Removals or Emissions?

The carbon footprint of future wood-sourcing

Borttagning eller utsläpp? Koldioxidavtryck i framtida köp av träråvara

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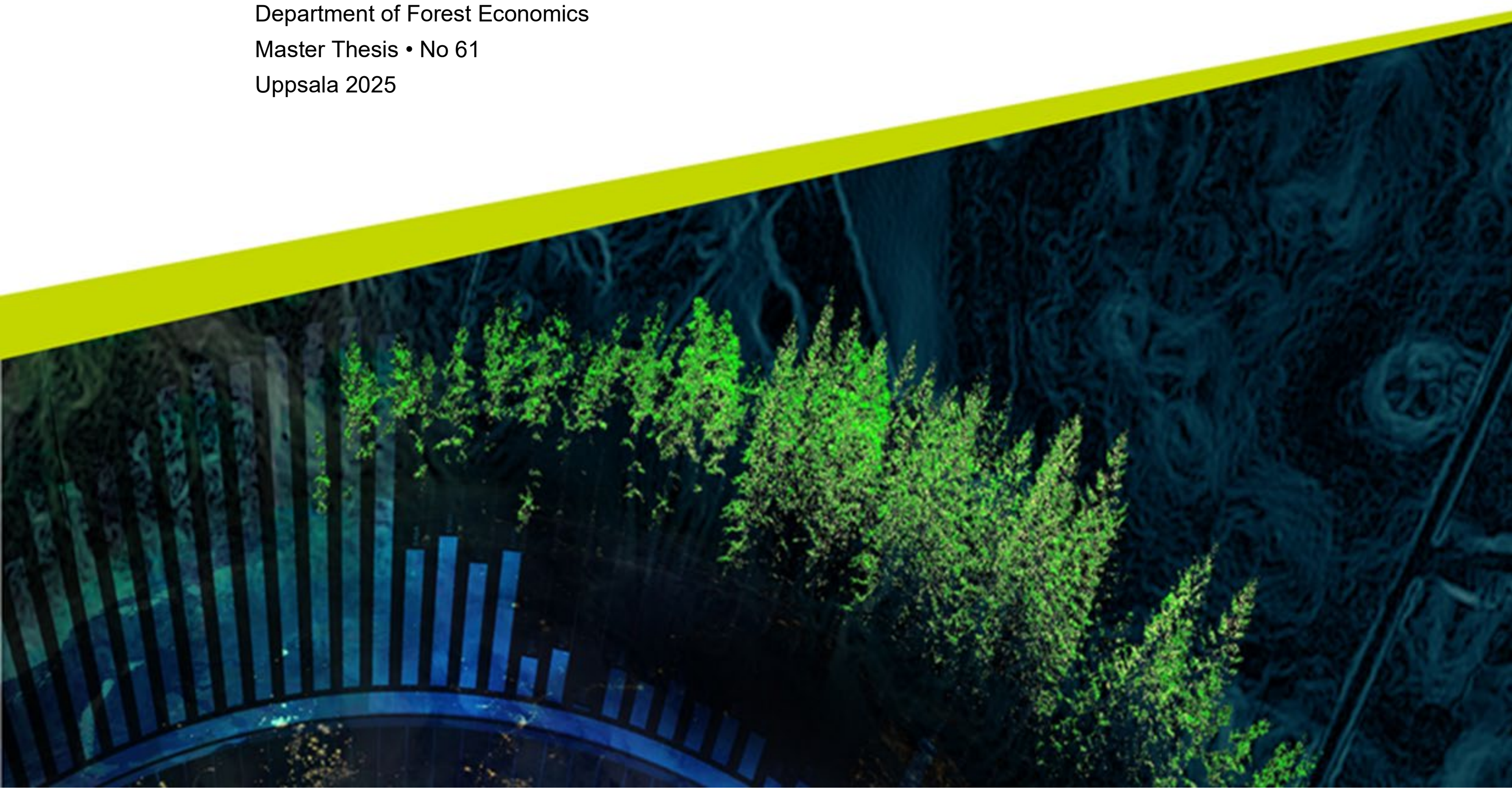

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Summary

Human activity has profoundly altered the environment (IPCC 2023), placing increasing pressure on both consumers and producers of goods and services that negatively impact the environment to adopt more sustainable practices. Within the EU (European Union), regulations such as the CSRD (Corporate Sustainability Reporting Directive) and ESRS (European Sustainability Reporting Standards) mandates companies to increase transparency around greenhouse gas emissions, and depending on the company, report their greenhouse gas emissions. One area receiving increased attention, particularly among companies dealing with biogenic products (e.g., those derived from biogenic materials such as wood) is the accounting of biogenic CO_2 removals and emissions (GHG protocol 2024), which refers to carbon fluxes resulting from biological processes such as forest growth.

However, delays in guidance from the GHG (Greenhouse gas) protocol and the suspension of the wood commodity pathway from the SBTi (Science Based Target initiative) have left companies with limited clarity on how to properly report and account for biogenic CO_2 emissions and removals.

This study examines the biogenic CO_2 emissions and removals associated with IKEA's wood sourcing. It develops a methodology and model for accounting for these flows and applies it to forecast the biogenic CO_2 removals or emissions. The time frame of 2025 to 2050 was selected for analysis in Sweden and Poland, two of IKEA's main sourcing countries.

The methodology, i.e. the developed model, uses Microsoft Excel as the primary software and integrates publicly available forest data with IKEA's projected wood sourcing volumes. It applies scenario analysis to examine the long-term development of biogenic CO_2 emissions and removals between 2025 and 2050. The inputs to the model include national forest inventory data from Sweden and Poland, fixed values from the 2006 IPCC Guidelines and IKEA's sourcing volume forecasts. The output is the estimated biogenic CO_2 emissions or removals attributed to IKEA for the time period. The scenarios used in the model were developed to reflect varying assumptions about forest growth rates and sourcing volumes.

The results indicate that sourcing wood from both Sweden and Poland is expected to result in net removals of biogenic CO_2 over the studied period. However, the removals are projected to decline over time, which raises the concern that these countries will contribute to emissions in the future. To mitigate emissions associated with wood sourcing, IKEA could increase their usage of recycled materials, while this would reduce their corporate emissions, it would not contribute to biogenic CO_2 removals. Nonetheless, given the declining trend of biogenic CO_2 removals in the studied sourcing countries, this strategy may be preferable if the long-term goal is to avoid biogenic CO_2 emissions.

Keywords: biogenic products, carbon accounting, forestry, land use, sustainability

Sammanfattning

Mänsklig aktivitet har fundamentalt förändrat jordens miljö (IPCC 2023), vilket har ökat trycket på både konsumenter och producenter av varor och tjänster som påverkar miljön negativt att agera mer hållbart. Inom EU ställer regelverk som CSRD och ESRS krav på att företag ska bli mer transparanta kring utsläpp av växthusgaser, och beroende på företaget, rapportera utsläpp av växthusgaser. Ett område som får allt större uppmärksamhet bland företag som hanterar biogena produkter (såsom produkter från biogent material som trä) är redovisningen av biogena CO2 utsläpp- och upptag (GHG Protocol 2023), vilket syftar på kolflöden som uppstår genom biologiska processer som skogstillväxt.

Förseningar i vägledningen från GHG-protokollet och avstängningen av SBTis ”wood commodity pathway” har lämnat företagen med begränsad klarhet kring hur de på ett korrekt sätt ska redovisa biogena CO2 utsläpp- och upptag.

Studien undersöker biogena CO2 utsläpp- och upptag kopplade till IKEAs trärråvaruförsörjning. Studien utvecklar en metod och modell för att redovisa dessa flöden och tillämpar den för att förutse utvecklingen mellan 2025 och 2050 i två av IKEAs viktigaste försörjningsländer: Sverige och Polen.

Metoden, eller den utvecklade modellen använder Microsoft Excel som mjukvara och integrerar offentligt tillgängliga skogsdata med IKEAs förväntade inköpsvolymer. Modellen applicerar scenarioanalys med målet att utvärdera den långsiktiga utvecklingen av biogena CO_2 utsläpp och upptag mellan 2025 och 2050. Indata i modellen inkluderar nationella skogsdata från Sverige och Polen, fasta värden från IPCC:s riktlinjer från 2006 och IKEAs förväntade inköpsvolymer. Output från modellen är de förväntade biogena CO_2 utsläppen eller upptagen tillhörande IKEA för tidsperioden. Scenarierna i modellen utvecklades med målet att reflektera olika antaganden om skogstillväxt och inköpsvolymer.

Resultaten indikerar att inköp av trä från både Sverige och Polen kommer att generera ett upptag av biogen CO_2 under den studerade perioden. Däremot förväntas upptagen minska, vilket väcker oro för att dessa länder i framtiden kan komma bidra med biogena CO_2 utsläpp. En möjlig åtgärd för att minska utsläppen är att IKEA ökar användningen av återvunnet trä. Detta skulle minska utsläppen kopplade till trärråvaruförsörjning, men inte bidra till biogena CO_2 utsläpp. Givet den minskade tillgången på upptag i de studerade länderna kan detta dock vara det bästa alternativet om det långsiktiga målet är att undvika utsläpp av biogen koldioxid.

Nyckelord: biogena produkter, kolredovisning, markanvändning, skogsbruk, hållbarhet

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Abbreviations

ABG	Aboveground Biomass	22
BAU	Business As Usual	34
BCEFs	Biomass Conversion and Expansion Factor	28
BGB	Belowground Biomass	22
BULiGL	Bureau of Forest Management and Geodesy	27
CER	Company Emissions and Removals	31
CF	Carbon Fraction	28
CSDDD	Corporate Sustainability Due Diligence Directive	13
CSRD	Corporate Sustainability Reporting Directive	3
EFRAG	European Financial Advisory Group	37
ESRS	European Sustainability Reporting Standards	3
EU	European Union	3
FLAG	Forest, Land and Agriculture	16
GHG	Greenhouse gas	3
GHG Protocol	Greenhouse gas protocol	13
GS	Growing Stock	30
HWP	Harvested Wood Products	30
IPCC	International Panel of Climate Change	13
MW	Molecular Weight	31
NACE	European Classification System	15
NCSC	National Carbon Stock Change	29
SBTi	Science Based Targets initiative	17
SKA22	Skogliga Konsekvensanalyser 2022	26
SLU	Swedish University of Agricultural Sciences	26
SOC	Soil Organic Carbon	23
TeDc	Temperate Continental Forest	20
TeDo	Temperate Ocenanic Forest	20
WBCSD	World Business Council for Sustainable Development	13
WRI	World Resource Institute	13

1 Introduction

This chapter provides the background and problem framing, with included examples from the industry. Furthermore, the research questions and project commission are introduced to outline the scope, purpose and delimitations of the study.

1.1 Problem background

Human activity has profoundly altered the environment, increasing the global average temperature, mainly through the release of greenhouse gases (IPCC 2023). The IPCC (**International Panel of Climate Change**) (2023) expects that consequences of the global temperature increase will include natural disasters such as flooding, storms, wildfires but also starvation, waves of migration and large areas becoming uninhabitable.

The pressure of acting more sustainably to address climate change and satisfy needs without compromising the environment has not only increased within the consumer group, but also the producers of goods and services (Trudel 2019). Society's demand on the industry to become more climate neutral have incentivised companies to become more transparent regarding the sustainability of their supply chain. This can be showcased by the increase in sustainability reports during recent years (KPMG 2022). Setting sustainability goals, such as achieving climate neutrality or a "net zero" when it comes to emissions, allows companies to communicate their environmental goals and drive their strategies to reduce and improve environmental impacts. Moreover, within the EU, the CSDDD (**Corporate Sustainability Due Diligence Directive**) (EU 2024/1760) also mandates companies to be transparent regarding their environmental impact.

With the increasing demand of becoming more transparent, companies seek guidance on how to translate sustainability guidelines into management strategies. To make these efforts succeed, they require tools that not only support sustainable decision-making and planning but also help define what makes an action a sustainable practice, including how different choices may affect ecosystems and the climate, both positively and negatively.

Biogenic CO_2 emissions could be described as the CO_2 that is released by natural biological processes, while biogenic CO_2 removals would be the opposite, CO_2 absorbed from natural biological processes. These processes involve living matter such as trees or algae. The demand for clear guidance on accounting for biogenic CO_2 removals and emissions has increased in recent years (GHG Protocol 2024). At the same time, regulatory frameworks such as the CSRD (**Corporate Sustainability Reporting Directive**) are coming into effect, adding pressure on companies dealing with biogenic products to disclose their climate impact. The retail sector, especially the furniture segment, offers a diverse range of primarily physical products, which allows for a more tangible evaluation of their environmental impact (Luis Ruiz-Real 2016). Companies within the retail industry will most likely be subject to greater scrutiny and higher expectations from consumers compared to other industries such as healthcare and public administration (*Ibid*).

The scrutiny of retailers intensifies when the company uses biogenic material in its products, making it even more important for the enterprise to be transparent and demonstrate that the material is used efficiently to minimize the climate-impact (Independent group of Scientist appointed by the secretary general 2019). Quantifying biogenic CO_2 removals and emissions when dealing with biosourced products contributes to a company's transparency. Furthermore, it helps provide a clearer understanding of GHG emission calculations and reduces supply chain leakage, thereby enhancing sustainability performance. The framework *GHG protocol,* issued by the World Business Council for Sustainable Development and the World Resource Institute (GHG Protocol n.d) is actively working on the "Land Sector and Removals Guidance". The mentioned guidance would provide instructions on how companies should account for emissions and removals from land management, land use change, biogenic products and more (*Ibid*). The guidance helps companies in the land sector report on impacts like land use change and carbon storage in biogenic products—issues that are increasingly important to both regulators and consumers.

