# Operationalising Climate Justice in Social Life Cycle Assessment: An Approach for *Just* Energy Transitions


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Names: Laure Herpain

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Supervisors: Dr. Linda Kamp, Anna Melnyk, Dr. Robert Istrate

Programme: MSc Industrial Ecology

University (and student ID): Leiden University (s2577569) & Delft University (6117007)

“Is there a measure on earth?

There is none.”

— Friedrich Hölderlin (1770-1843)

# Acknowledgments

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# Executive Summary

Social Life Cycle Assessment (S-LCA) is a prevalent tool in industrial ecology (IE) for evaluating social impacts across products and systems' life cycles. Policymakers and industrial actors increasingly use it to guide their decisions in the energy transition. Although the energy transition is widely recognised as generating new and reinforcing existing climate injustices, the intersection of climate justice and S-LCA remains largely unexplored in the literature. In this light, the thesis deals with the following research question: How can Social Life Cycle Assessment be critically evaluated and advanced to better account for climate justice in the energy transition? This research uses an exploratory and prescriptive design with participatory data collection methods (e.g., elicitation interviews) and content analysis. It first identifies and explains the main limitations of current S-LCA practice in addressing climate justice. Specifically, it demonstrates various methodological constraints—for most, already reflected in the literature—as well as epistemic constraints that have thus far remained unexplored within the identified literature. Then, it develops a climate justice-based approach to operationalise climate justice in S-LCA practice through four pillars: decoloniality, inclusivity, reflexivity, and relationality. By rendering S-LCA more responsive to climate justice, this research supports S-LCA practitioners to undertake more critical and reflexive S-LCA assessments of energy systems, thereby preventing S-LCA practice from unintentionally perpetuating injustices in relation to the energy transition. Future work should further advance the climate justice-based approach through empirical applications and spur collaboration among S-LCA experts, climate justice advocates, and affected communities across energy supply chains.

# Foreword and Positionality Statement

Including a positionality statement as part of a thesis's foreground is not just fulfilling an ethical formality. Rather, it serves as a reminder to the reader that any product of knowledge, such as my thesis, is never objective or neutral. Especially when dealing with highly politicised topics, such as climate justice, the reader must understand who laid these words and in what context.

Therefore, let me present myself. I am a white Belgian-Dutch woman writing a thesis as part of the Master's (MSc) in Industrial Ecology (IE), a joint degree between TU Delft and Leiden University. I am neither an ethicist nor a fully accomplished engineer. I have an academic background in environmental sciences. My lived experiences are rooted in Western onto-epistemologies and influenced by forms of techno-determinism.

The reader should also be aware that researching climate justice and S-LCA for one's thesis is not an arbitrary choice either. The choice of topic follows the trajectory of an ongoing research process, coordinated by the Climate Justice in IE (CJIE) initiative. This initiative arose after a letter signed by 80 people from the IE community highlighted the need for topics such as equity, power, and justice to be integrated within our Master's programme. Following that, we organised student-led workshops and a session during the International Industrial Ecology Day 2024, examining the relevance of climate justice to the field of Industrial Ecology. With Tadé Whenu and Sevi Kocagöz Castelli, we also conducted a research project at TU Delft to identify "what", "how", and "why" we should integrate climate justice in IE. As such, the present research is not an isolated intellectual exercise but builds directly on the work of the CJIE working group.

That being said, I try to stay aware of how my positionality and lived experiences frame certain assumptions and biases. I indeed try—to the best of my ability—to engage in reflexivity and to be critical of the lenses through which I conduct this research. However, it is inevitable that my privileges, education, gender, cultural background, ethnicity, and socio-economic class influence both the research process and findings of my thesis.

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# Glossary of Terms

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| **Anti-capitalism** | Political and ethical positions that criticize capitalism's inequalities, exploitation, and ecological harm and seek alternative ways of organizing economy and society. |
| **Anti-racism** | Active practices and policies that challenge systemic, institutional racism and the social structures that normalise racial hierarchy. |
| **Capitalism** | An economic system where most production and resources are privately owned, businesses compete for profit, and markets play a central role in organizing work and investment. |
| **Colonialism** | A system where a powerful country invades, occupies, and controls another territory to exploit its land, labor, and resources, reshaping politics and culture in the process. |
| **Decolonial** | Approaches that aim not only to critique coloniality but to undo it in practice, and transforming power, land, and institutions. |
| **Distributive justice** | Distributive justice asks how the benefits (e.g., access to clean and affordable energy) and burdens (e.g., high costs) are distributed across groups and places. |
| **Epistemology** | A branch of philosophy that studies knowledge: what it is, how we gain it, and how we can tell knowledge from mere opinion. |
| **Epistemic** | Adjective of the noun 'epistemology', meaning anything that relates to knowledge or evidence.<br>*Example:* If someone claims "This medicine works," epistemology asks: "What evidence supports that claim? Scientific experiments or just personal stories?" These questions are epistemic. |
| **Exploitation** | Taking unfair advantage of people's labor or resources by benefiting from them far more than they are compensated or respected. |
| **Extractivism** | An economic model based on large-scale removal of natural resources (e.g., minerals, oil, forests) for export and profit, with little to no concern for local people or ecosystems. |

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| **Feminism** | Movements and ideas that seek to end gender-based oppression and build social, political, and economic equality, often highlighting how gender intersects with race, class, and other power relations. |
| **Green colonialism** | Using environmental or climate goals to justify controlling land and resources in the Majority World, continuing colonial patterns under a green label. |
| **Green extractivism** | The same intensive resource grabbing found in extractivism, but justified in the name of green or lowcarbon transitions (for example, mining lithium or cobalt for batteries) while still harming local communities and environments. |
| **Hegemony** | How a dominant group secures shapes "common sense" so its power feels natural and legitimate, not just forced. |
| **Imperialism** | The broader political and economic domination of other regions or countries through military, economic, or cultural power, to secure markets, resources, and influence. |
| **Low-carbon energy technologies** | Technologies that produce energy with little or no greenhouse gas emissions, such as wind turbines and solar panels. |
| **Marginalisation** | The process by which certain groups are pushed to the social, economic, or political edges of society, with less power, resources, and recognition. |
| **Necropolitics** | Political ordering, often along racial or colonial lines, that decides who is allowed to live safely and who is considered disposable. |
| **Normativity** | Quality in philosophy describing the standards of what people ought to do, believe, or value, rather than just describing facts. |
| **Normative** | Adjective of the noun 'normativity', meaning what is good, right, or desirable, according to certain standards.<br>*Example:* Saying "We should prioritise climate mitigation as much as economic growth" is a normative statement because it expresses a value-based judgment about what is right or desirable. |

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| **Onto-epistemology** | Onto-epistemological approaches treat reality and knowledge as connected. The idea is that *what exists and how we can know it* influence each other, so they should be studied together. |
| **Ontology** | The study of what exists and what reality is like. It emphasises the existence of different realities not just different interpretations of the same reality.<br>*Example:* Many Indigenous ontologies understand reality as interconnected with the land, water, nonhumans, and life itself. |
| **Oppression** | Systematic and enduring harm, control, and devaluation of certain groups (for example by race, gender, class) embedded in institutions, culture, and everyday practices. |
| **Post-colonialism** | Approaches that examine how colonial histories still shape culture, politics, and identities after formal empire ends, often critiquing Eurocentric narratives. |
| **Procedural justice** | Procedural justice focuses on how decisions are made and whether these processes are transparent and inclusive. |
| **Recognitional justice** | Recognitional justice refers to the acknowledgement of systemic injustices experienced by, as well as the rights and interests of, marginalised groups as legitimate in policy-making. |
| **Sacrifice zones** | Areas and communities that are deliberately exposed to pollution, danger, or degradation so that others can benefit from economic or energy development. |
| **Transdisciplinarity** | An approach to knowledge and research that goes between, across, and beyond individual disciplines to solve complex problems.<br>*Example:* A climate justice project that brings together climate scientists, local communities, NGOs, and policymakers to co-design just mitigation strategies is transdisciplinary. |
| **Values** | Principles people use to judge what matters (e.g., fairness, responsibility, or sustainability) |

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# Chapter 1: Introduction

## 1.1. Societal and scientific relevance

In the face of the unprecedented climate crisis, governments are attempting to shift toward fossil fuel-free futures, a process commonly called the "energy transition" or "green transition" (Harichandan et al., 2022). In spite of the urgency of this transition, it involves significant trade-offs and competing interests, rendering decision-making highly complex (Sundaram et al., 2024). To navigate these complexities, policy makers, industry actors, and decision-makers increasingly rely on the Life Cycle Sustainability Assessment (LCSA) framework, which encompasses all three pillars of sustainability: environmental, economic, and social (Zimek et al., 2019; Bouillass et al., 2021). This MSc thesis focuses on the social dimension of LCSA, operationalised through Social Life Cycle Assessment (S-LCA).

First, the societal relevance of this research relies on the profound social implications of the "green transition". Indeed, increasing evidence shows that this transition, beyond causing environmental damage, reproduces patterns of dispossession, exclusion, and inequality (Andreucci et al., 2023; Dunlap & Laratte, 2022). As S-LCA evaluates the positive and negative impacts of energy systems on different groups of people, it is therefore imperative that the method accurately identifies and represents these injustices. By operationalising climate justice within S-LCA practice, this research reinforces the method's capacity to serve as an inclusive and just decision-making tool for the energy transition.

Second, the scientific relevance of this thesis concerns the improvement of S-LCA at a turning point in its development. In fact, the method remains, to this day, in the "search for standardisation phase", as explained by Ramos Huarachi and his colleagues (2020, p.6). Before its practices become fully standardised, this research makes use of this window of opportunity to ensure that S-LCA outcomes favour a transition that is as *just* as it is "green". As Williams and Doyon (2019) point out, "we cannot achieve a sustainability transition without justice, indeed that an unjust transition is not sustainable" (p.1). This research thus situates itself at a pivotal moment: One in which aligning LCA practices with principles of justice is not only possible but also necessary.

## 1.2. Problem Definition & Objectives

The transition to low-carbon technologies often results in considerable harm to the very people and places expected to experience some of the worst effects of climate change itself (Owen et

al., 2023; Walter et al., 2025; Ogunbode et al., 2024). Across the supply chains of these renewable energy systems, injustices arise such as land dispossession, labour exploitation, green extractivism, toxic exposure, and unequal energy access (Marin et al., 2023; Tornel, 2023; Andreucci et al., 2023). Within this context, it remains unclear whether S-LCA practice, as commonly practised, is able to adequately capture these forms of injustice. Clarifying whether S-LCA, as currently practised, integrates justice dimensions, therefore appears as a first research objective.

This uncertainty holds paramount normative implications. If S-LCA fails to explicitly account for justice dimensions in the energy transition, it runs the risk of reinforcing injustices and becoming a tool for necropolitics (Mbembé 2003; Dunlap & Laratte, 2022). In other words, S-LCA practice could unknowingly legitimise policies for the energy transition benefitting European elitist populations, while burdening the very people experiencing some of the worst effects of climate change itself (Mbembé 2003; Dunlap & Laratte, 2022). Identifying ways S-LCA can integrate justice dimensions is therefore a second research objective.

This research responds to this dual problem about uncertainty and normative risks by first identifying and explaining the gaps and limitations between climate justice principles and current S-LCA practice. Second, it proposes a climate justice-oriented framework for S-LCA practitioners. Taken together, this research aims to support S-LCA practitioners to undertake more critical S-LCA assessments of energy systems, thereby preventing S-LCA practice from unintentionally perpetuating injustices in the energy transition. If the energy transition is to be *de facto* just, climate justice should become an integral part of social sustainability assessments of energy systems.

## 1.3. Research questions

By exploring the theory and practice behind S-LCA from a climate justice perspective, the thesis deals with the research question: “How can Social Life Cycle Assessment be critically evaluated and advanced to better account for climate justice in the energy transition?” The research holds two sub-questions:

(1) How and why does current S-LCA practice address—or not—climate justice principles?

(2) How can climate justice principles be operationalised into a practical S-LCA approach to reduce the risk of reproducing injustices in the energy transition?

## 1.4. Research outline

Following this introductory chapter, Chapter 2 frames the research within the current literature on S-LCA and climate justice. Chapter 3 expands on the conceptual framework, furthering the definition of climate justice in praxis. Chapter 4 explains the methodology of the research, including its worldview, strategies of inquiry, and research methods. Chapter 5 presents the results from the data collection and the resulting analysis. Chapter 6 builds on the latter to interpret the findings, while bringing forth the implications, limitations, and recommendations of the research. Finally, Chapter 7 concludes by synthesising the research.

# Chapter 2: Literature Review

To better contextualise the thesis project, this section synthesises the literature on which the research seeks to build. First, it introduces the state-of-the-art of S-LCA by drawing mainly from the fields of Industrial Ecology and Sustainability Science. Second, it introduces climate justice as a concept, a framework, a body of literature, and a grassroots movement by drawing mostly from Political Ecology, Political Philosophy, and Sustainability Transitions. Lastly, the research gap is identified through a brief literature review utilising the Web of Science databases.

## 2.1. Social Life Cycle Assessment

The field of Industrial Ecology studies the systemic relationships between society, the economy, and the natural environment, in relation to sustainability issues (International Society for Industrial Ecology, 2025). It highlights the need for "a systems perspective in environmental analysis and decision making" so as to prevent narrow and incomplete analyses that overlook critical variables or bring about unintended consequences (Lifset & Graedel, 2002). One key application of this system's perspective is the use of the Life Cycle Thinking (LCT), which examines products, processes, facilities or services from resource extraction up to and including end-of-life treatment (*idem*). A formal framework that embodies this LCT is the Life Cycle Sustainability Assessment, which analyses the total system of processes involved in the life cycle of a product, system, or service; all referred to as a "product system" (Bruijn et al., 2002). LCSA includes all pillars of sustainability: environmental, economic, and social. Even though some scholars claim an equal degree of importance, the LCA community at large has been focusing more on the environmental and economic issues, while marginalising the social component of sustainability (Zimek et al., 2019; Ramos Huarachi et al., 2020).

Ramos Huarachi and his colleagues (2020) trace the historical trajectory of S-LCA through four stages: the first steps towards S-LCA (1996–2009), the uncertainty years (2009–2012), the development years (2013–2016), and the search for standardisation (2017-present). While the precursor methods of environmental life cycle assessment (E-LCA) were developed in the 1960s, the first attempt to include the social dimension came in 1996 with O'Brien et al., who suggested combining E-LCA with a social perspective in what they named Social and Environmental LCA (SELCA; Ramos Huarachi et al., 2020). It was not until 2006, however, that multiple methodological proposals to evaluate social impacts with the LCT were published

(Dreyer et al., 2006; Hunkeler, 2006; Norris, 2006; Weidema, 2006). These contributions marked a turning point: The LCA community acknowledged that the mere inclusion of social aspects in E-LCA was perhaps not rendering justice to the social pillar of sustainability. Rather, the community realised that it was necessary to develop a new dedicated singular method (Ramos Huarachi et al., 2020).

As a result, the United Nations Environment Programme (UNEP) and the Society of Environmental Toxicology and Chemistry (SETAC) launched a Life Cycle Initiative. In 2009, this Initiative developed some guidelines for Social Life Cycle Assessment, which formally introduced S-LCA as a method (UNEP & SETAC, 2009). Updated in 2020, these guidelines, often referred to as "UNEP Guidelines", form a map for supporting stakeholders in the assessment of social and socio-economic impacts of product systems on people (UNEP, 2020). UNEP describes S-LCA as a methodological framework that combines quantitative and qualitative data to inform decision-making processes "in the prospect of improving the social performance of an organisation and ultimately the well-being of stakeholders" (UNEP, 2020, p.20).

Despite the presence of UNEP Guidelines for S-LCA, S-LCA remains in search of standardisation (Ramos Huarachi et al., 2020). S-LCA practitioners to this day use a wide variety of methods, models, and data (UNEP, 2020). While distinctively different to E-LCA, S-LCA still uses some of its modelling capacities and systematic assessment processes. For instance, it uses a functional unit (FU) and activity variable and follows the quantitative E-LCA framework of unit processes (van Dulmen et al., 2025). Further, the UNEP Guidelines present S-LCA as aligned with the ISO 14040 standards for E-LCA. This shared methodological framework is meant for S-LCA to be compatible with the rest of the LCSA framework, namely life cycle cost (LCC) and E-LCA (van Dulmen et al., 2025). As such, S-LCA follows the methodological phases of (1) goal and scope, (2) life cycle inventory (LCI) analysis, (3) life cycle impact assessment (LCIA), and (4) interpretation (see Figure 1).

From all the phases, the goal and scope phase is most influential in this iterative process, as it specifies the core requirements that govern all subsequent stages of the assessment. For the inventory analysis phase, it sets the functional unit, reference flow, system boundaries, modelling type, allocation, and data requirements. For the impact assessment phase, it determines the LCIA approach (i.e., Reference Scale (RS) approach or the Impact Pathway (IP) approach), impact (sub)categories, indicators, and characterisation factors. As for the interpretation phase, the conclusions, limitations, and recommendations must align with the stated goal, intended use, and audience—all elements defined in the goal and scope phase.

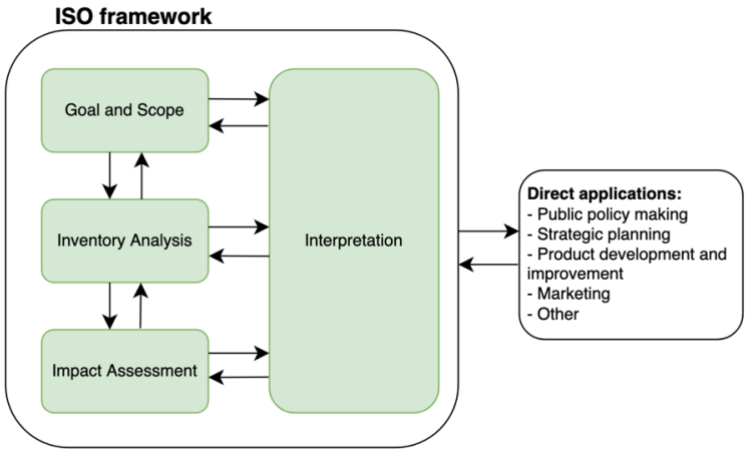


Figure 1: ISO framework diagram based on Bruijn et al. (2002)

UNEP's S-LCA framework draws upon a stakeholder approach that evaluates both positive and negative impacts on six distinct stakeholder categories: workers, local communities, value chain actors, consumers, children, and society (UNEP, 2020). Each stakeholder category represents a group of persons who are involved or susceptible to being affected by the related activities of a certain product system's life cycle (*idem*). Linked to each stakeholder category are 31 social and socio-economic impact subcategories (e.g., forced labour, delocalisation and migration, wealth distribution), as shown in Figure 2. These impact subcategories for S-LCA are described in the Methodological Sheets from UNEP (UNEP, 2021). As illustrated by Figure 2, these subcategories are assessed through various inventory indicators for which qualitative, semi-quantitative, and quantitative data are collected (Bouillass et al., 2021).

These indicators are then evaluated according to either the RS or IP approach. The UNEP Guidelines seem to tend more towards the RS methodology, which weighs performance or risk in opposition to established values in databases like Product Social Impact Life Cycle Assessment (PSILCA) and Social Hotspot Database (SHDB). Alternatively, the IP approach is theoretically underdeveloped and does not have adequate case studies to support its implementation (van Dulmen et al., 2025).

