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The Bumpy Road to Biodiversity Management for Apparel Companies

The Case of Nudie Jeans

Master's thesis in Circular Economy

Nhu Anh Phan

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF ENVIRONMENTAL SYSTEMS ANALYSIS

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Report no. E2021:069
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

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ABSTRACT

This research looks into how the roadmap for biodiversity initiatives in Nudie Jeans, a denim company based in Gothenburg, Sweden, can be set up. Specifically, the interest revolves around the motivation for and understanding of biodiversity disclosure and management, from which the gaps and challenges along with future solutions are identified. The objective was approached with a combination of interviews and literature review, from which a ranking of environmental data exchange and a SWOT analysis were derived. Furthermore, the suggested future steps were derived from a modified version of Science-Based Targets.

It was found that the company has a growing interest in tackling biodiversity impact on its own operations. This interest arises from its own awareness of risks and the increasing attention of the fashion industry to mitigate the risks of biodiversity decline. The main purpose for assessing and managing biodiversity impact was identified to be for internal knowledge exchange and learning. Biodiversity management is desired to be a part of sustainability management of the company and this system is expected to be communicable, effective, and simple to use. However, the company has not devised specific strategies and action plans, mainly due to the infancy of corporate biodiversity initiatives, the perceived lack of capacity to handle the complexity of biodiversity impact, and the low expressed interest of customers in biodiversity issues. Regarding data availability, the raw material and the retail stages have the most environmentally related information, while the logistics and distribution stages have little data on these issues. Furthermore, the most available information in the supply chain is related to operations and general environmental compliance. This includes material volume and emissions, followed by hazardous chemicals, energy and emissions, while the information related to soil and ecosystem is least kept track of. In addition, many of Nudie Jeans' current sustainability works have positive associations to counter biodiversity losses. For future outlooks, it was suggested that Nudie Jeans establish a mitigation hierarchy based on materiality assessment and value chain mapping, to properly benchmark its biodiversity goals with quantifiable data in focus areas. A list of practical environmental improvement areas is also compiled, consisting of both technical and social pro-biodiversity interventions that the company can bank on. The most critical issues are seed conservation and identification of biodiversity hotspots from the upstream of the supply chain, but strengthening engagement with suppliers and consumers should also be emphasized.

Keywords: biodiversity assessment, environmental governance, non-financial information disclosure, corporate social responsibility

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Crafting this thesis has been quite a journey, not only because corporate biodiversity management is such a nascent and multifaceted topic, but the pandemic also brings on certain peculiarities of the time. As such, I would like to send my thanks to the following people, without whom fiddling with virtual meetings and rolling with the drudgery of research would have been far less pleasant:

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Warm regards to you and yours,

Nhu Anh Phan

Gothenburg, Spring 2021

Table of Contents

List of Acronyms

AFIRM	The Apparel & Footwear International Restricted Substance List Management Working Group
CBD	Convention on Biological Diversity
EC	European Commission
EMAS	EU Eco-Management and Audit Scheme
ERP	Enterprise Resource Planning
ESG	Environmental, Social and Governance
EU	European Union
FSC	Forest Stewardship Council
FWF	Fair Wear Foundation
GHG	Greenhouse Gas
GOTS	Global Organic Textile Standards
GRI	Global Reporting Initiative
GMO	Genetically modified organism
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
LUC	Land use change
MEA	Millennium Ecosystem Assessment
NCP	Natural Capital Protocol
NJ	Nudie Jeans
OECD	Organisation for Economic Co-operation and Development
OSC	Organic Content Standard
PEFC	Program for the Endorsement of Forest Council
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SBT	Science-Based Target
SDG	Sustainable Development Goal
SIWI	Swedish International Water Institute
UN	United Nations
USDA	United States Department of Agriculture
WBCSD	World Business Council for Sustainable Development
WRI	World Resource Institute
WWF	World Wide Fund for Nature
ZDHC	Zero Discharge of Hazardous Chemicals

1. Background

1.1. Biodiversity and corporate biodiversity assessment

Biodiversity refers to the network and variety of life on Earth, with all its complexity and intricacies (CBD, 2006). Its existence is pivotal to sustain the wellbeing of humans and non-human species, yet increasingly under threat of decline and destruction largely due to our extractive and contaminating activities on natural resources. There has been rising interest in understanding and tackling this crisis among scientific communities, political bodies and industries (Addison et al., 2020). On an international level, Aichi Biodiversity Targets, the part and parcel of the United Nations (UN) biodiversity framework established by the Convention on Biological Diversity (CBD), set out a list of strategic goals for the betterment of biodiversity in the 2011-2020 period (CBD, 2020). The European Commission (EC) also plays its part, notably by recently initiating the Biodiversity and Business Platform to boost political dialogues on the topic (EC, 2020). Nevertheless, these efforts have been fragmented and inconsistent. On a firm level, studies of national enterprises in Sweden (Rimmel & Jonäll, 2013) and the Netherlands (Lambooy et al., 2018) as well as meta-analysis of multi-national companies have shown that biodiversity, as a part of non-financial information disclosure, was neither properly reported nor understood by investors (Adler et al., 2018; Skouloudis et al., 2019). Among the potential firm-level environmental impacts, investors and account managers ranked carbon emissions to have a significantly higher priority compared to other issues like land use, water, and chemical pollution (Lambooy et al., 2018). Disproportionately prioritizing some environmental issues means paying less attention to or even neglecting others. To alleviate the current status quo, it is important that biodiversity is adequately conceptualized and communicated, and its human impact on is sufficiently assessed through effective metrics. For a fuzzy and value-laden concept like biodiversity, however, it is easy to consider the simpler and more measurable factors while ignoring the trickier and less tangible aspects, i.e., the map is not the territory (Addison et al., 2020). This poses the challenge to improve metric quality as well as its performance over time and across space.

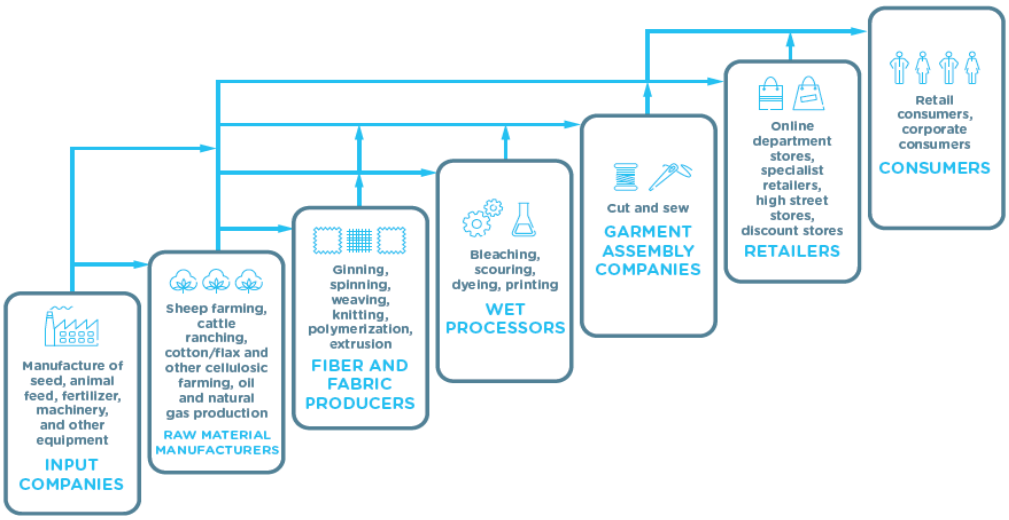

Figure 1: *How clothes are made - A typical supply chain of textile production and retailing.* Taken from Capital Coalitions (n.d.).

1.2. Nudie Jeans and the journey to sustainable fashion

Nudie Jeans (NJ) company, the main subject of this research project, is a clothing company headquartered in Gothenburg, Sweden (Nudie Jeans, n.d.a). Like other clothing companies, NJ has an international cohort of suppliers and partners, along with collaborations with different actors in the short, medium, and long terms.

NJ has been active with their sustainability works from their early days. Annual sustainability reports are disclosed and posted on its homepage, which provide information about the company's works toward sustainability as a part of their corporate social responsibility actions (Nudie Jeans, n.d.b). Despite these efforts, biodiversity has not been touched upon. This is partly because of the multinational settings of their operations and the overall complexity of the textile supply chain (Fig. 1), which makes it complicated for the brand to fully account for its responsibilities and dependencies. Furthermore, many of biodiversity impact are site-specific, temporal, and often concentrates on the upstream stages of the supply chain where NJ does not have direct control. This presents the challenges to benchmark biodiversity impact and build a disclosure and management roadmap comprehensively so that biodiversity values can be effectively recognized and reaped by relevant stakeholders.

1.3. Aims & Objectives

The objective of this research is to uncover how the roadmap to assess the biodiversity impact and structure the works of the supply chain of Nudie Jeans can be established. Specifically, I would like to first understand the perception of NJ staff and their suppliers with biodiversity issues related to their supply chain and their motivation to tackle their biodiversity impact. Secondly, the existing environmental works of NJ will be identified in order to see the connection between its sustainability works and biodiversity assessment and the remaining gaps that a biodiversity roadmap should fulfil. Finally, from such analysis, possible pathways and bottlenecks are provided.

My work was a part of a bigger project on uncovering NJ's relationship with biodiversity in which I partner with Clara Wickman. While my focus is on why and how the roadmap can be initiated from a conceptual and strategic point of view, Wickman's work investigates the biodiversity impact of NJ when it comes to cotton and TENCEL production, both qualitatively with interviews and quantitatively with a life-cycle assessment approach in combination with the drivers, pressures, state, impact and response **(**DPSIR) model (Wickman, 2021). Both of our works apply the direct drivers of biodiversity decline set by IPBES. The drivers and impact of biodiversity changes deciphered in her work is instrumental to analyze potential interventions NJ and its stakeholders can undertake. My part, on the other hand, has a more general scope by trying to assess the performance of biodiversity in NJ as a whole and thus would contribute to providing broader insights into the findings Wickman obtained.

1.4. Research questions

The research questions and sub-questions are as follows:

What are the perceptions and motivations of Nudie Jeans and its suppliers in countering biodiversity loss?

- How is biodiversity and biodiversity decline perceived by Nudie Jeans and its suppliers?
- What do Nudie Jeans and its suppliers aim to understand, assess, and monitor when it comes to the biodiversity impact of its operations?

How can Nudie Jeans effectively set up a roadmap for biodiversity management and assessment?

- What kind of environmentally-related data do Nudie Jeans and its suppliers keep track of and to what extent are they managed, relatively and across different tiers of the supply chain?
- What is the state of environmental works at Nudie Jeans with regards to direct drivers of biodiversity loss?
- What are the remaining gaps and key environmental action points for Nudie Jeans and its suppliers to look into for their biodiversity initiatives?

1.5. Limitations

1.5.1. Scope

While it would be interesting to consider the perspectives of all actors in the supply chain in constructing the indicators, this is not realistic given the scale and scope of this project. Hence, I aim to look at primarily the key stakeholders and the segments of the supply chain where most of the biodiversity impact incur. This essentially include NJ personnel and suppliers at the raw material stages. Furthermore, as around 94% of textile fibers volume of the company come from cotton (Nudie Jeans, n.d.b), the interviews would gear towards cotton producers among all the suppliers.

As the company of interest is NJ, the findings would directly revolve around the company operations, although the lessons can be relevant to other firms in other industries as well. While NJ is only at the beginning state of their biodiversity initiatives, the starting point of the roadmap will not be from a blank slate, but from the existing environmental sustainability works that NJ is doing. Regarding communications with NJ side, viewpoints of biodiversity can be incompatible from site level to corporate level due to, *inter alia*, local regulations, economic conditions, and varying interest to tackle the issue.

It should be highlighted that the focus is on the impact of the company on the environment or biodiversity, rather than the other way around, as the research targets how NJ can manage its biodiversity impact and dependencies. Although the rising biodiversity loss may hamper the business operations in many ways, it is viewed as the result of inaction or ineffective actions from the company.

Although biodiversity values encompass both environmental and social components, this study primarily orients towards environmental side as they constitute the direct drivers of biodiversity loss. Nevertheless, in order to environmental factors to be accounted for, the managerial and organizational aspects would be considered in the analysis. The study would also only look at issues related to how a roadmap for biodiversity assessment can be established, not the design of the metrics or the implementation of biodiversity works for NJ.

1.5.2. Terminology

Several terms would be used interchangeably throughout the report. Firstly, the industry that Nudie Jeans belongs to would be called "textile", "clothing", "apparel", or more specifically "denim" as this is the main product category that NJ is specialized in. Terms like "company", "firm", and "organization" is used to address a commercial business, i.e., a group or organization that markets and sells goods and/or services for profits (Cambridge Dictionary, 2021). This thus may refer to NJ or its suppliers, while terms like "retailer" and "brand" only mention Nudie Jeans or similar companies that sell the final products to customers with their own image and "personality" and also belong to the downstream of the supply chain. In real life, "company" and "brand" (name) may overlap (such as with Sony, Volvo or H&M), but this is not always the case (such as with Procter & Gamble which has many brands like Gillette or Olay) (Acevedo, 2017).

On the other hand, stakeholders and actors are also treated as synonymous despite their minor differences (Hollebeek et al., 2020). In addition, the concoction of data, information and knowledge used in the report may cast confusion as well. Data refers to the raw, "unfiltered", or "unrefined" information, such as in numbers or statements, while information is usually considered "useful" data which usually undergoes a certain degree of processing to fit the specific context or analysis (Liew, 2007). Knowledge encompasses another level of conceptualization. It is yielded from information, which associates with values, beliefs, or meanings for humans to be used for actions in even more specific settings (Liew, 2007). It can be said that information is the base, or the body where knowledge arises.

Knowledge surrounding biodiversity decline and its assessment can be derived from both scientific communities and industries, although the government plays a certain role in incentivizing such knowledge to be formed or paid attention to, such as via pro-biodiversity policies or funds. Such interactions between universities, government and private sectors have been documented and conceptualized in models like Triple Helix model (Cai & Etzkowitz, 2020). Having knowledge in the topic is important for strategy and actions to slow down or halt biodiversity loss to be taken place. These works will be called "works", "interventions", "initiatives" or "contributions" in the thesis.

Finally, the loss of biodiversity will also be termed "decline", "halt", or "crisis", while the threats associated with the loss are sometimes viewed as "risk", which technically comprises of both the negative effect of something and the probability of such effect happening.