1.2 Problem

Biogenic removal potential can be defined as the capacity of biological systems, in this case forests to remove and store carbon dioxide from the atmosphere (Fallasch & Böttcher 2024). However, the quantification of biogenic removal potential is a research field with many challenges (Iordan *et al.,* 2018). Quantification is a known problem-solver (McGill 2007) and could lead better decision-making and planning when it comes to biogenic removal potential and sustainable forest management. This could not only improve the sustainability reports of companies within the retail industry, but it could also improve the contribution of the industry handling biogenic material reaching the 1,5°C global temperature increase goal (Iordan *et al.,* 2018).

Currently, various models exist to quantify emissions and removals across different industries. One widely used framework is the Product Standard, developed by the GHG Protocol (2011), which aims to provide a comprehensive assessment of a product's full life-cycle emissions, both non-fossil and fossil. This standard enables corporations to identify and prioritize areas with the greatest GHG reduction potential.

The IPCC guidelines for National GHG inventories outlines various methodologies with distinct data requirements applicable on national level assessments (IPCC 2006). These methodologies build the foundation of the GHG Protocol's efforts in developing the Land Sector and Removals Guidance, which has the aim to adapt to a corporate level.

A methodology mentioned in the IPCC guidelines is the Stock Change Approach, described by Pingoud *et al*., (2006), which quantifies net carbon dioxide emissions and removals at a regional or national scale. It is meant to be used by countries to quantify their carbon stocks. This approach calculates the annual change in carbon stocks by accounting for both standing forest biomass and harvested wood products.

At an operational level, software's used by practitioners such as FPInterface aims to evaluate and optimize forest operations in terms of their greenhouse gas emissions. The software accounts for all input factors from fossil sources and the removal of biogenic material from the forest. According to Blounin & Cormier (2012) this enables users to visualize the environmental impact of each action taken within a specific forestry operation. However, this software does not count biogenic CO_2 removals, but rather the fossil-based emissions related to harvesting and biogenic emissions occurring when wood is removed from the forest.

While these standards and methodologies provide valuable insights into current emissions and removals, both total and biogenic, they do not account for dynamic changes resulting from different land management strategies and a change in sourcing- and material strategy, such as switching from virgin wood to recycled material. As previously mentioned, there is still no established guidance for corporations on how to systematically assess biogenic emissions and removals associated with land use, land-use change, and biogenic products (GHG Protocol 2024), leading to different methods being used which generates different results. Standardized guidance is essential for companies seeking to optimize their land use impact and enhance carbon sequestration potential.

Greenhouse gas emissions, particularly carbon dioxide, come from both natural sources like biomass decomposition and human activities such as fossil fuel-based industries. In contrast, carbon sinks like forests help absorb CO_2, keeping the atmospheric levels in check (Streiff 2021; FAO 2003; Dombeck & Moad 2001).

This is further supported by Streiff (2021), who found that globally, forest's sequestered twice the amount of carbon dioxide that it emitted between 2001 and 2019. Today the forest not only sequesters carbon, provides essential environments for many of our planet's species and ecosystem services such as biodiversity conservation, recreation and water purification, (Daily 1997) , it also produces everyday products, including everything from paper towels to buildings. Many of these products are considered essential, suggesting that forests will continue to be actively managed according to sustainable methods rather than left untouched in the future.

Consequently, sustainable forest management is crucial, particularly when considering long-term ecological and economic needs. Sustainable forest management is not only essential to improve and conserve the environment for many key species, but it can also work as a climate mitigating action, since forests acts as a carbon sink (Streiff 2021) and forest management could reduce the impact of natural disturbances such as forest fires or storms (Repo *et al.,* 2024). According to the IPCC (2023), forestry has a relevant role if we are to reach the goal of 1,5°C global temperature increase since it can both reduce emissions and contribute to sequestration of CO_2.

1.3 Climate Impact of the Retail Industry: Specifically, Furniture Retail and Manufacturing

The NACE (**Statistical Classification of Economic Activities in the European Community**) classification system provides a standardized way to categorize industries. NACE code G47.5.9 specifically refers to "Retail sale of furniture, lighting, and other household articles in specialized stores," and NACE C31 covers "Manufacture of furniture," both relevant to the retail industry's environmental impact.

The retail industry can be described as the selling of goods and services directly to consumers for everyday consumption (Marketos & Theodoridis 2006), it has many different classifications, including chain stores, supermarkets, and departmental stores. Consumers play a vital role and contribute largely to the variation in supply available at retail stores (Lee *et al.,* 2017).

The retail industry, which includes sectors such as furniture retail (NACE G47.5.9) and furniture manufacturing (NACE C31), is known to have a significant environmental impact.

Naidoo & Gasparatos (2018) argue that retailers have both direct impacts from retail operations and indirect impacts from production and other supply chain activities. However, the authors also note that it is an increasing trend for retailers to "go green," driven by stakeholder pressure and environmental policy. Because the retail industry is so diverse, with products ranging from food to physical goods to services, there is no blueprint on how the whole industry can measure its emissions and removals from activities that contribute to biogenic emissions and removals. However, quantification of climate impact in biogenic products in retail is possible (Guest *et al.,* 2013) and the author suggests that it may be a good start for retailers dealing with biogenic products.

1.4 Biogenic Products in the Retail Industry

Biogenic products, such as wood, play a central role in the sustainability performance of companies manufacturing and brokering them due to their carbon storage potential. Biogenic products are described as a sustainable and environmentally friendly substances derived from plants, animals, microorganisms, algae, or biopolymers (Finkbeiner *et al.,* 2012; Conte 2019). Examples include wood, paper, and other plant materials. For retailers using or selling biogenic products, such as wood, the supply chain plays a critical role in determining the company's sustainability performance, as it significantly impacts the emissions reported in their sustainability reports. At the foundation of the supply chain is the tree itself, which sequesters carbon from the atmosphere during its growth through photosynthesis. Over time, this process stores carbon within the biomass of the tree. Research indicates that forest management practices influence the amount of carbon sequestered by forests (Profft *et al.,* 2009), making it a key consideration in sustainability efforts. For retailers, this connection is especially important because forest management directly affects the greenhouse gas emissions linked to the products they sell. This becomes even more critical when the retailer owns or controls a sizable part of the supply chain, as they can directly influence these practices. By prioritizing sustainable forest management, retailers can reduce their carbon footprint while aligning their operations with broader environmental goals.

1.5 The Knowledge Gap

The FLAG (**Forest, Land, and Agriculture**) sector is estimated to contribute approximately 22% of global annual GHG emissions (SBTi, 2022), while also holding significant potential for climate change mitigation. Consequently, corporations operating within this sector must adopt more sustainable practices to reduce their environmental impact while continuosly following up their efforts.

Existing frameworks aimed at evaluating biogenic carbon removals on a national scale provide insights into emissions accounting. However, gaps remain in the quantification of CO_2 removals and emissions on a company level (Peer 2024). These emissions and removals are especially important for industries that rely on biogenic materials such as wood, since a large part of their emissions and removals are not accounted for. Available methodologies offer ways to assess emissions and removals at a national level. However, they do not adequately address the corporate level, changes in land management activities and wood sourcing strategies, which can be considered crucial when trying to improve the impact of a company's carbon sequestration potential.

Forests are considered essential but sensitive carbon sinks (Streiff, 2021). However, current trends indicate that forests are becoming sources of emissions in some countries. This due to increased harvesting intensity and the increased presence of pests, such as the spruce bark beetle (Phoenix 2024: Luke 2025). High harvesting intensity may lead to a decrease in carbon sequestration, and vice versa (Jandl *et al.,* 2007; Gorte 2007). The impact of wood sourcing practices on biogenic CO_2 removals remain poorly quantified at the corporate level. This gap of knowledge is especially relevant for retail companies like IKEA, which procure large volumes of wood and have significant potential to influence sustainable forestry practices across their supply chains.

1.6 Aim and research questions

This study aimed to forecast the potential future trends in biogenic emissions and removals for a company primarily engaged in biogenic products, from the company's own perspective. Additionally, it sought to develop an Excel-based calculation tool at the company level, using scenario analysis to support projections.

The following research question was answered:

- *What will be the evolution of aboveground net biogenic land-related emissions and removals for a company within the retail sector?*

The practical goal of the study was to develop:

- A user-friendly scenario analysis tool will be developed in Excel to calculate emissions and removals associated with the company's wood sourcing strategies and usage of virgin compared to recycled wood from 2025 to 2050.

1.7 Delimitations

The focus of the study was to analyse the future biogenic emissions and removals related to wood sourcing from a company's perspective. To ensure that the study was feasible, some delimitations had to be made. IKEA sources wood from a variety of different countries, in various parts of the world. The scope of this study was limited to Sweden and Poland. Geographical limitations were made because of the climate variations affecting the growing season and fixed values associated with global ecological zones (IPCC 2006). Sweden and Poland also accounted for a large share of IKEA's total raw material sourcing (IKEA 2024), which solidified their selection as a good fit for the study.

The data used in the study was restricted to secondary data sources. To forecast growth of forests and harvesting intensity, extensive national forest assessments would have had to be done, which are not only difficult, but also time-consuming. National forecasts on forest growth and harvests based on historical data done by public institutions ensured that the data quality remained high. However, there are some disadvantages to using only secondary sources of data, such as potential information gaps or the uncertainty surrounding the data collection process (Serra *et al.,* 2018). (Serra *et al.,* (2018) also argued that the main advantage when using only secondary sources of data is efficiency, since the data collection process was more streamlined.

Considering theoretical delimitations, the study used interdisciplinary literature. However, more attention was paid to frameworks that are widely used within forestry, land use and greenhouse gas accounting. These include the GHG Protocol, SBTi FLAG and the IPCC 2006 guidelines for national greenhouse gas inventories. Other frameworks, with more comprehensive climate policy models, could have enhanced the analysis. This study, however, placed greater significance on approaches which were more in line with the main research questions and available secondary data.

Throughout their lives, wood products are known to be able to store CO_2. However, the stored CO_2 is eventually released back into the atmosphere is these items are not recycled or reused at the end of their lives (SSB 2009). Since the proportion of the company's wood products that will be recycled versus the proportion that will be discarded is not known, delayed emissions are not taken into consideration in this analysis.

The boundaries were defined to help the reader get a broader understanding of what was and what wasn't included in the study, and suggested where more research could have provided a broader view of the phenomenon.

1.8 Comission

Ikea, the global furnishing company known for its affordable self-assembly wood-based furniture, was founded by Ingvar Kamprad in 1943. To complete the company vision of creating a better everyday life for the many people, IKEA aspires to sell affordable furniture while reducing its climate footprint. Sustainability initiatives include reducing plastics in packaging, introducing plant-based food options, and transitioning to certified wood sourcing, reducing emissions by 22% from 2016 to 2023. IKEA (2025) has committed to the SBTi net zero goals, which includes a 50% reduction of GHG emissions by 2030 and a 90% reduction by 2050, the baseline is set to 2016.

This study evaluates the evolution of aboveground net biogenic land-related emissions and removals from IKEA's wood sourcing starting in 2025 through 2050. It will model land management activities affecting carbon removals and develop an Excel-based decision-support tool aligned with the GHG Protocol's Land Sector and Removals guidance. Specifically, it will address the following questions.

- *Based on growing stock inventory data from public data sources and databases, and overlaying with future wood supply availability, what is the evolution of aboveground net biogenic land-related emissions/removals associated with IKEA's wood sourcing expected until 2050?*

1.9 Outline

An outline is provided to help the reader manoeuvre the structure of the thesis. To lead the reader from the formulation of the problem to analysis and discussion, each chapter builds on the one before it. *Figure 1* serves as an outline for the study.

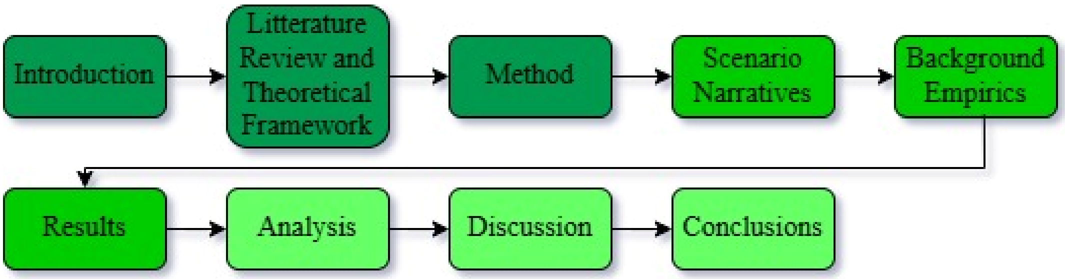

Figure 1: Outline for the thesis, visualized by the author.

Chapter 1, *Introduction* presents the research problem and explains how the study intends to answer it. The chapter outlines the scope of the study and the research question addressed. Chapter 2, *Literature Review and Conceptual Framework* provides an overview of current research and existing frameworks related to accounting for carbon removals and emissions. These sources are then used to develop the conceptual framework. Chapter 3, *Method* provides future researchers with a blueprint for conducting a project like this one, with parameters and sources of data outlined. Chapter 4, *Scenario Narratives* introduces the analyzed scenarios. Chapter 5, *Background Empirics* provides "good-to-know" information intended to give the reader a better understanding of Chapter 6, *Results* which presents the study's findings. Chapter 7, *Analysis* reintroduces the conceptual framework which is used to analyze the results. Chapter 8, *Discussion* discusses the research question and other points of interests that emerged during the analysis. The chapter also discusses limitations of the study. Chapter 9, *Conclusions* concludes the study by reconnecting to the aim and presents additional implications.

2 Literature Review and Conceptual Framework

This chapter contains an extensive overview of current research related to accounting for carbon removals and emissions. The review of literature consists of guidelines and standards, some on national and some on company-level. The literature used will act as the building stones of the conceptual framework.