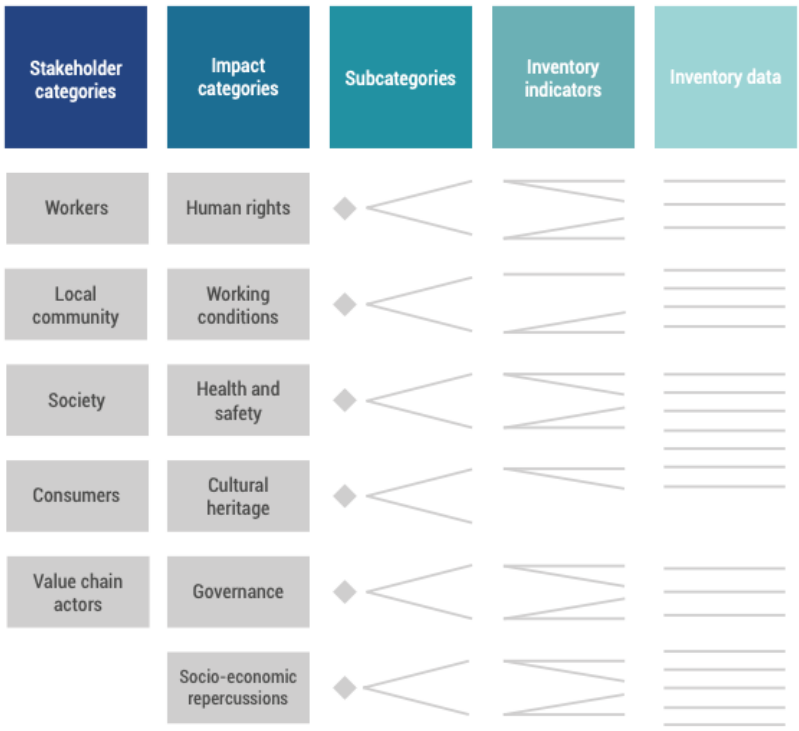


Figure 2: Assessment system from categories to inventory data taken from UNEP (2020)

In spite of the UNEP Guidelines and its Methodological Sheets, S-LCA continues to face various methodological challenges, as consistently shown in the literature. Building on Ramos Huarachi et al.'s identification of a lack of standardisation (2020), a review of 111 studies on S-LCA reveals that it remains "a young and immature method" (p.23), leading to uncertain, non-transparent, non-reproducible results (Pollok et al., 2021). More recently, the situation appears largely unchanged as a review by Chabrawi and her colleagues (2025) demonstrates that S-LCA still "deals with methodological challenges, lacking a homogeneous code of practice despite the significant efforts from UNEP Guidelines to pursue systematisation and homogenisation" (Chabrawi et al., 2025, p.1039).

These methodological challenges and their respective consequences are numerous. First, there exists no consensus on how to select functional units, (sub)impact categories, and indicators (Neugebauer et al., 2014; Chabrawi et al., 2025; Petti et al., 2018). This leads to arbitrary selections and undermines comparability across studies (*idem*). Second, although participatory approaches are encouraged by the UNEP Guidelines, they are not typically implemented in practice, and if they are, only in an extractivist or symbolic manner, often due to a lack of guidance (Tokede & Traverso, 2020; Sehlin MacNeil et al., 2021; Sureau et al., 2018). The lack of meaningful stakeholder participation often results in assessments that

privilege the perspectives of practitioners and commissioners, rather than the affected stakeholders (Zanchi et al., 2018; Tokede & Traverso, 2020).

Third, there is no guidance or standardised set of instruments for S-LCA data collection (Chabrawi et al., 2025; Grubert, 2020). In practice, this means that practitioners rely on data collection methods that differ markedly from one study to another. Fourth, there is an overreliance on secondary data from databases recommended by UNEP (e.g., SHDB, PSILCA), which mostly report at a country or regional level, and a corresponding scarcity of robust, primary, site-specific data (Chabrawi et al., 2025; Grubert, 2020; Bamana et al., 2021). This reliance on aggregated data can mask within-country heterogeneity and local vulnerabilities (*idem*). For instance, Bamana et al.'s (2021) case study on cobalt mining in the Democratic Republic of the Congo highlights how UNEP's methodological guidance fails to capture local exposure risks and health impacts. As they put it:

> *"[…] individuals near at-home or industrial mining operations are at increased risk of falling into mine shafts and exposed to greater air pollution that can affect respiratory health. UNEP's methodological sheets note that pollution from activities pertaining to a supply chain can negatively affect human health through multiple pathways. Yet, there is no specific indicator in the methodological sheets for measuring this relationship aside from 'pollution levels by country', which does not capture the heterogeneity of effects in local communities."*
> *(Bamana et al., 2021, p.1709)*

Together, research shows that these various methodological issues can lead to skewed, biased, or non-comparable results, since choices on indicators, data source, and collection procedures are highly discretionary and not guided by a shared code of practice (Pollok et al., 2021; Martínez-Blanco et al., 2014; Grubert, 2020). This supports the existing literature that describes S-LCA as a value-laden practice (Goldman & Baum, 2000; van Haaster et al., 2017; Grubert, 2018).

## 2.2. Climate Justice

This section first defines climate justice by presenting its core meanings and major approaches, as well as the actors at play. It then situates climate justice in relation to environmental and energy justice. This overview serves to establish the conceptual foundation for understanding climate justice within the context of this thesis.

## Conceptualisation: Meanings, Actors, and Approaches

There exists a wide variety of ways to approach climate justice, including—but not limited to—as a concept, a framework, a body of literature, and a grassroots movement (Wang & Lo, 2021; Caney, 2014; Schlosberg & Collins, 2014; Sultana, 2022). Even though scholars and advocates theorise and practise climate justice in different ways, these approaches all start from considering climate change as a matter of justice (Caney, 2014; Harris, 2019). They converge in regarding climate justice "in terms of the fairness, equity, and rightness of responses" toward climate change issues (Harris, 2019, p.3).

To understand what climate justice is about, one needs to first understand what climate *injustice* entails. Activist and frontline storytellers are particularly important in this regard, as they bring forth lived experiences and material consequences that are often obscured in abstract policy discourse. For instance, an American-Pakistani climate justice advocate, Ayisha Siddiqa (2022), asserts that "what is for the Global North [Minority World] a conversation about carbon emissions, is a reality of hunger, homelessness, helplessness, and indescribable suffering for us" (p.400). Ina Maria Shikongo, a climate justice activist involved in the Fridays for Future International movement, tells the story of how the Canadian oil and gas company, ReconAfrica, expects to drill 397 million barrels of oil and more than 2 trillion cubic feet of natural gas from the Kavango Basin—her ancestral homeland in Namibia (ReconAfrica, 2025; Shikongo, 2022). She blames ReconAfrica for polluting the water and the environment, but also that "it is threatening to disrupt the ways of the Kavango and the San peoples who live off the lands of working as subsistence farmers and hunter-gatherers" (Shikongo, 2022, p. 400). She sees this "largest oil play of the decade" as a form of colonialism in which the oppressed peoples will be displaced or killed for the mere benefit of the Minority World's development (p.399).

These lived accounts are increasingly integrated in academic research on energy transitions. Much of this work is normative and interdisciplinary, drawing on political philosophy, ethics, political ecology, sociology, governance studies, Indigenous and decolonial studies—to name just a few. A growing body of literature demonstrates that low-carbon transitions reinforce climate injustices through green colonialism and extractivism (Dunlap & Laratte, 2022; Andreucci et al., 2023; Hamouchene & Sandwell, 2023; Zografos & Robbins, 2020; Müller et al., 2022). Indeed, many renewable energy technologies for the Minority World (e.g., solar panels, lithium batteries) require "transition minerals", which extraction often correlates with increased land grabs, displacements, and environmental pollution in

communities in the Majority World[1] (Hamouchene & Sandwell, 2023; Zografos & Robbins, 2020; Müller et al., 2022). Consequently, communities that have contributed least to global emissions are often disproportionately affected not only by climate impacts but also by transition governance itself (Ogunbode et al., 2024; Schlosberg & Collins, 2014). Andreucci and his colleagues (2023) describe this phenomenon as "decarbonisation by dispossession", whereby mineral-intensive technologies expand new extractive frontiers and create sacrifice zones in formerly colonised countries, reproducing patterns of colonialism. Extending this critique, Dunlap and Laratte (2022) interpret the Minority World's green transition governance as a necropolitical ordering that decides whose lives are worthy of protection and whose lands, bodies, and futures are disposable.

In view of these climate injustices, climate justice recognises the disproportionate impacts of climate change on low-income, Black, Indigenous, People of Colour (BIPOC) communities around the world, as well as the people least responsible for the problem (UC Center for Climate Justice, 2024; Ogunbode et al., 2024). In this light, climate justice is about addressing (historically) uneven impacts, vulnerabilities, adaptive capacities, and responsibilities in relation to the climate crisis and its resulting socio-environmental problems (*idem*).

Building on this definition, Simon Caney (2014), a political philosopher, further distinguishes climate justice between *Burden-Sharing Justice* and *Harm Avoidance Justice*. Burden-Sharing Justice poses the question of how the burdens of combating climate justice should be shared fairly between those who have caused climate change, those who have the ability to pay, and those who have benefited from the activities that cause climate change (Caney, 2014). This question is mostly addressed by climate justice advocates and various non-governmental organisations (NGO's) such as the Climate Action Network, Climate Justice Alliance, and Movement Generation. They argue that developed countries, which have historically polluted more, as well as the countries that have benefited from colonialism, imperialism, and capitalism, should assume responsibility by providing sufficient climate finance and loss-and-damage compensation (Flavia Nakabuye, 2022; Stefan Gaarsmand, 2018; Narain, 2022).

[1] "Majority World" refers to countries in Asia, Africa, the Middle East, Latin America, and Indigenous peoples; when combined holds most of the world's population (Alam, S., 2008). The research uses this as an alternative to 'Global South', which is considered inaccurate given that all "Global South countries" are not always geographically located in the South (Khan et al., 2022). The Majority World reframes the narrative by reminding us that these populations constitute most of the world's people.

Harm Avoidance Justice, by contrast, concerns itself with avoiding harm to those most at risk from climate impacts and transition processes (Caney, 2014). To determine who should bear this responsibility of avoiding harm, Caney (2014) differentiates between first-order and second-order responsibilities. First-order responsibilities covers what agents must do directly to prevent climate injustices (e.g., reducing emissions, enabling harm compensation), whereas second-order responsibilities fall on those actors who are especially well-placed to enable climate justice by shaping the conditions under which the other agents can fulfil their first-order responsibilities (e.g., creating norms that discourage high emissions lifestyles, engaging in civil disobedience). As such, there exists a wide variety of actors who can hold first- and second-order responsibilities in relation to climate justice. This is supported by Trott and her colleagues (2023), who show, through a systematic literature review on climate justice action papers (2008-2020), the complexity and multifaceted nature of climate justice mitigation actions. These actions exist across various spaces (e.g., countries, communities, systems) and scales (e.g., intergenerational, local versus global).

For instance, many social, indigenous, and youth movements often embody second-order responsibilities by opposing themselves to marginalisation, exploitation, oppression, and other systems derived from capitalism and colonialism (Sultana, 2022; Perkins, 2019). These movements focus—amongst other things—on challenging the endless capitalist growth, diverging from fossil fuel industries (Perkins, 2019), resisting extractive activities and low-carbon energy projects (Temper et al., 2020; Goodman et al., 2025), and engaging in a praxis of solidarity, collective, and participatory-based actions (Trott et al., 2023; Ritchie, 2020).

Taken together, these scholarly, advocacy, and movement-based perspectives show the conceptual breadth and the diversity in approaching climate justice. Building on these different understandings, this thesis approaches climate justice as a concept, framework, and practice that highlights the differentiated power structures, socio-environmental disparities, and how these are embedded within multi-scalar and multi-spatial contexts. It deliberately chooses climate justice as it foregrounds the social, colonial, racial, and environmental dimensions of the climate crisis and potential issues with energy transition policies. In the context of energy transitions specifically, climate justice deals with injustices embodied in the supply chain of low-carbon technologies, while acknowledging the extractive and colonial nature of the wider energy systems (Mulvaney, 2024).

## Climate justice in Relation to Environmental and Energy Justice

Having outlined the various meanings, actors, and approaches to climate justice, the next step is to situate it closely in relation to other justice concepts, such as environmental and energy justice. Because any attempt to define climate justice should acknowledge its conceptual fluidity and openness, rather than succumbing to a strict categorisation.

As Donna Haraway (2015) puts it: "All the thousand names are too big and too small; all the stories are too big and too small" (p.160). Following James Clifford, she explains: "[…] we need stories (and theories) that are just big enough to gather up the complexities and keep the edges open and greedy for surprising new and old connections" (Haraway, 2015, p.160). In this light, this thesis uses climate justice as an intersectional term that draws elements from various other justice-related concepts like environmental justice (Schlosberg & Collins, 2014), energy justice (Sovacool et al., 2017), ecological justice (Low and Gleeson, 1998), and eco-justice (Jhagroe, 2024). These terms are often used interchangeably, not because they are identical, but because their histories and applications overlap. In fact, they have influenced one another and, in many respects, fused at times (Schlosberg & Collins, 2014). Still, each concept possesses different emphases, and its applications differ through time, societies, and cultural contexts (*idem*).

Among these related justice concepts, environmental justice is particularly foundational, as climate justice is inextricably connected to the history and principles of environmental justice (Gilio-Whitaker, 2019; Schlosberg & Collins, 2014). Environmental justice first emerged in the United States (US) during the struggle for civil and human rights, in reaction to the disproportionately higher levels of exposure to environmental risks that low-income, Black, Latin, and Indigenous communities were experiencing (Rivera Maulucci, 2023; Walker, 2012). According to Schlosberg and Collins (2014), climate justice solidified itself in the 2000s by making explicit connections to the environmental justice movement: global greenhouse gas emissions are causing localised harms. As one of the first climate-justice-oriented organisations, CorpWatch, claimed: "climate change may well be the largest environmental justice issue of all time" (Bruno et al., 1999). This study chooses climate justice as it grew *from* the environmental justice movement and extends some of its core principles beyond localised pollution and regulatory inequality to embody the climate- and energy-specific dynamics at the heart of this thesis.

Energy justice represents another closely related and, at first glance, highly suitable concept for this research, particularly given its frequent application in energy transition studies

(Salter, 2023). Sovacool et al. (2017) define energy justice as "a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision-making" (p.677). Research often operationalises energy justice through the three tenets approach: procedural, distributional, and recognitional justice (Wang & Lo, 2021). However, this study does not adopt energy justice c for three main reasons.

First, energy justice is almost exclusively based on Western epistemologies and ontologies, which neglect non-Western ways of understanding justice and the world at large (Sovacool et al., 2017). Second, energy justice does not encompass decolonial thought; any analysis based on energy justice, therefore, neglects the lived realities of the Majority World communities, whose energy systems are embedded in colonial infrastructures and experiences filled with violence and dispossession (Tornel, 2023). Third, Lee & Byrne (2019) have shown that energy justice research often misses identifying some key driving forces that systematically reproduce injustices, such as capitalism, technicism, and industrialism. While some scholars have attempted to address these critiques (Sovacool et al., 2017; Castán Broto et al., 2018), the available evidence remains insufficient for this study to implement the concept.

Unlike energy justice, but like environmental justice, climate justice draws on non-Western epistemologies and ontologies by valuing activist knowledge, frontline storytelling, and Indigenous and decolonial scholarship as foundational to its definition. Further, climate justice encompasses the lived realities of the Majority World by acknowledging the existence of phenomena such as "decarbonisation by dispossession" and sacrifice zones. In contrast to energy justice, it consistently links injustices embodied in the supply chain of low-carbon technologies to extractivism, capitalism, and colonialism. Nonetheless, climate justice does not exclude all insights from energy justice. It does, for instance, include distributive, procedural, and recognitional insights, but it embeds them within a broader structural and historical critique. Therefore, in line with Haraway's call for theories that are "just big enough," this study adopts climate justice as a term that holds open the possibility for intersecting narratives and understandings—one that explicitly accounts for historical responsibilities, colonial and imperial legacies, racialised vulnerability, and the structural political economy of climate and energy systems.

## 2.3. S-LCA and Climate Justice

This last section of the literature review brings together the key concepts of this thesis, being S-LCA and climate justice, to examine whether there exists any bridge between the two. It begins with a systematic literature search followed by targeted desk research to complement and deepen the initial findings.

### Web of Science Literature Search

This research performed a short literature search through all Web of Science databases, covering the years 1637-2025. The search returned no results when looking for *Ts = "climate just*" AND ("social life cycle assessment" OR "social LCA" OR "S-LCA")*. This suggests that direct conceptual links between climate and S-LCA remain unexplored in the literature. To broaden the scope of the search, the researcher conducted a second search using more general LCA terminology:

Ts = "climate just*" AND "life cycle assessment"

This search yielded five articles, represented in Table 1. Closer content review showed that two results were irrelevant to this study: the review by Li and his colleagues (2024) and the article by Świąder et al. (2025). The review examines how Integrated Assessment Models (IAMs) represent interactions among economic growth, resource use, and environmental pressures, while the article investigates how different data sources and spatial scales change the estimated food-related carbon footprint of cities. Both academic works fall outside the scope of this study.

Of the three remaining results, only one directly touches upon the intersection of climate justice and LCA: García-Dory et al.'s (2022) article. This article calls attention to the importance for scientists involved in life cycle assessments to reflect on biases, gaps, and assumptions in order to avoid giving misleading results. They also call for diversifying knowledge sources in terms of data input. As they say:

> *"We must ask whose knowledge is included and whose is excluded, linking scientific assessments, including often highly technical life cycle assessments, to questions of justice. Exclusions that emerge from epistemic, procedural, and distributive injustices can damage life chances, while not achieving the aims of environmental protection and climate mitigation."*

The other two articles do not touch upon life cycle assessment but represent attempts to operationalise climate justice. On the one hand, Xue and her colleagues (2024) integrate climate justice considerations into absolute environmental sustainability assessment (ASEA) for chemical products. Although the present study focuses on the relative assessments of socio-economic impacts rather than absolute assessments of biophysical impacts, their work still illustrates how accounting for historical responsibility can significantly influence the study's results. On the other hand, Müller and her colleagues (2022) introduce "hydrogen justice" as a framework to examine justice issues in the emerging hydrogen economy. While this research neither touches upon nor employs sustainability assessment methods, it builds its framework around climate justice by including relational and epistemic justice as central pillars. As discussed later, both relational and epistemic justice also inform the climate justice praxis adopted in this thesis.

The results of this Web of Science literature search show that direct links between climate justice and S-LCA remain nonexistent. From the three somewhat relevant results, only one addresses climate justice in relation to LCA, whereas the two other relevant articles address climate justice without even engaging with LCA. While each of these articles holds some relevant insights for this thesis in terms of climate justice operationalisation, none of them relates to S-LCA.