2. Theoretical frameworks

2.1. Biodiversity

2.1.1. The concept and connection to sustainability

According to CBD, biodiversity refers to the diversity of life on Earth on genetic, species and ecosystem levels. Biodiversity underpins all economic activities and all elements of human well-beings (Addison et al., 2020). The contribution that biodiversity brings to humankind is usually seen through the concept of ecosystem goods and services. A common delineation of these goods and services is compiled from a synthesis report by the Millennium Ecosystem Assessment (MEA) (MEA, 2005), an expert-driven four-year study for policy makers initiated by UN Secretary-General Kofi Annan. MEA aims to evaluate the impact of ecosystem changes and strengthening scientific foundations in conservation and sustainability works (MEA, n.d.), and according to the group, ecosystem goods and services comprise of four main categories as in Table 1.

Table 1: *Categorization of ecosystem goods and services by Millennium Ecosystem Assessment.* Adapted from MEA (2005, pp. 6, Fig. A).

Ecosystem goods and services	Definition	Examples
Provisioning services	Goods produced or provided by ecosystems	Food, fiber, chemicals or genetic resources
Regulating services	Benefits obtained from ecosystem processes	Climate, pest, or air quality regulation
Cultural services	Non-material benefits obtained from ecosystems	Sense of place, aesthetics, spiritual values
Supporting services	Supports three other sets of services	Photosynthesis, nutrient recycling, or soil formation

All these goods and services have direct or indirect contributions to human well-being constituents with varying strengths and potential to be mediated by socio-economic factors (MEA, 2005). Interestingly, the term "ecosystem services" was replaced by Nature's contributions to People in the latest IPBES report (IPBES, 2019). There are other ways to term what nature constitutes, such as Mother Nature or Nature's gifts. This denotes the multitudinous ways that biodiversity represents for different social groups, yet it is also challenging to ensure that their values are holistically considered in biodiversity assessments and initiatives.

Biodiversity is also a vital component in sustainable development. Sustainability is, as the famed definition in the Brundtland Commission Report goes, safeguarding the need of the present generations without compromising on that of future generations (UNESCO, n.d.). Sustainable development is typically divided into three pillars: environmental, social and economic segments, and the transition there would not happen without resilient natural ecosystems of which biodiversity is a critical part. To this end, biodiversity is essential both as a foundational property of nature or the environment and its social and economic values for humankind. Biodiversity has been identified as one of the five global risks to society in the sustainability realm, alongside

climate change, extreme weather, food and water crisis (Stockholm Resilience Center, 2020). In this thesis, biodiversity is thus considered a sustainability issue.

2.1.2. Biodiversity loss

Biodiversity loss is detrimental on virtually any production system where raw material is needed, from food production to energy systems. Despite its importance, biodiversity decline is rising globally with different rates and magnitude depending on the areas. The 2019 IPBES report concluded an average of 25% of flora and fauna on Earth are "already threatened with extinction" (IPBES, 2019). The rate of species extinction, however, varies greatly across species. The global Living Planet Index, for instance, showed a marked 52% decline in vertebrate species in the past 50 years. The IUCN Red List of species survival indicated a stark reduction in coral population of 20% between 1980 and 2000, whereas amphibians, birds and mammals are in relatively less vulnerable conditions (Aiama et al., 2015). The global insect population is declining by 40% with 2.5% rate of decline annually. On an ecosystem level, almost half of natural ecosystems have deteriorated compared to baseline level, and more than one-fifth of biotic integrity, have eroded in communities on land.

Five main direct drivers of biodiversity loss were identified in the IPBES report, covering the terrestrial, freshwater, and marine ecosystems (IPBES, 2019). This includes:

- Habitat degradation, loss or fragmentation
- Bio-resource exploitation
- Climate change
- Pollution
- Invasive species

These drivers are further influenced by indirect drivers of human life, which comprise of values and behaviors on demographic and sociocultural aspects, economic and technological aspects, institutions and governance, and conflicts and epidemics (IPBES, 2019).

To get a clearer picture of the consequences of biodiversity losses, economic valuation of these services is increasingly adopted with some forms of natural capital accounting. In their widely cited paper, Costanza et al. (2014) estimated the global loss of ecosystem services caused by land use change amounted to $US 4.3–20.2 trillion/year with variations across 16 biomes. The findings score coral reef as the most "expensive" biome at more than $US 360,000/ha*year, followed by mangroves at $US 190,000/ha*year (Costanza et al., 2014). The study further provides a conceptual model on the embeddedness of the societal systems on natural systems, which illustrates the idea of the environment as capitals (Fig. 2). Accordingly, human well-being is influenced by social, human, and built capitals. These capitals are subsets of natural capitals, which affect well-beings via ecosystem services.

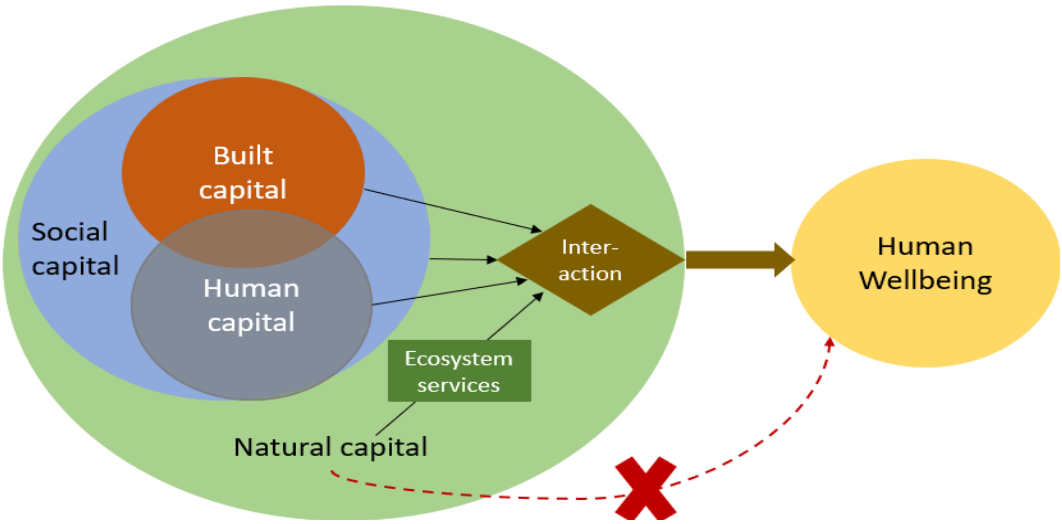

Figure 2: *Linkages between different capitals and human well-beings with possible windows for changes.* Adapted from Costanza et al. (2014, pp. 153, Fig. 1).

The integration of natural capitals into economic accounting is also emphasized in the recent and influential Dasgupta review on the economics of biodiversity. The report is an independent review led by Professor Sir Partha Dasgupta for Her Majesty's Treasury, the body that governs public financing in the UK (Fletcher, 2021). "Nature" here is both recognized as an asset and an economic good, for the functions it provides for human lives, and as an entity with intrinsic existence and values independent of humankind. At present, human demands overshoot Nature's supply, which is influenced by "the "stock" of natural assets and its ability to generate" (Fletcher, 2021, pp. 1). This contributes to the marked rate of biodiversity decline, for instance, with the current extinction rate varying between 100 and 1000 times of the baseline level and being on the rise. The findings further reveal the alarming rate of decline of natural capitals by almost 40%, while human capital per person only grew by more than 10% with a doubling global population between 1992 and 2012 (Fletcher, 2021).

2.1.3. Challenges with countering biodiversity decline

Initiatives related to biodiversity can be incredibly complex due to the scope and site specificity of the impact. Tradeoffs and synergies are present in extracting natural resources in producing our goods and services (OECD, 2021). Accordingly, many initiatives can be multifunctional, e.g., afforestation may have positive impact on carbon offsetting, while others can cancel out each other's benefits, for example investing in bioenergy plantation for climate mitigation versus land use change impact. Solutions like conservation and restoration programs that work on ecosystem level may not be beneficial on species and genetic level, or the focus on certain animals or plants may not have an encompassing net positive impact on the environment such species are located (Heink & Kowarik, 2010). For example, the vulnerable status of species like leopards and wolves sharing the same protected habitats increases in panda conservation areas (France-Presse, 2020). This is oftentimes exacerbated by the lack of knowledge of nature and biodiversity. It is not yet a common practice to align environmental policies that can enhance the co-benefits and manage potential clashes, which undermines the "transparency, accountability and exchange of lessons learned" (OECD, 2021). These factors contribute to the situation where the five Aichi Targets

on strategic biodiversity goals have poor or moderate progress on most indicators (Earth.org, 2020).

Many models, frameworks and indicators are constructed to conceptualize biodiversity and prioritize focus areas. For example, IPBES bases its biodiversity assessment on the Driver-Pressure-State-Impact-Response (DPSIR) Framework, which is often used to structure environmental quality assessment for policy makers, from which indicators can be developed (IPBES, 2019). Nevertheless, it is not explicit from the framework which pathway should be taken for interventions to be implemented and indicators to be constructed. Hence, more action-oriented frameworks and strategies should be present in the toolbox to steer progresses.

2.1.4. Combating losses

Public sectors

The political ambition is lagging behind the rate of biodiversity decline. Less than 1% of environmentally related tax collection in OECD countries belongs to biodiversity and the total environmental tax only makes up roughly 5% of all tax revenues. Among about 90 countries implementing accounts related to UN System of Environmental-Economic Accounting, the standard for natural capital accounting, only one-third has developed some ecosystem accounts (OECD, 2021). Furthermore, natural accounts do not have the equal footings with economic accounts, and their integration is shown to be methodologically and mechanically challenging (OECD, 2021). Very few countries and public banks are able to assess their spending on biodiversity despite the growing adoption of some level of green budgeting. OECD pointed out that “green” measures only accounts for less than one-fifth of post-pandemic recovery package, of which only 7% is pro-biodiversity (OECD, 2021).

From an economic standpoint, the Dasgupta review suggested the awareness of the embeddedness of social and economic systems in Nature is crucial and urgent to take actions, especially as conservations are less expensive than restoration of degraded nature. It identifies the root of the problem from institutional failures, which is strongly associated with the indirect drivers listed by IPBES. Given the finite resources Nature can provide, the review raises the impetus for institutional rearrangements that are more polycentric and can hold accountable for ecosystems and transformation in the financial sector. In particular, the authors promote a global standard to account for the dependencies of and the impact on Nature from businesses and financial institutions through measurement and disclosure, alongside national financial accounts (Fletcher, 2021). This narrative is echoed in a very recent OECD Environmental Policy Paper, which provides a guideline to integrate natural capitals and biodiversity into the economy, especially the financial sectors. The paper points out, *inter alia*, the need to mainstream biodiversity risks, scale up investments and foster systems innovations (OECD, 2021).

At the same time, economic evaluations may come with many counterarguments (Admiraal et al., 2013; Costanza et al., 2014). Putting a price on something is often entrenched with ethical implications and is technically challenging, especially

considering the weaknesses of willingness-to-pay methodology. A risk of commodification may emerge, for example, with ownership of genetic resources.

Private sectors

Private sectors play tremendous roles in biodiversity impact and their involvement in biodiversity works can create or reinforce leapfrogs to halt biodiversity losses. Such incorporation of non-public stakeholders is called biodiversity mainstreaming into the society.

Companies with a certain level of biodiversity disclosure are few and far in between. Among 3,500 companies holding the majority of global market capitals, less than 1% of business models align with SDGs 14 and 15, i.e., Life below Water and Life on Land (OECD, 2021). Less than 10% of all 150 top Fortune Global firms provided significant reporting in their biodiversity works (Adler et al., 2018). And for companies that do, while the disclosure act is positively correlated with their extent of biodiversity partnerships for companies, these reports are often riddled with inconsistencies, generic statements, and the lack of holistic views (Addison et al., 2020; Adler et al., 2018; OECD, 2021).

Nevertheless, businesses have started to pay attention for the material risk of biodiversity decline from site to corporate level in various sectors regardless of their sizes. This often embodies the disclosure of biodiversity information, which is usually based on indicators that are activity driven (Addison et al., 2020). It is important to place corporate biodiversity assessment into the overall context of sustainability reporting. Companies often follow frameworks like GRI and aligns their reporting to a certain extent with SDGs (GRI, n.d.b). The adoption of both is voluntary. The former contains a series of standards where firms can choose to either fully integrate GRI into their sustainability reporting, which requires the use of all Universal Standards and sectorally related specific Standards (GRI, n.d.a). GRI does have a specific standard for biodiversity, which helps uncover needed actions to be implemented to tackle biodiversity impact of firms, yet its standards do not sufficiently foreshadow strategic roadmaps to get there (Addison et al., 2015).

The Sustainable Development Goals (SDGs), which were derived from the Millennium Development Goals, sets up a core 17 goals with a basket of targets and projects (UN, n.d.). SDGs and GRI standards are tightly linked, and the list of GRI indicators with direct connections with SDGs has been reported (GRI, n.d.b). Biodiversity goals are in many ways intertwined with SDGs, with both trade-offs and synergies (OECD, 2021). An example can be observed with the impact of land use change on issues like food security and biodiversity. Since both GRI standards and SDGs are only suggestive but not instrumental for company to strategize and build their business models, frameworks that support businesses for decision making are also extremely important.

2.1.5. Natural Capital Protocol and Science-Based Targets

Overview

For companies to ease into measure, track and monitor their environmental impact, frameworks that impart decision making like Natural Capital Protocol (NPC) and Science-Based Targets (SBT) are incumbent. NPC is a risk-oriented framework supported by EU Platform on Biodiversity and Business (Capitals Coalition, n.d.). It consists of four main stages, namely Frame, Scope, Measure and Value, and Apply, which assists companies to identify a business's desirable agenda on biodiversity and unveil different pathways of actions and their impact on the ecosystem (Capitals Coalition, n.d.). The Coalition has specific biodiversity guidelines for further integrating biodiversity value into natural capital assessments. Here, biodiversity is regarded as a standing issue, not just an add-on of climate change.

Similarly, SBT (Science-Based Targets), which are developed by Global Common Alliance, offers a framework and a process for businesses to benchmark their environmental targets in a step-wise approach (SBTN, 2020). The founder organizations behind SBTs, termed Science-Based Targets Network (SBTN), include a consortium of global non-profits such as WWF, UN Global Compact, and WRI (SBTN, n.d., TBC, n.d.a) . The network sets up the momentum for SBT initiatives (SBTi) whose main objective is to bridge the gap between nature and business from a scientific angle (SBTN, n.d.). The targets here specifically refer to "measurable, actionable, and time-bound objectives" which could be established and enacted by actors (SBTN, 2020, pp. 5).