2.1 Estimating Annual Change in Biomass: The Gain Loss Method

Forests act as carbon sinks by sequestering carbon from the atmosphere during their growth phase and as carbon sources during other natural processes such as decomposition and wildfires (IPCC 2006). The *gain-loss method*, outlined in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* provides a framework for estimating biomass carbon stock changes by quantifying annual gains and losses. This approach is applicable across different levels of analysis but is most effective when biomass fluctuations are relatively small compared to the total biomass stock (IPCC 2006). The method accounts for both aboveground and belowground carbon fluxes as seen in *Figure 2.*

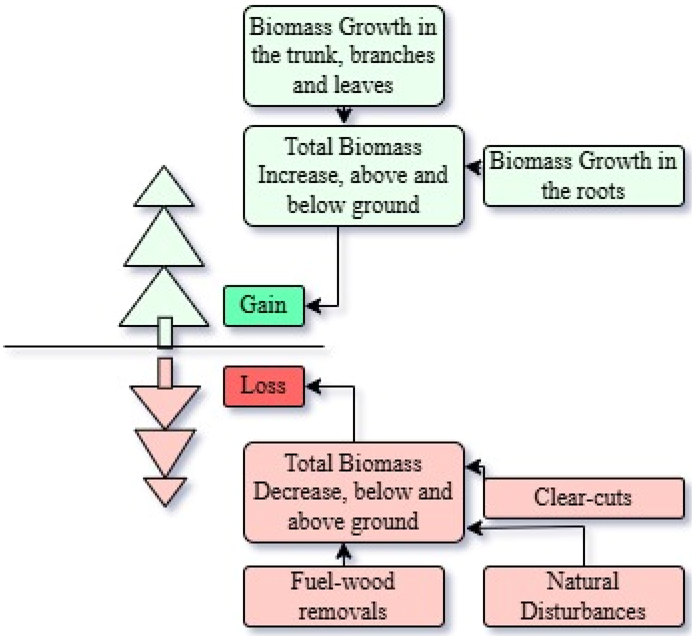

Figure 2: The gain-loss method, based on International Panel of Climate Change (2006).

Figure 2 illustrates the *gain-loss method* and the flow of carbon within forest biomass, underscoring both the gains and losses over time. Biomass increases occur through growth in the trunk, branches, leaves and roots. Biomass decreases occur during clear-cuts, fuel-wood removals and during natural disturbances.

To ensure accuracy in calculations, forests must first be classified into well-defined forest types, with their respective areas quantified in hectares. A representative case is Poland, which comprises both Temperate Continental Forest (**TeDc**) and Temperate Oceanic Forest

(**TeDo**), each of which must be accounted for separately. Following the definition of forest types, biomass growth is estimated for each forest type within its corresponding climatic zone. Thereafter, biomass losses are quantified by considering the following factors: wood removals, fuelwood removals, and natural disturbances. To mitigate potential errors, including accounting errors and oversimplifications, each forest type is assigned specific parameters, such as growth rates and belowground-to-aboveground biomass ratios, based on established assumptions.

2.1.1 The Stock-difference Method

The Stock-Difference method estimates carbon stock changes by comparing carbon stocks at two different points in time (IPCC 2006). This approach is especially useful when high-quality forest inventory data is available. However, it does not differentiate between growth, harvest, or natural disturbances, making it less precise for identifying the specific drivers of carbon stock changes.

By comparison, the Gain-Loss method estimates carbon stock changes by balancing carbon inputs (e.g., growth) and outputs (e.g., harvest, decomposition). Notably, the Gain-Loss method is the only approach applicable at Tier 1, 2, or 3 levels (McRoberts *et al.*, 2018), whereas the Stock-Difference Method is limited to Tier 2 and 3 applications. McRoberts *et al.,* (2018) argues that the Stock-Difference Method is relatively easy to implement in countries with comprehensive forestry data and tends to have lower uncertainty compared to the Gain-Loss Method. However, the study found that both methods produced comparable results in practice.

The Stock-Difference method is inherently limited as it provides only a temporal snapshot of carbon sequestration, rather than a dynamic representation of fluxes over time. The resulting estimates are highly dependent on the chosen accounting period (IPCC n.d). This limitation is illustrated in *Figure 3*, where two hypothetical forests demonstrates different growth rates, resulting in variations in their carbon sequestration rates.

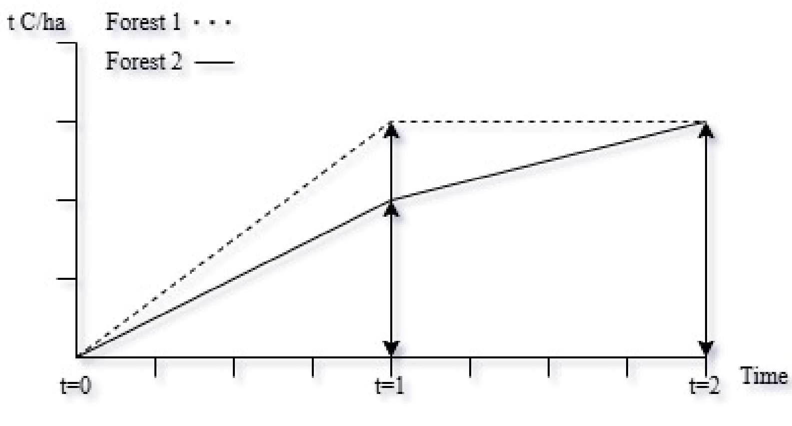

Figure 3: Effect of measurement timing in the Stock-difference method, based on IPCC (n.d).

As described in *Figure 3* when the Stock-Difference method is applied at *t=2*, both *Forest 1* and *Forest 2* would yield identical estimates despite their different sequestration rates.

However, when applying the method at *t=1* the results would differ between the two forests, which highlights the method's sensitivity to the timing of the measurement.

2.2 Carbon Pools and System Boundaries

Clear definitions of carbon pools and system boundaries are critical because they determine how carbon stocks and fluxes are accounted for, affecting the accuracy and comparability of results. A carbon pool can be defined as "a reservoir of carbon; a system which has the capacity to accumulate or release carbon" (FAO 2009). In forest ecosystems, five main carbon pools are considered (Grant *et al.,* 2021). A visual explanation of the carbon pools and the carbon fluxes between them can be found in *Figure 4.*

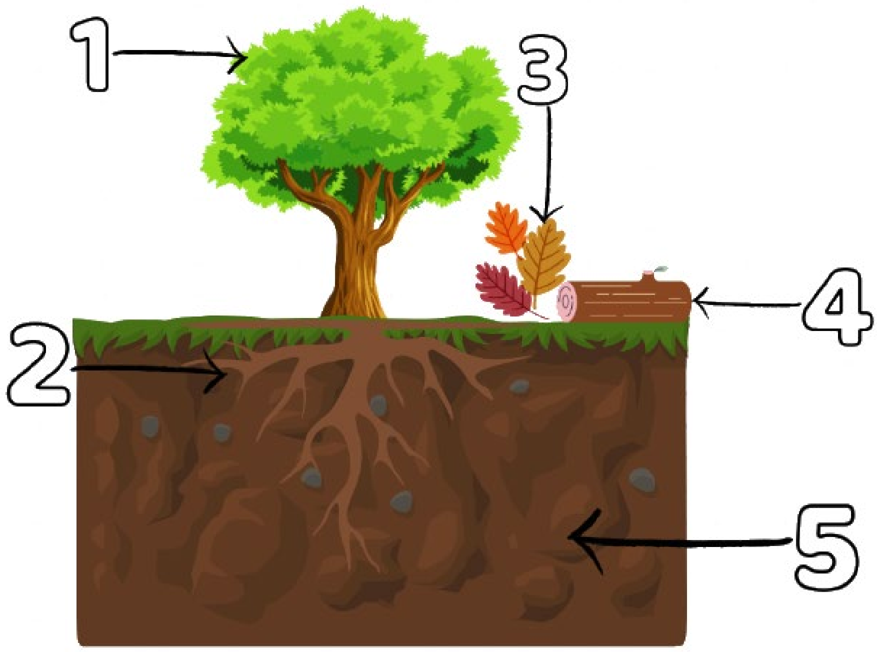

Figure 4: Carbon pools in the forest, inspired by Hoover and Riddle (2020, 5).

Figure 4 illustrates the carbon cycle in the forest, which starting with carbon sequestration, which happens as trees grow and accumulate carbon in the pool ABG (**Above-ground biomass**) (marked with a 1 in *Figure 4*) or BGB (**Below-ground biomass**) (marked with a 2 in *Figure 4*). As trees or part of the trees die, carbon is transferred from pool 1 or 2, to pool 3 illustrated as litter or pool 4, illustrated as deadwood. After some time in these pools, the carbon is transferred to pool 5, the *soil-organic carbon pool*. The time spent in these pools varies from region to region. Carbon can leave the forest ecosystem through harvesting of timber, ending up in the HWP (**Harvested Wood Product**) pool (Hoover & Riddle 2020). An overview of the carbon pools and their role in this analysis can be viewed in *Table 1.*

Table 1. Carbon pools and their relevance to the study

Carbon Pool	Description	Relevance	Data Availability	Inclusion in Study
Above-Ground Biomass	Carbon stored in living trees	Key focus for estimating biogenic emissions and removals	Generally well-documented through forest inventories (IPCC 2006)	Included
Below-Ground Biomass	Carbon stored in roots	Irrelevant for aboveground emissions analysis	Estimated through a constant measuring the relationship between above- and below ground biomass (IPCC 2006)	Excluded
Deadwood	Carbon stored in fallen and dead trees	May contribute to emissions and removals	Varies heavily by region and forest type Estimation is difficult due to practical limitations (IPCC 2006)	Excluded
Litter	Carbon stored in leaves, needles and small debris on the forest floor	Minor contribution regarding carbon flux	Limited data compared to ABG, leading to high uncertainties (IPCC 2006)	Excluded
Soil Organic Carbon (SOC)	Carbon stored in forest soils	Long-term carbon sink, but not part of aboveground flux	Very complex and high uncertainty (Scharlemann *et al.*, 2014)	Excluded

Table 1 introduces the main carbon pools within the forestry biome and their relevance to the study. It is widely recognized that soil organic carbon constitutes the largest proportion of the forest ecosystem carbon stocks (Dixon *et al.,* 1994; Grant *et al.,* 2021; FAO 2006; Scharlemann *et al.,* 2014). However SOC (**Soil Organic Carbon**) emissions vary depending on the land use following deforestation. For instance, significant emissions occur when forests are converted to cropland, such as soybean plantations (Villarino *et al.,* 2017). Scientists have not yet reached a consensus on the estimated size of the global SOC stock (Scharlemann *et al*., 2014), and the availability of reliable data remains limited. Given these uncertainties, SOC is excluded from the scope of this study and will not be accounted for. Above-ground biomass is the primary focus of the study for two key reasons. First, it is the most relevant carbon pool in the context of forest harvesting, as the harvested portion of a tree consists of aboveground biomass. Second, other carbon pools such as litter and deadwood contribute minimally to net carbon fluxes at the forest level, and their measurements can be highly uncertain depending on the region.

2.3 Science-Based Targets Initiative and Forest, Land and Agriculture Targets

The SBTi is a globally recognized standard-setting body that provides structured frameworks for the setting of corporate, science-based climate targets (Peer 2024). It ensures that companies' definitions of carbon pools, system boundaries and decarbonisation pathways are both credible and science based. Peer (2024) mentions that after its launch in 2015, the SBTi has experienced explosive growth with many of the world's largest corporations incorporating its methodologies into their sustainability strategies.

The FLAG sector is estimated to account for 22% of the global annual GHG emissions, while simultaneously offering up to 30% of the mitigation potential by 2050 (SBTi 2022), making the sector a key lever for emission reduction. The SBTi FLAG emissions and removals are calculated using the IPCC guidelines and methodologies. Given the sector's significant role in climate change mitigation, companies engaged in forestry, paper production, and land-use activities are mandated to establish FLAG-specific targets (Anderson *et al.*, 2023). This allows the companies using SBTi's frameworks to account for and claim both emissions and removals within their value chain.

Companies within the FLAG sector should account for all their activities contributing to GHG emissions or removals. *Figure 5* illustrates activities relevant to companies within the forestry sector.

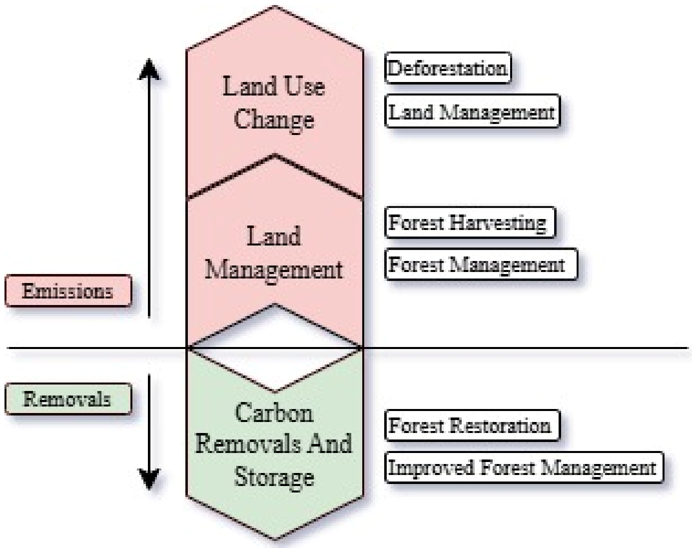

Figure 5: Science Based Target initiative Emissions and Removals for a company within the Forest, Land and Agriculture sector, based on Science Based Target Initiative (2022).

