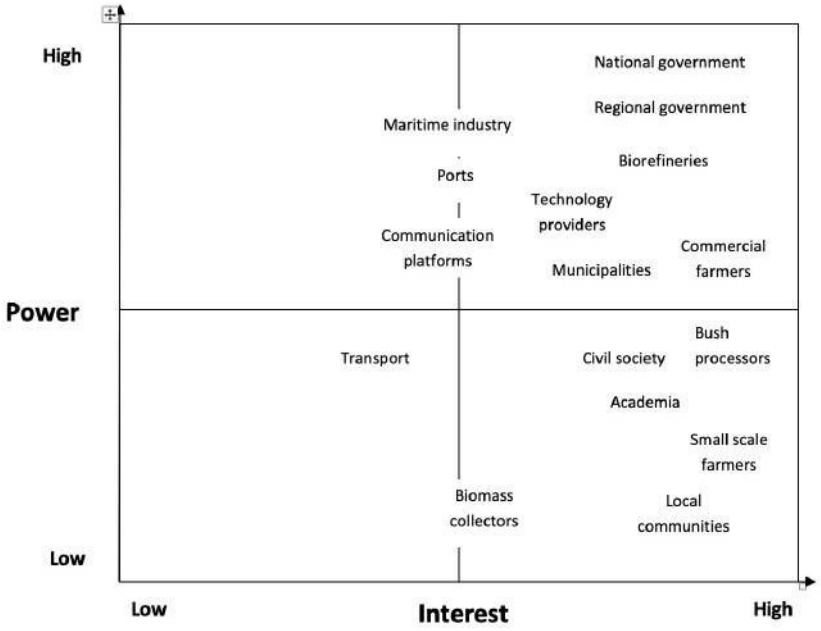

Figure C8.1 - Stakeholder power-interest grid Namibia

Workshop protocol

- Break up in 3 smaller groups, representing a mix of stakeholders
- Break-out session 1 - Forecasting: Discuss an ideal scenario for +20 years. Participants can choose options for the different variables of the value chain. The following tools are used:
  - Empty biofuel value chain scenario where participants can fill in their ideal choices (Figure A4).
  - Poster representing different variables of the biofuel value chain, to be filled with post-its (Figure A5).
  - Table with options to choose from for each variable (Figure A6).
- Break-out session 2 – Subcategory ranking: Rank the different subcategories according to their importance. The following tools were used:
  - Mentimeter (Figure C8.2 and C8.3)
- Break-out session 3 - Backcasting: Create a roadmap for how to achieve the ideal scenario. Identify steps for what is needed in +5 and

+10 years to achieve the ideal scenario. Discuss roles, responsibilities, and challenges. Tools:

- Poster of a roadmap, to be filled with post-its (Figure A7).

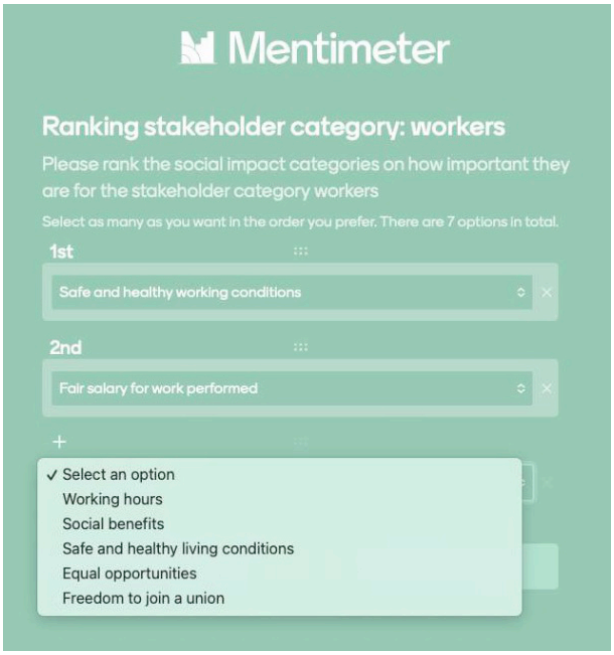

Figure C8.2 - Mentimeter tool used for choosing the ranks of subcategories

Figure C8.3 - Example of ranking results of the worker subcategories from one of the three groups during the workshop

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LIST OF PUBLICATIONS

Journal articles

* van der Veen, S., Asveld, L., & Osseweijer, P. (2024). Designing bio-based value chains for social justice: The potential of Capability Sensitive Design. *Energy Research & Social Science, 117*, 103724.
* van der Veen, S., van Rechteren Limpurg, E., Asveld, L., and Chandrasekaran, S. (2025). Strengthening Social Life Cycle Assessment for a just bioeconomy: Insights from Namibia's bush-based value chains. *Sustainable Production and Consumption, 57*, 198-212.
* van der Veen, S., Asveld, L., & Osseweijer, P. (2025). Inclusive pathways to a sustainable bioeconomy: Balancing inclusion and economic feasibility in new bio-based value chains. *Cleaner and Circular Bioeconomy*, 100200.