Science-Based Targets Approach

SBTi has experienced a strong and rapid growth. Companies and countries that in total contribute to roughly 20% of global GDP already set or are in process of setting SBT targets for climate change by March 2020, five years after SBTi inauguration (IKEA Foundation, 2020). While SBT is known for climate actions, it has now gone a step further to reduce and mitigate the risks of nature degradation and loss systematically in four focus area, namely biodiversity, fresh water, land, and ocean (TBC, n.d.a). When it comes to biodiversity, a biodiversity guideline and biodiversity hub are formed to complement the existing works of the consortium.

Underlying the development of SBTi is the concept of planetary boundary (Alberts, 2020). Developed by a research group in Stockholm Resilience Center since 2009, the concept presents nine planetary boundaries, or nine key processes that govern the stability and resilience of the Earth system (Rockström et al., 2009). The health and functioning of these processes is crucial for human welfare. The group further defines this as "a safe operating space for humanity", indicating that keeping resource utilization within these boundaries is the prerequisite for sustainable development (Rockström et al., 2009).

While the planetary boundary provides a guiding principle for SBTi, SBT framework is nevertheless more practical and industry-driven. The process consists of five main steps: (1) Assess, (2) Interpret and Prioritize, (3) Measure, Set and Disclose, (4) Act,

and (5) Track (SBTN, 2020, pp. 14-15). Following these steps enables organizations to have a clearer picture of their biodiversity impact and their possible action plans to mitigate negative effects. SBT also provides specific sectoral guidelines, including the apparel sector (SBTi, n.d.)

At the core of the assessment step of SBTs lies materiality assessment and value chain mapping. Materiality is defined as what "matters most" to a business and its stakeholders on environmental and social dimensions, or non-financial information (KPMG, 2014, pp. 2). As such, assessing materiality, via screening tools provided by SBTs, helps the given company identify where the problem areas prevail in relation to its economic activities (SBTN, 2020). This can help the company prioritize its ESG strategies and initiatives (KPMG, 2014).

By 2013, almost 200 out of 250 biggest firms globally already measured material impact of their businesses (KPMG, 2014). The recent years also witness the growing integration of materiality into reporting frameworks and accounting standards, such as in GRI guidelines and Sustainability Accounting Standard Board (SASB) (KPMG, 2014). The EU Directive on non-financial information disclosure further raises the importance of incorporating materiality as a part of the company's non-financial disclosure (EC, n.d.a). In addition, SBT acknowledges that its materiality focus is societal rather than financial, and expects adherents to "take voluntary actions (at times above and beyond what is regulated)" (SBTN, 2020, pp. 16).

Together with materiality assessment, value chain mapping assists practitioners to associate the impact and dependencies of the organization and its supply chain with the value chain, i.e., "a series of activities, sites, and entities" throughout the product or service lifecycles (SBTN, 2020, pp. 18). Value chain is generally divided into the upstream stage, where the raw material extraction, production, and manufacturing happen, and the downstream stage, where the distribution and sales, as well as end-of-life treatments like reuse and recycle, occur (SBTN, 2020, pp. 18-19). Defining the scope of the value chain is extremely important as the areas under operations of a given firm do not exist in silo, but surrounded by a bigger, multifunctional system. The degree that the firms exhibit control is thus coined "sphere of control" and "sphere of influence" (SBTN, 2020, pp. 18-19).

The process of mapping the value chain includes hotspot assessment. As the name suggests, this assessment has a spatial focus, as many of the impact on nature, like biodiversity and water, are site dependent (SBTN, 2020). Finding hotpots would give the companies an estimate of the relative intensity of their activities across the value chain. Refining the data on materiality assessment and value chain mapping would supply valuable input for step 2, Interpret and Prioritize (SBTN, 2020, pp. 18-19).

SBTN further carves out an action plan called ARRRT, which stands for Avoid, Reduce, Restore & Regenerate, and Transform (TBC, n.d.a; SBTN, 2020, pp. 9). ARRRT is a series of sequential steps aimed to guide companies to take science-based yet practical actions to protect the environment. The idea is based on the mitigation hierarchy, a set of guidelines developed by International Financial Corporation's Performance Standard 6 to assist development projects to achieve "no net loss" in biodiversity (Smithsonian, n.d.). No Net Loss and the Net Positive Approach also encompasses EU Biodiversity Strategy to halt biodiversity loss via steps throughout the

project's lifecycle to ensure the least negative impact are generated (EC, n.d.c). Close to ARRRT, the mitigation hierarchy comprises four steps: avoid, minimize, restore, and offset based on the sequence and preference of execution. The definitions are explained as follows (Kering, n.d., TBC, n.d.b, Smithsonian, n.d.).

- Avoid: Measures belong here if they lead to impact that should be avoided or eliminated. This is the most effective way to counter or mitigate the risks, but should be incorporated early on the in project. Examples: changing operation sites or suppliers that work in biodiversity hotspots.
- Reduce, or Minimize: For impacts that are unavoidable, measures should be taken to reduce the severity of the impact as much as possible. Examples: changing business practices, introducing new technologies, engagement strategies, or reducing resource use for certain activities.
- Restore & Regenerate: When impacts cannot be fully avoided or reduced, measures are taken to improve degraded environments and restore natural habitats. Examples: Afforestation, planting trees, land reclaims, etc.
- Transform, or Offset: After the previous three steps have been implemented, measures are taken to handle the remaining impact on the sites and to extend the impact on a broader scale. Examples: landscape planning, pro-biodiversity governance among actors.

2.2. Apparel supply chain

2.2.1. History

Cloth making is one of the oldest businesses in the world. Clothes do not only offer protective layers against harsh temperature and less hospitable environmental conditions but also represent our status, class and socio-cultural groups (Kothari & Gupta, 2010). Flax and cotton, two of the oldest natural fibers in the world, had their earliest estimated use in 5000+BC and 5000-3000 BC, relatively (Textile School, 2018). Before the 18th century, the industry was small-scale, mainly domestic, and village based, with a local network of farmers, ginners, weavers and spinners. This was usually coined the "cottage" industry (Godley, 1997). Multiple innovations such as flying shuttle, spinning jenny and cotton gins happening throughout the 18th century have enabled the industry to significantly mechanize, improve efficiency, and centralize the textile production and distribution system (Godley, 1997; Yürek et al., 2019). Textile development was seen as both the main catalyst and the result of Industrial Revolution, and henceforth the growth of steam power and coal power harvesting also goes hand in hand with the progress of the industry (Godley, 1997; Yürek et al., 2019). Producers, for the first time in history, were able to export their fibers and finished garments. As the first industrialized country in the world, Britain became the global textile manufacturers, with their cotton primarily imported from the Indian subcontinent (Kothari & Gupta, 2010; Godley, 1997; Yürek et al., 2019).

Man-made fibers came into commercial use by the early 20th century with the first one being rayon. Since then, a whole new lineup of manmade fibers has been developed with different functionality and environmental impact (Textile School, 2018). This

contributes to the growing complexity of production methods and material composition of clothes.

Such transition also helped popularize the concept of fashion to a broader range of customers. Once reserved for the better off, the increasing affordability means that more people could buy clothes beyond their essential needs. These social and technological progresses, embedded in the history of craftsmanship, trade and colonialism, enabled once tailor-made clothes to mass-produced ready-to-wear items. This bridged the way to the off-shore mass production of apparel that began in the 1980s and the fast fashion phenomenon of the 2000s (Bhardwaj & Fairhurst, 2010). As a result, the modern apparel supply chain is characterized by international and fragmented trade flows and layers of tiers (Fig. 1). These developments have also contributed to increasing diffusion of fashion trend information, and the availability of fashion clothing to a broader range of consumers since the Industrial Revolution. On top of that, while retailers and manufacturers have certain liberty to shift to different raw material producers in case the fiber quality or other production issues go south, producers usually have less flexibility and belong to the less profiting side of the supply chain (Bhardwaj & Fairhurst, 2010; Godley, 1997; Yürek et al., 2019).

2.2.2. Biodiversity impact of the apparel sector

Due to the fragmented nature of the current industry, the social and environmental implications remain largely unaccounted for. Until big events like Dhaka garment factory fire in 2012, the largest fire in the history of the country, what happens behind a finished garment is mostly unknown to customers (Prentice & De Neve, 2019).

The interest for apparel companies to tackle sustainability and biodiversity issues has quickly garnered in recent years due to the increasingly perceived operational, regulatory and financial risks of inaction and the awareness of material impact of their businesses (Aiama et al., 2015). Furthermore, a development of biodiversity strategy and biodiversity fund by Kering group, the French based multinational giant in luxury goods like Gucci and Bottega Veneta, casts a steering impact on the fashion industry (Kering, n.d.). Kering uses SBT frameworks and tools extensively in its projects. Aiming to transform one million hectares of crop and rangeland via “regenerative practices”, Kering’s works on biodiversity can be considered pioneering in the fashion industry.

The impact of current apparel sector on the environment occurs in every stage of the supply chain. Table 2 summarizes how the sector contributes to direct drivers of biodiversity losses from the IUCN report by Aiama et al. (2015).

The raw material stage generally has the most significant impact on biodiversity losses (Ross et al., 2015). Growing natural fibers for clothing, whether from plants or animals, take resources like land, energy, and water across different agro-climatic conditions, and in most cases lack a sustainable supply chain, e.g., competition with food and bioenergy production or production in high biodiversity risk or water risk areas (Aiama et al., 2015). The use of chemicals as pesticides, herbicides or fertilizers may lead to nutrient runoff and consequently eutrophication and hampering soil health. Wildlife-derived materials like python skins places great pressure on wildlife and illicits illegal wildlife trade activities and introduction of invasive species, such as minks in fur farms

where minks are not native (Aiama et al., 2015). On the other hand, more environmentally benign solution like organic farming only accounts for the minor streams of fibers, usually for more niches markets, with uncertain future trajectories (Aiama et al., 2015; Seed & Soil Taskforce, 2015).

Table 2*: Dependencies and pressure of the apparel sector on biodiversity loss.* Summarized from Aiama et al. (2015, pp.10-14, Table 1).

	Habitat loss, degradation or fragmentation	**Bio-resource over-exploitation**	**Pollution**	**Climate change**	**Invasive species**
Raw material	Natural fiber growth is resource-intensive & lacks a sustainable value chain Increasing wildlife demand Husbandry Polyester is fossil fuel-driven Production in more biodiversity-rich areas	Deforestation Husbandry	Agro-chemical Manure Wastewater Toxic chemicals like antimony released during recycling processes Discharged pollutants from pulp mills	GHG emission sources: LUC (forested → cropped land and pasture area), agro-chemicals, and paper & pulp industry Less energy intensive than other steps	Wildlife trade (Burmese python) Alien animals in fur farms like minks Alien plants like bamboos
Processing & Manufacturing	Due diligence processes	N/A	Energy, water, and chemicals, especially in dyeing and tanning	Energy use and dependent on materials For polyester: 70% of total energy use occurs here	N/A
Distribution & Logistics	N/A	N/A	Road construction, transport process	Outsourcing leads to increased trade flows, hence increased energy consumption	(Unknown) potential for invasive species
Retail	Over-consumption Seasonal → fresh collections	N/A	Waste Chemicals & water for washing	Significant energy use in washing, drying & ironing	N/A

With manmade fibers, the contribution of polyester and other materials derived from fossil fuel is growing markedly and now occupies the largest flow of fibers. Their sustainability is contentious, as they may be superior in certain technical performances like material strength or water saving, but problematic in others such as material

sourcing and discharged pollutants from cellulose-based industries. Recycling fibers is one way to curb the demand for virgin materials, yet this process is technically challenging for the fiber blend in garments and released toxic chemicals like antimony. Furthermore, the production of micro- and nano-fibers from textile contributes significantly to the discharge of microplastics, which amounts to around 35% of primary microplastics in marine environment and persist for a long time in terrestrial environments (Henry et al., 2019).

Processing and manufacturing fibers is usually subject to due diligence processes and has no impact on bio-resource overexploitation and invasive species per se. However, this stage uses great amount of energy, water and chemicals, especially in the dyeing, tanning and washing cycles (Peters et al., 2021). The exact extent of this depends very much on the type of materials used, but for polyester around 70% of energy use in the supply chain is generated in this stage (Aiama et al., 2015).

Technically, distribution and logistics does not have direct impact on habitat and bioresource exploitation. Transporting goods and services and constructing transport infrastructure, however, are energy intensive as well as incur emissions and release pollutants (Valodka et al., 2020). Yet the segregation between “production countries” and “consumption countries” makes it more energy intensive to deliver the right products to the right place at the right time, and warehouse management usually requires extra energy demand (Peters et al., 2021). It is also possible that invasive species may be inadvertently introduced due to the transport processes, but the impact is unknown (Aiama et al., 2015).

On retail stage, the adoption of new fashion trends and the short turnovers of clothing collections makes overconsumption or stock mismanagement prone to happen, which generates more waste (Bhardwaj & Fairhurst, 2010; Peters et al., 2021). This is deeply connected to sociocultural, institutional, and technological factors that constitute indirect drivers of biodiversity loss (Aiama et al., 2015). Furthermore, washing, drying, and ironing clothes requires a significant volume of chemicals and water, which makes this stage the biggest driver for climate change in many cases (Peters et al., 2021; Ross et al., 2015; Valodka et al., 2020).

While it is useful to clarify the impact of the clothing industry on biodiversity loss, the actual impact for a certain firm should be judged on case-by-case basis, especially with the lack of quantifiable data and persisting scientific uncertainties. From the information provided in this chapter, it is not clear what and how businesses can work to tackle biodiversity losses.

2.2.3. Nudie Jeans and its sustainability ethos

Nudie Jeans is a multinational clothing company group consisting of 13 entities across Europe and the United States (US), from which Svenska Jeans Holding AB owns the outstanding stock. The headquarter is based in Gothenburg, Sweden and covers all business aspects such as design, marketing, HR, sales, and sustainability. In addition, Nudie Jeans has a network of suppliers in eight countries in Asia and Europe where different fibers and garments are produced. 49% of sold products by volume are via wholesale, whereas retail and e-commerce channels stand at 28% and 23%, respectively

(Nudie Jeans, n.d.c). It is interesting to note that the brand is only co-owned equally by three people, with no external investors.