Figure 5 mentions both activities leading to GHG removals and emissions. Deforestation is a well-documented source of emissions (SBTi 2022), and companies in the FLAG sector are advised to commit to zero deforestation, with a cut-off date in 2025. Land management practices within the forest sector, such as converting natural forests into plantations, can lead to short-term carbon dioxide emissions and should be included in a company's accounting (IPCC 2006). Similarly, harvesting activities like clear-cutting contribute to short-term emissions and must be accounted for (IPCC 2006). In contrast, SBTi (2022) mentions activities such as restoring degraded forests and improving forest management can enhance carbon sequestration, supporting companies' claims of removals.

The SBTi framework has been widely recognized for enhancing corporate awareness of climate responsibilities and facilitating the implementation of science-based emissions reduction targets (Tilsted *et al.,* 2023). However, some researchers argue that the methodologies used are not applicable at a company level. Peer (2024) argues that the global carbon budget, one of the scientific concepts supporting the SBTi, is not directly applicable to company-level targets. Similarly, Tilsted *et al.,* (2023) emphasizes that the SBTi gives companies considerable flexibility in determining how and when they meet their climate commitments, which may result in the delayed emission reductions until the final years before the target deadline. Nonetheless, Tilsted *et al.,* (2023) maintains that the SBTi has the potential to drive meaningful change when it comes to climate action among companies.

2.4 Conceptual framework

A model has been developed to forecast and evaluate emissions and removals from IKEA's wood sourcing between 2025 and 2050, as shown in *Figure 6.* The model combines elements from the *IPCC* (Gain-Loss method and Stock-Difference method), *SBTi-Flag* and other previous studies on the subject. The *Gain-Loss method* is used to estimate carbon stocks using aboveground biomass, and the *Stock-Difference method* provides a more nuanced result since it measures the development of the aboveground carbon stocks for each year. The model is specifically designed for IKEA's wood sourcing because of the data availability but it could be used for other companies as well, if they provide data regarding their procurement of virgin wood.

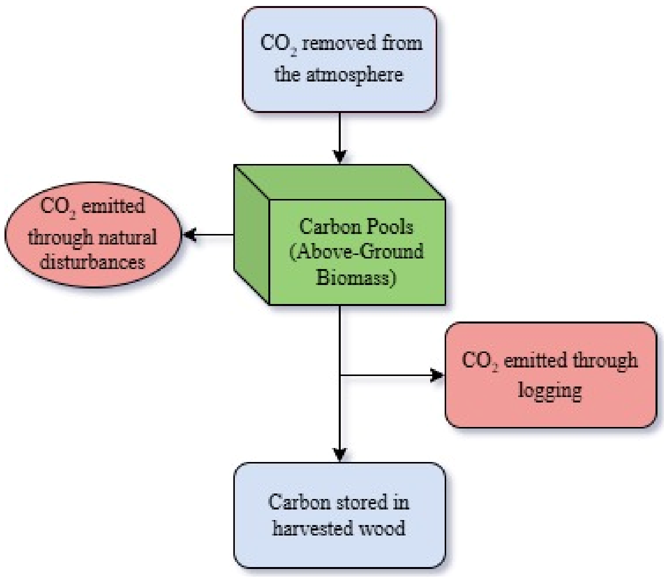

Figure 6: Conceptual framework, visualized by the author.

Figure 6 reveals relevant factors accounted for in this study, based on earlier research and litterature. The factors "CO_2 removed from the atmosphere", "CO_2 emitted through natural disturbances" and "Carbon Pools (Above ground biomass)" are calculated using fixed values, provided by the IPCC (2006) and national growth models. The factor "carbon stored in harvested wood" is calculated using a combination of anticipated harvests (up until 2050) and fixed values, provided by the IPCC.

The next chapter will provide insights into the exact methodology used while further explaining the formulas and data used in the thesis.

3 Method

The methodological approach is introduced and assessed in this chapter. A literature review and a scenario analysis using quantitative data from secondary sources form the foundation of the project. The subchapters and the research problem are closely related to maintain coherence.

3.1 Methodological Approach

The research adopted an approach to build a decision-making support tool for assessing a company's biogenic emissions and removals. The SBTi wood commodity pathway's suspension (SBTi 2024) highlighted the shortage of studies on biogenic emissions and removals in businesses that primarily dealt with wood-based products. To incentivise companies to set goals for cutting emissions and increasing biogenic carbon removals, more research was required. Quantitative, forecasted data gathered from secondary sources was used in this study.

3.2 Data Collection

Established national forest growth models from Sweden and Poland were the main tools used to gather data from secondary sources. IKEA's wood supply strategy for these nations and IPCC fixed values were among the additional secondary data used. National stock change factors and the quantity of carbon removed or emitted per nation and year were among the variables considered.

3.2.1 Secondary Data

The following chapters introduced the sources of secondary data used in the study. Among those were SKA22 (**Skogliga konsekvensanalyser 22**), BULiGL (**Bureau of Forest Management and Geodesy)** and the 2006 IPCC guidelines for national greenhouse gas inventories.

3.2.2 Skogliga Konsekvensanalyser 2022

SKA22 was a consequence analysis tool developed by Skogsstyrelsen in collaboration with the SLU (**Swedish University of Agricultural Sciences**), with the goal of modelling the development of Swedish forests for up to 100 years. The analysis was released in 2022 and was based on a multitude of relevant factors, such as national goals from the Swedish Parliament and national climate goals (Skogssstyrelsen 2023). The analysis was made using Heureka RegWise in which data from the current state of the forest was gathered, and then forecasted using different functions regarding the growth, death and logging of the forest. The tool contained six different scenarios for the future (SLU 2022). The tool allowed for the user to retrieve projected national forest data, such as forest inventory and harvests up to a given year. Parameters retrieved from SKA22 were presented in *Table 2*.

Table 2. Retrieved data from SKA22

Retrieved Parameters	Unit
Expected Forest Growth for Sweden (2025-2050)	m^3sk
Expected Harvests for Sweden (2025-2050)	m^3sk

Table 2 presented parameters retrieved from SKA22. The values served as input data for modelling future biogenic CO_2 removals and emissions related to woodsourcing from Sweden.

Different metrics used to model SKA22 were collected during different time periods. Data used for modelling expected harvested volume in Sweden were collected between 2011 and 2015, based on harvesting records (Skogsstyrelsen 2022), while data for modelling the expected forest growth were collected between 2016 and 2020 through inventory plots. Since SKA22 forecasts both expected forest growth and harvested volume, two key parameters used in this study, which aligned well with study's purpose. However, forecasted data naturally comes with limitations. The main purpose of SKA22 is to provide the Swedish Parliament a guidance regarding legalisations surrounding forestry in Sweden, and fundamentally, the forecasted data is not confirmed by more recent observations (*Ibid*).

3.2.3 Bureau for Forest Management and Geodesy State Enterprise

Throughout Poland, the state-owned Bureau for Forest Management and Geodesy was tasked with creating forest management plans and carrying out forest inventories with the intended purpose being updating and storing forestry data from all forms of ownership (BDL 2025). By combining ecological, social, and economic factors, the enterprise ensured sustainable management of forest resources for both state-owned and private forests (BULiGL 2023). BULiGL carried out regular statewide forest inventories; the data was used to forecast both the growth of the forest and project the quantities of wood harvested (BULiGL 2023b). BULiGL provided estimates for timber harvesting and forecasts on the growth of state-owned and private forests. Parameters retrieved from BULiGL were presented in *Table 3.*

Table 3. Retrieved data from BULiGL

Retrieved Parameters	Unit
Expected Forest Growth for Poland (2025-2041)	m^3ub
Expected Harvests for Poland (2025-20xx)	m^3ub

Table 3 presented parameters retrieved from BULiGL. The values served as input data for modelling future biogenic CO_2 removals and emissions related to woodsourcing from Poland.

The data used to forecast expected forest growth and harvested volume in Poland was collected through national forest inventory plots, forest management records and forest monitoring records (BDL 2025b). The forecasts contains both expected forest growth and expected harvested volume, which aligns with the study's purpose because of its usage in the model.

Neither Bank Danych o Lasanch or BULiGL mentioned limitations regarding the forecasting made. However, forecasted data could only be viewed as guidance and remained unverifiable.

3.2.4 Company specific data

Company specific data were provided by IKEA. The spatial data included hypothetical volumes of timber sourced from Sweden and Poland (year-by-year) 2025-2050. Parameters were presented in *Table 4*.

Table 4. Retrieved data from IKEA

Retrieved Parameters	**Unit**
Hypothetical Volume sourced from Sweden (2025-2050)	m^3ub
Hypothetical Volume sourced from Poland (2025-2050)	m^3ub

Table 4 presented parameters retrieved from IKEA. The values served as input data for modelling future biogenic CO_2 removals and emissions related to company woodsourcing.

The company specific data provided by IKEA and presented in *Table 4* was originally arranged for hypothetical internal planning purposes, to estimate the volumes of wood to be sourced from Sweden and Poland. The data does not come from the real woodsourcing strategy of IKEA. Expected sourced volumes from IKEA were a crucial part of the model, as they directly determine the extent of biogenic CO_2 removals or emissions linked to IKEA's wood sourcing. The data provided by IKEA was covered by a non-disclosure agreement and thus could not be disclosed, nor could the collection of the data. Any missing data were forecasted using the FORECAST.ETS function in Excel.

The usage of forecasted sourcing volumes could be deemed necessary. However, it introduces limitations. Forecasts are sensitive to external factors, such as fluctuations in timber and furniture markets, as well as economic conditions like tariffs. Despite the limitations, the use of this data is justified given its direct relevance to the study's scope.

3.2.5 The 2006 IPCC Guidelines for national greenhouse gas inventories

The IPCC Guidelines for national greenhouse gas inventories provided default values used in the calculations. The values were specific to the different global ecological zones and contained CF (**Carbon Fraction**) of raw materials and BCEFs (**Biomass Conversion and Expansion Factors**), a term that scaled up the measured trunk volume to total tree biomass (IPCC 2006). Parameters retrieved from the IPCC were presented *Table 5*.

Table 5. Retrieved data from the 2006 IPCC guidelines for national greenhouse gas inventories

Retrieved Parameters	**Unit**
Carbon Fractions	Factor
Biomass Conversion and Expansion Factors	Factor

Table 5 presented parameters retrieved from IKEA. The values served as fixed input data for modelling future biogenic CO_2 removals and emissions.
The original purpose of the 2006 IPCC guidelines for national greenhouse gas inventories was to provide structured methods and guidance for countries to estimate and report greenhouse gas emissions and removals from land use, land-use change, and forestry (IPCC 2006). The fixed parameters included in the guidelines such as CF and BCEFs were based on peer-reviewed scientific studies and designed for national-level greenhouse gas accounting. While the IPCC allows for the use of these default values, they recognize their limitations and recommends that countries use country-specific data that better reflect local conditions. In this study, fixed factors from the IPCC are applied in equations that support the modelling of biogenic CO_2 removals and emissions. Given their scientific character and relevance to forest carbon accounting, the use of these values were justified, although their limitations and generic nature are acknowledged.

3.3 Analysis Method

The following subchapters provides a step-by-step procedure of the analytical process, information regarding usage of software, exogenous and endogenous factors and information regarding the development and analysis of scenarios.

Scenario Analysis, defined by Porter (1985) as "an internally consistent view of what the future might turn out to be, not a forecast, but one possible future outcome", is widely used across various fields, including the environmental field, to help with decision-making (Tourki *et al.,* 2013). Tourki *et al.,* (2013) recommended three steps for creating a successful scenario analysis, *Analysis*, which included Problem & Scope Definition and Identification of Key Factors, *Scenario Development* and *Evaluation.*

3.3.1 Model Development

This study developed a model to calculate aboveground emissions and removals related to a company's wood sourcing using excel. The model integrated forest growth projections, harvesting projections, and specific ordered quantities from the company. The purpose of the model was not only to provide a method for assessing the long-term impacts of sourcing wood from specific countries but also to evaluate the effect of switching to other materials, such as recycled wood.

3.3.2 Exogenous and Endogenous Factors

Exogenous factors were presented in *Table 2,3,4,5.* A full breakdown of exogenous and endogenous factors could be found in *Table 6.*

Table 6. Exogenous and endogenous factors used in the model

Category	Factor	Description	Unit
Exogenous	Projected Forest Growth Sweden	Projected growth of the Swedish forest 2025-2050, derived from SKA22	m^3sk
	Projected Harvest Sweden	Projected harvests of the Swedish forest 2025-2050, derived from SKA22	m^3sk
	Projected Forest Growth Poland	Projected growth of the Polish forest 2025-2050, derived from BULiGL	m^3ub
	Projected Harvest Poland	Projected harvests of the Polish forest 2025-2050, derived from BULiGL	m^3ub
	Carbon Fraction	Amount of carbon per ton of raw material, derived from IPCC (2006)	Factor
	Biomass Conversion and Expansion Factor	Scales measured trunk volume to a full tree, derived from IPCC (2006)	Factor
Endogenous	NCSC factor	A term that measures the balance between forest growth and wood harvesting	Factor
	Company Emissions and Removals	Company Biogenic CO_2 Emissions and Removals related to their woodsourcing	CO_2eq

Table 6 revealed exogenous and endogenous factors used in the model. The time series data may have contained gaps. As a way of ensuring a smooth and continuous dataset, the missing values were projected using the FORECAST.ETS function in Excel. The function applied an exponential smoothing method based on historical data to predict missing values. Exponential smoothing methods were the most widely used forecasting methods (Osertagová & Ostertag 2012), which contributed to the validity of the study.