Table 1: Results of literature review search on all databases of Web of Science on the 4th of December 2025

| Document Type | Publication year | Authors | Article Title | Source Title | Times Cited in all databases of Web of Science | Relevance to this thesis |
|---|---|---|---|---|---|---|
| Article | 2022 | Müller, Franziska; Tunn, Johanna; Kalt, Tobias | Hydrogen justice | Environmental Research Letters | 58 | Relevant |
| Article | 2022 | García-Dory, Fernando; Houzer, Ella; Scoones, Ian | Livestock and Climate Justice: Challenging Mainstream Policy Narratives | IDS Bulletin – Institute of Development Studies | 4 | Relevant |
| Article | 2024 | Xue, Ying; Bakshi, Bhavik R. | Ecosystem Science-Based Absolute Environmental Sustainability Assessment of Chemical Products with and without Climate Justice | ACS Sustainable Chemistry & Engineering | 2 | Relevant |
| Review | 2024 | Li, Hao; Fan, Pengru; Wang, Yukun; Lu, Yang; Chen, Feng; Zhang, Haotian; Zhang, Bin; Wang, Bo; Wang, Zhaohua | Integrated assessment models for resource-environment-economy coordinated development | Wiley Interdisciplinary Reviews: Energy and Environment | 2 | Irrelevant |
| Article | 2025 | Świąder, Małgorzata; Schafer, Luke John; Lysák, Marin; Henriksen, Christian Bugge | How data collection may affect the carbon footprint - The case of carbon foodprint accounting for cities | Ecological Indicators | 2 | Irrelevant |

## Desk Research

Because the prior systematic literature search found no study that explicitly operationalises climate justice within S-LCA, this thesis conducted additional desk-based research to unravel existing, yet scattered, academic contributions that integrate—not climate justice per se but—related concepts (i.e., social justice, gender justice, energy justice) or justice-relevant dimensions (e.g., participatory approaches) into S-LCA.

Neugebauer et al. (2014), for instance, suggest impact pathways explicitly addressing social well-being and social justice. They propose pathways for "fair wage" and "level of education" as social midpoint categories, linking them to endpoint categories "economic welfare, damage to human health and environmental stability". Sánchez et al. (2025), on the other hand, integrate gender aspects in their study on electric vehicle Li-ion batteries to explicitly address gender justice. They do so by including gender-related indicators, such as 'presence of gender non-discrimination policy', 'number of sexual harassment incidents', and 'presence of maternity leave policies'. While both of these studies represent serious attempts at including either social or gender justice, neither provides a structured framework or specific guidance for S-LCA practitioners to base their work on.

In contrast to the first studies, Fortier et al. (2019) move beyond isolated indicators and towards structured and systemised assessments by proposing a framework for S-LCA practitioners to account for energy justice in their studies. This framework suggests a range of indicators for four major stakeholder groups (i.e., electricity consumers, local communities, workers, and society). However, one could point out the lack of methodological transparency and participatory approaches in the selection and validation of these indicators. These limitations render Fortier et al.'s (2019) work at odds with procedural justice—one of the core tenets of energy justice that their work seeks to advance.

A second strand of contributions does not explicitly anchor itself in a defined justice theory but nonetheless still advances justice-related dimensions in S-LCA. A key example is Bouillass et al. (2021), who suggest a step-by-step S-LCA framework to enhance stakeholder participation, thereby indirectly promoting procedural justice. Their framework combines sectoral risk assessment with a multi-actor participation approach to identify and prioritise significant impact (sub)categories. Applied to a case study comparing electric and internal combustion cars, the approach proves how different social groups like workers, unions, users, and public authorities perceive social risks differently. This application also demonstrates how including all perspectives, especially the affected stakeholders, improves the

representativeness and legitimacy of S-LCA outcomes (Bouillass et al., 2021). In so doing, the study moves beyond top-down, enterprise-driven indicator selection and addresses the recognitional justice deficit in S-LCA—a limitation shown in this thesis (see Section '2.1. Social Life Cycle Assessment').

In a similar vein, Bamana et al. (2021) introduce a framework for S-LCA data collection practices that were shown to be useful for eliciting the lived, situated, and heterogeneous social realities. These data collection practices include interviews, focus groups, local public records, cross-validated scales, sustainability development goal data, and remote sensing and imagery. Although Bamana et al.'s (2021) work does not explicitly engage with justice, its emphasis on contextual specificity and acknowledgement of the differentiated local impacts aligns closely with the perspectives brought forth by climate justice activists and frontline storytellers (see Section '2.2. Climate Justice').

**Research Gap**: To this date, there exists no published work on operationalising climate justice within S-LCA. Only a few studies exist that integrate related concepts to climate justice or justice-relevant dimensions into S-LCA. However, these studies remain either limited, partial, and/or methodologically weak. Taken together, they illustrate emerging but methodologically uneven efforts to bring justice considerations into S-LCA. Addressing this research gap is crucial to fulfil this thesis's objective, that is, preventing S-LCAs from becoming a technocratic tool that legitimises necropolitical dynamics in the energy transition (see Section 1.2, 'Problem Definition and Objectives').

# Chapter 3: Climate Justice Praxis

This chapter presents the conceptual framework of *climate justice in praxis* that guides the upcoming data analysis section of this thesis. It then expands on the four pillars that form this framework and situates them in relation to the broader framework.

Since the thesis addresses the question of operationalising climate justice in S-LCA, one needs to go beyond mere conceptualisation and look at climate justice *in praxis*. Sultana (2022) defines praxis as "theoretically informed practice with reflection, one where there is continual feedback and integration" (p.119). Following this definition, she considers climate justice praxis as a practice seeking to operate systemic changes to "address structural inequities and destabilise power systems that produce various climate injustices" (*idem*). As such, she emphasises the need for climate justice praxis to be grounded in feminist, anti-racist, post-colonial, decolonial, anti-capitalist, and activist perspectives (Sultana, 2022). In line with her climate justice praxis and building on the literature review's insights (see Chapter 2), this thesis determines climate justice around four pillars: (1) decoloniality, (2) relationality, (3) inclusivity, and (4) reflexivity.

This thesis understands climate justice praxis as a flower (see Figure 3). Climate justice itself forms the centre of the flower, from which the four pillars emerge as petals. Beneath the surface, in the soil, one can identify the flower's roots, which represent the various perspectives as advanced by Sultana (2022), being activism, anti-capitalism, feminism, anti-racism, and post-colonialism. These roots extend outward to blue spheres, i.e., water and nutrients, which represent both academic fields and lived, community-based knowledge systems. These include political ecology, sociology, political philosophy, ethics, sustainability transitions, NGOs, grassroots movements, and BIPOC communities. The soil represents the shared world in which these knowledge systems are embedded and interconnected.

As such, Figure 3 illustrates the flows of ideas, experiences, and epistemologies from both academic and non-academic settings that sustain the roots and enable the flower to exist. In this way, the thesis aims to acknowledge all the diverse intellectual, political, and community-based contributions that constitute the foundation of this thesis.

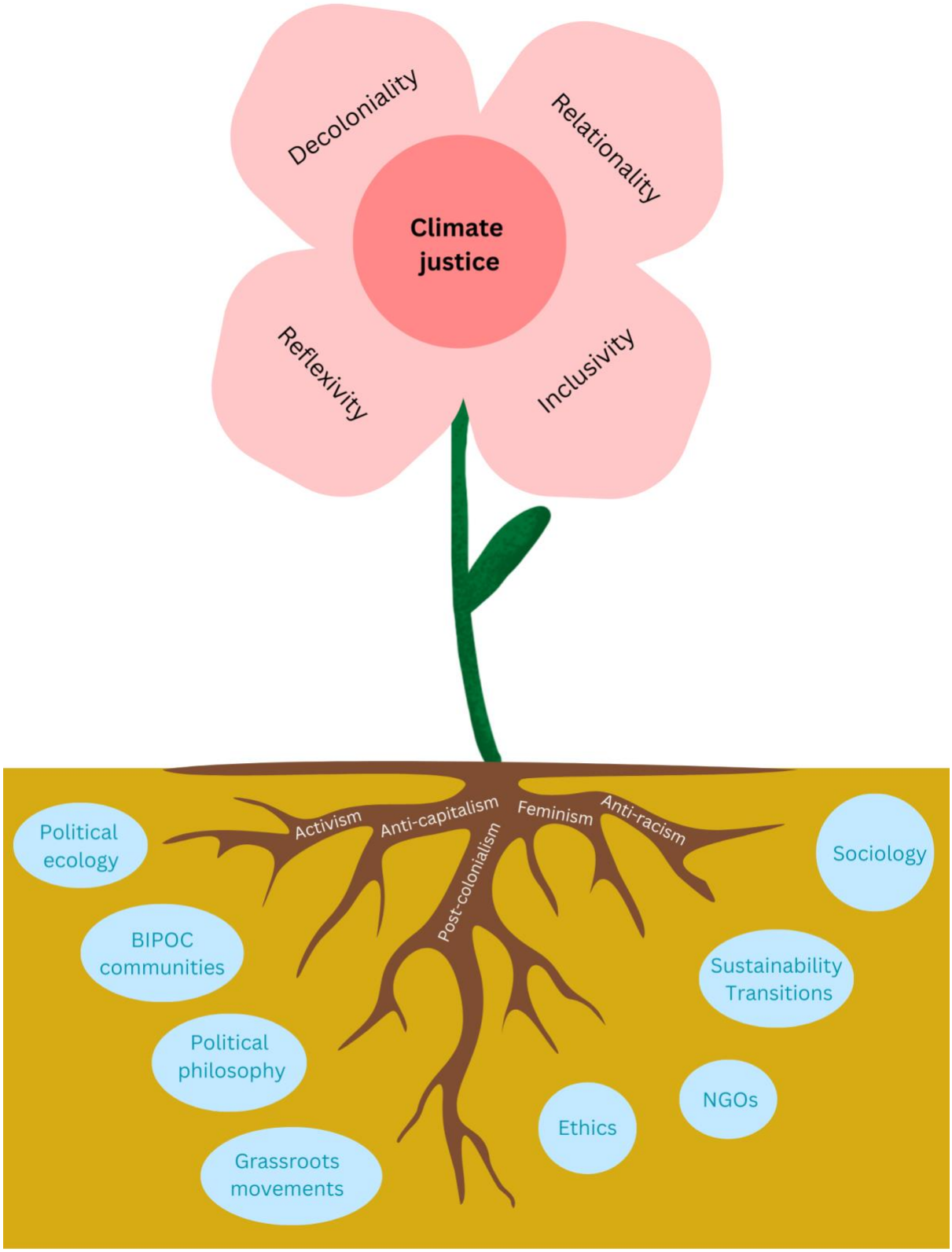


Figure 3: Flower representing climate justice praxis with its four pillars as petals and its grounding as roots (author's work).

## 3.1. Decoloniality

Adopting a decolonial perspective means critically reflecting on how existing power dynamics and colonial histories of oppression are persistent in impact assessments. Such an approach requires "reckoning with how the values, violence, and structures" of coloniality shaped *and continue* to shape the assessment of energy systems (Tornel, 2023, p.49). The Māori scholar Linda Tuhiwai Smith (2022) explains that the main challenge for researchers, who try to decolonise methodologies as "a set of knowledge-related critical practices" (p.xii), lies in working with both colonial and decolonial knowledge systems, decentring the first while centring the second. She further illustrates by saying that decolonising methodologies forces the researcher to confront the hegemony of Western academia not only in its methodologies, but also in its philosophy, pedagogy, ethics, organisational practices, paradigms, and discourses (Tuhiwai Smith, 2022).

As such, decolonising impact assessments or other methodologies has to do with more than simply critiquing colonialism. Such an exercise is an invitation for researchers to acknowledge, question, and critique the colonial ways of assessing energy systems in the Minority World by rendering visible and challenging what in the assessments excludes, limits, or discredits on colonial bases (Boyd, 2021). It is the researcher's responsibility to become aware of different ways to understand the world and actively attempt to reconfigure power dynamics within the process of research (Linda Tuhiwai Smith, 2022). For instance, researchers could draw from Indigenous understandings of ethics and knowledge, through principles such as reciprocity, interconnectedness, accountability, and relationality (*idem*).

## 3.2. Relationality

Integrating a relational perspective entails recognising the centrality of relationships in determining rights, responsibilities, and ways of being in the world (Jones et al., 2024). Drawn from Indigenous principles of kinship politics, relationality underscores the interconnectedness linking humans, animals, and more-than-human entities into a large web of relations that is *kinship* (Larsen, S. C., & Johnson, 2017; Jones et al., 2024). As noted by Potawatomi scholar Kyle Powys Whyte, relationality operates through interdependence grounded in shared responsibilities (2021). These responsibilities require the following qualities: consent, trust, and reciprocity (Jones et al., 2024; Whyte, 2021).

Relationality also encompasses the relationships connecting climate justice advocates with governments, NGOs, corporations, and Indigenous peoples (Whyte, 2021). According to

Whyte (2020), colonialism, capitalism, and industrialisation have systematically induced climate injustices and brought us to what Whyte describes as a *relational tipping point*: a breakdown of ethical relationships. In this sense, relationality is not merely descriptive of interconnectedness, but a diagnostic of today's injustices: without re-established or repaired relationships grounded in consent, trust, accountability, and reciprocity, any climate praxis risk reproducing the very harms they seek to address (Whyte, 2020). Along the same lines, Larsen & Johnson (2017) call for:

> *"[…] a balance between the members of this interrelated web where one member, such as humans, are not allowed to dominate, and where everyone, humans in particular, have lessons to learn about their responsibility to listen and observe their relatives' interactions, in becoming ethical members of this family" (p.121).*

## 3.3. Inclusivity

Inclusivity in climate justice praxis entails more than "just adding participants" to the research project. Rather, this pillar reconfigures whose presence, knowledge, and needs matter in the research process, and to what extent people, other than the researcher, can shape its goals, methods, data, and outcomes (Mikulewicz et al., 2023; Sultana, 2022; Newell et al., 2021).

On the one hand, inclusivity concerns itself with who is involved in the research and under what form: as co-researcher, as participant, as consulted stakeholder, as reviewer, etc. (Perkins, 2023). These roles entail whose capacities and vulnerabilities are recognised and how far participation moves beyond mere consultation or tokenisation to have a real influence on the research process and outcomes (*idem*). However, as Mayes and Arya (2024) demonstrate in their article on climate-justice participatory research, simply labelling a project as "participatory" or "co-produced" does not in itself dismantle entrenched power relations or privilege. To avoid reproducing power hierarchies, researchers should explicitly redistribute power and resources between the researchers and the participants, while remaining iterative and reflexive along the entire research process (Forsyth & McDermott, 2022).

On the other hand, inclusivity challenges what counts as legitimate knowledge within research. From a climate justice praxis, this pillar calls for embracing plural epistemologies in research, where the ways of knowing and experiences of those most affected by climate injustices hold as much legitimacy and recognition as Western ones (Wilkens & Datchoua-

Tirvaudey, 2022). This perspective enhances epistemic justice by challenging hierarchies in which Western scientific knowledge systems are regarded as the sole or the superior basis for valid knowledge, while other knowledge systems are marginalised, extracted, or reduced as simple "add-ons" to Western ones (Davies & Stranding, 2023). Building on this understanding, engaging with inclusivity requires researchers to proactively create conditions in which participants can shape the research on their own terms, rather than merely giving insights for data within predefined Western epistemic paradigms (Wilkens & Datchoua-Tirvaudey, 2022; Davies & Stranding, 2023; Sultana, 2022).

That being said, inclusivity recognises the homogeneity of people, where overlapping differences of gender, class, age, citizenship, and privileges determine exposure to climate injustices in the context of the energy transition (Johnson et al., 2020). This pillar thus also pays attention explicitly to intersectionality, rather than treating people as unified wholes (*idem*).

## 3.4. Reflexivity

Reflexivity, as the fourth and last pillar, cuts across the three other ones by inviting researchers to continuously reflect on their positionality throughout the research process. According to Jamieson and her colleagues (2023), reflexivity represents an iterative and continuous process of knowledge production, in which the researcher critically reflects on how their privileges, education, gender, cultural background, ethnicity, socio-economic class, imply certain assumptions and biases which, in turn, influence the research. For instance, reflexivity requires the researcher to question the framing chosen to study a certain phenomenon, because what counts as a problem for the researcher shapes what solutions appear plausible and whose experiences matter (Woroniecki et al., 2019). As such, this pillar, that is reflexivity, defies the concept of a "neutral researcher" by recognising that researchers inevitably influence their own research, often in ways they might not even be aware of (van Geene et al., 2025).

Even though reflexivity is a well-established concept within qualitative research, it struggles to pervade quantitative research as it is commonly perceived as subjective and, therefore, incompatible with positivist ideals of objectivity and scientific rigour (Field & Derksen, 2020). However, many authors argue that reflexivity strengthens, rather than weakens, quantitative research by being a means to deal with the researcher's influence on the research by either isolating it or working it into the research (Jamieson et al., 2023; van Geene et al., 2025; Field & Derksen, 2020). By taking a reflexive stance, researchers can intentionally

and transparently engage with and, when necessary, reshape the underlying motivations and assumptions of their study (Ricker, 2017).

# Chapter 4: Methodology

This section concerns itself with the methodological approach of this study. It presents the underlying philosophical worldview, the research design derived from this worldview, and the specific research methods, in turn, related to the research design. This study follows an action research design to explore the operationalisation of climate justice in S-LCA practice. To do so, it uses elicitation interviewing as a data collection method and content analysis as a data analysis method.

## 4.1. Worldview

The thesis is grounded in an advocacy and participatory worldview, which holds that research is intrinsically intertwined with politics and focuses on bringing about social change (Creswell, 2009). In this light, the project positions itself not as a neutral and detached inquiry but as *action research*, where the researcher acts as a change agent seeking to improve a real-world problem in a participative manner (Gray, 2022).

The literature review (see Chapter 2) clearly demonstrates the need to critically evaluate and advance S-LCA as a tool for supporting just energy transitions; in response, this research seeks to do so through collaboration with S-LCA and climate justice experts. Drawing insights from various fields, such as political ecology and political philosophy, while building upon critical theory and decolonial thought, the researcher and the participants bring plural epistemologies together into a joint understanding of the subject matter. As such, this thesis is practical, transdisciplinary, and collaborative, completed *with* others, instead of *on* others (Creswell, 2009).

## 4.2. Research Design

This section describes the overall research approach or design logic of this action research project. This project is mostly exploratory because it represents an entirely new field of inquiry (see 'Research Gap', p. 23), that is, the exploration of the intersections between S-LCA and climate justice. Yet, the research also encompasses prescriptive elements because it advances a novel climate justice-based praxis approach to S-LCA.

To guide this transdisciplinary and participatory research, this research follows an iterative inquiry strategy for action research inspired by Lang et al.'s article "Transdisciplinary research in sustainability science: practice, principles, and challenges" (2012). Drawing on Lang et al.'s

ideal-typical model of transdisciplinary research proposed in the article, this thesis follows three phases:

**(1) Collaborative problem framing**

**(2) Co-creation of solution oriented approach**

**(3) Critical evaluation**

Figure 4 summarises these three phases. Phases 1 and 2 relate to a sub-research question, while Phase 3 represents the discussion section of this thesis. Together they form an interconnected and iterative process. The literature review and conceptual framework constitute the backbone of all three phases.