Marketing and selling a wide range of clothing from trousers and jackets to T-shirts and undergarments, NJ specializes in denim products, notably jeans. More than half of NJ's products by volume are sold in Europe, while the rest is equally divided in Asia, North America, and Australia and New Zealand (Nudie Jeans, n.d.a).

Claiming itself to be a sustainable denim brand, the company works actively in many sustainability areas, both environmentally and socially. NJ is a part of the FairWear Foundation (FWF), which ranked the company in Leaders position since 2009, and Textile Exchange, which also puts the company in Leading position since 2019 (Nudie Jeans, n.d.b). Its so-called environmental philosophy was proudly placed first in the "About" section prior to typical business information and organizational structure (Nudie Jeans, n.d.c).

Its sustainability ethos currently mainly lies in their usage of organic cotton and recycled material streams, both of which have been growing in volume over the years. Used jeans are also collected, quality-screened, cleaned and fixed to be sold as post-consumer recycled jeans in their Rebirth collection (Nudie Jeans, n.d.b). Furthermore, as a part of their loyalty program, the company has been growing their repair services for customers with the establishment of repair stations and the collaboration with other companies as "repair partners". As a result, the number of jeans that are fixed, reused, and recycled has grown remarkably in the last few years. In 2019, NJ repaired 63,281 pairs of jeans and collected 11,573 pairs. The sales of reused jeans increased by 20% between 2018 and 2019, amounting to more than 3000 pairs (Nudie Jeans, n.d.b).

Transparent production is another aspect that NJ places itself on. Key financial numbers in revenues, earnings, assets, and equity ratio can be viewed on their webpage. When it comes to non-financial disclosure, Production Guide is available on their website, which gives out information about their suppliers, the associated materials and final products, the volume and logistics issues (Nudie Jeans, n.d.b). Its sustainability report is also published annually which discloses their sustainability governance, activities, certification, and future goals with detailed descriptions in 100 pages. These strategies put NJ in the niche mid-end market for environmentally conscious customers.

3. Methodology

To approach the research questions, I used a combination of literature review and interviews or email correspondence. The former provided a background on biodiversity and sustainability disclosure and assessment in private sectors especially textile companies, while the interviews within the NJ supply chain were intended to help understand the expectations, perceptions, and aims of the NJ supply chain with regard to biodiversity. In parallel to this, seeking recommendations from environmental specialists on biodiversity management was also instrumental to the process.

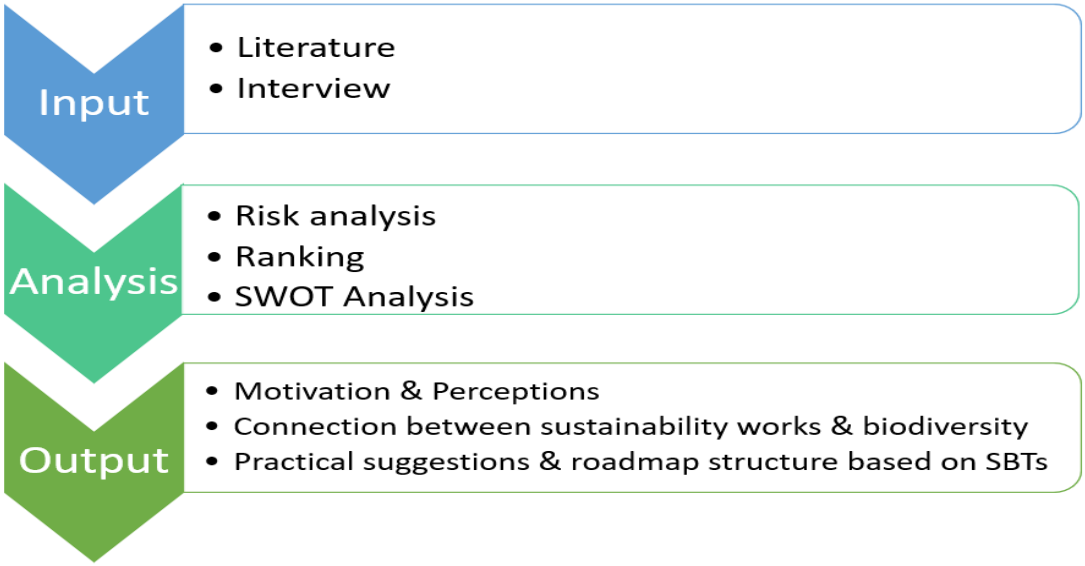

Figure 3*: A schematic view of the research methods*

The research was divided into three parts, namely "input", "analysis", and "output", and the processes can be viewed in Fig. 3. Firstly, a preliminary literature review on corporate biodiversity management and international biodiversity initiatives from scientific articles and white papers was conducted. I then carried out semi-structured interviews with several actors from NJ representatives and suppliers and a biodiversity consultant to discuss the current understanding and actions related to biodiversity. Such information from the literature and interviews were consolidated to find the motivation and perceptions to tackle biodiversity issues. This was qualitatively done in the form of a risk analysis. Furthermore, environmental data were ranked across four tiers of the supply chain, namely raw material, processing and manufacturing, distribution and logistics, and retail stages. The former two were considered the upstream part and the latter ones are the downstream part of the supply chain. While the actual stages of apparel production and consumption are much more layered and opaquer with networks of farmers, cooperatives, ginners, weavers, and spinners, I considered this demarcation sufficient to provide a bird-eye view of the biodiversity impact and works of each level without making the analysis obscured. Given the sustainability agenda that NJ already has, the result of the ranking helped to understand the extent that sustainability and environmental works in the supply chain can be connected to (future) biodiversity commitments.

Following the ranking, a SWOT analysis was done as a critique to the availability (or lack of) of information, strategies, or actions on biodiversity protection. This paves the way for some recommendations on future practical steps and structures for a biodiversity roadmap at NJ in line with Science-based Targets. The detailed processes of the interviews, analysis methods, and SBT framework are explained in the following sections.

3.1. Interviews

3.1.1. Select and categorize interviewees

The involved interviewees were divided into three main groups: employees at NJ, suppliers of NJ, and biodiversity specialists (Table 3). Interviewees that are working at NJ include the environmental manager and the product developers, and the suppliers of NJ include the representatives of the Indian and Turkish organic cotton farming cooperatives. The environmental manager first introduced us to these actors and Wickman and I made further interview requests and follow-up questions. With the Turkish supplier, our initial contact did not agree to an interview as the person did not feel fully equipped for a discussion. This contact however sent us some documents about non-GMO cotton use in the country. We managed to set up an interview with the marketing and sales executive at Agrona (Table 3).

Table 3: *List of interviewees, with contact methods and information exchange*

Actor type	Name	Position	Contact	Topics covered
Nudie Jeans' employee	**Eliina Brinkberg**	Environmental Manager at Nudie Jeans	Email correspondence and semi-structured interview with follow-up questions	Nudie Jeans' sustainability works
	Jenny Henriksson	Product Developer at Nudie Jeans	Semi-structured interview	Nudie Jeans' product development and supplier networks
	Jon-Ivar Unsgaard	Product Developer at Nudie Jeans	Semi-structured interview	Nudie Jeans' product development and supplier networks
Nudie Jeans' supply chain representatives	**Srikar Yenuka**	Agronomist at Chetna Organics, Nudie Jeans' Indian supplier	Semi-structured interview with follow-up questions	Chetna's works and partnership with Nudie Jeans
	Ashok Kumar	Agronomist at Chetna Organics, Nudie Jeans' Indian supplier	Semi-structured interview with follow-up questions	Chetna's works and partnership with Nudie Jeans
	Onur Uçak	Marketing & Sales Director at Agrona, Nudie Jeans' Turkish supplier	Semi-structured interview with follow-up questions	Agrona's works and partnership with Nudie Jeans
Biodiversity specialists	**Louisa Durkin**	Consultant in Agro-food and Biodiversity at Metabolic	Semi-structured interview	Corporate biodiversity assessment
	Meena Menon	Journalist and Author of two books in organic cotton in India	Semi-structured interview	Cotton industry in India
	Therese Rudebeck	Program Officer at Stockholm International Water Institute	Semi-structured interview	Corporate water assessment and governance

For non-NJ actors (who are also termed biodiversity specialists), I used a semi-snowballing approach to find potential interviewees. For academic actors, I first asked my supervisors and teachers and from their suggestions. I contacted and conducted an interview with the consultant in Agro-Food and Biodiversity at Metabolic, a sustainability consulting firm based in Amsterdam, the Netherlands. To find suitable participants, I looked into organizations that are active in biodiversity research such as Stockholm Resilience Center, Textile Exchange, EU Business and Biodiversity Platform, GRI, SIWI, WBCSD, and WWF, and authors that come up often on my scientific literature. In the end, I contacted the contact email of the webpage of Textile Exchange and WBCSD as they are more specialized in company corporate assessments and have specific email address for the issues, an ex-manager at GRI and a program coordinator at SIWI via my personal connections, and two researchers that publish actively in biodiversity indicators and corporate biodiversity management. Only the SIWI researcher agreed to do the interview, while other actors did not respond, ceased to respond after initial conversations, or refused to do the interview.

For industry actors, I contacted three multinational apparel companies of different sizes that claimed to be sustainable or pro-biodiversity and published their sustainability reports annually or biannually via their contact form or contact person about sustainability on the websites. However, they either did not respond or refused to do the interviews.

In addition to industry and academic actors, I also had an interview with a journalist who writes extensively about organic cotton in India, which was useful to look at the cotton industry in India through a historical lens.

3.1.2. Conduct the interviews

Wickman and I did most of the interviews with NJ together, except for the interview with the product developers which I did on my own. We developed our own set of interview questions relevant to our research objectives and questions. All interviews were conducted virtually via Zoom, and before each meeting we introduced our background and our thesis projects and asked the interviewees to do the same. Prior to each meeting, for anonymity purposes we asked if the actors were comfortable with the interviews being recorded, and if what they said was explicitly mentioned in our analysis in direct or indirect quotations. All interviewees agreed for their answers to be recorded and used in the thesis.

All interviews were semi-structured to give the participants the liberty to express their perspectives and understanding on related matters more freely, while still conforming to the central themes of the research. A primary question list for each category of interviewees was prepared before the interviews, which can be found in Appendix 1 for each category of interviewees. However, this list is suggestive rather than prescriptive, so spontaneous questions or discussion points were also come up during the interviews to explore further into an issue.

I took notes during the interviews, revised, and wrote a summary for each conversation based on the initial notes and the recordings. For interviews we did together, Wickman and I also exchanged interview notes and aligned the information of these interviews. After that, these summaries sent to the participants for cross-checking. In some cases

when further clarification is needed, including the ones with NJ's environmental manager and the Indian and Turkish suppliers, follow-up questions and discussion points were sent to the corresponding interviewees. The finalized interview summary can be found Appendix 2 of the thesis.

3.2. Analysis

The motivations and perceptions on biodiversity, and the status of sustainability works and their possible connection to biodiversity were derived from the interviews. In addition, a risk awareness analysis, a ranking of the visibility of environmental information, and a SWOT analysis were conducted to understand the motivations and understandings of the supply chain of NJ with regards to biodiversity management as well as the possible transition pathways to pro-biodiversity actions The details of each analysis are explained in the below sub-sections. Moreover, the existing sustainability works of NJ were also aligned with the different direct drivers of biodiversity loss described by IPBES (2019) to see possible synergies, which relates to Wickman's thesis on drivers and states of biodiversity loss.

3.2.1. Risk analysis

The potential risks (and dependencies) in relation to biodiversity of the supply chain of NJ were viewed in four angles: operational, reputational, financial, and regulatory risks. This division is adapted from the six biodiversity-related risks to businesses defined by OECD (OECD, 2019) and the four motivations to tackle biodiversity by Kering (Kering, n.d.). The former one further includes "market risks" and "materiality of risks" beside the four aforementioned risks, while Kering's report focuses on operations, reputations, synergies with sustainability works, and regulations. Given that no direct work on biodiversity has been taken place at NJ, the four main risks would give a good overview of the present understanding of the company's dependencies on biodiversity.

3.2.2. Ranking of the visibility of environmental information

With the combination of interview analysis and literature review, the aim for biodiversity disclosure and management was identified for NJ and its suppliers. The visibility of environmental data in material, water, energy, chemical, soil and ecosystem was ranked across different tiers of the supply chain with the score of 0 to 4. The lower scores represent less knowledge on the listed components, while a higher score indicates a more comprehensive information availability. Table 4 lists the environmental components used for the ranking, which were adapted from a Metabolic's report on material criticality (Metabolic, 2021). While this is not topically related to biodiversity directly, I believe it is methodologically relevant. The result of the ranking is given in Table 6, and the detailed calculations are provided in Appendix 3 and the attached Excel file.

Table 4*: Environmental categories used for ranking of data visibility in Nudie Jeans' supply chain*

Material	Water	Chemical	Energy	Emission & Waste	Ecosystem
Origin	Water usage	Chemical use	Energy consumption	GHG emissions	Soil health
Quality	Wastewater management	Hazardous chemical		Waste handling	Ecosystem health
Composition					Land use change
Volume					
Recycled content					
Recyclability					

The score was calculated based on four criteria that overall constitute data availability or visibility, whose score is binary (either 0 or 1) per environmental category and for each supply chain tier. As such, score 0 indicates little to no data on a given environmental category within the specific criterion, while score 1 means that the firm has good or complete data on a given environmental category within the specific criterion. As there are four criteria, the score ranges between 0 and 4 per supply chain tier. These four proxy-indicators, or criteria are based on the three aspect MRV establishment. MRV, stands for measuring, reporting, and verifying, is used by many national organizations for data collection and control, compliance, and mitigation actions in the field of sustainable development and climate change (MRV Africa, n.d.; Mucci, 2012). A notable example of that is EU emissions trading system, in which MRV is incorporated as a part of its compliance cycle (EC, n.d.b). While there is no unified frameworks and clear definitions of MRV, an established MRV system in this thesis refers to the presence of management practices, strategies, and/or action plans in the MRV realm (Mucci, 2012).

- Monitoring refers to the measurement, calculation, or accounting of given information (MRV Africa, n.d.; Mucci, 2012). It is hereby represented by "data collected and measured". This category represents monitoring activities. It indicates whether or not the supply chain tier compiles and analyzes data for the listed environmental component, from the interviews and reports.
- Reporting describes documentation processes for relevant parties, i.e., if data are reported with transparency and follow specific formats, frameworks, or protocols (Mucci, 2012). It is seen via two indicators:
    - Environmental goals present: Having goals, commitments or benchmarks is important in environmental management. From the information provided by the interviews and literature revies, NJ and its suppliers were ranked according to the presence of these goals (temporally and spatially) across the given environmental component (Table 4) and whether these goals are enacted.
    - Information disclosed: If the information related to the given environmental component is available to retrieve from public reports or interview, it then matches this category.