3.3.3 National Carbon Stock Change Factor

In this section, the NCSC (**National Carbon Stock Change**) Factor was discussed, the factor measured the balance between forest growth and wood harvesting to assess the selected countries' carbon sequestration potential. The factor provided an understanding of how well a country was removing CO_2 through wood harvesting, which in turn helped predict company emissions and removals when sourcing wood from the country. A positive NCSC factor indicated that a country was contributing to carbon removals, whereas a negative NCSC factor would indicate that emissions were occurring through the country's wood harvesting. The equation for calculating the NCSC was presented in *Formula 1*.

Formula 1: National Carbon Stock Change Factor

$$NCSC_t = \frac{\Delta GS}{HWP_t} = \frac{GS_{t+1} - GS_t}{HWP_t} \qquad (1)$$

Where:

$NCSC_t$ = the national carbon stock change factor at time *t*

ΔGS = stock change between two years in m^3sk

GS_t = forest stock in m^3sk at time *t*

GS_{t+1} = forest stock in m^3sk at time *t+1*

HWP_t = harvested volume in m^3ub at time *t*

In *Formula* 1, $NCSC$ was defined by dividing the stock change (ΔGS) by the harvested wood (HWP_t). The estimations of GS_t, GS_{t+1} and HWP_t were done through data collection from secondary sources mentioned in previous subchapters. There was no optimal $NCSC$, the higher, the better. To ensure that the problem described in *Chapter 2.1.1* would arise, $NCSC$ was measured each year. A visualization of the calculations could be found in *Figure 7.*

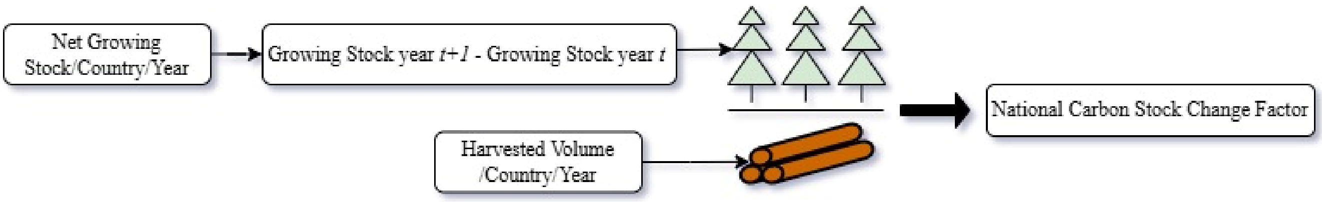

Figure 7: Calculating national carbon stock change factor, visualized by the author.

Figure 7 visualized the calculation process of the NCSC factor. National data was used to predict the $NCSC$ factor, which implied that as long as the total forest stock of the country increased, the $NCSC$ factor would remain positive. To find a more accurate Carbon Stock Change factor, regional data could have been used. However, this would have required quality data on a regional level, which at the time of making this study was not available for the selected countries. After calculation of the $NCSC$, it was multiplied by the amount of wood sourced by IKEA from the selected country, as visualized in *Figure 8.*

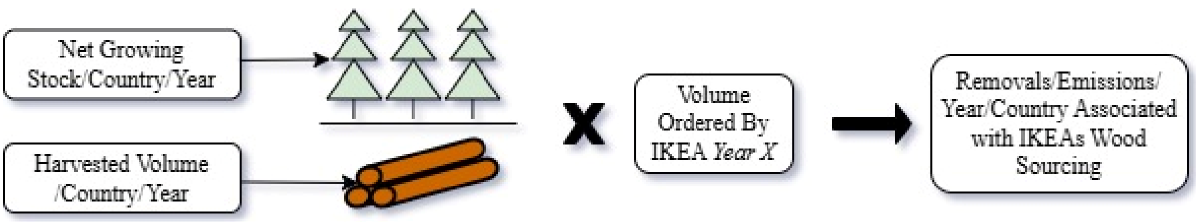

Figure 8: The national carbon stock change factor applied to IKEA's wood sourcing, visualized by the author.

Figure 8 visualized how the $NCSC$ was used to calculate the contribution of IKEA's wooden products to the selected countries' carbon removals and emissions. A high contribution of removals would have indicated that the country was a good sourcing country, from the perspective of a company wanting to maximize biogenic CO_2 removals.

3.3.4 Application of the NCSC factor

In the following section, the application of the $NCSC$ factor was discussed. To apply the factor, sourcing amount per year and country was required, along with fixed values such as CF and BCEFs. The purpose of *Formula 2* was to get an understanding of the actual future removals or emissions related to the company's wood sourcing. The way of applying the $NCSC$ factor could be viewed in *Formula 2.*

Formula 2: The application of the National Stock Change Factor

$$CER_{tx} = NCSC_t * CF * BCEFs * V_{tx} * MW_{CO2}/MW_C \qquad (2)$$

Where:

CER_{tx} = Company emissions or removals associated with its wood sourcing at time *t* from country *x*

$NCSC_t$ = the national carbon stock change factor at time *t*

CF = The carbon fraction of the material

$BCEFs$ = The biomass conversion factor (t/m^3)

V_{tx} = Volume sourced at time *t* from country *x*

MW_{CO2} = Molecular weight of CO_2 (44g/mol)

MW_C = Molecular of weight of C (12g/mol)

In *Formula* 2, CER_t was defined by multiplying the $NCSC_t$ with a CF and the $BCEFs$. The values for the CF and $BCEFs$ were provided by the IPCC (2006). The value of the $NCSC_t$ was calculated by using *Formula 1.*

3.3.5 Implementation and reproducibility

An outline was supplied to guarantee that the model could have been duplicated by future researchers and further utilized for calculations of other nations and companies. First, exogenous data was to be gathered from secondary sources by the researcher. The future growth rate of national forest and anticipated national harvests were the data required. Depending on the nation, this data should have been publicly available. National institutes were typically the source of this kind of data, which was favoured since they were generally considered a trusted source. The FORECAST.ETS function in Excel was to be used to supplement any missing data to guarantee a continuous dataset and a more thorough outcome.

Formula 1 was implemented after the data-gathering and any missing data was added. This approach determined the $NCSC$ factor. The $NCSC$ factor was then multiplied by the amount of wood sourced by the company, a positive $NCSC$ factor would have yielded biogenic CO_2 removals for the company, whereas a negative $NCSC$ would have yielded biogenic CO_2 emissions. Scenarios were defined by the researcher. To implement the scenarios the values of the cell from the year chosen were changed. For more comprehensive scenarios, the IF-function in Excel was recommended. To determine the company's biogenic CO_2 emissions or removals, *Formula 2* was implemented.

For future researchers who would want to expand or replicate the model, the most crucial part was to ensure consistency in data sources. If the model were to be applied in different regions, carbon fractions and expansion factors would differ (IPCC 2006).

3.4 Scenario Development

Developing scenarios could be done by various approaches (Roubelat 2000); scenarios could range from the imagination of a single individual to a group process (*ibid,* Hulse *et al.,* 2004). Robinson (1988) described backcasting, where a future state was assumed and the sequence of developments that could lead there were described. This study took inspiration from Robinson (1988), and the scenarios presented in *Table 7* were based on different assumed future states from stakeholders that were considered probable as of today.

Table 7. Examined Scenarios

Scenario	Explanation	Harvesting Intensity	Sourced Volume
BAU	Sweden and Poland maintain current forestry practices; IKEA's sourcing strategy remains consistent	• Sweden: 70% of annual growth • Poland: 74% of annual growth	• Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year
A Global Increase in Wood Demand	Harvesting intensity is increased in both Sweden and Poland the selected countries; IKEA's sourcing strategy remains consistent	• Sweden: 85% of annual growth • Poland: 87% of annual growth	• Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year
Recycled Vs Virgin Wood	Sweden and Poland maintain current forestry practices, IKEA's sourcing strategy changes, decreasing the procurement from both countries by 30% in 2030	• Sweden: 70% of annual growth • Poland: 74% of annual growth	**Before 2030:** • Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year **After 2030:** • Sweden 1,3-1,5 million m^3ub/year • Poland: 3,6-4,4 million m^3ub/year

Table 7 introduced the scenarios examined in the study, further explanation for each scenario could be found in *Chapter 4.*

3.5 Quality of Research

Heale & Twycross (2015) described validity as the extent to which a concept was accurately measured in a quantitative study. They provided the example that a survey designed to measure a specific theme but instead measured another related theme would not be considered valid. To ensure validity, the secondary data collected in this study came from national institutions, peer-reviewed studies and directly from the case company.

Reliability was described by the Heale & Twycross (2015) as a measurement of the consistency. Ensuring reliability in this study was proven to be a hard task since it used experimental, futuristic data, which had yet to happen, and there were factors that could have an impact on these numbers, such as geopolitical tensions, the market value of timber, and climate change. However, the model uses established tools from national institutions to forecast values such as expected forest growth and expected forest harvest, ensuring reliability. To further ensure reliability, different scenarios where developed to reflect different future states. The way the study was performed was clearly defined and a blueprint, or step-by-step guide, was added to the method chapter, which ensured external reliability (Brymann & Bell 2017).

3.6 Evaluation and Justification of Methodological Choices

"It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change."

- Charles Darwin

According to Börjeson *et al.,* (2006), scenario analysis offered numerous benefits to a corporation, but it was especially effective at encouraging the creation of robust and flexible solutions in a changing business environment. To build resilient strategies that improve long-term organizational stability, the authors highlighted the significance of considering external scenarios; those that were outside the company's direct control. Peterson *et al.,* (2003) supported this point of view by emphasizing the robustness that scenario analysis offers. Peterson *et al.,* (2003) also highlighted its creative aspect since scenario analysis provided an organized method for thinking through complicated and unknown future turnouts.

Furthermore, Van der Heijden (2005) asserted that the fundamental goal of scenario analysis, which was to present several possible futures, encouraged valuable conversations among stakeholders and thereby improved decision-making transparency. But the author also pointed out that this strategy's efficiency relied on how well the stakeholders understand the presented scenarios, highlighting that overcomplicating scenarios might have a negative effect on the transparency.

The risk of overcomplicating scenarios was one of the main limitations of scenario analysis in decision-support tools, according to Bradfield *et al.,* (2005). Their research indicated that too much technical complexity might result in a lesser likelihood of implementation. They advised putting user-friendliness first and avoiding needless technical complexities in the analysis to overcome this difficulty; a stance that this study took. Furthermore, Bradfield *et al*., (2005) emphasized the problem of bias in scenario development, which could have originated from both the analyst and external specialists. Instead of concentrating only on the "most likely" outcome, they proposed a combination of several different scenarios to lessen the chance of confirmation bias. This stance was implemented in this study through the usage of varying scenarios in both the analysis and the secondary data.

4 Scenario Narratives

This chapter presents the three scenarios developed in dialogue with the stakeholders. Each scenario reflects a plausible future, derived from current trends and scientific research. The goal of the scenarios is to examine what would happen to IKEA's biogenic CO_2 removals or emissions if they were to occur.

4.1 Scenario 1: Business as Usual

The *BAU* scenario was created with the intention of simulating a future where forestry practices remain the same for the years between 2025 and 2050. For Sweden that corresponds to approximately 70% of the yearly forest growth being harvested and for Poland about 74% of the growth being harvested. IKEA's hypothetical sourcing volumes are kept consistent throughout this scenario, with about 2 million m^3ub being sourced from Sweden per year and 6 million m^3ub being sourced per year from Poland.

4.2 Scenario 2: A Global Increase in Wood Demand

A global increase of timber demand has been projected since the 90's (Skog *et al.,* 1998) and the demand is expected to rise even further in the coming years (FAO 2022). As scientific and technological advancements are made, wood can now be used in a multitude of products such as bioplastics and cellulose (Toghyani *et al.,* 2020; Lavanya *et al.,* 2011), which will reduce our reliance on plastics made from fossil fuels. An increase in demand for wood and wooden products could lead to an increase in harvests.

This scenario was modelled with the aim of simulating a future where forestry practices are intensified to satisfy the growing demand for biogenic products derived from wood. The objective of the scenario was understanding how this future state would affect a company's biogenic CO_2 removals or emissions. To simulate this future, harvesting intensity was increased, corresponding to approximately 85% of the total growth in Sweden being harvested, and 87% of the total growth in Poland being harvested. The scenario uses identical sourcing volumes as the *BAU* scenario to keep results consistent.

4.3 Scenario 3: Recycled Vs Virgin Wood

Post consumer wood waste management has become a trending topic within the European Union, and companies such as IKEA have pledged to increase their usage of recycled wood in their manufacturing (IKEA 2025). Ratajczak *et al.,* (2018) highlight the clear ecological and economic benefits of using recycled wood. This scenario aimed to simulate a future where forestry practices remain unchanged from current levels, but IKEA decreases their sourcing volumes to increase usage of recycled wood, and to assess the impact this would have on IKEA's biogenic CO_2 removals and emissions.

The harvesting intensity is set to the same values as in the BAU scenario, corresponding to 70% of the yearly forest growth being harvested in Sweden and roughly 74% of the growth being harvested in Poland. Since IKEA has a goal of using 30% recycled wood in its manufacturing from 2030, the hypothetical sourced volumes from Sweden and Poland are reduced by 30% in 2030, corresponding to approximately 4 million m^3ub being sourced from Poland per year and 1,4 million m^3ub being sourced from Sweden per year after 2030.

5 Background Empirics

This chapter provides background information on the forestry practices in the selected countries. This includes legislations related to forestry and future proposals for the forestry-sector in respective countries. The chapter also introduces the usage of recycled wood and provides comprehensive information regarding international and EU standards.

5.1 Forestry in Sweden

Wood has remained a major export-material, and Sweden's forests have served as a catalyst for the nation's industrial development (Beland-Lindahl *et al.,* 2015). To guarantee that the natural resource never got depleted, the Swedish government established the Forest Protection Act in 1903 (*ibid*), which back then required private forest owners, no matter the size, to replant after harvesting. Over the past century, the Forest Protection Act has undergone revisions, and additional legislation has been added. The most recent change was in 1993 (SLU 2018) and forest owners are now expected to not only maintain a high return of wood but also improve the environmental performance of the forest.