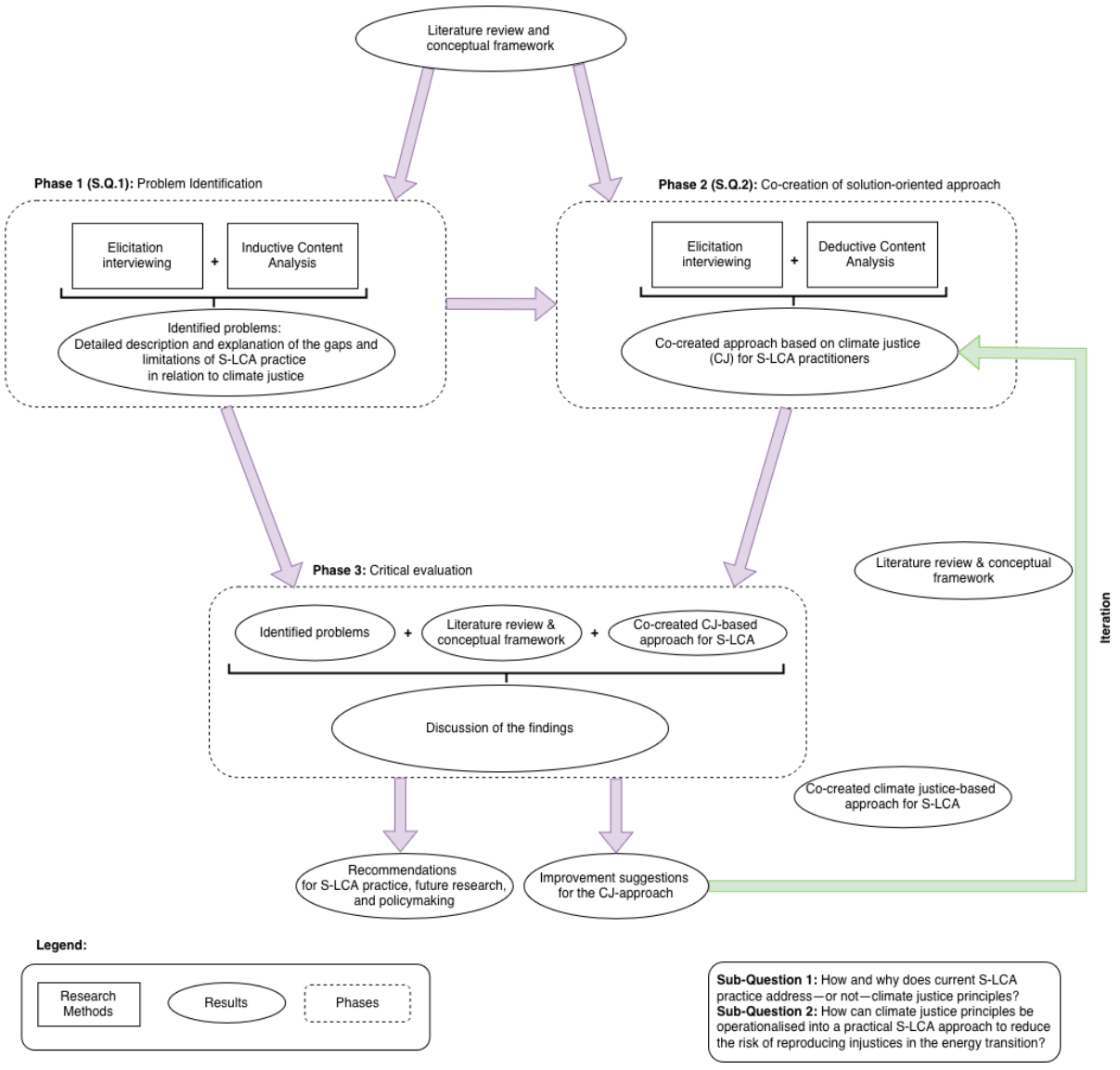


Figure 4: Research design based on Lang et al.'s (2012) three phases for transdisciplinary research

## Phase 1—Collaborative problem framing

Phase 1 consists of identifying and describing the problem at hand (Lang. et al, 2012). The problem is translated into a boundary object that is researchable and enables the translation of the insights into scientific knowledge and societal implementation. This phase deals with the following sub-research question: How and why does current S-LCA practice address—or not—climate justice principles?

This phase provides a detailed description and explanation of the gaps and limitations of S-LCA practice in integrating climate justice. Unlike the model of Lang et al. (2012), it does not include the research participants in defining the research objectives or questions, nor does it rely on a collaborative research team. This difference is a result of the thesis project's constraints: The research is an individual process where the problems and questions were defined at the earliest stage, before the research could even turn collaborative. However, the research method used for this phase, that is, elicitation interviewing, allows participants to orient and frame the research problem through their perspectives and experiences. While this first phase is less collaborative than envisioned in Lang et al.'s model, it still retains a participatory dimension.

## Phase 2—Co-creation of a solution-oriented approach

Lang et al. describe this phase as the "actual doing of the research" with the co-production of a solution to the problem identified in Phase 1. Phase 2 aims at answering the following sub-research question: How can climate justice principles be operationalised into a practical S-LCA approach to reduce the risk of reproducing injustices in the energy transition?

The co-production in this case materialises into a step-by-step approach for S-LCA practitioners to operationalise climate justice in their practice. The design of this approach holds certain criteria laid by Langkau et al.'s (2023) work on creating a stepwise approach for prospective LCA. Although their work does not directly address S-LCA nor climate justice, it provides clear guidance on how to create a new framework for LCA practitioners. As such, the present research adopts three criteria, as outlined in Langkau et al. (2023):

- The approach should be easily applicable and understandable by small-scale S-LCA practitioners.
- The approach should be based on the steps as outlined by the UNEP Guidelines, and aligned with its terminology, so it can be readily integrated into the existing S-LCA framework as determined by the UNEP Guidelines.

- The approach delivers practical benefits, both scientifically and societally.

Following this set of criteria, the researcher created an initial draft of the climate justice-based S-LCA approach through an interactive process of discussions with the supervisors and reflexive analysis (see Appendix 1). The researcher already filled some of the boxes of this initial draft based on the literature review's insights to provide concrete examples for the participants. She then used the draft as prompting material during elicitation interviews, where participants and the research collaboratively modified it in real time. Thereafter, the researcher synthesised the interview's inputs and iteratively refined and validated the approach through a validation round (see further section 4.3.1).

### Phase 3—Critical evaluation

This phase focuses on critically evaluating the outcomes of Phases 1 and 2. In Lang et al.'s (2012) model for transdisciplinary research, Phase 3 constitutes an additional, dedicated empirical phase. Due to time constraints, this thesis does not conduct this third research phase. Instead, the discussion section of this thesis embodies the evaluative and integrative functions of Phase 3. As a matter of fact, the discussion evaluates the first two phases of the research in light of future researchers, practitioners, and policymakers, as Lang et al. (2012) recommended. For instance, the discussion entails recommendations on how to improve the climate justice-based approach for future research. These improvement suggestions can be reintegrated into Phase 2, thereby closing the loop (see Figure 4).

## 4.3. Research Methods

This section describes the research methods used in this thesis project. Building on the research design, this thesis employs transdisciplinary and participatory qualitative methods as data collection methods, and content analysis as a data analysis method. Table 2 shows the two sub-questions underlying the main research question, as well as their distinctive research methods.

Table 2: Summary of sub-questions and related research methods

| Sub-questions | Data Collection Methods | Data Analysis Methods |
|---|---|---|
| How and why does current S-LCA practice address—or not—climate justice principles? | Elicitation interviewing | Inductive content analysis |

| | | |
|---|---|---|
| How can climate justice principles be operationalised into a practical S-LCA approach to reduce the risk of reproducing injustices in the energy transition? | Elicitation interviewing | Deductive content analysis |

### 4.3.1. Data Collection Method

To conduct the three phases in a transdisciplinary and participatory manner, the research utilises elicitation interviews to answer both research sub-questions.

Elicitation interviewing refers to an oral interviewing technique that draws on visual, verbal, physical or written stimuli to help participants articulate their ideas (Barton, 2015; Kahlke et al., 2024). Unlike the more commonly used in-depth interviews that solely rely on oral discussion, elicitation interviews encourage the use of prompts, such as diagrams and concept maps, to be part of the interview. They facilitate connection between the researcher and the participant, facilitate communication, support the expression of tacit knowledge, and promote deeper reflection (Barton, 2015). This technique is specifically suited for this study because the interviews function as a co-production of knowledge that includes the co-creation of a framework. Indeed, the visual and diagrammatic nature of the framework renders elicitation a great tool for participants to present their insights while being able to sketch or draw conceptual elements during the interview. Elicitation interviews not only help in constructing (i.e., participants discuss something they create), but also in arranging (i.e., participants organise and discuss concepts), and explaining (i.e., participants articulate their understanding of a concept); all functions are essential for collaborative framework development (Kahlke et al., 2024).

This research abides by the ethical standards established by the Human Research Ethics Committee (HREC) of TUDelft by ensuring informed consent from the participants, avoiding any form of harm, and respecting their privacy. As such, the researcher required the participants to sign a declaration of informed consent before each interview (see Appendix 3). By signing such a form, participants have consented to the use of their name, position, and expertise in the report. All participants could review and approve this before the report's submission. Appendix 2 provides more information on how the checklist, Data Management Plan, and Informed

Consent Forms supported the researcher in handling the thesis's ethical concerns with the necessary care.

### Sampling Strategies for Elicitation Interviewing

Regarding the sampling strategy, the study utilises non-probability purposive and snowball sampling. It is purposive as the research selected participants based on specific characteristics relevant to the research subject (Gray, 2022). The research indeed carefully chose eight research participants, each holding specialised knowledge and/or lived experiences relevant to the intersection of S-LCA and climate justice. The strategy is also based on snowball sampling, where the researcher identified a few participants relevant for the research, who in turn, identified others through their network (Gray, 2022). Table 3 summarises key information on the research participants.

Table 3: Information on the research participants

| Participants | Position | SLCA Expertise | Climate Justice Expertise |
|---|---|---|---|
| Participant 1 | Postdoctoral researcher in Energy & Sustainability Systems | Applied SLCA expert with focus on methodological development, value-chain representation, and prospective SLCA in energy systems | No expertise, but research interest in social impacts of energy transitions and decarbonisation pathways, including burden shifting |
| Participant 2 | PhD candidate in Energy Justice & Governance of Sustainability | No expertise, but conceptual familiarity | Research explicitly focuses on forms of (in)justice in the Dutch energy transition to advance participatory decision-making tools |
| Participant 3 | PhD candidate in Climate change, & Complex Systems and Networks | No expertise, but interest through lifecycle-based justice discussions | Research explicitly focuses on operationalising energy justice in models used in decision-making processes |
| Participant 4 | PhD candidate in Philosophy of Engineering, Technology Assessment, and Science | Methodological expert with focus on ethical assessment of the SLCA framework | Research explicitly focuses on the ethical assessment of SLCA in the context of the energy transition |
| Participant 5 | PhD candidate in Industrial Ecology | Applied and methodological expert in SLCA with focus on conceptual foundations and added value of SLCA compared to qualitative social assessments | No expertise, but basic familiarity with climate justice concepts through her academic background in Industrial Ecology |

| | | | |
|---|---|---|---|
| Participant 6 | PhD candidate in Industrial Ecology | No expertise, but conceptual familiarity | Research explicitly focuses on modelling how climate change affect well-being, inequalities and justice across income, gender, and social groups |
| Participant 7 | Associate Professor in Civil Engineering | No expertise, but conceptual familiarity as applied and methodological expert in E-LCA | Research focuses on sustainability assessment, value-sensitive design, and justice concepts (e.g., such as intergenerational and distributional justice) |
| Participant 8 | PhD candidate in Industrial Ecology | Critical applied and methodological expert in S-LCA and E-LCA | Research critically examines LCA from a climate justice and political economy perspective |

### Conducting Elicitation Interviews

The research conducted data collection through online elicitation interviews, with the help of an interview guide, which can be found in Appendix 4. Each interview lasted around 60 minutes and was recorded with the researcher's computer-built-in microphone. Following the guide, the interview started with an introduction to build a connection with the participant, explain the purpose of the project, and introduce the interactive and visual components of the interview. Then, the researcher prompted the participants with three questions aiming at answering the first sub-research question, thereby realising the collaborative problem framing. After that, the researcher embarked the participants on the co-creation process, aiming at answering the second research question on operationalising climate justice. To do so, the researcher introduced the stimulus, being the draft approach (see Appendix 1), and invited the participants to (1) construct, (2) (re-)arrange, and (3) interpret or critique elements of the draft approach. In this co-creation process, participants were invited to critically reflect on other participants' insights to enable collaboration, despite not being together[2]. Lastly, the interview ended with conclusive questions and explanations of the next steps, including the validation round.

During the interview, both the researcher and the participant would interact in real time using the draw.io platform online. After the co-creation elicitation interview, the researcher synthesised the participants' insights and updated the matrix accordingly. The revised version of the approach was then shared with the participants for a validation round, which serves to review how their input was interpreted and integrated. Participants could then request any clarifications or adjustments, or withdraw any information given during the interview. They could do so by either directly modifying the draw.io document or sending written comments back that were subsequently implemented in the matrix or transcript. The elicitation interview with the validation round supports an iterative, co-creative research process, as proposed by Lang et al. (2012).

[2] A focus group was initially considered the ideal setting for such a collaborative project as this thesis, but it was not possible given half of the participants resided abroad.

### 4.3.2. Data Analysis Methods

This thesis uses qualitative content analysis to scrutinize and interpret the empirical data. It employs inductive content analysis for the first research question and deductive content analysis for the second one.

#### Inductive Content Analysis

For the first phase of the research on participants' perceptions of how current S-LCA practice addresses climate justice, the analysis of the interviews followed an inductive qualitative content analysis. This type of research method derives codes and categories directly from raw textual data, rather than through a predefined framework (Gray, 2022). The data for this phase of the research arises from the first three questions of the interview guide (see Appendix 4). This data was transcribed and analysed through content analysis. This process resulted in a total of 39 initial codes across all transcripts. Through this content analysis, the researcher iteratively organised the open codes in categories and, while doing so, found other relationships between categories, until selecting final categories. The first two categories identified were 'perceived extent to which current S-LCA practice integrates climate justice' and 'primary explanations for why S-LCA does not comprehensively address climate justice'. These two categories were refined into five dimensions: (1) indirect integration, (2) inadequate integration, (3) failed integration, (4) methodological constraints, and (5) epistemic constraints. Table 4 shows an example of this dataset with open codes. The analysis was then followed by situating the data within the literature review.

Table 4: Examples from the dataset developed through inductive content analysis

| Dimension | Open Code | Participant | Raw data |
|---|---|---|---|
| Methodological constraints | Ambiguity of UNEP Guidelines | Participant 5 | "UNEP Guidelines being very, very ambiguous into what S-LCA actually is. I spent six months opening this document every day and I still didn't really understand when you would perform a social LCA, what the UNEP Guidelines want you to do." |

| | | | |
|---|---|---|---|
| Epistemic constraints | Limitations of S-LCA epistemology in translating lived experiences | Participant 2 | "Quite often you will see that stakeholders themselves will also focus on translating their experiences, their feelings, what they see around them into scientific language and scientific data" |

### Deductive Content Analysis

For the second phase of the research on operationalising climate justice in S-LCA, the analysis of the interviews followed a deductive qualitative content analysis, where data were categorised according to a predefined frame (Gray, 2022). The frame represents, in this case, the matrices (see Appendix 1). The columns represent the four pillars of climate justice (see Chapter 3), while the rows represent the 17 elements cited in the "goal and scope definition" phase of the UNEP Guidelines. This phase was selected because the whole research process in LCA is anchored in this goal and scope phase. Indeed, as stated in the literature review on S-LCA, it pre-determines what is modelled in the LCI, how impacts are characterised in LCIA, and which questions the interpretation phase is allowed and required to answer. Thus, analysing the climate justice principles at this level offers the greatest leverage for shaping the entire S-LCA practice, while also remaining feasible within the scope of this thesis. To do so, the present deductive content analysis follows the three steps proposed by Flick (1998):

1. **Summarising content analysis**: paraphrasing of the material and elimination of irrelevant passages
2. **Explicating content analysis**: clarification of ambiguous or contradictory passages by contextualising the data by including defining terms and extracting statements from the transcript
3. **Structuring content analysis**: identification of key features in the data, and further focus on these specific features

For the third step, the researcher identified five key features: (1) assumptions and value choices, (2) S-LCA practitioner, (3) inclusion or exclusion of stakeholders, (4) social impact (sub)categories selection & involvement of stakeholders, (5) data. These features were identified by the participants themselves as the most important aspects to examine. This choice also clearly reflects in the data itself, as these five features—being five rows in the matrices of Appendix 1—contain by far the highest number of inputs compared to the other rows.

Inevitably, however, this choice narrows the analysis to particular elements of the results, thereby excluding others. This limitation also reflects a broader drawback of deductive content analysis. As Gray (2022) notes: “the very conceptual structures that deductive content analysis imposes on the data may obscure some of the interpretations that may have emerged inductively from within it” (p.329). This study accepts this limitation due to time constraints. Future research should, though, engage in a more in-depth analysis of the remaining material (see Section 6.4).

# Chapter 5: Results

This chapter presents and analyses the empirical data collected through the elicitation interviews. It is organised into two sections, following the first two phases of the research design (see Section 4.2). The first section advances the results of the collaborative problem framing phase (i.e., identified problems), while the second one presents the climate justice-based approach resulting from the co-creation phase. After describing the findings as they are, each section analyses them in relation to the literature review.

## 5.1. Phase 1: Identified Problems

This section presents the results concerning the first sub-research question on how and why current S-LCA practice addresses climate justice principles.

While Appendix 5 contains all results for this first research phase, Figure 5 synthesises these results by presenting participants' insights across two axes. The x-axis captures the perceived extent to which current S-LCA practice addresses climate justice. It ranges from "failed integration" to "indirect integration". Noticeably, the axis does not extend to "comprehensive integration", as none of the participants claimed that S-LCA practice comprehensively addresses climate justice. The y-axis represents participants' primary explanations for their perceptions of climate justice integration within S-LCA, ranging from epistemic constraints to methodological constraints. Together, these axes display two spectrums rather than binary divides to reflect the nuanced and varying perspectives expressed by the participants.