- Verifying is the procedure to validate and verify data quality, either by in-house or external personnel (MRV Africa, n.d.; Mucci, 2012). In this study, this is represented by "certification or internal verification conducted". This indicates whether the data category is externally validated, and if knowledge of existing regulations and certifications is present in the level of the supply chain.

3.2.3. SWOT Analysis

After the motivations, perceptions, and the current status on biodiversity initiatives were explored, a SWOT analysis was then provided to see the overall potential and remaining gaps of assessing, disclosing, and managing biodiversity impact in the NJ supply chain. SWOT is a technique to identify strengths, weaknesses, opportunities, and threats for strategic planning, which can provide simple yet robust guideline for organizations and personnel in decision making (Kenton, 2021). In this study, the four angles of the SWOT analysis were done by consolidating information qualitatively from the combination of interview results and literature reviews. The outcome of the analysis was finally revised after follow-up discussions with NJ's staff.

3.3. Adaptation of the Science-Based Target Frameworks

A list of practical strategies on future biodiversity initiatives was comprised based on the SWOT analysis, the interviews with the biodiversity expert, and the second round of literature review. The SBT framework was also discussed as a suggestion to structure the roadmapping processes of the biodiversity works. Similar to biodiversity strategy development at Kering, the framework used in the study was simplified into three main steps, i.e., "Assess", "Mitigate, and Monitor, Report" and "Verify", as shown in Fig. 3. This modification is due to the early stages of biodiversity works that NJ is now in, which necessitates a more simple and pragmatic schematic view of how the roadmap may look like, rather than the full-on framework.

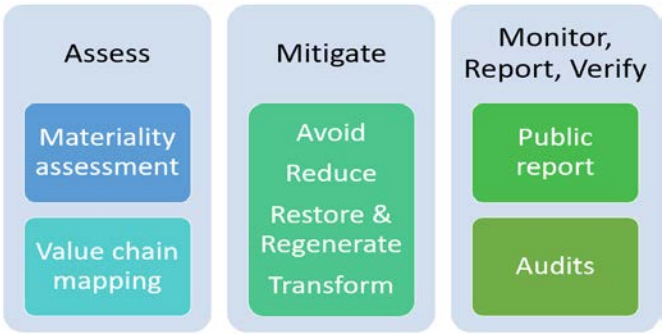

Figure 4: *An adaptation of SBT framework*

The "Assess" stage comprises materiality assessment and value chain mapping, whose concepts are explained in section 2.1.5. Due to insufficient data, a full materiality assessment was not performed, but a compilation of material issues and their materiality would be described. Regarding the value chain mapping, different tiers of the supply chain were mapped with each of the five direct drivers of biodiversity loss and ranked according to the intensity of their overall impact. This ranking is based on both the interviews with NJ's staff and supply chain, biodiversity specialists, and NJ's sustainability report. Value chain mapping is tightly associated with materiality

analysis as the latter provides the overall pictures of issues to pay attention to, while the former places the relative impact of these issues on the specific part of the product lifecycle.

Using the input from the Assess step, the "Mitigate" stage is based on the mitigation hierarchy or the ARRRT framework of SBT with four sequential steps that are also explained in section 2.1.5, to set up practical benchmarks and actions NJ can follow. The last stage, called "Monitor, Report, Verify" is to monitor and refine the knowledge and actions from the previous two steps. It is proceeded in forms of audits and disclosed with public reports to relevant stakeholders. The focus of this study is on the first two steps, i.e., Assess and Mitigate, rather than the last one, again as NJ has only begun to consider its biodiversity impact.

4. Findings

4.1. Motivations for a biodiversity management system

According to the environmental manager, the main rationale to manage and assess the biodiversity impact of NJ is for education for the company employees and the supply chains. Since NJ has tackled sustainability from many angles, developing a way to manage the biodiversity impact of their operation is necessary for a more comprehensive sustainability management and disclosure.

The interviews with the environmental manger and product developers revealed that while Nudie Jeans has shown certain interest in the biodiversity issues, their motivations are more reactive to the trends of clothing brands rather than proactive at developing concrete steps to counter biodiversity decline. The interest itself was initiated from NJ interactions with other brands in 2019. Nudie Jeans stated that the desired focus is on the area of impact that directly, or largely, affects NJ's current and future operations, rather than a more comprehensive ambition to regenerate or ameliorate the environment where the supply chain is located.

Furthermore, the degree of motivations at NJ also hinges on consumer awareness of the issue. From the conversations I had with the environmental manger and product developers, as customers have not "paid attention" and raised voices substantially about the issue, the company's drive to speed up the progress in this area is low at present. Such statement is different from how NJ's sustainability actions stem so far. As such, both the developers and managers said that these works were initiated before sustainability has marketing values and embedded as a core business principle by the founders of the company. This can be seen for instance with the use of organic cotton, for which NJ identifies itself as an early adopter in the clothing industry.

While sustainability is seen at the heart of NJ's operations, the product developers also noted that NJ attracts customers first-hand due to the design and fabric quality, before environmental and social values come into play with more weightage in the past five years. In other words, the interviewees at NJ contented that the company is intrinsically interested in sustainability of the clothing industry, and this goes beyond the gains in revenues and customers for portraying themselves as a sustainable company.

When it comes to biodiversity aspects, however, the same intrinsic interest and actions are not evident, although generally corporate biodiversity management and biodiversity mainstreaming are still nascent for industry players. It is nevertheless interesting that tackling biodiversity decline not entirely driven by social pressure or profits, as mentioned in the literature, but the desire to know and be educated about the issues.

Organizationally, the environmental manager commented that biodiversity agenda in the company should be integrated in and work in line with its sustainability commitments. Sustainability initiatives in general have started from employees lower in the corporate structure, which is also different from what is reported in the literature, but executive decision making is needed to diffuse a more firm-wise environmental management system. This is expected to go similarly with biodiversity actions. On the supply chain level, company staff has repeatedly mentioned the efforts to build up relationships with suppliers and patterns with aligned sustainability visions, such as sourcing organic cotton and conserving water and energy at the manufacturing stage.

4.2. Status of sustainability works at NJ and their connections to biodiversity

4.2.1. The perceived risks of inaction against biodiversity decline

In this section, I would like to dwell into the interviews that I conducted with NJ and its suppliers and identify the potential and perceived risks from biodiversity losses of the company's supply chain. The result is summarized in Table 5.

Table 5: *Potential risks of biodiversity loss for business activities of Nudie Jeans*

Risks	Perceived potential risks for Nudie Jeans
Operational	• Chetna & Agrona: Drought as the rising risk for cotton production • Areas with high water risks and biodiversity hotspots may suffer from more losses due to inaction • Loss of partnerships due to insufficient biodiversity actions • Lack of capacity to mitigate or handle consequences of biodiversity losses
Reputational	• Customers' loss of interest in purchasing Nudie Jeans' product as a result of non-action or inadequate actions against biodiversity decline from Nudie Jeans
Financial	• Stock quality and quantity negatively affected due to biodiversity decline • Missing out opportunities and early-mover advantages on clean technologies and materials due to the lack of actions • Divestment and declining support from pro-biodiversity groups
Regulatory	• Loose pro-biodiversity regulations and disconcerting national, regional and international agenda, especially in the upstream stages, make it challenging to develop company's biodiversity strategies and actions

All the interviewees showed basic understandings of the definition and concept of biodiversity and biodiversity loss. It is note-worthy the interviewees were less literate and showed some hesitance to discuss in greater details biodiversity impact in the

company context, such as the degree of impact across different tiers and in different places of the supply chain. This is in line with the lack of information

Considering the risks the company might encounter due to biodiversity decline, especially as a result of inactions or inadequate actions against it, four main risks can be identified. Operational risks refer to the risks associated with the operations across all tiers of the supply chain. According to the interviews with the suppliers in India and Turkey, the drivers of biodiversity decline are most evident in disruption in seasonal patterns, especially in the increase in the frequency and severity of drought, soil dynamics, and the presence of invasive species. This coincided with NJ's identification of high water risk area via Aqueduct Water Risk Atlas developed by World Resource Institute, where Indian suppliers emerged as the highest water risk area followed by Turkish and Tunisian ones (Nudie Jeans, n.d.c).

Chetna Organic representatives in India further noted the decrease in the genetic diversity of their local seeds to be the concern, which is largely attributed to the lack of governmental support in seed conservation and the promotion of GMO seeds. Other environmental issues, such as pollution, were barely touched upon during the interviews.

Regarding overall biodiversity impact, all interviewees from NJ said that the upstream stage of the supply chain, i.e., the raw material production and processing stage, has the biggest relative impact on biodiversity. Due to missing information on different aspects of biodiversity, this can be seen as only speculations.

In the future, as both the rate of biodiversity decline and the interest in tackling biodiversity losses are on the rise, NJ may risk missing out on innovation and R&D opportunities corresponding to growing resource scarcity that directly (such as with decreasing organic cotton acreage) or indirectly (such as with water crisis) affects their supply without timely and effective actions. This is also related to reputational risks, as the interest from customers to consume NJ's products, especially loyal or returning customers, may dwindle if environmental issues related to NJ's operations are not fully accounted for.

When it comes to financial risks, the reduction in biological diversity from genetics, species or ecosystems level may cause a reduction in the quantity and quality of the garment available to the brand. For example, companies may miss out the variation of garments that can be generated due to the decreasing genetic diversity among the indigenous cotton varieties. The degradation in soil health and other land quality factors due to pollution and water scarcity pressures the raw material producers and manufacturers to compromise on how and how much fiber and clothing can be produced. In the long run, the company may face divestment from not living up to its sustainability agenda when biodiversity becomes more mainstreamed.

For regulatory barriers, there are significant gaps between the overall environmental regulations across different countries that NJ is based. A prime example is the different amount and schemes of subsidy of organic farming between cotton producers in India and in Turkey, as mentioned in the interview with organic cotton journalist and author, which leads to a significant difference in the amount of income that producers may receive after the fiber is sold. As the upstream suppliers of NJ are mainly established in

low-income countries with lax regulations, it may create a hindrance for NJ to apply their environmental initiatives in terms of social responses and overall engagement in environmental stewardship works.

4.2.2. The visibility of environmental data in NJ's supply chain

Table 6 summarizes and compares the degree of information that NJ and its suppliers have and exchange with various environmental information in chemical, ecosystem, energy, emission, material, soil, water, and waste, as explained in section 3.2.2.

Table 6: *The knowledge of environmental data across different tiers of the supply chain of Nudie Jeans*

	Raw material	**Processing & Manufacturing**	**Distribution & Logistics**	**Retail**	**Sum**
Material origin	4	1	1	4	10
Material quality	4	4	0	4	12
Material composition	1	2	0	4	7
Material volume	4	4	4	4	**16**
Recycled content	2	4	0	4	10
Recyclability	0	0	0	2	2
Water usage	3	4	0	2	9
Wastewater	1	2	0	0	3
Chemical use	3	2	0	0	5
Hazardous chemicals	4	4	0	4	12
Energy usage	4	4	2	2	12
Emissions	4	3	3	4	**14**
Waste handling	0	0	0	3	3
Soil health	3	0	0	0	3
Ecosystem health	0	0	0	0	0
LUC	0	0	0	0	0
Sum	**41**	36	11	**37**	

Note: For each supply chain stage and each environmental component, a lower score is highlighted in red while a higher score is highlighted in blue. The highest and lowest scores are represented in a sharper shade, while the middle ones have a lighter shade. With the total score, the color scheme varies between dark green and white. The components with the highest scores are also boldened.

Across the supply chain, the information related to material volume and emissions receive the most visibility, followed by toxic chemicals, energy usage, material quality and origin. This is also the essential information for quality assurance and due diligence

processes. In contrast, data related to biodiversity like soil health and ecosystem health were the least known and exchanged.

Per supply chain tier, Raw material and Retail levels have the most data on environmental impact, in contrast to Distribution & Logistics level. The raw material stage is known to have a significant dependence on biodiversity, while on retail level Nudie Jeans is responsible for collecting information on its supply chain as a part of its reporting process. Distribution and logistics have less overall impact on biodiversity considering the direct drivers beside energy use and pollution, so it is reasonable why the visibility on the impact of this stage is less known.

4.2.3. The linkage between NJ's sustainability works and biodiversity

This section focuses on how current sustainability works of NJ can be correlated to reduce or relieve direct drivers of biodiversity loss (IPBES, 2019). In a similar approach to Table 2, the pro-sustainability actions from each of the tiers of the supply chain, namely raw material, processing and manufacturing, distribution and logistics, and retail, were collected and mapped with the five drivers when relevant to see if they may generate positive biodiversity effects. This method is under the assumption that biodiversity commitments at NJ can be the extending arm of its sustainability strategies, rather than starting from a blank slate.

As NJ has not assessed the exact biodiversity impact of their activities, the extent and the specific impact a given action creates remains considerably speculative The compilation of these action was from both the interviews and NJ's sustainability reports. The result is summarized in Table 7.

Regarding disclosure on environmental works in general, NJ report is GRI referenced and their works are self-aligned with SDGs qualitatively (Nudie Jeans, n.d.c; GRI, n.d.a). Their stores in Europe are certified with the Swedish Environmental Diploma, and they are all transitioning to ISO system for more universal standards with their non-European stores and a more comprehensive environmental management.

When it comes to actions and strategies, it seems that many of the works have already shown to have positive impact on the biodiversity in the areas that Nudie Jeans is operating. The company comes up with a sustainable material tool with sustainable sourcing policy, which enables the brand to select more environmentally friendly options for their garments to a larger extent. The material tool consists of Sustainable fibers, Non-sustainable fibers and Do not use sections. Among sustainable fibers, three classes of fibers were also categorized based on recyclability, biodegradability, certification and recycled and reused content (Nudie Jeans, n.d.b). Class 1 is claimed to be the most sustainable materials and include fibers like recycled cotton, reused NJ products, traceable, organic, and/or Fairtrade cotton, lyocell. Class 2 and Class 3 comprise fibers that are less sustainable than class 1, but still the better options, such as recycled polyester, certified organic cotton, certified organic hemp for Class 2, and some animal products like alpaca, yak, mohair, and silk that are certified for Class 3.