The Swedish forestry strategy incorporates the principle of "never harvest above the growth rate" and for more than a century, the volume of wood in the forest has increased annually (Sweden's Environmental Protection Agency 2023). From a biogenic removal's perspective, Sweden has historically been a good country to source wood from. The country's NCSC factor has remained positive because of the increase of wood-volume in the forest.

5.2 Forestry in Poland

Around 300000 people are either directly or indirectly employed by Poland's forest sector, which accounts for about 2% of the country's GDP (**Gross Domestic Product**) (Żornaczuk-Łuba 2015). The state owns and manages 7,6 of the 9,1 million hectares of forest that cover the country (*ibid*). Between 1990 and 2015, the volume of wood in the Polish forests nearly doubled, which can be attributed to the introduction of the Forest Act. The law focused on sustainable forestry and mandates a forest management plan for all forests owned by the state. A simplified forest management plan is required for private forests exceeding 10 ha (Kancelaria Sejmu 2023). The legislation also permits forest owners, both state and private, to restrict public access. Restrictions may be implemented for a variety of reasons, such as protecting endangered species or a plantation (*ibid*). A ranger is responsible for enforcing the rule and can identify and penalize violations.

Poland has achieved recent success from a biodiversity perspective, such as the successful preservation of the European Bison, a species that nearly went extinct but now roams the state forests (Żornaczuk-Łuba 2015). Poland's forests face significant pressure today. Kassenberg (n.d) denotes that the forests are expected to not only supply the increasing demand of timber but also absorb carbon dioxide and provide wildlife habitat.

5.3 Recycled and Virgin Wood

Reusing material rather than discarding it after usage is currently the goal of an increasing number of companies with the intention of going circular (Garcia *et al.,* 2024). To combat climate change and reduce emissions associated with dealing with products at the end of their life, organizations like the European Parliament are supporting the use of recycled wood. The International Organization of Classification (**ISO**) (2019, 1) defines post-consumer wood or recycled wood as

"Wood generated by the end-users of wood products that has fulfilled its intended purpose, including materials returned from within the distribution chain".

The GHG protocol (2013) classifies post-consumer recycled wood as a scope 3 emission. Post-consumer wood waste management is viewed as a critical environmental concern (Garcia *et al.,* 2024) and IKEA have pledged to manufacture one third of their products from recycled wood by 2030 (IKEA 2025). However, using recycled wood in manufacturing does not result in biogenic CO_2 removals since the carbon sequestration happens during the tree's growth period (Andersen *et al.,* 2021). However, it reduces company emissions (Myhren *et al.,* 2024). The basic challenge for companies is whether to use virgin wood to be able to claim more biogenic CO_2 removals or to use recycled wood to reduce emissions.

5.4 Sustainability Standards and Reporting Frameworks

As companies and policymakers seek to improve sustainability performance, standardized methodologies for measuring and reporting environmental conditions are becoming more and more important. Various frameworks and standards exist to assess sustainability throughout the lifecycle of each product. The following sections offers an overview of these key standards and their role in shaping sustainability practices.

5.4.1 ISO and Carbon Footprint

Product level standards, such as the ISO 14067 has the purpose of quantifying and reporting the carbon footprint of specific products (ISO 2018). The life cycle assessment (**LCA**) approach covers all stages of the product, from raw material to end-of-life disposal. The standard allows for distinguishing between fossil emissions and biogenic CO_2 emissions and removals, which is particularly relevant for products derived from forestry. Fossil emissions could include the operating of machinery and processing at the sawmill, while biogenic removals include the growth of the forest (*ibid*). The standard follows the IPCC guidelines to ensure that biogenic CO_2 is correctly accounted for and is generally used in corporate sustainability strategies, helping companies pinpoint where removals or emissions happen during their products life cycle.

5.4.2 Product Environmental Footprint

Other methodologies that focus on the product level includes the Product Environmental Footprint (PEF), which, like the ISO 14067, aims to communicate a product's environmental impact throughout its lifecycle. It assists companies measure and communicate their environmental performance and is used in EU policies by both private and public organizations (European Union 2021). Compared to ISO 14067, which emphasizes GHG emissions (ISO 2018), PEF provides a broader scope, assessing impacts like land use and water (European Union 2021). The ISO 14067 can serve as a tool to partially fulfil PEF requirements.

5.4.3 Corporate Sustainability Reporting Directive

To incentivise sustainable practices, the European Union (**EU**) has released the Corporate Sustainability Reporting directive (EU n.d). The directive sets mandatory sustainability reporting requirements for companies and must be implemented into national law by member states. The directive applies to large companies, listed SMEs, and some EU firms with significant revenue-streams within the EU. For companies dealing with wooden products, reporting requirements cover not only GHG emissions, *scope 1, 2 and 3* but also biogenic carbon removals and emissions, alignment with SBTi FLAG and transparency regarding recycled content of wood-based products (EU n.d). The directive aims to enhance transparency and comparability in corporate sustainability reporting.

5.4.4 European Sustainability Reporting Standards

The European Sustainability Reporting Standards (**ESRS**) define what sustainability data companies must disclose. The standards apply to all sectors and aims to help stakeholders assess a company's impact on people and the environment. Developed by the European Financial Reporting Advisory Group (**EFRAG**), the standards align with EU policies and international standardization initiatives (EU 2023). ESRS serves as the reporting framework for the CSRD, and they are closely related. While CSRD defines who must report, ESRS specifies what and how to report (EU n.d).

6 Results

In this chapter, the results from the project are presented. The results are derived from the Scenario analysis tool the study had the aim of developing and presented in their respective country and scenario. The first scenario is Business as Usual, the second represents an increase in wood consumption and the third represents a shift towards using recycled wood.

6.1 Scenario Summary

As previously introduced in *Chapter 3,* the study examined three scenarios determined plausible. Examined scenarios are revisited in *Table 8.*

Table 8. Revisiting examined Scenarios

Scenario	Explanation	Harvesting Intensity	Sourced Volume
BAU	Sweden and Poland maintain current forestry practices; IKEA's sourcing strategy remains consistent	• Sweden: 70% of annual growth • Poland: 74% of annual growth	• Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year
A Global Increase in Wood Demand	Harvesting intensity is increased in both Sweden and Poland the selected countries; IKEA's sourcing strategy remains consistent	• Sweden: 85% of annual growth • Poland: 87% of annual growth	• Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year
Recycled Vs Virgin Wood	Sweden and Poland maintain current forestry practices, IKEA's sourcing strategy changes, decreasing the procurement from both countries by 30% in 2030	• Sweden: 70% of annual growth • Poland: 74% of annual growth	**Before 2030:** • Sweden: 1,8-2,2 million m^3ub/year • Poland: 5,4-6,6 million m^3ub/year **After 2030:** • Sweden 1,3-1,5 million m^3ub/year • Poland: 3,6-4,4 million m^3ub/year

Table 8 clarifies the scenarios which are analyzed in the study. To give the reader a "bigger picture", the following subchapters present the development of both the standing volume, harvested volume, and the NCSC (National Carbon Stock Change) factor for each of the countries. Biogenic CO_2 removals or emissions associated with IKEA's wood sourcing for each country are presented at the final subchapter.

6.2 Sweden

The following subchapters present results derived from Sweden under the *BAU* and *A Global Increase in Wood Demand* scenarios. Results include standing volume, harvested volume and the NCSC factor.

6.2.1 Standing Volume

The standing volume of wood in the Swedish forests is presented in *Figure 9.* Maintaining current forestry practices would result in a 19,4% increase in standing volume between 2025 and 2050. Increasing the intensity of the forestry practices would result in a 9,5% increase.

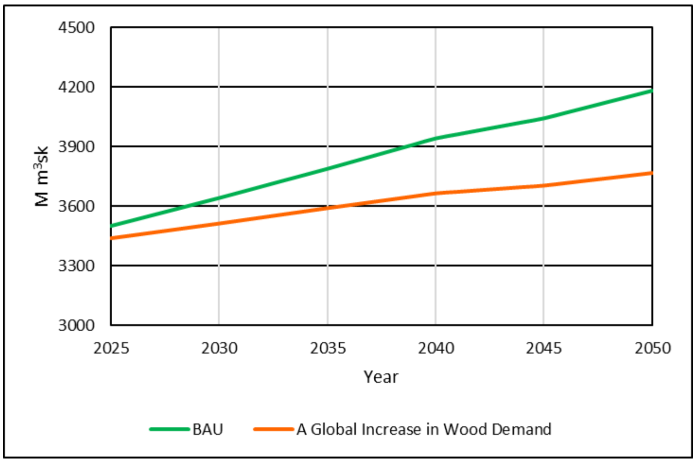

Figure 9. Standing Volume between 2025 and 2050, Sweden.

As seen in *Figure* 9, this corresponds to a total growth of 681 M m^{3}sk or approximately 27,2 M m^{3}sk per year under the *BAU* scenario. Moreover, under the *A Global Increase in Wood Demand* scenario the growth corresponds to a total of 327 million m^{3}sk, or approximately 13,8 million m^{3}sk per year. The growth does not take the harvested amount into account. Harvested volume is presented in *Figure 10.*

6.2.2 Harvested Volume

Figure 10 demonstrates that under the *BAU* scenario, harvested volume per year increases by approximately 9% between 2025 and 2050. The harvested amount sees an increase of apporixmately 0,25 M m^{3}sk per year which is well below the growth of the standing volume. During the *A Global Increase in Wood Demand* scenario, harvested volume per year increases by approximately 6,3% over the studied period. The harvested amount sees an increase of 0,2 M m^{3}sk per year which is lower compared to the *BAU* scenario, however, the intensity starts at a much higher rate.

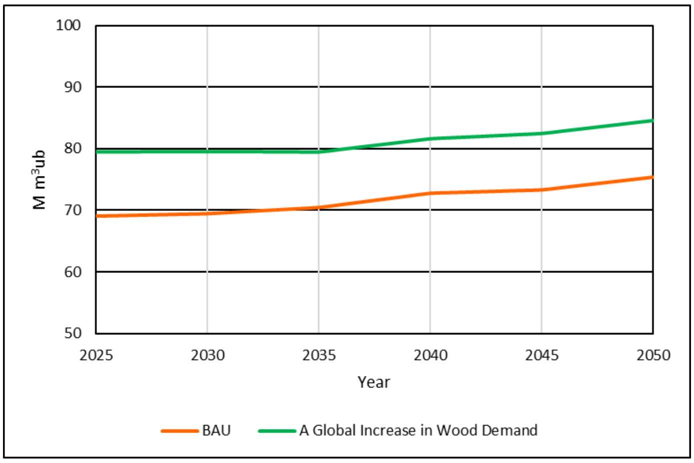

Figure 10. Harvested Volume between 2025 and 2050, Sweden.

Figure 10 demonstrates that both scenarios shows a similar increase in harvested volume over time, with the *BAU* scenario having the greater increase but still not reaching the harvesting intensity of the *A Global Increase in Wood Demand* scenario.

6.2.3 National Carbon Stock Change Factor

Scenario *BAU* yields a steady increase of the NCSC factor between 2025 and 2035, shown in *Figure 11*. However, it declines heavily in 2040 and does not recover to its earlier levels during the following years. Scenario *A Global Increase in Wood Demand* yields a more stable NCSC factor, but the sharp decline in 2040 is still very visible and the factors value in 2050 is still lower compared to 2025. The decline of the NCSC factor during the period of 2035-2040 could be explained by the increase in harvesting intensity which is visible in *Figure 10.*

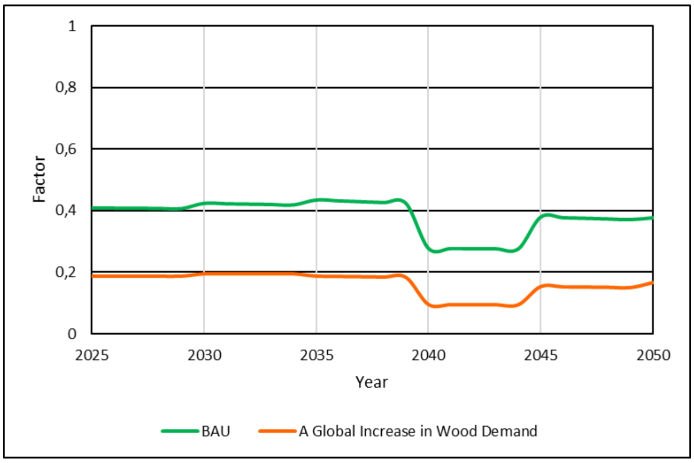

Figure 11. NCSC Factor between 2025 and 2050, Sweden.

Figure 11 underscores that the *BAU* scenario has a more favourable NCSC factor, suggesting that an increase in harvesting intensity may have adverse effects on biogenic CO_2 removals.

6.3 Poland

The following subchapters introduces results for Poland under the *BAU* and *A Global Increase in Wood Demand* scenarios. Results include standing volume, harvested volume and the NCSC factor.

6.3.1 Standing Volume

The standing volume of wood in the Polish forests are presented in *Figure 12.* Maintaining current forestry practices would increase the total standing stock by 12,2%, or 355 M m^3sk in total between 2025 and 2050. Increasing the intensity would result in a 6,9% increase, or 199 M m^3sk.