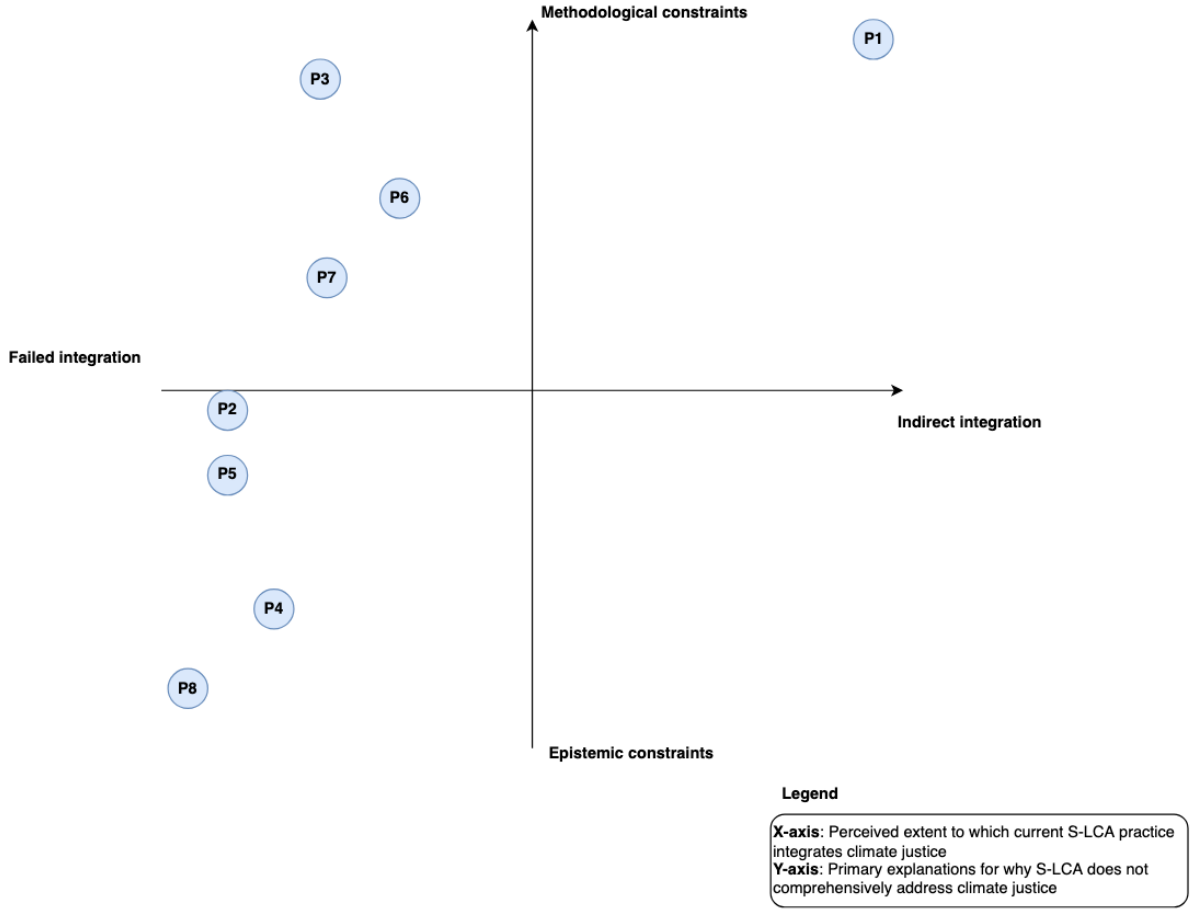


Figure 5: Double-axis figure to map participants' perceptions of climate justice integration within S-LCA and their primary explanations

### 5.1.1. Results: Perceptions of Climate Justice Integration within S-LCA

This sub-section focuses on the x-axis, answering the first part of the research question, being, *how* does current S-LCA practice address climate justice principles?

As shown in Figure 4, all participants, with the exception of Participant 1 (P1)[3], agree with the statement that current S-LCA practice inadequately or fails to address climate justice. P1 is not diametrically opposed to the other participants, though, as they do not claim that S-LCA practice comprehensively addresses climate justice. Rather, they state that S-LCA addresses climate justice, but only so *indirectly* by encompassing (sub)categories related to the concept, such as forced labour, child labour, and community impacts. As such, they state that climate justice "is not the direct goal of S-LCA" but that practitioners can make an "indirect effort" for its integration in S-LCA. P1, therefore, gives the most optimistic assessment of S-

[3] For simplicity, the participants are referred to as Participant 1 (P1), Participant 2 (P2), and so on, throughout the text.

LCA's current capability in accounting for climate justice, though still acknowledging its limitations.

At the other end of the horizontal spectrum, P8 advances a more radical critique than any of its counterparts. P8 claims that S-LCA practice currently fails to, and will never be able to, integrate climate justice. P8 indeed considers S-LCA as an obsolete framework, which should not be used at all. As P8 puts it, "it does not make sense at all to expand social LCA with climate justice" as "it [S-LCA] is just an inherently wrong approach". P8 further contends that S-LCA functions as "a perpetuating tool, meaning it perpetuates the system of exploitation which it is meant to uncover." This position demonstrates not only a rejection of climate justice integration within S-LCA, but also a fundamental questioning of S-LCA's validity and legitimacy, as a framework as well as a practice.

Between these two ends of the x-axis lie all remaining participants (see Figure 4). These participants express various degrees of scepticism about S-LCA's ability to address climate justice, without fully rejecting it altogether. As such, they position themselves closer to P8 than to P1. For instance, P5 expresses uncertainty on whether S-LCA is suitable for qualitative assessments, and thereby climate justice. P5 puts it as such: "I am just anyway already quite hesitant on how social LCA could […] capture climate justice […] because S-LCA does not capture anything qualitative and it also should not." While P5 expresses uncertainty about the function of S-LCA, participant 4 asserts that S-LCA, at its core, "tries to promote social sustainability and justice by assessing impacts and risks using indicators." At the same time, P4 recognises how S-LCA, as currently practised, can reproduce injustices, aligning with P8's insights on S-LCA as a "perpetuating tool". As P4 further explains: "When used as a decision-making tool, [S-LCA] can be misused to state that it is solving things that it does not." However, whereas P8 rejects S-LCA altogether, P4 articulates a dilemma about whether it should still be used despite its flaws. As P4 reflects: "[…] we are lacking alternatives of methods, right? […] whether we should be happy with what we have […] or whether it is too harmful and to not use it at all, but then what are we doing in terms of [assessing] social sustainability and social justice."

**Conclusion:** The results indicate a spectrum of perspectives on how S-LCA engages with climate justice. One participant claims current indirect integration, whereas another one claims impossible integration and categorical S-LCA's rejection, and the remaining participants inadequate integration with potential for modification.

### 5.1.2. Results: Primary Explanations

This sub-section builds upon the previous one by expanding on the participants' explanations as to why S-LCA, indirectly or inadequately integrates climate justice, or completely fails to do so. As shown in Figure 4, the y-axis situates participants along a spectrum between methodological and epistemic constraints. Notably, most participants evoked a combination of constraints; therefore, their positioning on the figure represents the dominant orientation of their reasoning. As such, Figure 4 shows half of the participants (P1, P3, P6, P7) positioned closer to the methodological end of the spectrum and the other half (P2, P4, P5, P8) closer to the epistemic one.

#### Methodological constraints

Participants whose justification predominantly focuses on methodological constraints—P1, 3, 6, and 7—argue that the current tools and procedures of S-LCA are insufficient or limited to operationalise climate justice. Across these accounts, a central methodological issue arises: There is no standardised guidance or established practice for integrating climate justice within S-LCA. Participant 1 illustrates this point by mentioning the difficulty of operationalising climate justice, as there exists "no general consensus or guidance" in UNEP Guidelines, or elsewhere, on how to do so. Participant 5 further asserts that the UNEP Guidelines, specifically, are overly flexible, blending approaches in ways that allow S-LCA practitioners to shape and determine the study to their liking. P5 indeed mentions that UNEP Guidelines are very ambiguous: "I spent six months opening this document every day, and I still did not really understand when you would perform a social LCA, what the UNEP Guidelines want you to do?" This lack of protocols and guidance, they argue, leads to a non- or poor integration of climate justice in S-LCA.

This methodological gap also hampers S-LCA practitioners from engaging with reflexivity, particularly when it comes to identifying and critically reflecting on underlying assumptions and biases throughout the research process. Several participants argue that, without structured protocols, practitioners are unlikely to deal with these assumptions and biases, which can lead to important justice implications. For instance, P1 highlights how unexamined assumptions about system boundaries can obscure climate injustices in relation to material extraction, noting that: "if we focus in the top tiers of the value chain, only the production, manufacture, or the use of the technology, we are missing these climate justice problems that are affecting the vulnerable groups who extract these raw materials." Similarily,

P8 gives another example on how assuming unrealistic system boundaries can neglect important social impacts. As P8 explains, when practitioners define the "system boundaries [as] cradle-to-gate, […] which does not exist in reality", then "we are caught in a production system logic where we produce to gates and all the relevant impacts are ignored." P8 further illustrates that, by assuming such system boundaries, practitioners might know the impacts of phosphate's production for grenades but "the way the grenades are used to blow up children in Palestine becomes out of the question."

While these examples underline the consequences of unexamined assumptions, some participants stress that critically reflecting on the latter is extremely demanding. Participant 3 points out that addressing these assumptions requires "a tremendous amount of cognitive effort to be reflective of every single assumption", making it "unreasonable to expect people to do this […] unless there is a very strong regulation or guidelines". P4 supports P3's view by explaining how difficult practising reflexivity is for S-LCA practitioners, often engineers through formation, and that they *need* explicit guidance indicating "here is an assumption being made", or "here is the space for biases".

Moreover, participants criticised the participatory approaches, as given by the UNEP Guidelines, arguing that they are too limited to support meaningful inclusivity. Participant 7 highlights how "often the practice is to give a survey", which P7 describes as "not very informative of what the realities are, especially if you are seeking to involve vulnerable groups." Echoing this concern, P3 signals how participatory practices are often instrumentalised in S-LCA practice. P3 contends that practitioners most often involve stakeholders to increase social acceptance of the study, rather than to advance inclusivity.

Nonetheless, several participants note that, even if the UNEP Guidelines would provide specific guidance on how to integrate climate justice in S-LCA, practitioners would still be limited because of a lack of available data. As P4 explains: "Even if practitioners want to include some climate justice-related subcategories, they might not be able to because there is a lack of data, which is a limit of the method, not the engineer's capacities." P4 further portrays this as the most significant problem in S-LCA since practitioners will "only assess what is technically possible to assess, but not what they should assess; what is normatively justifiable to assess." This, in turn, P4 says, "limits the scope of the study" and the extent to which S-LCA can account for climate injustices. As such, Participant 8 contends that "the uncertainty underlying […] the assessment is higher than the value it brings."

## Epistemic constraints

Participants whose justification predominantly focuses on epistemic constraints—P2, 4, 5, and 8—argue that the S-LCA framework and the practitioners' epistemologies limit or entirely prevent the operationalisation of climate justice in S-LCA.

P2, P4, P5, and P8 all trace S-LCA's epistemic limitations to its alignment with E-LCA, as part of the LCSA framework. As Participant 4 questions, this structural alignment raises the concern of "whether S-LCA's conceptual closeness to E-LCA is a good idea in the first place". Participant 8 explains that the problem stems from S-LCA being designed to fit the LCSA framework, which is rooted in a post-positivist worldview that assumes an approximation of "an objective truth that can be measured." Consequently, S-LCA became "an accounting tool", which cannot and is not meant to "uncover questions related to climate justice" because its "structurally disconnected from the questions it's asking." P8 argues that the socially and politically embedded lived realities that S-LCA aims at assessing require alternative paradigms, other than post-positivism, to account for their multifacated nature. Participant 2 also critiques S-LCA's reductionist logic by noting that it "cannot cover any or every part of the lived experience of social impact." P2 further criticises the paradigm of S-LCA as it is based on Western epistemologies, which require "stakeholders themselves to translate their experiences, their feelings […] into scientific language and scientific data." By being embedded in Western scientific epistemologies, P2 argues that S-LCA is unable to capture the lived realities of climate injustices in energy systems.

Some participants (i.e., P2, P3, P4, and P8) further argue that this foundational mismatch translates into a systematic inability to account for historical and structural dimensions of climate injustices, such as colonialism, imperialism, capitalism, and extractivism. Participant 2 points out that social impacts, such as dispossession and sacrifice zones, will always stay misevaluated if one isolates these from their respective "power structures, […] hierarchies, financial dependencies […] and colonial legacies". Participant 7 agrees by saying that, in reality, "a product is not going to be produced or used in isolation […] of justice and power", but also notes that it is "naive to expect that every social LCA will be […] a thorough analysis of power dynamics."

Furthermore, participants assert that epistemic constraints also emerge from the practitioners themselves, who most often have limited to no knowledge in ethics or social sciences, thereby making it difficult to integrate climate justice principles. When asked "who is doing the social life cycle assessment", Participant 4 answers that "it is engineers […] it is a

method created by and for engineers." So, "it is not their fault that they do not have this awareness" on climate justice because they simply never received training to acquire the skills needed to engage with such concepts. As Participant 3 reminds, "it is the educational and professional backgrounds of the practitioners" that determine the extent to which practitioners will engage with the various climate justice principles.

> **Conclusion:** Half of the participants assert that S-LCA's limitations in addressing climate justice mainly stem from the absence of clear methodological guidance and a lack of data, while the other half emphasises deeper epistemic constraints, embedded in both the S-LCA framework and the practitioners themselves. By being methodologically immature and epistemologically narrow, S-LCA is limited in its capacity to comprehensively capture the lived and locally situated realities of climate injustices in energy systems.

### 5.1.3. Analysis of Results

This section serves to reflect on the results by critically reflecting on them and situating them in relation to the literature. Before delving deeper into the main analyses of the results, it is important to note that most participants perceiving S-LCA as failing or inadequately integrating climate justice confirm the insights of the short systematic literature search on Web of Science (see Section 2.3, 'S-LCA and Climate Justice'). There exists, thus, not only no study, but also no practice yet, that directly and explicitly attempts to operationalise climate justice within S-LCA. This reinforces the need for the upcoming phase of this research, being the co-creation of a climate justice-based approach for S-LCA (see Section 5.2, 'Phase 2: Co-created Climate Justice-Based Approach for S-LCA').

## Methodological Constraints

The findings confirm critiques that S-LCA remains methodologically immature and fragmented (Ramos Huarachi et al., 2020; Pollok et al., 2021; Chabrawi et al., 2025; van Dulmen et al., 2025). Indeed, participants consistently pointed to the absence of protocols, ambiguous guidance, and excessive flexibility, especially in relation to the UNEP Guidelines. These observations substantiate Pollok et al.'s (2021) description of S-LCA as a "young and immature method" and Chabrawi et al.'s (2025) demonstration of S-LCA's methodological challenges, including a lack of a "homogeneous code of practice". This points towards the fact

that S-LCA may very well still be in the "search for standardisation" phase that, according to Ramos Huarachi and his colleagues (2020), started almost ten years ago. Furthermore, participants' experiences of the method's lack of data relate to another critique about the limited availability of quantifiable and reliable data for S-LCA, especially primary and site-specific data (Chabrawi et al., 2025; Grubert, 2020; Bamana et al., 2021). The participants raised the same consequence, being an overreliance on secondary aggregated data, which, in turn, can mask within-country heterogeneity and local vulnerabilities (*idem*). By being methodologically non-standardised and empirically under-resourced, current S-LCA practice is limited to operationalising climate justice.

Moreover, although UNEP Guidelines encourage stakeholder participation, the results show that the inclusion of affected stakeholders is often instrumentalised and tokenised for "justice washing". In line with the literature, participants have warned that these mere symbolic types of inclusivity lead to perspectives of designers and manufacturers outweighing those of affected stakeholders experiencing climate injustices (Zanchi et al., 2018; Tokede & Traverso, 2020). From a relationality lens, purely figurative forms of participation also constitute a violation of the consent, trust, and reciprocity between the practitioners and the stakeholders (Whyte, 2021; Larsen & Johnson, 2017). In fact, by utilising these forms of participation, S-LCA advances the *relational tipping point*, that is, the breakdown of ethical relationships with no possibility of return, as described by Whyte (2020). From a decolonial point of view, these figurative and extractivist forms of participation transform stakeholder engagement into a procedural formality for legitimising some predetermined objectives instead of meaningful co-definition of the goal and scope. In doing so, S-LCA undermines its own claims to social legitimacy and reinforces already-asymmetrical power relations between practitioners and affected stakeholders.

## Epistemological Constraints

Beyond the already-documented methodological weaknesses, the findings unravel deeper epistemic limitations that are absent from the literature so far. Participants demonstrate how S-LCA, basing itself on E-LCA's modelling capacities and framework, induces an epistemological misalignment. While this assimilation has been defended on the grounds that it enables integration within the LCSA framework (UNEP, 2020), participants revealed that this design choice prevents S-LCA from comprehensively assessing the lived and situated realities of climate injustices in energy systems. In fact, S-LCA is embedded in a post-positivist

paradigm that decontextualises data and privileges Western epistemologies that translate complex social impacts into accounting metrics, thereby depoliticising them. In doing so, alternative forms of knowledge, storytelling, and grassroots accounts (e.g., Indigenous locally situated knowledge) become methodologically illegible. This exclusion, in turn, reproduces the very hierarchies of knowledge systems that climate justice praxis seeks to dismantle (Sultana, 2022).

These findings on the epistemic constraints of S-LCA's framework directly discredit the purpose laid by IE to use LCA, as a way to *systematically* analyse relationships between society, the economy, and the natural environment, "so as to prevent narrow and incomplete analyses that overlook critical variables or bring about unintended consequences" (Lifset & Graedel, 2002). Rather than offering a systems perspective, S-LCA seems to represent a fundamentally reductionist tool that is incapable of capturing the structural drives of the climate crisis, including colonialism, capitalism, and extractivism. As such, it cannot analyse phenomena with compelling social impacts, such as "decarbonisation by dispossession" (Andreucci et al., 2023), sacrifice zones (Dunlap & Laratte, 2022), or "green extractivism" (Müller et al., 2022), despite being more than common climate injustices in the context of the green transition (Hamouchene & Sandwell, 2023; Zografos & Robbins, 2020).

At the individual level, participants pinpointed a parallel epistemic constraint, that is, the role of S-LCA practitioners as normative gatekeepers. Consistent with prior literature (van Haaster et al., 2017; Grubert, 2018; Goldman & Baum, 2000), they recognise S-LCA as a value-laden practice. Building on this observation, they also stress the responsibility of the practitioners in engaging with reflexivity in terms of positionality, normative choices, assumptions, and biases—a call echoing the findings of García-Dory et al.'s research (2022). They highlight how this responsibility is not applied in practice due to not only a lack of guidance and protocols, but most importantly, due to the demographic and disciplinary profile of practitioners. Indeed, S-LCA practitioners are often Western-trained engineers, with no training in ethics and social sciences. This creates an S-LCA practice swimming in an epistemic monoculture that marginalises perspectives essential to climate justice praxis, such as feminist, anti-racist, post-colonial, decolonial, and activist ones (Sultana, 2022).

**Conclusion:** The research's findings reveal a spectrum of views about current S-LCA's capacity to operationalise climate justice. It ranges from "indirect integration" to "inherently wrong, perpetuating tool", passing through "inadequate yet reformable".

On the one hand, there is one dominant view of current S-LCA being immature, but there is room for improvement. This view encompasses the critiques regarding the methodological immaturity of the tool, which confirm the existing literature: The lack of protocols, ambiguous and excessively flexible UNEP guidance, and data gaps are known obstacles to standardisation of its practice. On the other hand, a lesser dominant view rejects this "fixing the framework" narrative and discards S-LCA as inherently wrong. This perspective reveals the epistemic limits of S-LCA that remain absent from the literature so far. It considers S-LCA as currently embedded in a post-positivist epistemology that decontextualises the lived and situated experiences of climate injustice and renders more-than-Western knowledge systems methodologically illegible.

Taken together, these identified limitations do point to the diagnosis that current S-LCA fails to fulfil its own life-cycle promise within the field of industrial ecology. Instead of providing a *systemic* assessment of social impacts for improving the well-being of the stakeholders, it represents a flawed and—for some participants—structurally unjust decision-making tool for rendering the energy transition actually just. This diagnosis poses the question if, with all the identified limitations, S-LCA is deemed improvable or is doomed to obsolescence. The forthcoming Phase 2 represents an attempt to "improve" S-LCA by transforming the shortcomings diagnosed in Phase 1 into concrete guidelines for an S-LCA climate justice-based approach.

## 5.2. Phase 2: Co-created Climate Justice-Based Approach for S-LCA

This section presents the results concerning the second sub-research question on how to operationalise climate justice into a practical S-LCA approach. These findings are based on the first phase of the research process.