Table 7: *Nudie Jeans' existing actions towards sustainability and its connection to biodiversity loss direct drivers.* Black: Actions by Nudie Jeans, Blue: Actions by suppliers

	Habitat loss, degradation or fragmentation	**Bio-resource over-exploitation**	**Pollution**	**Climate change**	**Invasive species**
Raw material	Prioritize organic materials for virgin natural fibers, mainly certified by GOTs, OCS and USDA Organic Minimal and only certified animal-derived textile PEFC & FSC-certified cellulosic fibers FSC-certified wooden hangers Prioritize recycled fibers EMAS-certified trims Sustainable sourcing strategies Identify areas with high water risks Multicropping, cover crop & mixed crops Soil sampling	Organic farming India: Seed conservation program & land reclaim Turkey: Ban genetically modified seeds	Organic agro-chemicals Restrict or ban toxic chemicals based on REACH, AFIRM and ZHDC initiatives Turkey: water drippers that reduce 40% water uptake	Chetna, India: Land reclaim Avisera (bag and package supplier): plant trees in Colombia to offset carbon	Minimize wildlife-derived products via sustainable material tools and sourcing policy
Processing & Manufacturing	Due diligence processes	N/A	Restrict or ban toxic chemicals Wastewater management system Water-saving in dyeing and washing Dyeing: Save Blue (Turkey,	Turkey: Increased renewable energy usage to 100% by 2025	N/A

			reduce 55% water use), Indigo Juice (Italy, reduce 15% water use) Washing: Ozone wash, laser tech Reduce stone washes Turkey: Increased renewable energy usage to 100% by 2025		
Distribution & Logistics	N/A	N/A	N/A	Freight transport accounts for 15% of emissions, 66 wt% of outgoing deliveries are by trucks (1%), 34 wt% by air (14%) Maximize rail transport for incoming deliveries and business travels Promote e-commerce and loyalty program	N/A
Retail	Controlled product flows Circularity program in lifecycle extension & waste minimization: Repair faulty items, reuse leftover fabrics,	N/A	Care guide to reduce water use "Guppy Friend" washing bags to trap microplastics	Map emission based on GHG Protocols in all three scopes Increasing renewable energy use	N/A

	give away samples, and implement internal purchasing policies Set up repair stations & recycle partners Apply Miljödiplom (integrated environmental management) in many EU repair shops	Lifecycle extension & waste minimization: Repair faulty items, reuse leftover fabrics, and give away samples Map water usage	in offices and stores In-house and external carbon offset projects

Overall, the company puts priorities on recycled materials and emphasize the use of certified organic fibers when it comes to virgin natural fibers. As organic farming does not use synthetic fertilizers and pesticides, instead the use of cover crops, mixed crops and multicropping is used to replace nutrient needs for the plants and the soil. This potentially reduces the risk for habitat loss, degradation or fragmentation, pollution coming from the use of organic agricultural chemicals. In addition, the Turkish supplier also started to apply laser-coding for their cotton buds to increase the traceability, as said from the interview with the representative. The level of transparency in material volumes and the very high extent of traceability of each fiber on country's level can potentially reduce the risks of wildlife trade. For synthetic fibers, either recycled polyester or manmade cellulosic fibers are used, such as with TENCEL as they have lower energy and water needs.

Nudie Jeans further develops chemical policy based on various standards like REACH, AFIRM and ZHDC, and maps water use and energy use based on three scopes as provided by Greenhouse Gas Protocol. The company has been involving in both in-house and external carbon offsetting projects as a part of their climate change initiatives.

From the interviews with the environmental manager and product developers, it seems that the brand has very stringent environmental and social standards in searching for and maintaining relationships with suppliers, although no clear strategies were given. To tackle biodiversity loss, all the cotton suppliers of Nudie Jeans practice organic farming and crop diversification, including intercropping, cover crops and the cultivation of nitrogen-fixing plants. On top of that, Agrona has been implementing water-dripping system to conserve water use, ozone washes to reduce water use in wet processes and reduce stone washes in general. However, only water usage was taken into account, among all aspects of water management, and no water map with different water types was yet carved out, making it difficult to see if the suppliers' actions added up to mitigate or reduce this vulnerable condition. At the same time, Chetna focuses on collection and filing of their local seeds, soil sampling and land reclamation. Chetna farmers are further encouraged to grow food crops beside cotton for extra means of livelihoods. Both Agrona and Chetna noted that knowledge-building and practical

training for farmers are necessary to mitigate the impact of climate change and biodiversity decline on their works.

On the other hand, it appears that Nudie Jeans has little interaction with or in-depth knowledge in the biodiversity works of the suppliers. The company has taken steps to measure its emission throughout the supply chain over three scopes, for instance, but that only seems to be in line with works from Swedish partners and reporting for customers rather than serious strategizing and actions.

4.3. SWOT analysis of current states of biodiversity management

In order to analyze the current state of NJ's biodiversity initiatives, I used the SWOT analysis. The structure of the SWOT analysis is explained in section 3.2.3, while the points of analysis were based on previous findings on the motivations and the status of biodiversity management at NJ, as well as the connection between biodiversity initiatives and sustainability initiatives (section 4.1 and 4.2). In addition, the perspectives of the biodiversity specialists are also incorporated in this section. The results are summarized in Table 8.

Table 8: *SWOT Analysis of existing biodiversity-related sustainability works at Nudie Jeans*

Strength	**Weaknesses**
• Cover general environmental issues: material, water, emission, and chemicals • General understanding of biodiversity • All biodiversity drivers are accounted for to different extents • Strong interest and financial portfolio to be transparent and take initiatives	• Lack effective data management system and strategies (Reactive > Proactive) to counter biodiversity halt • Insufficient engagement with stakeholders • "Business" data gets divorced from sustainability data • Scientific uncertainties
Opportunities	**Threats**
• Synergies with existing sustainability works • Similarities with other (denim) brands	• Post-pandemic supply chain resilience • Upsizing • Low-support political climate

Among sustainability works, NJ has touched upon many components, including material, water, emission, chemicals and waste. The stakeholders at the company and among the suppliers showed a basic understanding of the definition of biodiversity, the state and drivers of biodiversity losses and possible options to tackle them. For example, Chetna is very active at seed conservation and organic farming training programs, while Agrona utilizes the water drippers to conserve energy and cotton labelling for improved traceability.

The environmental manager further said that NJ has relatively generous budget to take more actions. It is quite clear that sustainability in general is a big part of their main business strategies, not just a marketing tool.

There also seems to be many synergies stemming from current sustainability efforts that have spill-over effects on biodiversity conservation, as described in Table 6. This sets a solid foundation for the company to develop its biodiversity agenda. Furthermore, as there is not a myriad way to produce certain garments, biodiversity work can very well be cross-cutting in different producing and retail companies in the textile industry. According to the program officer at SIWI, each industry has very specific impact on biodiversity, so collaborating with companies with the same products would collectively accelerate the experience and knowledge in corporate biodiversity commitments.

As for the weaknesses, many of the reported data are not quantifiable. Many are only statements that may or may not be significant in overall accounting. While the biodiversity consultant at Metabolic remarked that the lack of data, especially spatial data, is expected, and the initiatives can be proposed from the clarifications of which data are available, it seems that NJ is unaware of which biodiversity-driven data are essential and should be collected in the first place. For metrics and frameworks that companies follow to assess their environmental impact (especially water impact), the assumptions, points of reference and system scopes behind what is reported should be paid attention to. The problem with the lack of data and structure to manage data lies in the prioritization of actions and strategies. As mentioned by the program officer at SIWI during the interview, it is possible that an action can be positive in relative terms, but not in absolute impact.

In addition, no communication related to biodiversity has yet been done across the supply chain, rather each supplier takes their own initiatives when they see fit. This and the lack of data management system further hinder the acquisition of knowledge and strategy development in the topic.

On the other hand, it is evident sustainability reporting is not connected to financial reporting at NJ. This means that there is no number on cash flow, revenues or overall economic situation connected with sustainability works. The lack of linkages may inhibit the motivations to take more actions.

The Metabolic consultant further input that the links between financial risks and biodiversity losses on firm level can be hard to foresee, let alone disclose. Although companies care about their images, the company needs to be internally motivated to develop its biodiversity initiatives.

There are several future threats related to biodiversity that may hamper the operation of NJ. Lacking a clear picture, NJ may take actions that are sporadic, inconsistent and hard to track. Prioritization of where and how to generate positive changes is still an imminent challenge for the company and its supply chain. To cope with the pandemic impact on the resilience of the supply chain, there needs to be recovery strategies to recoup economic losses that are also in line with biodiversity and environmental protection.

Furthermore, as NJ is growing, its expansion would put pressure on the production of products and services derived from natural resources. This makes the supply chain even more complicated to account for. Without having a robust system in place, the effectiveness of its current works may very much be likely to be stagnant or untimely.

Given NJ's international suppliers, the regulations on biodiversity are vastly different. For example, genetically modified cotton seeds are banned to be used in Turkey, while their use is popular in India, which poses the issue of seed guardianship (as these seeds are distributed by private companies) and disrupts the local biodiversity that is better suited to local cotton breeds and the local textile industry to a varying extent. The regulations on organic farming of cotton are also different in Turkey and in India. Organic markets are generally more insulated in Turkey, guaranteeing more income stability for the farmers. In contrast, while cotton is one of the most important cash crops in India, the government has not provided sufficient protection and pricing incentives that target the farmers, according to the supplier and journalist. In a broader picture, as explained in section 2.1.4 on combating biodiversity halt from private and public sectors, the current global political climate is not supportive of biodiversity loss counter-actions, compared to other environmental actions like climate change and carbon budgeting. This is event from the dedicated funding to the inconsistencies and incongruences of existing frameworks and reports.

Private actors cope with disconcerting regulations by certifications and forming farming cooperatives on the raw material stage. From the discussion with the journalist on organic cotton, although these two methods can help promote organic farming in India, they do not always benefit the farmers, leaving them the receiving ends. Certifications are expensive and cannot often be purchased from individual farmers. Farming cooperatives often sell the organic fiber at a premium price, but it is the cooperative, not the farmers themselves are the recipients of these markups. All in all, these approaches cannot replace ineffective national regulations in the long run. Without a strong governance from the national, regional, and international level, it is difficult for companies in any industry to align and account for the right actions.

4.4. A working approach toward constructing biodiversity metrics

4.4.1. Materiality assessment and value chain mapping

Given the existing state of biodiversity works at NJ analyzed in previous section, this chapter aims to structure the assessment of biodiversity impact at NJ via Science-based Targets. The actual framework consists of many steps but this study uses a more simplified version, as explained in section 3.3.

In line with the interview with the biodiversity consultant, materiality assessment and value chain mapping is suggested as the first critical step to quantify biodiversity impact. The framework and the process are described in more details in section 2.1.5, and this part is to apply them in the case of NJ from the collected information.

Materiality assessment

The goal of the materiality assessment is to provide the information on which part of NJ's operations is highly material, potentially material, or not material. The information given here is derived from the interviews and NJ's sustainability report, and the analysis is done by the author. The result is given in Table 9.

Table 9: *Materiality issues in Nudie Jean's supply chain.* Dark blue: High materiality, medium blue: potential materiality, light blue: no materiality

High materiality	Potential materiality	No materiality
• Production in biodiversity-rich land • Water consumption • Energy for processing and transport • Waste	• Genetic resources from non-native seeds and GMO cotton contamination • Processing chemicals	• Intensive natural fiber production • Pesticide and other synthetic agrochemical use • Wildlife trade • Operations in water-scarce areas

As a denim company, NJ purchases the bulk of its raw materials from cotton, making cotton farming highly material. As the majority of sourced cotton is certified-organic, however, intensive cultivation and the use pesticide and other synthetic agrochemicals are generally not a material concern for NJ suppliers. Moreover, NJ does not source wildlife derived products, and the very limited animal-derived products sourced by the company follow strict certification. This should render the effect on wildlife trade negligible. However, the biodiversity risks may still remain in producing cotton and non-cotton materials in biodiversity-rich areas (Wickman, 2021) and the use of seeds that are not local variants.

For the former one, the knowledge on the impact of fiber production on natural habitats and the local species is limited (Table 6). The latter one is related to genetic resources and is especially pertinent in India due to the cultivation of GMO seeds there, which further affects the processing stage when GMO cotton gets mixed with organic cotton. According to the journalist, this presents a contamination issue as there is often no separation of GMO and organic cotton in processing centers and it is impossible to discriminate them in case of mixing. Even when non-GMO seeds are used but are not local variants, it is not certain that the impact of growing these breeds on local biodiversity is benign. Because NJ does not purchase GMO fibers, what imparts materiality comes from possible contamination with GMO cotton, the use of non-native variants, and the cultivation on biodiversity-rich land.

Beside vegetation resources, water consumption should also be considered as high materiality. While cotton is generally a water-intensive crop, according to NJ's sustainability report, NJ does not have any supplier producing in areas of high water risks (Nudie Jeans, n.d.b), alleviating some of the material impact. Furthermore, the program officer at SIWI remarked that in many processes of textile production, water use is actually circular, or recycled. Because some of NJ suppliers, such as the Turkish one, employs water-saving methods in growing crops, dyeing, and washing (Table 7), and NJ also bans the use of many toxic chemicals (Table 7), it can be said that its water impact is lesser than regular denim brands. On the other hand, there is the growing drought issue in some suppliers (Table 5), so the company needs to analyze how these factors add up to at NJ.

When it comes to energy use, a company with multinational network of suppliers incurs substantial energy expenditure from transport. NJ has strived to curb emissions by limiting air travel, developing e-commerce program, and using clean energy in its officers (Table 7). In addition, its suppliers, such as the Turkish one, also set target to increase its renewable energy use. Nevertheless, it is not certain to what extent energy-efficient and clean energy measures can still be applied to curb energy consumption and emissions.

Another issue is with the growing waste streams of NJ's supply chain, as a result of its increasing sale. NJ has taken steps to reduce the outflows by emphasizing on longevity in its products as well as increasing the collection and sale of reused and recycled materials and products (Table 7). However, it is unclear what the suppliers manage their waste.

Finally, NJ's supply chain, especially in the processing stage, uses chemicals for dyeing and washing. While NJ has different measures to ensure toxic chemicals are not used, in accordance with EU chemical regulations (section 4.3.2), the eco-toxicity of the chemicals that are used is largely unknown. Therefore, processing chemicals can be an issue of potential materiality.