Conference proceedings

* 'Designing inclusive bio-based value chains - Involving smallholders through capability sensitive design'. Oral presentation at the EU-SPRI conference *Challenging Science and Innovation Policy,* Utrecht, NL, June 2022.
* 'Designing inclusive bio-based value chains - Involving smallholders through capability sensitive design'. Oral presentation at the Human Development and Capability Approach (HDCA) conference, Antwerp, BE, September 2022.
* 'Linking stakeholders along new bio-based value chains: Accounting for different values and capabilities'. Workshop by Susan van der Veen and Sivaramakrishnan Chandrasekaran at the Second International Conference on New Pathways for a Just and Inclusive Energy Transition: Connecting Multiple Stakeholders and Levels (ICNP), Groningen, NL, June 2023.
* 'Designing for inclusive bio-based value chains: Involving stakeholders via Capability Sensitive Design'. Oral presentation at the SCORAI-ESCP-WUR Conference Transforming Consumption-Production Systems Toward Just and Sustainable Futures, Wageningen, NL, July 2023.
* 'Towards inclusive and sustainable bio-based value chains: a dialogue between industry, civil society and academia'. Dialogue and debate

session by Susan van der Veen and Lotte Asveld at the SCORAI-ESCP-WUR Conference Transforming Consumption-Production Systems Toward Just and Sustainable Futures, Wageningen, NL, July 2023.

* 'Institutional design for bio-based value chains'. Oral presentation at the Human Development and Capability Approach (HDCA) conference, Sofia, BG, September 2023.
* 'Capability sensitive design for bio-based value chains – A case study on coffee and cocoa residues in Colombia.' Poster presentation at the Human Development and Capability Approach (HDCA) conference, Sofia, BG, September 2023.

CURRICULUM VITAE

Susan van der Veen was born on the 28th of September 1990 in Groningen, the Netherlands. After completing her high school education in 2009, Susan travelled through Latin America for five months to learn Spanish, an experience that sparked her curiosity in other people and cultures. Throughout her academic and professional career, she has been driven by a commitment to building more sustainable and socially just societies.

Susan completed a Bachelor's in Cultural Anthropology at Utrecht University (the Netherlands) in 2014, enriched by an honors programme, a minor in development geography, and fieldwork in Spain. She continued to develop a strong interdisciplinary foundation through a multidisciplinary research Master's in Sustainable Development at Utrecht University (the Netherlands), completed in 2017. Her studies took her to Latin America again for fieldwork projects, focused on the social impact of sustainable coffee production in Peru and lithium extraction in Argentina. These projects deepened both her empirical research experience and her engagement with global development questions. To further specialize in the field of international development and gain practical experience, she started the Advanced Master's in International Development (AMID) at Radboud University in Nijmegen (the Netherlands) in 2019.

Before beginning her doctoral research, Susan gained broad professional experience across civil society, financial, and public sectors. She contributed to SOMO's research on international value chain injustices during her internship in 2017, improved organizational processes as a product manager at Triodos Bank in 2017-2018, and conducted policy-relevant interviewing work for Labyrinth Onderzoek & Advies in 2019. As part of the AMID program, she worked as a policy officer at the Dutch Ministry of Foreign Affairs on sustainable production and trade, where she helped organize international conferences on living wage and child labor in global value chains. These roles strengthened her analytical approach, organizational skills, and ability to collaborate across sectors and stakeholder groups.

Since December 2020, Susan has been a PhD candidate at Delft University of Technology (the Netherlands), conducting research within a multidisciplinary team on sustainable and inclusive value chains for biofuels derived from residual biomass streams. Her work included qualitative field research with stakeholders in Spain, Colombia, and Namibia, contributing to several peer-reviewed publications on Capability Sensitive Design, Social Life Cycle Assessment, and inclusive pathways for a just bioeconomy. Throughout her doctoral trajectory, she has combined analytical rigour with a commitment to real-world impact, consistently seeking concrete, practicable improvements in complex sustainability challenges.

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