The results of the second phase are summarised in two matrices (see Appendix 6), representing together a co-created climate justice-based approach for S-LCA. These matrices compile the full set of insights per participant. The cells within the matrices reflect the first step of Flick's (1998) method, i.e., 'paraphrasing the material', while the boxes outside of the matrices represent the second step, that is, the explicating of the participants' insights by contextualising and nuancing them. Notably, the matrices do not include Participant 8, as they declined to engage with them due to a fundamental rejection of S-LCA, seen as an inherently wrong approach (see Section 5.1.1). Indeed, P8 considers S-LCA as a perpetuating tool, thereby rendering the operationalisation of climate justice in S-LCA an obsolete exercise in their eyes.

The forthcoming sub-sections represent the third step of the content analysis by Flick, as they further elaborate on the key features identified by the participants. These features are derived from Appendix 6, corresponding to five of its rows: (1) assumptions and value choices, (2) S-LCA practitioner, (3) inclusion or exclusion of stakeholders, (4) social impact (sub)categories selection & involvement of stakeholders, and (5) data.

### 5.2.1. Results: Five Key Features

The results about the key features are summarised and synthesised through two different, but complementary ways. On the one hand, Table 5 below provides a detailed synthesis based on the matrices in Appendix 6. In contrast to the appendix, which retains participant-level details, Table 5 offers a consolidated overview—though limited to the five key features—since it merges redundant and overlapping entries into a more concise summary, where individual contributions are no longer traceable.

On the other hand, Figure 6 provides a simplified and practitioner-oriented version of Table 5. It revisits the climate justice praxis flower as a heuristic device for applying parts of the co-created climate justice-based approach in S-LCA practice. Each petal represents a specific applicable way to operationalise climate justice in relation to the S-LCA practitioner(s), assumptions and value choices, stakeholder inclusion and exclusion, impact categories, and data practices. By using this flower, S-LCA practitioners can let themselves be guided by the principles of decoloniality, relationality, inclusivity, and reflexivity, and all the foundational work that has led to this approach to be what it is. Since Figure 6 functions as a basic entry point for the approach's application, practitioners should also refer to Table 5 and Appendix 6 for more clarification on the short-listed guidelines of Figure 6.

Table 5: The five identified key features in the data for structuring content analysis

| Considered Items | Reflexivity | Inclusivity | Decoloniality | Relationality |
|---|---|---|---|---|
| **S-LCA practitioner (and team)** | **Include** a positionality statement and **explain** which parts of the positionality influence this study<br>**Critically reflect** on motivations, disciplinary backgrounds, and limits of expertise | **Compose** a transdisciplinary team to make sure that choices about stakeholders, indicators, and scope are informed by the merging of academic and non-academic knowledge<br>**Include** the positionality of involved stakeholders and contrast them with researcher's one | **Explicitly acknowledge** when expertise is limited to dominant academic or engineering perspectives<br>**Question and act** on whether additional training beyond academic and engineering backgrounds is needed to ensure ethical reflection skills and facilitation | **Acknowledge** how practitioner position (e.g. government-linked vs independent) affects stakeholder relationships and willingness to participate |
| **Assumptions & value choices** | **Require** explicit justification for the selection of subcategories, and indicators, recognizing these as normative choices that shape the study's outcomes<br>**Critically reflect and justify** choices in relation to uncertainty and missing | **Include** the assumptions and values choices of involved stakeholders and contrast them with the researcher's | **Acknowledge** that assumptions embed implicit value judgments that may reflect dominant perspectives<br>**Decolonise** by undertaking training on | |

| | | | | |
|---|---|---|---|---|
| | data<br>**Make** all assumptions explicit and explain them, with the help of ethicists and social scientists, if necessary | | how to critically reflect on these assumptions and choices | |
| **Inclusion or exclusion of stakeholders** | **Critically reflect** on (1) how this inclusion/exclusion constitutes a normative judgment about who is considered valuable and worthy of protection from injustices; (2) how this inclusion-exclusion may influence the study's results<br>**Challenge** (1) confirmation bias about pre-defined ideas on which stakeholders might be the most affected to avoid systematically excluding relevant stakeholders; (2) claims of limited time, tools, and resource constraints, as justification for exclusion | **Invest** time and effort to identify stakeholders affected by climate injustices, especially the ones in the Majority World, who are often overlooked<br>**Ensure** representativeness by including different individuals within each stakeholder category<br>**Involve** stakeholders from the start and iteratively, while minimising participation burden<br>**Verify** whether the stakeholders recognise themselves in the categories assigned by the framework and whether they think that the selection of individuals is | **Decolonise** power structures between the SLCA practitioner(s) and the included stakeholders by co-defining the SLCA's goal and scope in relation to the stakeholders' needs<br>**Prevent** knowledge extractivism<br>**Examine** power relations between stakeholders (e.g., who controls the resources, profits from the production of the technologies, or benefit | **Investigate** if some included stakeholders may self-censor or provide constrained input due to financial dependency, perceived power asymmetries with the SLCA practitioner(s), or distrust in the entity commissioning the study |

| | | | |
|---|---|---|---|
| | **Acknowledge** how your positionality, or your institution, shapes power dynamics with stakeholders<br>**Recognise** the limitation of standardised categories that erase differences in roles, and power positions between different individuals representing the same category | representative of the stakeholder category | from the use of the latter?) and take this analysis into account when considering whether the product enables justice or (re)produces injustices |
| **Social impact (sub) categories selection & involvement of stakeholders** | **Critically reflect** on confirmation bias about pre-defined ideas on which (sub)categories might be the most relevant, and thereby potentially excluding other (sub)categories<br>**Require** valid justification why certain (sub)categories are selected and others not<br>**Be transparent** about which impacts are invisibilised due to the | **Let** stakeholders choose relevant (sub)categories and indicators in relation to justice<br>**Use** deliberative and co-creation processes (e.g. workshops) | **Acknowledge** when sub-impact categories and indicators are selected because data are available, rather than because they are normatively relevant to affected stakeholders<br>**Decolonise** by purposely selecting indicators that |

| | | | |
|---|---|---|---|
| | selection that is often not comprehensive | | align with climate justice principles |
| **Data** | **Acknowledge** the non-neutrality of data by specifying how the data was produced within institutional contexts, and generally **critically reflect** on data sources<br>**Critically reflect** on the social databases' country- and sector-level nature and the resulting loss of granularity and specificity, leading to obscuring local climate injustices<br>**Be transparent on** data gaps, assumptions, and generalizations made to data limitations, limiting what injustices will be analysed<br>**Critically reflect** on the sensitivity of data and be aware that some stakeholders may hesitate to share information on sensitive topics like climate injustices | **Ensure** security and anonymity of affected stakeholders through informed consent<br>**Include** primary data by co-creating spaces for stakeholders to share their insights and validate this data<br>**Acknowledge** which stakeholders and impacts are not included simply because of poor representation due to missing or low-quality data, leading to proxy assumptions or the aggregation into "rest of the world" (i.e., often Majority World stakeholders) | **Pluralise** epistemologies (e.g., storytelling)<br>**Decolonise** the hegemonic Western meaning of data by treating storytelling and lived experiences as valid data<br>**Challenge** unjust proprietary data systems and render own collected data open source<br>**Be aware** of "justice washing", as stakeholders who are willing to share data may not represent those experiencing injustices |

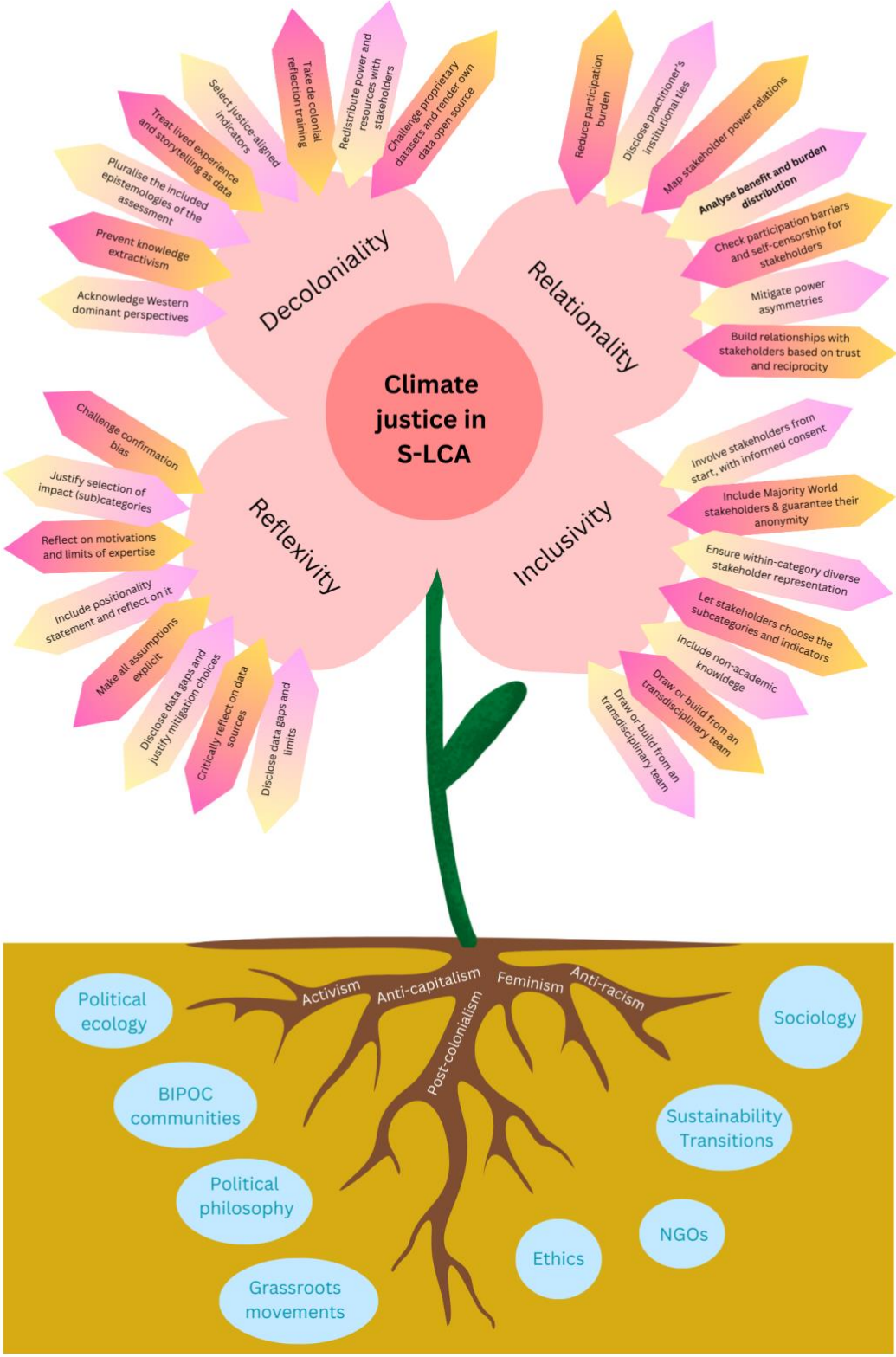


Figure 6: Climate Justice Praxis Flower applied to five key features of the co-created climate justice-based approach for S-LCA practice (author's work)

### 5.2.2. Analysis of Results

The analysis of the results centres on Table 5 and Figure 6, rather than the entire co-created climate justice-based approach for S-LCA practice, as presented in Appendix 6. In doing so, it is important to acknowledge that the analysis does not provide an exhaustive account of all findings. Indeed, the five key features are interconnected and influenced by other items in the matrices that are not analysed further here. As one participant puts it: "All of the considered items are interrelated. For instance, 'SLCA practitioners' influence the 'motivation for the study' and the 'assumptions and value choices' in the scope definition." Therefore, while the following section delves deeper into these five items, one should remain aware of their interconnecteness with the other items of the matrices (see Appendix 6).

The analysis reveals a certain "normative decision chain" between these five key features (see Figure 7). By this, the researcher refers to a sequence of interdependent value-laden choices in which earlier ones shape and constrain later ones—with normativity entering the process upstream and propagating downstream. The S-LCA practitioner determines the assumptions and value choices which, in turn, determine which stakeholders are included or excluded. These inclusion decisions define which impact (sub)categories are selected, which finally determines what kinds of data are collected. Figure 7, thus, illustrates this chain in an Euler diagram, showing how the more nested features are dependent on prior choices made in the more embedded features.

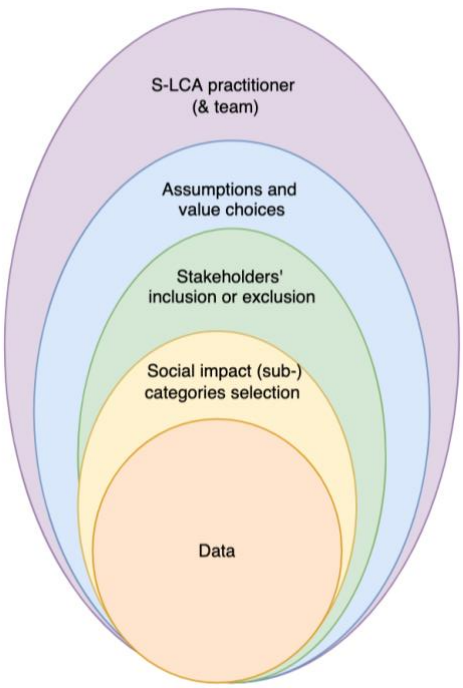


Figure 7: Euler diagram on the normative decision chain of the five identified key features

## S-LCA practitioner (and team)

The findings strongly challenge the S-LCA practitioner's ideal of "a neutral engineer", as assumed in the UNEP Guidelines. Instead, all participants acknowledge the role of the practitioner as a normative gatekeeper, whose positionality, disciplinary backgrounds, and institutional affiliations shape the entire research process. As normative gatekeepers, they also emphasise that practitioners thus have "moral obligations and duties to other humans because we are humans". This finding is in line with Goldman and Baum's (2000) claim that social impact assessments are never neutral or value-free endeavours and Caney's (2014) claim that researchers have a responsibility to act on their responsibilities, as second-order agents.

To act on such responsibilities, the participants emphasise the need for practitioners to engage with reflexivity. For instance, they recommend practitioners to include positionality statements and critically reflect on how their motivations, disciplinary backgrounds, as well as limits of expertise, influence the research process and, ultimately, its outcomes. This way, practitioners can enact Caney's (2014) Harm Avoidance Justice by addressing their own blind spots, normative assumptions, and knowledge limits upfront before they propagate through the normative decision-making chain and negatively influence the more nested layers. This, in turn, reduces the risk that S-LCA practice unintentionally reproduce or obscure harms affecting those most vulnerable to climate impacts and energy transition processes.

Furthermore, inclusivity and decoloniality at this level were primarily framed in terms of team composition and training. As shown in Table 5, the findings suggest that practitioners may need additional training beyond their academic and engineering backgrounds to develop ethical reflection skills—essential to climate justice praxis. Although participants recognised S-LCA as a primarily individual-operated practice, some participants advanced the need for creating transdisciplinary teams. Adopting transdisciplinary would enable the practice to not be dominated by the usual academic and engineering perspectives but rather informed by the merging of various disciplines and practices. This finding answers the call of the Māori scholar Linda Tuhiwai Smith (2022) about decolonising methodologies by decentering dominant knowledge systems and centering other knowledge systems. Participants did warn though that composing a transdisciplinary team is limited by time and funding.

Through Figure 7, one can deduce that the S-LCA practitioner and its eventual teammates set the premise for the entire subsequent layers. The findings point toward the fact that the more S-LCA practitioners integrate climate justice principles, the more these principles

naturally cascade downward in the assumptions and value choices, the inclusion or exclusion of stakeholders, the selection of social impact (sub)categories, and ultimately the data.

## Assumptions and value choices

Whereas the "practitioner (and team)" layer deals with who conducts the study, and therefore who holds normative agency over it, the "assumptions and value choices" layer focuses on how that agency materialises practically in normative assumptions and decisions. All participants insisted that S-LCA is not a value-free framework, as supported by van Haaster et al. (2017) and Grubert (2018), and specified that value-choices are intrinsic, not incidental, in S-LCA practice.

However, the findings go further than the literature by suggesting how practitioners should not only recognise, but also provide reasonable and explicit justification on the assumptions and normative choices underlying *all* steps of the research process. As such, the participants reject the vague guideline of UNEP asking practitioners to "define the researcher's assumptions and values choices" (2020, p.42). Instead, they not only advocate for practitioners to justify their normative choices along the research process, but also to critically reflect on uncertainty and missing data and render all resulting assumptions explicit in the report.

In this light, participants highlight reflexivity, once again, as the key climate justice pillar to enable reflection on these assumptions and value choices. Echoing the literature review, by taking a reflexive stance, researchers can intentionally and transparently engage with and, when necessary, reshape the underlying assumptions and choices of the assessment (Ricker, 2017). Yet, as the first phase of the study about the epistemic limitations shows, S-LCA practitioners often face difficulties in engaging in the praxis of reflexivity, as many are trained as engineers and have limited to no competencies in this practice (see Section 5.1.3). Therefore, the participants recommend S-LCA practitioners to seek training for gaining reflexive skills, such as courses on "decolonising science". However, they also acknowledge that S-LCA practitioners in the academic world often have little inherent motivation, as well as insufficient time, to follow such training due to the often-hyper-productivistic and pressuring mindset of current academic settings. As one of the participants exemplifies, despite their longing for a course in ethics, they did not follow through with it:

*"In the end, I didn't do it because it is a distraction from what I'm doing, it's not directly relevant to the current paper I'm writing. So then it's just a delay to the paper, basically. And of course, perhaps I could have still done it anyway if I just stood my ground, but […] you're definitely reminded of that you need to publish a paper. It also takes cognitive effort. And it takes time that you might not have."*

## Stakeholders' inclusion or exclusion

The findings confirm the literature: Choosing which stakeholders to include and which to exclude is a deeply ethical and political act (Tokede & Traverso, 2020; Sehlin MacNeil et al., 2021). Indeed, the inclusion or exclusion of stakeholders entails a normative judgement about whose voices are considered valuable and worthy of protection from injustices. While the UNEP Guidelines already encourage the justification behind such a process by inviting practitioners to describe "which stakeholders are included and affected" and the "stakeholder's involvement strategy" (UNEP, 2020, p.42), the findings indicate that this guidance is insufficient, as it leads to tokenisation and extractivism (see Section 5.1.3).

The participants suggest multiple ways to render to approach this step of the S-LCA practice. First, practitioners should critically reflect on confirmation bias, which visibilises stakeholders assumed to be "relevant" while systematically obscuring actual affected stakeholders. Second, they should categorically reject the common invocation of "limited time or resource constraints" as justifications for exclusion. Third, they should ensure representativeness by including diverse individuals within each stakeholder category, while recognising the limitation of UNEP Guidelines' categories that erase differences in roles, and power positions between different individuals supposedly representing the same category. These suggestions supports the premise brought forth by Johnson et al. (2020) that the individuals affected by climate injustices are homogenous, with differences in gender, class, age, citizenship, and privileges.

Throughout this process, the findings show that practitioners should involve stakeholders from the start althewhile ensuring the minimisation of participation burdens. To avoid extractive processes, as warned by Tuhiwai Smith (2022), practitioners should decolonise power structures between the S-LCA practitioner and the included stakeholders. This can take the form of co-defining the S-LCA's goal and scope in relation to the stakeholders' needs, ensuring stakeholders' confirmation on whether they identify with the

categories they are expected to represent, or letting stakeholders choose relevant subcategories and indicators in relation to climate justice.