Value chain mapping

From the materiality areas that are identified in the materiality assessment, mapping the value chain would help the company see which part of the value chain it has the more intense impact on biodiversity, i.e., against five direct drivers of biodiversity losses. Similar to the structure of Table 2 and Table 7, different supply chain levels were ranked against direct drivers of biodiversity loss in terms of impact from NJ. The information for this mapping is also from the interviews and NJ's sustainability report, and is predominantly qualitative, except for climate change row, which was based on the emission calculation from the sustainability report (Nudie Jeans, n.d.b). The result of the analysis is summarized in Table 10.

Table 10: *Ranking of the impact on direct drivers of biodiversity losses from different tiers of the supply chain.* Darker grey: More relative impact identified, lighter grey & white: less impact identified

	Habitat loss, degradation or fragmentation	**Bio-resource over-exploitation**	**Pollution**	**Climate change**	**Invasive species**
Raw material					
Processing & Manufacturing					
Distribution & Logistics					
Retail					

All the interviewees remarked that raw material production stage is the most impactful stage. However, the result here presents a more nuanced picture.

For the habitat destruction, the impact is the most intense in raw material stage due to fiber production activities that utilize vegetation resources and farming practices also influence the local habitats, soil, and species dynamics (as also explained in materiality issues). The second-most impactful is the retail part - due to the general increasing demand of different clothing items, the generated waste is also on the rise without proper treatment and management.

The processing stage casts less effects on this driver relatively, as it sometimes takes place in industrial areas, but a risk assessment to ensure no harm to the local environments must be periodically conducted. Finally, the distribution and logistics generally has no impact on this driver.

With the overexploitation of bioresource, processing, distribution and logistics, and retail tiers are technically irrelevant, i.e., their operations do not affect biological resources. The impact generated by the raw material stage is also expected to be limited as NJ uses only certified animal skins and wools in very limited amount.

Considering pollution as the direct driver for biodiversity loss, the impact seems to be most intense in processing and manufacturing stage due to the relative substantial amount of water, energy and chemical use. It is lesser in raw material stage due to the organic farming practices of the suppliers that can reduce the nutrient loads to some extents. The retail part also impacts pollution via waste disposal and incineration, but the exact numbers are not accounted for at NJ at present.

Climate change is the only driver backed by quantitative data from NJ's emission mapping. Accordingly, as production constitutes the highest emission, this combines raw material and processing stage. Considering that organic material production curbs much of the embedded emissions in the agrochemicals for natural fiber production, and NJ preferably sources recycled synthetic fibers or TENCEL, which is low in emission (Nudie Jeans, n.d.b; Wickman, 2020), the emissions generated in this tier should be lesser than that in supply with less sustainable practice. The processing and manufacturing, despite the accounting complexity, still consumes significant energy and emits GHG, making this the relative heaviest impact shares, followed by raw material production. The climate change effect from distribution and logistics comes after these two stages according to NJ's calculation, and is disproportionately derived from air travel. Last, retail stage produces the least relative impact related to climate change.

Finally, the impact on invasive species is overall not significant in NJ's supply chain. To compare among the tiers, the raw material stage is the one that is most easy to impact this driver, but this should be unintended NJ does not use wildlife or uncertified animal products in its material flows. Invasive species can also occur during transport, yet this could be argued to be negligible. Processing and retail stages are not relevant to this driver.

4.4.2. The mitigation hierarchy

Banking on the result of the materiality assessment and mitigation mapping in section 4.4.1, the mitigation hierarchy in ARRRT format was created. The setup of this framework is provided in section 2.1.5 and 3.3. The action points described here are based on NJ sustainability report and Kering's mitigation hierarchy. They also share NJ's aims in biodiversity management, which was analyzed in section 4.1. The result is compiled in Table 11.

Table 11: *Suggested action points for the mitigation hierarchy at Nudie Jeans*

Avoid	**Reduce**
• Non-sustainable materials • Sourcing in biodiversity-rich and high water-risk areas • Suppliers without environmental management system and do not follow due dilligence processes	• % of low-class and uncertified sustainable materials • Improve traceability at least on country level • Apply supplier's minimum requirements on environmental compliance and disclosure
Restore & Regenerate	**Transform**
• Identify areas with biodiversity and freshwater risks • Restore x ha of abandoned or low-fertility land via multicropping and revegetation • Initiate pilot projects in regenerative agriculture • Invest in organic & native cotton seed conservation programs • Account for water, chemical use and land use change impact	• Set up indicators on biodiversity conservation • Engage employees to integrate biodiversity into their daily life • Join alliances in fashion industry that promote biodiversity/conservation projects • Develop a circular business model and discuss with downstream and upstream suppliers

The mitigation hierarchy is divided into four parts: avoid, reduce, restore and regenerate, and transform. For the Avoid segment, since NJ is experienced in sustainable material prioritization, it has sufficient assets to curb the proportion of unsustainable materials, especially wildlife-derived materials and synthetic materials that are intensive resource use and emissions. This usually comes via the revision of NJ's sourcing policy, as NJ does not own its supply chain prevents sourcing in biodiversity-rich and high water-risk areas, is essential to reduce its biodiversity impact, even when data are not available for impact assessment. In addition, not sourcing in biodiversity-rich and high water-risk areas is essential to reduce its biodiversity impact, even when the data are not available for impact assessment. Suppliers without stringent environmental or biodiversity compliance should be avoided as well, particularly when they are located in countries with laxer regulations for biodiversity conservation. In order to ensure sound decision-making, the use of verifiable and scientific sources should be emphasized to a greater extent and as early as possible. In the company's sustainability report, for instance, better referencing could do good to sufficiently validate their specific actions or initiatives, especially when they are not yet certified.

When it comes to the Reduce part, class-2 and class-3 of its sustainable material tool (Nudie Jeans, n.d.b, section 4.2.3) should be minimized with a clear goal of percentage reduction. This should not lead to the lower quality of NJ's fibers or products and hence should go hand in hand with a robust resource enterprising system (ERP, more in section 4.4.3 and Table 12) to balance future demands and supplies and how to make the more sustainable choices.

In addition, although NJ has very high traceability of their fibers, there are rooms for improvement with certain materials like TENCEL. Technologies like laser labelling of cotton buds as in Agrona could greatly support this.

Furthermore, while both the sustainability and product development staff at NJ mentioned the selectiveness of their staff, no public document can be found on the minimum requirements for the suppliers. While trust is instrumental to build a sustainable partnership, it does not have a binding status or a structured approach at analyzing the suppliers as an established code of conduct with minimum requirements for different suppliers.

Within Restore and Regenerate, the first step that can be taken to counter biodiversity decline is to identify areas of dire resource situation, i.e., biodiversity and water risks. The later ones have been provided in NJ report, but without any proactive action from the brand to address it. These actions can be specified in goals such as in arable land restoration or reclaim on specific ecosystems where NJ's production activities are located. Investing in internal or external regenerative forestry and agriculture projects can be a good way to contribute to this. On a genetic level, seed conservation programs are essential to achieve a better understanding of the effect of organic farming on cotton quality parameters. This level of actions and strategies would also greatly benefit from more higher-quality data availability and analysis in water, chemical use, and land use change, since these aspects. Analytical tools like lifecycle assessments and material flow analysis should thereby be effective to structure and manage environmental information.

Finally, the Transform component first includes the establishment and application of biodiversity indicators at NJ. This is a cumbersome task as biodiversity is a complex issue and indicator setup requires the input of various stakeholders from the industry, academia, and the government. However, having key indicators in place can be very effective to keep track of the progress of the taken measures and communicate the results to different actors.

In addition, this step also entails external support in conservation projects and increasing engagement in biodiversity topics. Disseminating information here plays a critical role as communication with the supply chain and with the public was identified as a shortcoming in NJ's sustainability strategies, and mainstreaming biodiversity is still in the early days. Moreover, engagement projects with the brand employees can also be furthered as a part of employee engagement programs. With the partners and suppliers, joining alliances in the fashion industry that focus on biodiversity protection, such as via lobbying and knowledge sharing would be a great way to be updated on R&D possibilities and explore new collaboration in this area.

Many of the negative biodiversity impact from an apparel supply chain embodies a resource problem, and a higher-level measure for it is to develop a circular business model. NJ has been working on different circular initiatives, but integrating these activities in a more central work package and connecting with downstream and upstream suppliers would ensure greater net positive impact in the long run.

4.4.3. Some practical initiatives for NJ's biodiversity roadmap

In this section, some practical suggestions for NJ to get started with its biodiversity roadmap are provided and aligned with direct drivers of biodiversity loss. The result is compiled in Table 12. Most actions can have benefits on multiple drivers, but the actual impact remains speculative due to the lack of data.

Table 12: *Practical biodiversity-oriented environmental bottlenecks across different tiers of the supply chain of NJ and their estimated sphere of influence.* Grey: Actions with positive impacts on the specific drivers

Supply chain tier	Suggestions	Habitat loss, degradation or fragmentation	Bio-resource over-exploitation	Pollution	Climate change	Invasive species
Raw material	Organic & native seed programs	■		■		■
	Fiber length	■				■
	Soil nitrogen		■	■		
	Biodiversity hotspots	■	■			■
Processing & Manufacturing	Flexibility in fiber length	■				
	Lean manufacturing			■	■	
	Segregation of different water sources in water use			■		
Distribution & Logistics	Optimizing trade flows and stocks				■	
	Carbon offsetting			■	■	
Retail	Robust ERP			■	■	
	Circular business model		■	■		
	Business engagement & lobby works	■	■	■	■	■

For raw material stage, investing in organic and local seed multiplication and breeding programs are important not only to increase the fraction of organic farmland but also to minimize cross-contamination in farmlands and during the ginning stage. Each cotton-producing region provides slightly different fibers, but since fiber length is considered the core factor in the quality assurance of cotton, which is adverse for short fiber

varieties, it is essential to look into the fitness of different fiber lengths with the terroir, the processing machinery, and with the need in the final garment. Among all factors that influence soil structure and dynamics, a focus on nitrogen would be beneficial as the nutrient is often the key limiting factor in fertilization schemes, leading to either leaching with overapplication or low yield with underapplication. If organic farming is to be promoted, looking into organic nitrogen supplements and different vegetation scheme is of great importance. Identification of areas with biodiversity risks and water risks would be useful for the brand to be more reactive to the influence its suppliers have as well. In accordance with this identification work, biodiversity and water conservation activities need to go beyond generalizing analysis and adopt more nuanced approaches, such as with segregation into water types and the use of more regionally specific biodiversity maps.

For processing and manufacturing, lean manufacturing strategies to improve efficiencies of energy, material and water use would be important for the years to come. In line with the point on fiber length, more options to enhance the efficiency in manufacturing shorter fiber length should be explored. Although the suppliers have done works to cut down water usage, it is good to map water use across the supply chain and segregate it into different water types.

Distribution and logistics mainly influence biodiversity from emissions in their transport, so routing optimization, in both distance and time, would be essential. As NJ have been looking into carbon offsetting options, furthering these works can have positive impact on their emission budget.

With the retail stage, a good enterprise resource planning system which can estimate the changes in garment needs in the short, medium and long term can have spillover effect on their biodiversity works with raw material producers, such as in type of fiber and their characteristics. While NJ has been expanding their repair services and reused and recycled product, a full-fledged circular business model is instrumental to make sure they contribute to a smaller flow of virgin materials, curb wastage and does not generate harmful chemicals. Public engagement in biodiversity and lobby works are also interesting ways to raise public awareness of the apparel sector’s contribution to biodiversity decline and steer political climate with their existing and future sustainability agenda.

5. Discussion

5.1. Summary

The study set out to investigate how biodiversity assessment and management in NJ could be established and thus considers the aims, the present state of understanding, the gaps and challenges, and finally the possible ways to overcome barriers against corporate biodiversity works.

Considering motivations and aims, I found that the sustainability department at NJ is interested in incorporating biodiversity assessment into their sustainability reporting, and their main goal is for communications, especially internal knowledge exchange and reporting to customers, rather than in-depth scientific understandings. All interviewed

NJ actors shared the basic knowledge of biodiversity concept and biodiversity loss and noted the highest biodiversity impact in the raw material stage. Within the headquarter office in Gothenburg, the environmental manager and product developers associated the risks with losing customers and their operations having detrimental effects on water and soil. For the Indian and Turkish suppliers, climate change and irregular seasonal patterns, especially drought, are regarded as the most attention-grabbing impact of biodiversity decline. The Indian suppliers further mentioned the genetic resources of their organic cotton seeds as a critical issue, while the Turkish one pointed to GHG emissions and hence the need for clean energy adoption. The difference in focus may result from both geographic conditions of both countries, and human factors, such as farming practices and regulations.

Much of the current sustainability projects at NJ can be positively connected to direct drivers of biodiversity losses, notably the emphasis on the strict selection of sustainability-minded suppliers, the use of certified organic and recycled materials, the growing repair service and post-consumer recycled jeans collection. Its reporting partially follows GRI standards and SDGs providing the overarching vision. Many of its stores in Europe follow the Swedish Environmental Diploma for internal environmental management, and the company is transitioning to the ISO 14001:2015 standard for comprehensiveness and non-European store adoptions. Its suppliers are generally environmentally conscious, and as NJ's headquarter staff pointed out during the interviews, apparel suppliers globally have placed sustainability agenda increasingly high in their businesses. As cooperatives, both the suppliers from India and Turkey provided general technical training for their farmers as well as climate change adaptation. Both suppliers also employ different farming techniques like multicropping, cover crops and mixed crops to supplement necessary nutrients for the cotton plant. The Indian supplier actively works in local cotton seed conservation programs, while the Turkish applied water saving technologies in the farmland and fiber-tracing technology. Both suppliers have their own integrated environmental management systems and environmental goals independent of NJ's.

Nevertheless, there is not yet any plan or strategy in place, nor has there been any communication between NJ and their suppliers on biodiversity halt. Furthermore, the present sustainability disclosure lacks quantifiable data, making it hard to measure, track or verify the progress of their ESG governance. The visibility of the supply chain thus needs to be improved, as the company is branching out to more oversea businesses.

The findings concluded with a chapter on the suggested approach to disclose and manage the company's biodiversity dependencies and impact. This includes the identification of materiality impact in the supply chain and value chain mapping. While NJ does not have many materiality issues due to its sustainability practice, production in biodiversity-rich areas, water and energy use, and waste is considered to be highly material. GM cotton seed contamination, non-native seed use, and chemical use have potential materiality.