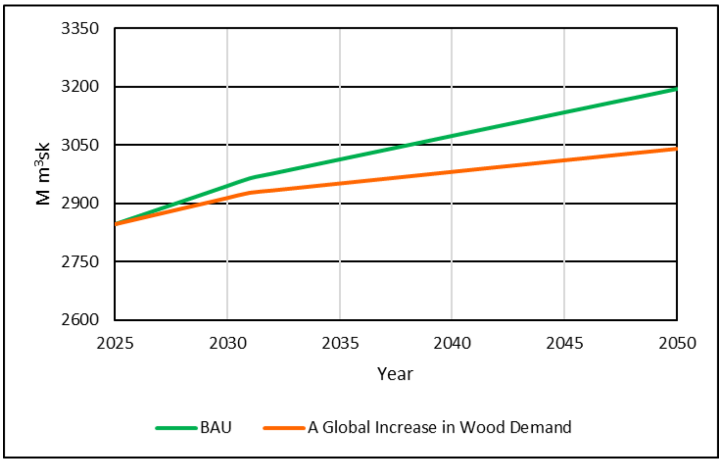

Figure 12. Standing Volume between 2025 and 2050, Poland.

Figure 12 illustrates that although both scenarios start at the same volume during 2025, the *BAU* scenario leads to a higher growth rate, about 14,2 M m^3sk per year compared to 7,9 M m^3sk per year, and an overall greater increase in standing volume.

6.3.2 Harvested Volume

Figure 13 reveals that under the *BAU* scenario in Poland, harvested volume sees a small decrease between the years of 2025 and 2050. The decrease of approximately 0,03 M m^3ub per year corresponds to a total of -1,6% decrease in harvesting intensity. The scenario *A Global Increase in Wood Demand* also sees a similar decrease in harvesting intensity, which corresponds to approximately 0,04 M m^3ub per year.

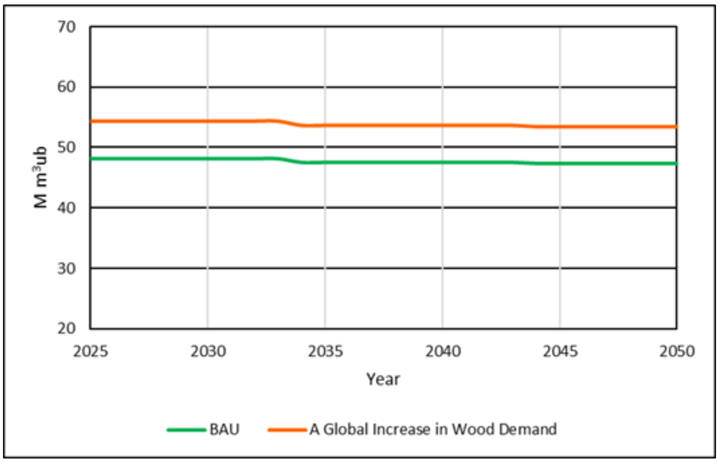

Figure 13. Harvested Volume between 2025 and 2050, Poland.

The trend visualized in *Figure 13* highlights the previously mentioned public pressure placed on Poland's forest resources (Kassenberg n.d). During both the *BAU* and *A Global Increase in Wood Demand* scenario the nation focuses on increasing their standing volume and does not plan on increasing the intensity of harvests during the period between 2025 and 2050.

6.3.3 National Carbon Stock Change Factor

Maintaining current forestry practices or increasing the intensity of harvesting yields a total decline of the NCSC factor over the years which can be seen in *Figure 14*. However, the slope of the decline slows down during later years, suggesting a stabilizing trend.

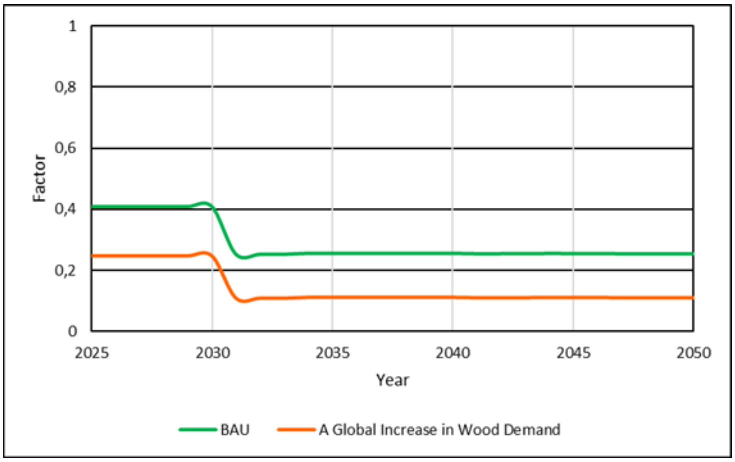

Figure 14. NCSC Factor between 2025 and 2050, Poland.

Figure 14 highlights the fact that Poland is becoming less of an attractive country in terms of biogenic CO_2 removal potential, with the *A Global Increase in Wood Demand* scenarios NCSC factor reaching a low of 0,1 in 2050.

6.4 Recycled or Virgin Wood

The following subchapters compares IKEA's biogenic CO_2 emissions or removals between the two countries. The data used for sourcing volumes is hypothetical due to confidentiality constraints. However, presenting artificial data helps visualize the impact of changing sourcing strategies.

6.4.1 IKEA's Sourcing Mix

IKEA's hypothetical sourcing strategy used for the scenario *BAU* and *A Global Increase in Wood Demand* is presented in *Figure 15.* The adjusted strategy for the scenario *Recycled or Virgin Wood* is presented in *Figure 16.*

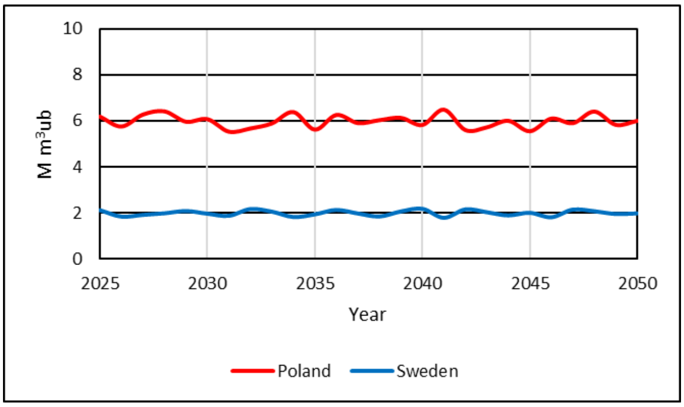

Figure 15. IKEA's sourcing strategy, BAU and A Global Increase in Wood Demand scenario, Sweden and Poland.

As seen in *Figure 15.* in the hypothetical sourcing strategy, Poland remains the biggest supplier of virgin wood for IKEA, and the country supplies about three times the amount of Sweden. *Figure 16* visualizes a reduction in sourced wood from both countries by 30% in 2030.

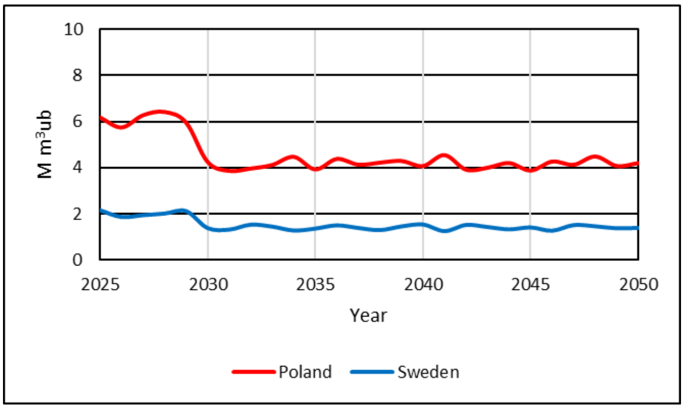

Figure 16. IKEA's sourcing strategy, Recycled or Virgin Wood scenario, Sweden and Poland.

As previously mentioned in *Chapter 4*, IKEA plans to use approximately 30% recycled wood for their manufacturing from 2030 (IKEA 2024). The assumption is made that this action would decrease the sourcing amount for Sweden and Poland by 30% as seen in *Figure 16*. The following subchapter derives the biogenic CO_2 removals from the different scenarios.

6.4.2 Biogenic CO_2 Removals or Emissions: Sweden

Figure 17 illustrates IKEA's biogenic CO_2 removals or emissions for the *BAU* Scenario, *A Global Increase in Wood Demand* scenario and *Recycled vs Virgin Wood* scenario for Sweden, revealing a negative trend.

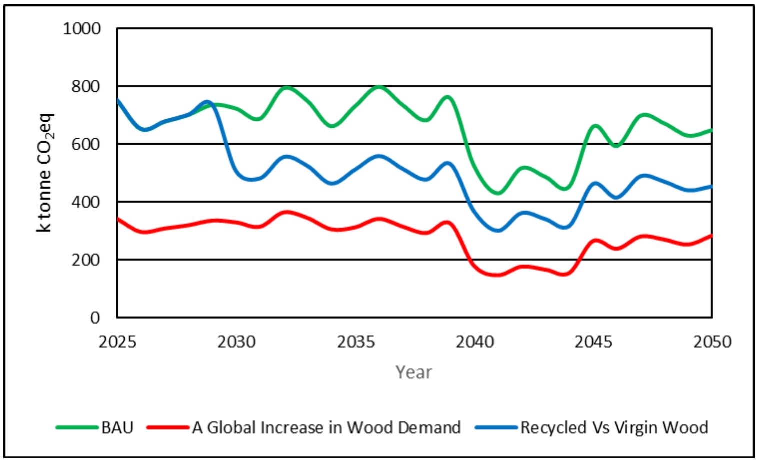

Figure 17. IKEA's Biogenic CO_2 Removals between 2025 and 2050, all scenarios, Sweden.

Figure 17 demonstrates that across all examined scenarios, the amount of biogenic CO_2 removals is inferior in 2050 compared to 2025. The *BAU* scenario maintains the highest levels of removals during the years but still shows a steady decline. The *Global Increase in Wood Demand* shows a similar decline but starts at a much smaller rate. The trends shown in *Figure 17* underscore the significance of sourcing wood from a country with sustainable forest management. Worth noting is that none of the examined scenarios contribute to emissions during the studied period, highlighting that sourcing wood from Sweden could be considered relatively safe in terms of biogenic CO_2 removals.

6.4.3 Biogenic CO_2 Removals and Emissions: Poland

Figure 18 illustrates IKEA's biogenic CO_2 removals or emissions for the *BAU* Scenario, *A Global Increase in Wood Demand* scenario and *Recycled vs Virgin Wood* scenario for Poland, revealing yet another negative trend.

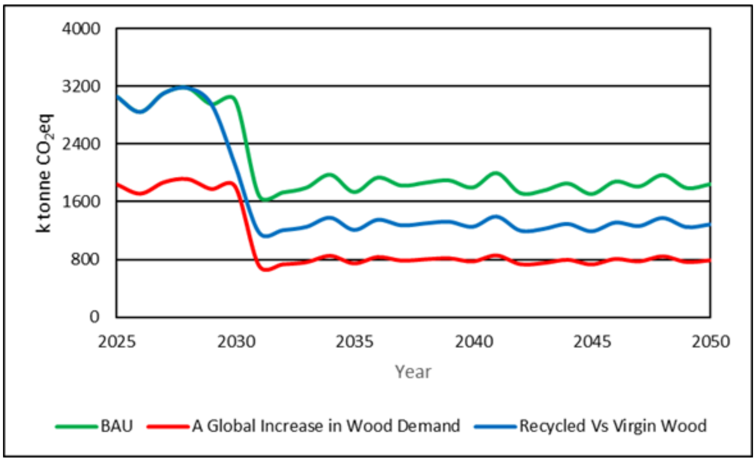

Figure 18. IKEA's Biogenic CO_2 Removals between 2025 and 2050, all scenarios, Poland.

Figure 18 shows that Poland's NCSC factor closely tracks the biogenic CO_2 removals related to wood sourcing from the nation. Around 2030, there is a noticeable drop, which is followed by a partial recovery and stabilization. However, compared to 2025, the amount of removals in 2050 is still lower. Critically, Poland did not go from net removals to net biogenic CO_2 emissions under any of the studied scenarios, indicating that the harvesting intensity stays within acceptable bounds.

Interestingly, compared to the *A Global Increase in Wood Demand scenario*, the *Recycled Vs Virgin Wood* scenario which represents lower sourcing volumes, results in higher biogenic CO_2 removals across both countries. This suggests that harvesting intensity has a substantial impact on biogenic removals compared to sourcing volumes.

Additionally, earlier studies have demonstrated that using more recycled materials reduces corporate emissions (Myhren *et al.,* 2024). This underscores the applicability and advantages of the *Recycled Vs Virgin Wood* scenario from the perspective of maintaining a high amount of biogenic CO_2 removals while simultaneously reducing corporate emissions.

7 Analysis

In this chapter, the empirical results are analyzed and interpreted in relation to the theoretical concepts and frameworks outlined in Chapter two. The conceptual framework is revisited and expanded by integrating the findings from the previous chapter. The chapter also aims to answer the research question presented in chapter one.

7.1 Key findings from the Results chapter

Key findings and their relation to previous literature will be presented in this chapter. To clarify how the findings relate to the conceptual framework, *Figure 19* illustrates how the main discussion points align with and extend the conceptual framework introduced in *Chapter Two.*

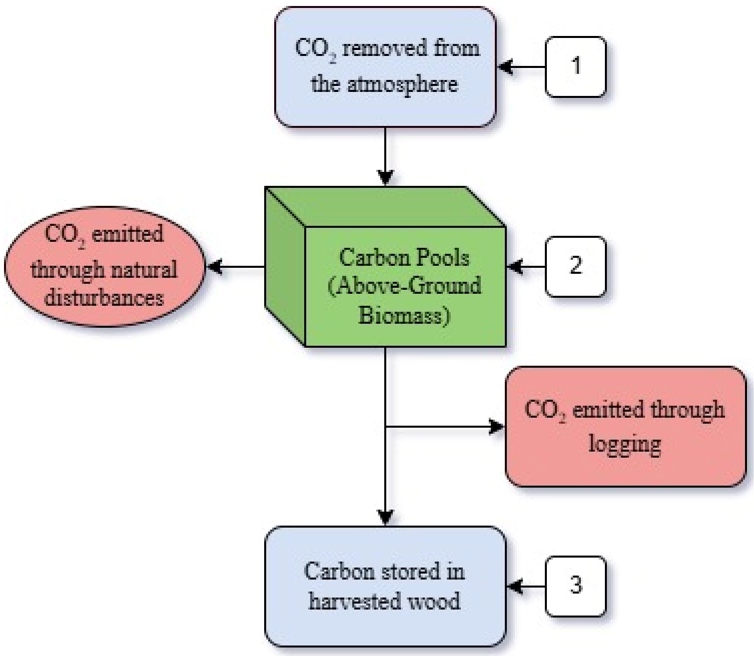

Figure 19: Conceptual framework with added bulletpoints.