Moreover, practitioners should become aware of whether some stakeholders are self-censoring due to financial dependency, power asymmetries, or distrust in the commissioning entity. This is because, even when practitioners do include stakeholders in a meaningful manner, their participation heavily depends on the S-LCA practitioner's capability to guide these relationships. As one participant explains: "No matter how included the stakeholders are, their genuine engagement hugely depends on trust and legitimacy in the practitioner and commissioner."

## Selection Social Impact (Sub)Categories & Involvement of Stakeholders

At the fourth layer of the normative decision chain, the selection of social impact (sub)categories represents yet another concretisation of normative decision-making. These findings substantiate Sureau et al.'s (2018) claim that this selection is grounded in normative value choices of what "ought" to be measured.

In this context, findings show that UNEP's Guidelines for this layer are insufficient. Participants stress the need to go beyond the mere description of which (sub)categories are selected and whether this selection involves stakeholders (see UNEP, 2020). They urge practitioners to explicitly provide valid justifications in the report for why certain (sub)categories are selected while others are not, and to be transparent about which impacts are thereby invisibilised through an inevitably non-comprehensive selection. Similar to the previous layer on the inclusion or exclusion, practitioners should be critical of their own confirmation bias and firmly reject the common invocation of "limited data availability" as justifications for non-selection.

Furthermore, the selection of these categories should not merely involve stakeholders; it should happen in deliberative and co-creative processes (e.g., workshops), where stakeholders themselves can define relevant (sub)categories. In this sense, this layer moves from stakeholder involvement as more consultation or tokenisation towards stakeholder inclusion as co-production, as encouraged by Perkins (2023). As a result, (sub)categories could be selected not because of simple "data availability", as often done in current S-LCA practice, but because they are normatively relevant to stakeholders. This shift, however, can only be realised if the S-LCA practitioner explicitly redistributes the available power and resources, as explained by Forsyth and McDermott (2022).

## Data

At the innermost layer of the normative decision chain, data practices (e.g., data collection, data type, and data quality requirements) represent the most concrete form of operationalisation of earlier normative decisions. Findings show that data are not "neutral" inputs but representations of situated lived realities framed by Western epistemic hegemony and methodological constraints. By drawing on this observation, participants join the call of Wilkens & Datchoua-Tirvaudey's (2022) for plural epistemologies through the inclusion of primary data and alternative forms of knowledge, such as storytelling. This would enable stakeholders to share their experiences, perceptions, and impacts in their own terms, not just translated into Western, scientific, and technocratic language. Otherwise, the epistemologies and perspectives of the S-LCA practitioner might overrun the ones of the involved stakeholders, leaving those of participants further marginalised (Tokede & Traverso, 2020; Sehlin MacNeil et al., 2021; Zanchi et al., 2018). In doing so, practitioners should proactively co-create a space where these same stakeholders can exercise informed consent. This space should secure their safety and anonymity, as information about climate injustices is highly sensitive.

On another note, as observed in the literature (Chabrawi et al., 2025; Grubert, 2020) and confirmed through the first phase of this research, data for S-LCA are scarce. And when it is not scared, it is often drawn from aggregated databases that reduce the granularity and specificity of data, often misrepresenting or obscuring the assessment of climate injustices, especially for Majority World stakeholders (Bamana et al., 2021). Participants point out the need to explicitly mention these data gaps, as they often induce much uncertainty and are transformed into assumptions and generalisations. Lastly, from a decolonial perspective, participants should challenge unjust proprietary data systems and, where possible, render their own collected data open source.

**Conclusion:** The analysis of the findings identified a normative decision chain that runs from practitioners to assumptions and value choices, to the inclusion or exclusion of stakeholders, to the selection of (sub)categories, and finally to data. Each layer thus nests within the previous one. This decision chain illustrates how normativity is not confined to a single stage of the S-LCA practice; rather, it is distributed across multiple stages. It makes visible where, and by whom, judgements are made about who counts, what counts, and how it is measured. It shows the power that S-LCA practitioners hold and how it operates cumulatively. Indeed, early choices at the "practitioner (and team)" and "assumptions and value choices" layers cascade down to determine eventually which injustices and experiences become visible or invisible.

By integrating the climate justice praxis in S-LCA practice, the same chain can function as a positively reinforcing pathway. Practitioners engage in more reflexive assumptions and value choices, which in turn lead to justice-motivated stakeholder inclusion and climate-justice-aligned (sub)categories, to finally result in plural, contextual data that mutually reinforce one another rather than depoliticising social impacts and injustices. Despite only representing a subset of the broader S-LCA practice, the layers analysed in this section demonstrate how normative influence accumulates across S-LCA practice.

# Chapter 6: Discussion

This chapter corresponds to Phase 3 of the adapted transdisciplinary-research-model for this thesis (see Section 4.2). It first critically discusses the findings of this thesis around three themes: (1) S-LCA in the context of broader critiques of modelling, (2) individual responsibility versus institutional accountability, and (3) risks of technocratising climate justice. Thereafter, the chapter expands on the implications of the research, its main limitations and future recommendations.

## 6.1. Critical Evaluation of the Findings

While the thesis already analyses the findings in light of the literature relating to S-LCA and climate justice (see Sections 5.1.3 and 5.2.2), this section takes a step back and critically evaluates the findings beyond the two central concepts of this thesis.

### S-LCA in the Context of Broader Critiques of Modelling

Some of S-LCA's limitations identified throughout this thesis align closely with critiques of other impact and modelling practices. Already in 1994, Naomi Oreskes, a prominent earth scientist and historian, wrote that the validity of numerical models is relative, not absolute. Models are useful for strengthening what "may be already partly established through other means", or to explore "which aspects of the system are most in need of further study" (Oreskes, 1994, p.144). However, models do not deliver hard truths, and S-LCA is no exception to this rule. Oreskes uses an interesting analogy, comparing models to novels:

> *"Like a novel, a model may be convincing, it may 'ring true', if it is consistent with our experience of the natural world. But just as we may wonder how much the characters in a novel are drawn from real life and how much is artifice, we might ask the same of a model: How much is based on observation and measurement of accessible phenomena, how much is based on informed judgment, and how much is convenience?"*
> *(Oreskes, 1994, p.144)*

While models may appear as truth-bearers, they inevitably involve researchers' "judgment" and "convenience", rendering them value-laden. From this perspective, largely studied in philosophy of science, the normative decision chain identified in S-LCA is not a peculiarity

unique to this approach. Rather, it can be seen as a shared feature with other impact assessment models and other models, where values enter through choices one must make when dealing with indicators, metrics, and uncertainty. In several of these modelling practices, and in contrast to S-LCA, structured guidance often exists precisely to make modelling assumptions and value choices transparent to policymakers and the public, whose health and safety may be at stake (Oreskes, 1998). For instance, Agent-Based Modelling (ABM) possesses the Overview, Design concepts, Details (ODD) protocol, which represents a standardised framework that aims at encouraging ABM practitioners to render visible their assumptions to the public, otherwise hidden (Anshuka et al., 2022). In this light, the co-created climate-justice approach may very well represent the first attempt at orienting S-LCA practice towards other modelling practices that already incorporate reflexive guidance.

## Individual Responsibility versus Institutional Accountability

The framing of this thesis assumes that all responsibilities lie on the S-LCA practitioner—an assumption that merits being somewhat deconstructed. By describing practitioners as "normative gatekeepers", the findings may unintentionally disregard the structural responsibilities that institutions, funders, and standards bodies hold. Even though findings pointed out UNEP's insufficient institutional support (i.e., ambiguous, over-flexible guidance for conducting S-LCA), the findings mainly showed the individual responsibilities of the S-LCA practitioner. S-LCA practitioners certainly *do* have a responsibility. As Caney (2014) puts it, researchers should be effective in conveying the necessary information so that policymakers can comply with their own responsibility, that is here, to operate a *just* energy transition. S-LCA practitioners are then responsible to provide S-LCA findings that actually enable policymakers to make informed decisions on which low-carbon technologies to choose from.

However, beyond this individual responsibility, one cannot overlook the political economy in which S-LCA operates. Who commissions S-LCA studies? Who pays for them? These political-economic dependencies influence the extent to which climate justice can be integrated into S-LCA. Indeed, funding, corporate interests, political agendas, or policy cycles shape to what extent practitioners can operationalise climate justice. For instance, even if the practitioner is well-intentioned in operationalising climate justice, it may be that they are obliged to co-opt with the interests of the corporation they work for, thereby structurally limiting the uptake of a climate-justice-based approach.

### Risks of Technocratising Climate Justice

One also needs to critically evaluate the value of rendering climate justice a praxis for S-LCA. By translating climate justice into the S-LCA apparatus, the approach runs the risk of being adopted as an additional technocratic layer. In doing so, it could be gradually reshaped to fit what is measurable and reportable, rather than retaining its more radical perspectives. As a result, S-LCA would become a tool for justice-washing, which would help legitimise the adoption of necropolitical policies. Commissioners could then label the findings as "climate just" without having had to alter underlying power relations, for instance. This scenario represents a risk, which may never materialise, as much as the scenario according to which climate justice praxis could unleash its potential in transforming S-LCA into a tool that favours biopolitics.

## 6.2. Implications for S-LCA Practice, Research, & Policy-Making

This subsection reveals the relevant implications of this thesis for S-LCA practice, research, and policy-making.

### Implications for S-LCA Practice

No pretence can be made here that the co-created approach for operationalising climate justice in S-LCA constitutes a full practitioner guide. However, it does propose a practical set of reflexive and participatory measures that practitioners can integrate into their practice to adopt climate justice praxis, thereby reducing the risk of reinforcing necropolitical decision-making within energy transition governance. Beyond addressing the methodological challenges with the commonly used UNEP Guidelines, this co-created approach serves as an opening for dialogue and learning among practitioners. In this regard, the thesis acts on a window of opportunity—a time in which S-LCA practice is still in search of standardisation—to raise awareness on S-LCA's limitations, many of which were left unexamined so far, and propose a potential avenue for addressing them before S-LCA standardises.

### Implications for Research

This thesis has many implications for academic research. First, it identifies a clear research gap: There is virtually no academic work explicitly operationalising climate justice within

SLCA despite scattered justice-related efforts (i.e., gender, social, and energy justice). Second, it unravels some of the epistemic constraints of S-LCA that were—until this day—unexplored. Third, it conceptualises a novel approach that defines climate justice praxis through four pillars: decoloniality, reflexivity, inclusivity, and relationality. Finally, it operationalises this approach in relation to S-LCA. As such, this thesis is not simply adding another piece of work to the already tremendously large mountain that is academic literature. Rather, it brings forth new insights that can facilitate the bridge between S-LCA and climate justice, and hopefully spur further research on just energy transitions.

### Implications for Policy-Making

This thesis is quite fundamental for policy-making because it establishes that, as currently practised, S-LCA often produces biased and skewed results. If policy-makers were to uncritically use this decision-making tool to guide the energy transition, they would inadvertently promote policies that may overlook negative social impacts on communities already disproportionately affected by the climate crisis. Therefore, this thesis delivers a renewed warning—built upon earlier critiques in the literature—that policy-makers should not treat S-LCA and similar impact assessment tools as standalone guides for policy decisions. Rather, it advances the necessity for cautiously interpreting the results of S-LCA in light of its various limitations and complementing them with other forms of research better suited to capturing complex, lived, and situated social realities. Policy-makers should also realise that S-LCA's inclusion within the broader LCSA framework does not automatically imply the same level of robustness or reliability often attributed to E-LCA.

## 6.3. Limitations

As with every research, the main findings need to be interpreted in the context of the study's limitations. The present research is, of course, not without limitations. Although there are probably more limitations, this section highlights the major ones, mostly linked to the study's methodology.

First, the sampling strategies limit the generalisability of this research. Because the research is exploratory in nature and based on a rather small purposive sample (n=8), the findings cannot be generalised to a broader population. Indeed, important categories may be missing or overshadowed due to the influence of a few dominant participants. In addition, the snowball sampling strategies, with participants referring to others from a similar professional

network, can lead to a rather homogenous sample and overrepresent certain perspectives (Gray, 2022). The research participants in this case are all individuals working in Western European academic institutions. Therefore, the results from this study are likely dominated by Western academic perspectives and are not directly generalisable to other settings or populations.

Second, the research could have benefited from adopting focus groups as a data collection method instead of elicitation interviews. Even though elicitation interviews were well-suited for co-creation, their short duration (i.e., 60 minutes) limited interaction and depth of discussion. For instance, the participants with less prior knowledge of S-LCA frequently sought clarification about the UNEP Guidelines (despite the introductory explanation and the various visual aids) and thereby slowed down the interview's progress. Focus groups could have prevented this issue by allowing a space and more time for participants to complement each other's knowledge and self-regulate discussions. In a similar line, time constraints also prevented an in-depth examination of all items described by the UNEP Guidelines for the goal and scope definition, thereby leaving participants the choice to select the items in the matrices they felt most comfortable with or interested in. By using focus groups, the researcher could have divided participants into smaller groups to systematically address all items with an equal amount of attention. Notably, this limitation directly contrasts with the co-created climate justice-based approach, which criticises the arbitrary selection of categories and encourages practitioners to justify their choices. In this research, participants had insufficient time to justify their choices, though.

Third, the deductive part of this thesis, where the researcher uses a predefined framework (i.e., climate justice praxis) to guide the co-creation sessions, induces limitations. As shown by the very findings of this research, classification is an inherently value-laden process. What we classify, how we classify it, and how we operationalise categories of that classification all reflect normative choices. Consequently, the research did not capture participants' perspectives entirely on their own terms, but rather through the pre-determined lens of climate justice praxis. This framing likely constrained participants' insights and prevented the emergence of alternative suggestions for improving the UNEP Guidelines. For instance, some participants more familiar with energy justice could have enriched the research with very different insights if it were not for the predefined framework.

Fourth, the research's short literature search on the Web of Science possesses limitations in terms of scope and depth. The search relied exclusively on the term 'climate just*', whereas it should have also searched for the climate justice pillars, i.e., 'decoloniality', 'inclusivity', 'relationality', and 'reflexivity'. Additionally, the review would have benefited

from searching for literature already connecting S-LCA with related concepts to climate justice, such as energy justice and environmental justice. As such, it likely renders this thesis incomplete by overlooking potentially relevant knowledge to the research questions.

Lastly, this research is limited in how it operationalises climate justice *in the thesis itself.* Although, as mentioned in the foreword and positionality statement, the researcher sought to remain reflexive throughout the research process, she failed at comprehensively integrating inclusivity and decoloniality in the research design. Indeed, all interviewees were academic individuals from the Minority World, whereas climate justice praxis explicitly emphasises the necessity to build on grassroots knowledge, lived experiences, and plural epistemologies from Majority World communities, as they are the most affected by the climate crisis. This composition of participants constrains the participatory and transdisciplinary ambitions of the research and also risks reproducing the epistemic hierarchies that the research's findings address. Therefore, it is important to note that the research reflects a partial, situated, and Western academic co-production of knowledge, which is epistemologically narrow and, thereby, is inherently limited.

## 6.4. Recommendations for S-LCA Practitioners, Researchers, and Policy-Makers

This subsection suggests recommendations for S-LCA practitioners, researchers, future research, and policy-makers. These recommendations are translated into directly actionable points to facilitate integration.

### Recommendations for S-LCA Practitioners

- ***R₁*** **Acknowledge your responsibility in advancing climate justice and be a changemaker**, even if it means challenging the institutional level. Act on your agency to improve S-LCA practice by calling out UNEP, your commissioner(s), and other actors, who are accountable for the injustices current S-LCA practice may perpetrate.
- ***R₂*** **Be continuously reflexive and critical** throughout the entire practice, even if it takes additional time and effort. Treat reflexivity as a core competence for S-LCA practice by following training on reflexive skills.
- ***R₃*** **Decolonise your research practices.** Start by reading the book of Linda Tuhiwai Smith (2022) 'Decolonizing Methodologies' to challenge your

understanding of the world. Move beyond 'PSILCA' and 'SHDB' databases and instead make use of databases that situate and contextualise climate injustices, such as the 'Environmental Justice Atlas' (EJAtlas), an interactive and collaborative database available online.

***R₄*** **Inform yourself on climate injustices in relation to the energy transition.** Start by reading Dunlap & Laratte's (2022) article. Move beyond academia to expose yourself to non-academic perspectives. For instance, watch the freely available documentary 'Africa's Green Colonialism' by Arte (2025)—a publicly owned service channel.

***R₅*** **Support peer environments in which uncertainty and knowledge limits can be openly communicated without penalty**. For that, first acknowledge that S-LCA practice is value-laden and lacks primary data.

***R₆*** **Meaningfully integrate participatory action research (PAR) principles in S-LCA practice**. Take as inspiration, while remaining critical of, Bouillass et al.'s (2021) participatory approach for the identification and prioritisation of impact subcategories.

## Recommendations for Researchers

***R₁*** **Broaden and diversify sampling** to pluralise perspectives and enable future research to be truly transdisciplinary. Include among S-LCA practitioners, non-academic practitioners and practitioners from the Majority World context. Include among "climate justice experts", grassroots movements actors, activists, critical decolonial thinkers, and Indigenous representatives.

***R₂*** **Use focus groups or other participatory methods** to collect data, instead of relying solely on in-depth interviews, to enable generation of insights through interaction rather than in isolation. Consider also involving participants as from the start to co-define the problems at hand and co-design the associated research questions.

***R₃*** **Conduct broader and more systematic literature review**. Expand search terms to include the four pillars of climate justice practice (i.e., decoloniality, inclusivity, reflexivity, and relationality), as well as energy justice and environmental justice. Include grey literature to account for non-academic perspectives.

***R4*** **Test co-created approach empirically** either by (a) applying it to a S-LCA study, or (b) critically reviewing existing S-LCA's. Evaluate the framework according to the pre-defined criteria of this study being: the applicability and accessibility for small-scale S-LCA pracitioners, the alignment with the UNEP Guidelines, and the scientific as well as societal relevance.

***R5*** **Operationalise and practice climate justice *in the research process itself,*** rather than treating it as a framework to research. Engage with the climate justice praxis flower (see Figure 3) and read Sultana's (2022) paper for further clarification on the foundations of this praxis.

***R6*** **Explore** the political economy of S-LCA (i.e., who commissions, who benefits, who is excluded) to understand structural barriers to adopting justice-oriented approaches.

## Recommendations for Policy-Makers

***R1*** **Act on your responsibilities of "norm-creator" in relation to S-LCA practice.** When mandating S-LCA in legislation, standards, or funding programmes, require explicit reporting on positionality, assumptions, normative choices, and study limitations. Read Caney's (2014) article to further understand your responsibilities in the creation of norms.

***R2*** **Systematically compare S-LCA findings with other research practices** to best inform decisions on low-carbon technologies.

***R3*** **Support** initiatives that debunk justice-washing impact assessments.

***R4*** **Make meaningful participation of affected communities a condition for accepting S-LCA studies** in permitting subsidies, or public procurement for energy-related projects.

***R5*** **Render** the S-LCA reports used for guiding policies in the energy transition open-source.

# Chapter 7: Conclusion

This study set out to answer the main research question: "How can Social Life Cycle Assessment be critically evaluated and advanced to better account for climate justice in the energy transition?" To do so, the research used transdisciplinary and participatory methods applied in two phases: (1) collaborative problem framing and (2) co-creation of solution-oriented approach. While each phase addressed a single sub-question, both phases collected data from the eight elicitation interviews and then used qualitative content analysis to analyze the results.