Figure 19 presents the conceptual framework with highlighted areas for discussion, which are further discussed in subchapters *7.1.1, 7.1.2* and *7.1.3.*

7.1.1 Carbon Sequestration (1)

In Sweden, growth rates are expected to slightly increase between 2025 and 2035 under the *BAU* scenario. By 2040, however, growth rates are expected to decline following an increase in harvest intensity, and national growth will not return to its prior levels before 2050. A decrease in the growth is directly correlated with a decrease in the potential for sequestering carbon since forests serve as carbon sinks during their growth phase (Streiff 2021; IPCC 2019; GHG Protocol 2023). The scenario *A Global increase in Wood Demand,* shows a similar pattern. Although growth rate does not experience the same initial surge as in the *BAU* scenario, it nevertheless declines by 2040 and continues to decline in the following years.

Under the *BAU* scenario, Poland follows a similar pattern, with growth rates increasing in the early years and then slightly declining between 2030 and 2040. Growth rates decline more sharply in the scenario *A Global Increase in Wood Demand,* which, according to Streiff (2021) would slow down the nation's ability to sequester carbon.

7.1.2 Above Ground Biomass (2)

The standing volume, or ABG, shows an increase across all examined scenarios. The overall standing volume increases by 19,4% in Sweden and by 12,2% in Poland under the *BAU* scenario. The ABG volume continues to increase even though the scenario *A Global Increase in Wood Demand* negatively affects growth rates. The increase of ABG is regarded as an enhancement of the nation's capacity of storing carbon, as the GHG Protocol (2023) guidance on Land Sector and Removals, states. Increases in standing stock must be accounted for as carbon removals until equilibrium or decline occurs. Furthermore, SBTi (2022) highlights the potential of the FLAG sector for emission mitigation. Based on current trends, both Sweden and Poland are expected to contribute to a larger carbon sink in the future. The trend of having an increasing wood stock (Swedish Environmental Protection Agency 2023) is also upheld.

7.1.3 Carbon Stored in Harvested Wood (3)

The NCSC factor shows a decreasing tendency across the analysed scenarios. Similar to the growth rate, Sweden's NCSC factor in the *BAU* scenario exhibits a modest increase in the first ten years, followed by a sharp decline from which it never fully recovers. A similar trajectory can be seen in the scenario *A Global Increase in Wood Demand*, which is expected to reach its lowest value by 2050. Both the *BAU* and *A Global Increase in Wood Demand* shows steady regression in Poland, most likely due to the anticipated rise in harvesting intensity.

A reduction in natural carbon sequestration may result from a shift towards less sustainable forestry practices with a higher harvesting intensity (Curran & Curran 2025), as indicated by the decline in the NCSC factor. A decrease in the NCSC factor or a similar measuring instrument could, according to the GHG Protocol (2023) influence calculations of net emissions and removals and may indicate a shift in FLAG-related accounting from carbon removals to emissions in the future. This would be especially prevalent in areas with increasing harvesting intensities. The chapter *Conclusions* further examines the consequences of the diminishing NCSC factor in Sweden and Poland.

7.2 Addressing the Research Question

The study had the aim of answering the research question:

- *What will be the evolution of aboveground net biogenic land-related emissions and removals for a company within the retail industry?*

The findings provide a framework for projecting future land-use-related biogenic CO_2 removals or emissions within a company's supply chain. These results are interpreted in compliance with methodological guidelines supplied by the SBTi FLAG (2022) and IPCC (2006).

For both Sweden and Poland, the NCSC factor shows a decline across all examined scenarios from 2025 to 2050. Figures *17 and 18* illustrate this decrease in biogenic CO_2 removals linked to IKEA's wood sourcing. The NCSC factor remains above zero during the evaluation period, despite the negative trajectory, suggesting a reduction in removals rather than net emissions. Future projections show continued growth in both Swedish and Polish forests up until the year of 2050. However, beyond 2050, standing forest volumes could decline, which would result in a negative NCSC factor, meaning the companies sourcing wood from the countries would have to claim biogenic CO_2 emissions instead of removals.

The research question proposed in the chapter *Commission*:

- *Based on growing stock inventory data from public data sources and databases, and overlaying with future wood supply availability, what is the evolution of aboveground net biogenic land-related emissions/removals associated with IKEA's wood sourcing expected until 2050?*

IKEA's biogenic removals are expected to decline in the years leading up to 2050 but will not become negative, meaning the company will not need to report biogenic CO_2 emissions for any of the sourcing countries during the studied period.

8 Discussion

The findings of this study are discussed in relation to other research reports in the following chapter. The research question posed in Chapter one is addressed and other points that surfaced during the analysis are taken into account.

8.1 What will be the evolution of aboveground net biogenic land-related emissions and removals for a company within the retail industry?

Using scenario analysis and the presented conceptual framework this study shows that sourcing wood from Sweden and Poland will contribute to biogenic CO_2 removals rather than emissions, across multiple scenarios, during the years from 2025 to 2050. This coincides with several studies mentioning how forests sequester carbon and how an increase in harvesting intensity will have a negative effect on carbon sequestration (Jandl *et al.,* 2007; Gorte 2007).

This study contributes to the development of biogenic carbon accounting guidelines, as existing frameworks are yet to meet expectations (SBTi 2024). It integrates methodologies and calculations from both the IPCC (2006) and GHG Protocol (2024), thereby strengthening the credibility of the tool and the derived results.

The developed tool by the study show that sourcing virgin wood from Sweden and Poland will contribute to biogenic CO_2 removals rather than emissions during the period from 2025 to 2050 which argues against some recently published findings, like Phoenix (2024), who in a recent interview with the minister of agriculture in Germany revealed that the German forests are contributing to biogenic CO_2 emissions rather than removals. Although these findings were only regarding the German forests, the findings are still relevant since the country has a similar structure of forests compared to Poland (IPCC 2006) which makes the countries comparable. A similar pattern is reported by the Natural Resource Institute Finland (Luke 2025), which claims that Finland's forests are turning into sources of emissions; a country with a forest structure comparable to Sweden's.

The results derived from this project show that the benefits regarding biogenic CO_2 removals of sourcing virgin wood from Poland and Sweden will decline during the years between 2025 and 2050. This raises important strategic considerations for IKEA and other companies within similar industries: Should they continue sourcing virgin wood, or instead reduce its use in favor of recycled wood?

On the one hand, using recycled wood does not result in any biogenic CO_2 removals (Andersen *et al.,* 2021), which may be a disadvantage. However, since removals are not required to be reported, and emissions are, the declining trend of the NCSC factor may lead to biogenic CO_2 emissions in the future. Thus, adapting early and switching to recycled wood could be advantageous. On the other hand, the NCSC factor remains positive throughout the period between 2025 and 2050, meaning removals are still claimable for both Sweden and Poland. This may incentivize IKEA to continue sourcing wood from these countries.

8.2 The Global Future of Forestry

Throughout the course of this project, several future scenarios have been explored, which led to the emergence of a critical point of discussion: what will the future of forestry look like? Historically, the forestry sector underwent critical transformations between the 1950's and 2000's, encompassing both positive and negative advancements (FAO 2003). In the early 2000's, the discourse surrounding forests expanded beyond the traditional role as a source of timber to encompass its importance for climate change mitigation, recreational value and as a provider of innovative, bio-based materials aimed at reducing society's reliance on fossil fuels (*Ibid).*

This evolving perspective is reflected in the famous quote by Ahmed Zaki Yamani, former Saudi Arabian Minister of Oil and Mineral Resources, who stated in 2000:

"The Stone Age came to an end not for a lack of stones and the oil age will end, but not for lack of oil" (Dale 2000, 29).

Similarly, Dombeck and Moad (2001) anticipated that societal perceptions of forests in North America would shift dramatically over the next decades, moving from a focus on raw material extraction to a greater appreciation of ecosystem services such as biodiversity conservation and carbon sequestration. These early insights, mapped out nearly 25 years ago, demonstrate that awareness of forests' multifunctional potential has been well established for a considerable period.

Despite the longstanding knowledge of the forests potential, recent research has revealed that the forests of developed countries like Germany and Finland have become net emitters of CO_2, which is highly concerning (Phoenix 2024; Luke 2025). As global demand for biogenic products derived from forestry continues to increase (FAO 2022), a larger proportion of forest growth is being harvested, subsequently reducing countries' NCSC factor. In some cases, this trend risks leading to negative NCSC factors.

Consequently, ensuring the sustainability of wood sourcing will become even more critical. Prioritizing procurement from countries with robust and realistic forest management legislation will become essential. Furthermore, companies with a large amount of influence in the supply chain must ensure that sourced wood complies fully with national laws and sustainable management practices to safeguard the long-term contributions of forests to earlier mentioned ecosystem services such as biodiversity conservation and carbon sequestration.

8.3 Limitations

The intention of the study was to provide companies with guidance on how to calculate and maximize their biogenic removal potential, with IKEA as the case study. The limitations of the NCSC factor are acknowledged, as it may overestimate removals associated with some countries, since it will remain positive as long as the total standing volume is increasing year-by-year.

A factor derived from more local data, such as from specific sourcing regions instead of countries would increase the accuracy of the results. However, this type of data requires large amounts of work each year and may not be publicly available, resulting in the use of national data instead.

As for Poland, the standing volume and harvested volume for the years of 2025 to 2050 are not all derived from BULiGL, but are instead modelled with regards to research articles and the different scenarios provided by SKA22 for Sweden. One example is the scenario *A Global Increase in Wood Demand*, in which Poland is assumed to increase its harvesting intensity at the same rate as Sweden.

9 Conclusions

This study aims to examine and analyze how biogenic CO_2 removals and emissions evolve in the future from the company's wood sourcing, according to the company. In the chapter Conclusions, this goal is revisited, and a summary of the main conclusions is provided. A few additional study recommendations and practical implications are provided as well.

The purpose of this study was to investigate and analyze, from the company's perspective, the possible future biogenic CO_2 removals and emissions related to a company's wood sourcing. Developing a method for calculating these removals and emissions was a primary goal, particularly given the delays in previous studies and anticipated recommendation and guidance in the field. Another objective was to provide businesses with a means to better understand and leverage the potential of handling biogenic materials in a way that contributes to removals rather than emissions. IKEA's wood sourcing practices, and the related future removals associated with that activity were the specific subject of the investigation. The findings can help guide decisions on the raw material procurement, such as choosing recycled wood instead of virgin wood, and more broadly support the development of strategies for reducing climate impact.

9.1 Practical Implications and Contributions

Using the developed methodology, the study has demonstrated that in all evaluated scenarios, Sweden and Poland will contribute to biogenic CO_2 removals rather than emissions. The national standing volume of both nations has historically trended upward and is expected to continue increasing, which has a significant impact on their NCSC factor and consequently, the quantity of biogenic CO_2 removals that are available for claim. Nevertheless, the NCSC factor exhibits a decreasing tendency between 2025 and 2050 across all scenarios, despite this increase in standing volume. If the global demand for wood rises, this decline is expected to become even more pronounced.

If the NCSC factor's decreasing trend continues, there will be fewer biogenic CO_2 removals, and a higher risk of future emissions related to wood sourcing. This knowledge can help companies like IKEA make informed decisions in the future, especially when deciding whether to switch to recycled materials because the opportunity to claim biogenic CO_2 removals may eventually fade.

The creation of a technique and practical guidance for businesses to account for biogenic CO_2 removals and emissions is one of the study's main contributions. This study acts as a pilot project and a first step toward more robust frameworks and future research in the field of biogenic carbon accounting, as previous research has halted and existing guidance is limited.

9.2 Methodological Reflection

For future researchers:

The national standing forest volume is the basis for the National Carbon Stock Change (NCSC) factor, which will continue to increase as long as the overall standing volume rises annually. Although national-level data were employed in this study, it is important to note that, with the right data, the NCSC factor could be computed at a more regional level. By doing this, it would be possible to pinpoint emissions and biogenic removals in particular areas of a country. This could therefore help businesses make regionally informed wood purchasing decisions by providing a more nuanced picture of where these changes are taking place.

It is crucial to evaluate the data's underlying assumptions and production processes when working with forecasts or future-oriented data based on unrealized events. This could entail speaking with the forecasting model developers or making sure the data originates from reputable sources like forestry or national statistical institutions. For the results to be credible and meaningful, it is essential to be transparent and careful about the assumptions and quality of the data.

Not all carbon pools within the forest biome is included in this study. To further develop the study, it would be preferable to broaden the study's scope beyond aboveground biomass and emissions and to include other carbon pools within the forest biome. These carbon pools, such as belowground biomass, litter, deadwood and soil organic carbon all affect carbon fluxes and would improve the study's results. Soil organic carbon is the greatest terrestrial carbon pool (Dixon *et al.,* 1994; Grant *et al.,* 2021; FAO 2006; Scharlemann *et al.,* 2014) and deserves particular attention, since it is also affected by forest management (Villarino *et al.,* 2017).

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