The first phase of the research aimed at identifying and explaining the limitations of current S-LCA practice in relation to climate justice. The analysis showed that S-LCA inadequately addresses, if not completely fails to integrate, climate justice. Even though the primary explanations for this statement are multifold, the present research categorised them into methodological constraints and epistemic constraints. The first category touches upon the lack of protocols, ambiguity and excessive flexibility of the UNEP Guidelines, as well as the data gaps, as being the primary explanation for why S-LCA does not comprehensively address climate justice. The second category reveals the epistemic and normative limits of S-LCA that inhibit the operationalisation of climate justice by decontextualising the lived and situated experiences of climate injustice, privileges quantitative metrics, and renders more-than-Western knowledge systems methodologically illegible.

The second phase explores the creation of a climate justice-based framework directly applicable to S-LCA practitioners. This resulted in two co-created matrices that operationalise each pillar across the UNEP goal and scope items. The analysis focused on five key features, which exposed the presence of a normative decision chain across S-LCA practice. This phase proposes concrete and directly applicable suggestions for S-LCA to operationalise climate justice, such as including a positionality statement, seeking transdisciplinary teams, co-defining goal and scope with affected stakeholders, letting them select the (sub)categories, treating storytelling as data, being explicit about data gaps and justice-washing risks.

Taken together, this research possesses important implications as it supports S-LCA practitioners to undertake more critical S-LCA assessments of energy systems, thereby preventing policy-makers from unintentionally promoting unjust energy transition policies. Given the research's limitations, continued research is needed to assess whether S-LCA, in its

pursuit for standardisation, will emerge as a tool supporting biopolitics or, instead, fade into obsolescence.

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# Appendix 1 — Initial Draft of Matrices

**What would you change to these guidelines to reflect/integrate climate justice?**

Decolonize... Include... Critically reflect... Relate x to y

| Considered items by UNEP | Objectives by UNEP | JUSTICE-ORIENTED OBJECTIVES |
|---|---|---|
| **Object of Study** | "Describe what is being assessed (product, service)" | |
| **Reasons for carrying out the study** | "Describe why this study is being carried out" | |
| **Intended audience** | "Describe who is the intended/ target audience" | |
| **Decision making support** | "Specify if this study intends to support decision making by claiming that one product or system is socially better (or equivalent) to another" | |
| **Potential improvements** | "Specify what are the potential improvement opportunities being sought through the knowledge that will be produced" | |

**What would you change to these guidelines to reflect/integrate climate justice?**

Decolonize... Include... Critically reflect... Relate x to y

| Considered items by UNEP | Objectives by UNEP | JUSTICE-ORIENTED OBJECTIVES |
|---|---|---|
| **Functions, the functional unit, the reference flows** | "Describe what is the product meant to do and how much of that service are we talking about" | |
| **Activity Variables** | "Describe what type of human activity is involved in producing this product" | |
| **System boundaries** | "Describe how much human activity is involved in producing this product" | |
| **Inclusion or exclusion of stakeholders** | "Describe which stakeholders are included and which are excluded. Specify why and how" | |
| **Context of activities of the product** | "Describe what is the local context in which the activities of the product life cycles are embedded" | |
| **Social impact (sub)categories selection & involvement of stakeholders** | "Describe which social impact categories are included or excluded. Describe how are these categories chosen according to the stakeholders" | |
| **Data** | "Describe what data will be gathered and how." | |
| **Choice of impact assessment method** | "Describe what method is used: (1) reference scale approach, or (2) the social impact assessment. Justify why" | |
| **Allocation** | "Describe what allocation decisions are made and justify why" | |
| **Assumptions & value choices** | "Describe what are the researcher's assumptions and values" | |
| **Limitations** | "Describe what are the limitations of the study" | |
| **Communication of results** | "Describe which results will be communicated and how." | |

# Appendix 2 — Research Ethics

This section concerns itself with the ethics of this Thesis Project Research. Properly defining the ethics in research helps the researcher to relate respectfully and responsibly to the participants of the research or others who may be influenced by it (Gray, 2022). This research abides by the ethical standards established by the Human Research Ethics Committee (HREC) of TUDelft. With the help of the help of the Data Steward at the Faculty of Technology, Policy, and Management, the researcher submitted an HREC application. This application includes (1) a signed version of the university's HREC Checklist, (2) a Data Management Plan, and (3) Informed Consent Forms for the interviews. This application was approved by the HREC before the interviews started. This approval means that the researcher commits to ensure informed consent from the participants, avoid any form of harm, and respect their privacy.

First, the Checklist ensures that the researchers correctly identify the potential risks of participating in the research and plan how to mitigate them. Second, the Data Management Plan explains how the researcher processes the data. In accordance with TU Delft's data management protocols, the data is safely stored on TU Delft's OneDrive and is only accessible to the researcher and the supervisors of this thesis. The data is planned to be erased from the university's cloud service two months after the completion of the project. Third, the Informed Consent Form (see Appendix 3) represent a legal and ethical agreement between the researcher and the participants to safeguard everyone's physical, emotional, and reputational state of being. The forms transparently expose the object and purpose of the study, as well as the potential risks of participation. By signing the forms, the participants:

- Has read and understood the core of the research and has had the opportunity to ask questions.
- Consents to participate in the study and to the described data processing, including recording, transcription, storage, anonymisation options, and the right to withdraw at any time.
- Consents to the use of their name, affiliation, and job title in the thesis report, with the possibility to review and approve this before publication
- Understands that the report may be made public in the future, and that explicit permission will be required before publication, including the right to request changes or refuse publication.

# Appendix 3 — Consent Form for Co-Creation Interviews

## Consent form for a Co-Creation interview: Operationalising Climate Justice in Social Life Cycle Assessment

### Purpose of Interview

We would like to invite you to participate in an interview regarding the master's thesis of Laure Herpain as part of the Industrial Ecology MSc programme (Leiden University and TU Delft). The thesis focuses on how climate justice principles can be systematically integrated into the Social Life Cycle Assessment framework to address its current limitations in capturing justice dimensions within the energy transition. The project aims to develop an iterative, practitioner-oriented approach that supports S-LCA users in embedding climate justice considerations throughout the entire assessment process. This co-creation interview will contribute to the thesis by providing insights on, while highlighting limitations, of the approach developed as part of the research.

### Interview Procedure

- Your **participation** is entirely **voluntary**, and you may withdraw at any time without providing a reason.
- You are welcome to interrupt the interviewer at any time or refuse to answer questions, without any consequences.
- The interview will last approximately 45-60 minutes and will be recorded and transcribed.
- The transcript will then be analysed, and the outcome of the analysis will be included in the thesis report, which will be used as part of the student assessment for the Thesis Research Project.
- All material collected during this interview will be stored within TUD OneDrive and will only be accessible to the involved student (Laure Herpain) and the responsible researcher (Anna Melnyk).

### Personal Data and Consent

- **Unless** you provide **explicit consent**, your **participation** will remain **fully anonymous** in the thesis. If you do give consent, the interview and thesis report may include personally identifiable information, such as your name, professional position, authored works, or organisational affiliations.
- After the first interview, and once your insights have been integrated into the iterative approach, you will be invited to a second interview (or contacted via email) to review whether the updated approach accurately reflects your input. During this step, you can also review the description of your profile that may appear publicly in the thesis output.
- Once the thesis report and appendices are ready, you will receive a draft and can raise any concerns regarding how you are represented in the thesis output, which will be made public.
- Only material you have consented to will be included in the public thesis.

### Data Retention and Archiving

- The recording and full transcript of the interview will be **deleted** at the latest **1 month** after the completion of the project. Only material you have consented to will be included in the public thesis.

- After completing the thesis research project, only anonymised and carefully de-identified data will be archived unless participants explicitly consent to the storage of identifiable material.

***Contact information:***
Laure Herpain
***Supervisory team:***
Dr. Linda Kamp
Anna Melnyk
Dr. Robert Istrate

| **PLEASE TICK THE APPROPRIATE BOXES** | **Yes** | **No** |
|---|---|---|
| I have read and understood the study information above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction. | ☐ | ☐ |
| I consent to the use of **my name, affiliation, and job title to be made public** in the thesis report and documentation. I understand I will have the opportunity to review how my name and/or affiliations are used before publication of any documents. | ☐ | ☐ |

I consent to participate in the study and to the data processing described above

| _____ | _____ | _____ |
|---|---|---|
| **Name of participant [printed]** | **Signature** | **Date** |

# Appendix 4 — Elicitation Co-Creation Interview Guide

## Opening & Introduction (5 minutes)

Thank the participant and present the informed consent form. Explain the thesis project and nature of the elicitation interview. Explain S-LCA as a practice (optional, for participants who are not so familiar with S-LCA).

- Could you introduce yourself?
- Can you briefly describe your role in relation to energy transition/S-LCA/climate justice?

## 1. Collaborative Problem Framing (5 minutes)

- How do you understand "climate justice" in the context of S-LCA?
- In what ways, if any, do current S-LCA practice already address climate justice?
- Where do you think S-LCA falls short in addressing climate justice, and why so?

## 2. Co-creation, Eliticitation Tasks (45 minutes)

**Introduce the stimulus: framework draft (5 minutes)**

Script: "I am going to show you a draft of the framework I have been working on. It is intentionally incomplete, and the goal of this session is for us to co-create its structure and content together." Then, show the visual framework and explain the climate justice pillars.

**Task A: construct – 15 minutes**

Participants can draw, annotate, or add new elements:

- What would you add to these guidelines to reflect/integrate climate justice?
- Would you sketch how you think these relationships work?

**Task B: re-arrange concepts – 15 minutes**

Provide table, sketches of another participant:

- Would you agree with what they present?
- What would you disagree with? Does anything feel misplaced?

- If you could reorganise these elements, what would you change?

**Task C: interpret and critique draft framework —10 minutes**

- What's your first impression when you see this?
- Can you walk me through how *you* understand the structure?
- What makes sense? What is unclear or missing?

## 3. Conclusion Questions (5 minutes)

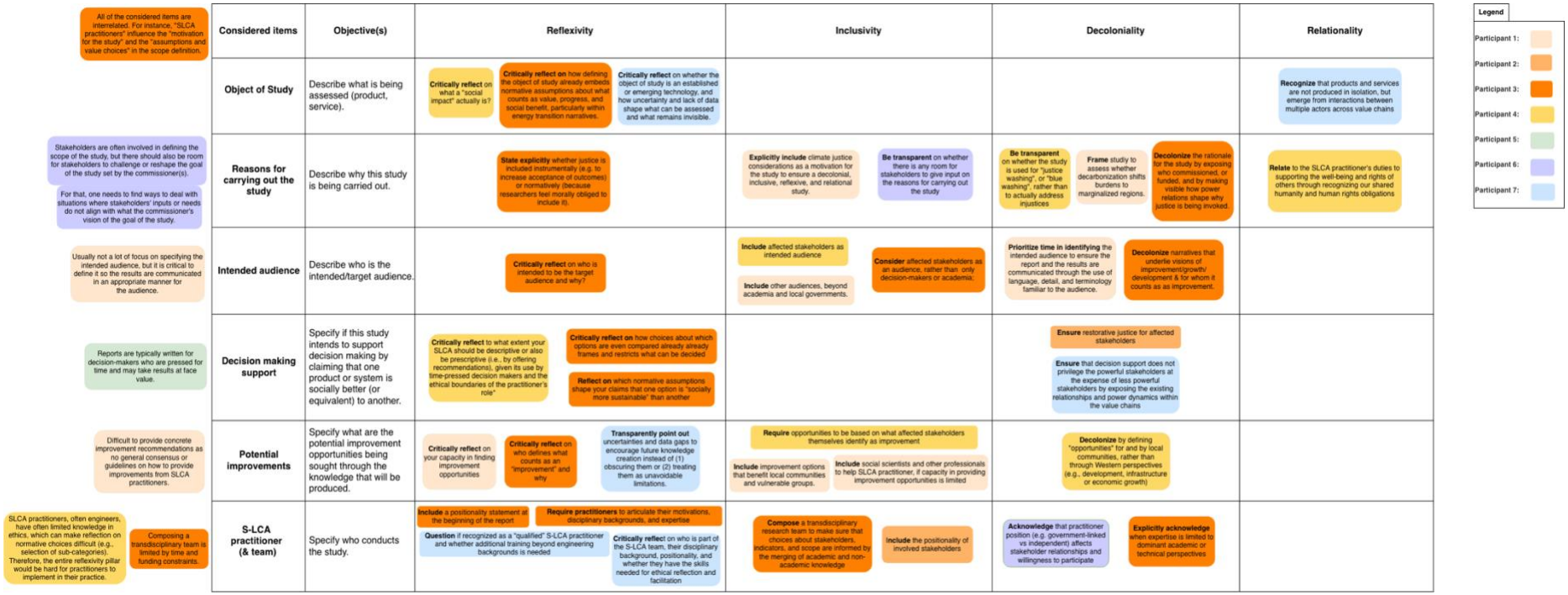
- Ask if they want to add anything
- Explain next steps, including the validation round
- Thank them

# Appendix 5 — Results Sub-Question 1

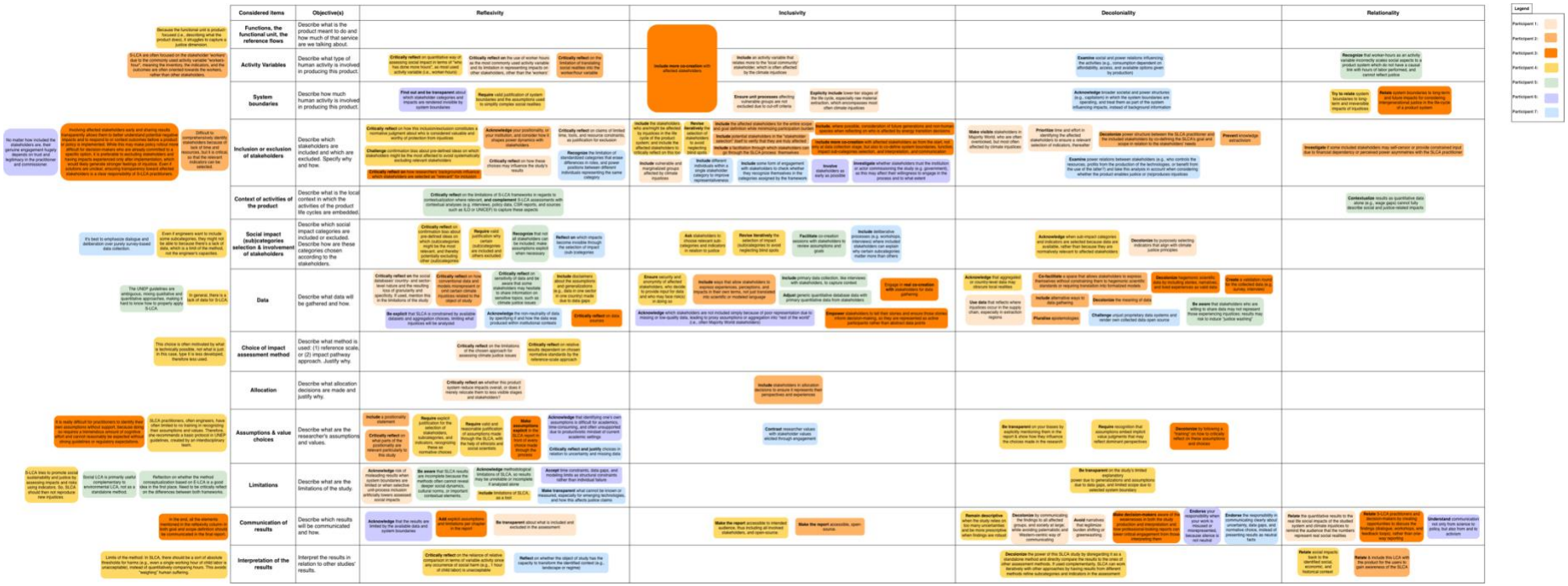
| Dimensions | Open code | Participant | Raw Data |
|---|---|---|---|
| Methodological constraints | S-LCA ommission of marginalised groups through system boundaries | Participant 1 | "If we focus in the top tiers of the value chain, only the production, manufacture, or the use of the technology, we are missing these climate justice problem that we are affecting vulnerable groups to extract these raw materials." |
| | Lack of data lead to system boundaries definition excluding climate injustices | Participant 1 | "In most of the study, the number of value chain stages that are evaluated in social life cycle assessment is usually lower than E-LCA because we don't have a data base like eco-invent. And this, the problem with climate justice... is when many of the burdens can move to the extraction of raw materials for the production of wind and solar." |
| | Lifecycle framing reveals upstream injustices | Participant 3 | "toxic extractivism... where do these materials come from? What sorts of justice impacts and exploitation happens... where you source these things from." |
| | UNEP guidelines' limited participatory approaches | Participant 7 | "often the practice is to give a survey and select, rank, prioritize, or in this kind of way... but it's not very informative of what the realities are, especially if you're seeking to involve vulnerable groups." |
| | Resource and capacity constraints to identifiy all affected stakeholders when researcher alone | Participant 1 | "The mapping of Stakeholders, it's difficult, because in many cases I don't have the necessary tools, time and resources to critically map all the stakeholders that can be affected across the value chain... from a single research group. And this also affect which indicators... are selected." |
| | No established guideline on how to operate climate justice | Participant 1 | "I think there are no general consensus. It's difficult to provide potential improvement measures apart from, okay, monitoring all the working rights, all the human rights about your value chain... because it's dependent on the context, on the people. So it's difficult to not have general guidelines..." |
| | No protocol or guidance for positionality | Participant 6 | "there is never a section there on who am I as a researcher... I don't see people asking these kind of questions or writing down their positionality in a paper." |
| | Ambiguity of UNEP guidelines | Participant 5 | "UNEP guidelines being very, very ambiguous into what S-LCA actually is. I spent six months opening this document every day and I still didn't really understand when you would perform a social LCA, what the UNEP guidelines want you to do?" |
| | Lack of guideline or regulation requiring S-LCA practitioners to be reflexive | Participant 3 | "To take the tremendous amount of cognitive effort to be reflective of every single thing that you put in there. It's not reasonable to expect people to do this... unless there is a very strong... regulation or a guideline that they are expected to do this." |
| | No protocol to help reflect on biases and assumptions | Participant 4 | "There is not protocol that help engineers by already stating where assumptions take place... already laying down 'Here's an assumption being made... here is like the space for biases'..." |
| | Lack of data leading to normative choices | Participant 7 | " for example, we were recently working on a paper dealing with impacts of PFAS removal. And we were making calculations, estimations of impacts to human health. But there's such a lack of data, things we don't know. that we just have to make a choice and say, okay, if we want to quantify for this inspiration, we choose this disease, but why? And why not all the others?" |
| | Lack of data leading to normative choices | Participant 4 | "And if the databases only have the subcategories, if they're only having these data, they will kind of assess what's technically possible to assess, but not what's what they should assess, what's what's normatively justifiable to assess." |

See this link for full table: https://leidenuniv1-my.sharepoint.com/:x:/r/personal/s2577569_vuw_leidenuniv_nl/Documents/Appendix_5_RQ1_Dataset.xlsx?d=w0b0d736b9d5c458c986c358355eb3f4f&csf=1&web=1&e=nPeJe4

# Appendix 6 — Results Sub-Question 2




See this link for better resolution: https://drive.google.com/file/d/1G_3OsPGkeo-5A6y7db-pcORk3Cu7pJZn/view?usp=sharing




See this link for better resolution: https://drive.google.com/file/d/1G_3OsPGkeo-5A6y7db-pcORk3Cu7pJZn/view?usp=sharing