Furthermore, taking all the supply chain tiers into consideration, the value chain mapping suggested that the raw material stage has the most relative impactful operation, especially in habitat destruction and invasive species. This can be mainly attributed to the nature of the industry on this level, which works most intensively with natural and biological resources, rather than the lack of measures to protect biodiversity

from the suppliers. The processing and manufacturing tier generates the greatest relative impact in pollution and climate driver, yet negligible influences on other drivers. The operations of the remaining two tiers – distribution and logistics and retails – generally do not have significant impact on the direct drivers of biodiversity loss.

On the other hand, I found that the impact on habitat, pollution, and climate change are in total greater than those of biological resource overexploitation and invasive species. We could further argue that the degree of significance of five main drivers is different from the ones identified by IPBES whereby land use change and pollution are the leading factors. As NJ primarily sources organic cotton which accounts for less than 1% of total cotton cultivation area (Seed & Soils Task Force, 2015), it is possible that land use change does not create sufficient impact to be considered significant. Nonetheless, both Indian and Turkish suppliers identified climate change effects, especially droughts and changing rainfall patterns, as the leading factor of biodiversity loss. Hence, climate change may be more of a concern, compared to land use change or pollution, for this case study. This result is also contributed by NJ's sourcing policy that minimizes the use of wildlife-derived natural fibers or emission-intensive synthetic fibers. In particular, organic farming helps lower the impact on biodiversity substantially.

These results were followed by a mitigation hierarchy and a list of essential environmental interventions in each tier of the supply chain in line with direct drivers of biodiversity losses, both conceptually and in practice. Many of the actions target several or all direct drivers of biodiversity decline, like setting up indicators, developing organic seed programs, and identification of biodiversity hotspots.

5.2. Implications

5.2.1. The importance of information systems in corporate biodiversity management

This study underscores the importance of a robust information system in corporate biodiversity assessment and management. Having good data and an effective structure to analyze and manage them is critical to see the dependencies and impact on biodiversity, identify business opportunities, and prioritize action areas. As companies tend to manage the issues that are more material to them, prioritization plays an essential role in maximizing the positive impact from finite resources.

SBT as a framework presents a comprehensive, action-oriented way to take into account the biodiversity impact of a company with its extensive toolbox. Furthermore, it is also convenient to apply the biodiversity case as NJ has been planning to implement SBT in their sustainability commitment.

Nevertheless, it poses the need for more operational tasks, pipeline management, and long-term strategic planning (IKEA Foundation, 2020) that NJ's supply chain may not have the capacity for. Furthermore, while collaboration among supply chain partners is the key to the successful application of SBT, it is not clear how that can be done effectively. It is also elusive how SBTi would be involved to monitor, implement, or hold the company accountable (IKEA Foundation, 2020). The IKEA Foundation

further criticizes SBTi for uneven adoption across sectors and markets. Accordingly, the penetration rate is significantly lower in carbon-intensive industries like oil and gas, in emerging markets, and for less mature players (IKEA Foundation, 2020). Despite the strong growth and market presence, the initiatives are still young, so further methodological development and corporate engagement are required to expand the players involved (IKEA Foundation, 2020) . Among those, the economic feasibility is not widely considered in SBT frameworks. As financial risks of biodiversity decline are not foreseeable, taking into account economic calculations like payback time, investment cost, and abatement potential in SBT projects (IKEA Foundation, 2020) can reinforce the connection between finance and biodiversity initiatives.

No matter what metrics and frameworks companies choose to follow to assess, the program officer at SIWI suggests that the assumptions, points of reference and system scopes behind what is reported should be made clear. For instance, initiatives can have varying absolute and relative impact, or the assessment differs on product level and company and supply chain level. These points are even more worth considering given the incompleteness of data.

5.2.2. Organic cotton: The savior of the biodiversity crisis for textile markets or a costly trial?

When it comes to cotton production, it is necessary to consider the differences in the production of organic, conventional and genetically modified cotton from technical and socio-cultural standpoint. This study assumed that organic farming practices are more beneficial for the local biodiversity compared to conventional farming, in terms of agrochemical use and cultivation practices. Conducting an LCA on main natural fibers in the textile market, La Rosa and Grammatikos (2019) found that organic cotton consumes less water and energy compared to conventional cotton. Delate et al. (2020) agreed with this, further claiming that organic cotton has less environmental footprint and the transition from conventional to organic systems improve organism composition and soil quality on the field. Nevertheless, irrigation and fertilization methods greatly matter in determining the amount of conserved water and cotton quality (Delate et al., 2020). In order to increase the yield of organic cotton, breeding techniques for high yield variants and management of pest and weed are critical (Delate et al., 2020). Organic cotton may suffer from contamination, as mentioned during the interview with the journalist, and cross-pollination, although it is not common (Delate et al., 2020). Finally, it is not certain to what extent organic cotton is resilient against the impact of climate change (Delate et al., 2020), like water scarcity and changing seasonal patterns.

While the focus of this thesis is on environmental aspects of biodiversity, biodiversity decline is also very much a social and an economic issue. Fiber production, for example, is associated with not only impact on the water or soil, but also land tenure, traditions, heritages and craftmanship. Because cotton becomes a cash crop in many low-income countries, especially India, many land areas that are used for food product have been converted to be fiber production for the promise of more income, but at the cost of food security, as remarked by the journalist.

Both the Turkish and the Indian suppliers of NJ has a cooperative of farmers which provide technical trainings, raise market power when selling their products and the

much-demanded stability to a farming community, they are in many cases an imperfect coping mechanism for the lack of effective policy instruments that support small-holders in national agricultural systems. The lack of more sustainable pricing model and sustainable value chains compounded by ineffective agricultural policies in the local countries have led to unfortunate instances like farmer suicides in India, which is endorsed with many local cotton seed varieties thanks to their diverse agro-climatic conditions (Seed & Soils Task Force, 2015; Menon, May 2021). Livelihood is thus an important topic to ponder upon in biodiversity conservation or restoration works.

Studies in the risks cotton farmers face in transitioning into an organic system, such as in cost and infrastructure, are few and far in between. As one of the main tradeoffs of organic cotton production seems to be short-term expense for environmental gains, there should be some mechanisms to protect the farmers against profit losses at the beginning. Indeed, the organic market is insulated in many countries with subsidy and other incentive schemes, but in countries when these schemes are less available, it is challenging for organic cotton farmers to earn sufficient income in international markets. As organic fiber sees the greatest growth among organic non-food sectors in the past few years, we need more dialogues and actions among companies, government, academia, and non-profit organizations like Textile Exchange, GOTS, and Organic Trade Association that these fibers are under the auspice of to safeguard the livelihoods of these farmers.

How the textile landscape can be transformed in the future depends not only on what is the most environmentally friendly solution, but also customer demand when it comes to apparel items. Since different items would need different optimal fiber characteristics (Seed & Soils Task Force, 2015), retailers should be able to have a robust ERP system to estimate the relative products such as T-shirts, denims or dresses. It is often assumed, for instance, that longer fiber staples of average 30mm in length, are more desirable (Kering & Textile Exchange, n.d.). In fact, different product ranges have different preferred lint, and favoring longer fibers without considering these nuances would impede the incorporation of native seeds which are usually of shorter length. It is an optimization issue and a resource problem to plan ahead in the medium terms which combination of products, of fibers and of seeds would be the most environmentally benign one, and the success of such is warranted on a well-established and updated accounting system.

5.3. Contribution to literature and future research avenues

The study contributes to the growing progresses in corporate biodiversity for apparel companies. Information is still scant on corporate biodiversity management, and there is no published empirical research of case studies for young and small clothing companies. On top of that, the conceptual model in Fig 4 can help categorize the works and the tools to achieve these. Starting out as a biodiversity research, the study convenes as rather an organizational and information management one. While I did not manage to recommend any indicators, it is still relevant for clothing companies grappling with initiating the processes of assessing their biodiversity impact or developing works to reflect on the actual motivations and perspectives behind their sustainability and biodiversity agenda. In addition, the list of practical bottlenecks and the mitigation hierarchy can help Nudie Jeans prioritize the issues and structure their roadmap.

Future research could further examine how linkages can be fostered between financial portfolios and biodiversity and sustainability, and how resulting complexity can be managed, both on firm level and national level. When it comes to strategies, comparative analysis of sustainability strategies from other fashion companies of different scales may provide an overview of what company usually reports and measures, and how it can be improved. Furthermore, as different levels of the supply chain have different relevant environmental issues, looking into how knowledge can be effectively exchanged is crucial. The way clothes are made is quite well streamlined and many companies share the same suppliers, or at least production countries, so there are rooms for companies to collaborate and work on the traceability of data. In more practical terms, as better data create better generalizations, companies need to develop a robust environmental information system that can be effectively shared across industry partners and can foster decision making, in the forms of assessment, reporting, or general corporate social responsibility works

Finally, how the solutions for biodiversity loss for the clothing industry looks like in the future depends greatly on potential business changes, i.e., clothing stocks, trends, and public awareness of the issue. For the academia and scientific community, this means that further scenario modellings of alternative environmental and social factors would be incumbent to reach the next biodiversity goals. For both public and private sectors, collaboration and transparency are still key for more a more sustainable system to take place.

5.4. Limitations

One of the main shortcomings of the thesis is the deficiency in stakeholder input. Since NJ is at such an early stage of biodiversity assessment, having more representatives in all tiers of the supply chain may provide more useful insights into the impact and risk of biodiversity loss as well as the practical bottlenecks. As NJ does not own the supply chain, this is even more necessary to develop and deploy biodiversity engagement programs.

The viewpoints here are skewed towards aspects surrounding cotton production and consumption landscape. While this is a core fiber in NJ's supply chain, considering only cotton is not sufficiently representative of material stocks and flows of the company.

The interview with the Indian suppliers had technical issues in sound and internet connection, which made it harder for Clara and me to articulate the questions and make sense of the answers. We listened to the recording again several times and sent follow-up questions to make sure that our notes were correct, but there could still be gaps in our interpretation and analysis due to this.

Regarding non-NJ actors, getting more responses from actors from biodiversity research centers, other denim and clothing brands, policy makers, and consultants would indeed have been more useful, especially in implementation stage. Nevertheless, as indicator construction and application are one of iteration, and as biodiversity impact is highly site-dependent, the number and the different expertise of interviewees were sufficient to create a primer of corporate biodiversity assessment at NJ.

Methodologically, the ranking of data visibility with the heat map in Table 6 suffers from some generalizations. Firstly, the supply chain is divided into four levels, but there are many suppliers on each tier with different environmental performances which can not be revealed with the binary scoring. Secondly, the four indicators are also connected to each other as a part of data management, rather than solo standing. For instance, firms that have data collected and measured on material quality are more likely to have certifications or internal validation for it. Finally, some environmental components should also have multiple indicators to assess them, such as ecosystem health. Therefore, while the table provides a good overview of environmental information flow within NJ's supply chain, it does not paint a nuanced picture of where or what to focus.

In addition, the qualitative analysis derived from the interviews is prescriptive of the current issues with biodiversity loss across the supply chain, the perspectives of actors toward these issues, and the possible solutions forward. However, actual ad-hoc measurement and evaluation would provide a more objective, or at least a less value-laden picture, and a higher level of accountability. This also begs the need for a more global standard and enabling political settings for private sectors to commit to their environmental goals.

Finally, parlance may conceal ideas. Many terms used in this thesis like sustainability, biodiversity or ecosystem services are like black boxes, i.e., wrapped in layers of conceptual blankets and may create reservations to learn or tackle, especially for people who are not specialized in these fields. While I have tried my best to articulate them clearly and put them into specific scope and context in this paper, I do see the need to communicate such concepts to make it relevant and easy to understand for different stakeholders.

6. Conclusion

The study investigates what Nudie Jeans as an apparel company can do to assess, manage, and disclose their biodiversity impact and dependencies. While the company does not have any plan or strategy in place for the issue, many of their existing sustainability commitments also provide biodiversity benefits, and the roadmap to corporate biodiversity management should build on this foundation. In addition, upscaling these works would require the involvement from the whole company and supply chain, not just the sustainability team.

Regarding information management, the raw material and the retail stage are the most well informed in the data related to environmental components, while the logistics and distribution stage has the least visibility in these issues. The supply chain has the most information management in material volume, hazardous chemicals, energy and emission, which are relevant to quality assurance and regulatory compliance, while the information related to soil and ecosystem is the least known.

Overall, the raw material production contributes most significantly to the direct drivers of biodiversity loss at NJ, but each level shares its unique impact and dependencies, depending on the characteristics of the industry of the tier. Therefore, the entire supply chain needs to work together to account for its impact and mitigate the potential risks.

For future outlooks, I strongly recommend the company to work the issue under the lens of data management, i.e., better data lead to better generalizations and decision making. On corporate level, the company needs more quantitative and spatial data from suppliers to perform more holistic biodiversity assessments The SBT framework is suggested to support Nudie Jeans in shaping the workflows and benchmarking biodiversity goals. From the mitigation hierarchy (Table 11) and the list of practical interventions (Table 12), the most critical and immediate areas to focus include identification of biodiversity hotspots to avoid operations, organic and native cotton seed conservation, and strengthening engagement with both upstream and downstream supply chain partners and consumers. In the long run, however, the role of robust pro-biodiversity national policies and roadmap, with integrated natural accounting systems, cannot be discounted to guide private sectors in the right direction.

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Appendix 1: Interview questions

In this section, three question lists were created for three groups of actors, i.e., NJ's staff, NJ's suppliers, and biodiversity specialists. For NJ's supply chain, the questions were mainly to gauge the level of understandings of biodiversity and biodiversity loss as a part of sustainability strategies and actions, as well as their main aims for biodiversity management and available data and action plans to support these aims. In addition, the collaborations with their partners regarding these topics were also touched upon. With NJ's employees, specifically, since their sustainability works can be well associated with their future biodiversity roadmaps, the connections were also discussed. On the other hand, for the biodiversity experts, the key questions were about complexity management for a multifaceted issue like biodiversity with a multinational supply chain. This also includes discussions on broader context like national and international governance and benchmarking.

A.1.1. With Nudie Jeans

Business - Biodiversity relations

- How do you define biodiversity and biodiversity loss with regards to the clothing industry?
- What does the interest in managing biodiversity impact in the company come from? How relevant do you think biodiversity (loss) is in your business operations?
- What are the major impact of NJ on biodiversity you expect to see?
- What are the major impact of biodiversity loss on NJ operations you expect to see?
- Which tier of the supply chain do you expect to see the most and least substantial impact of NJ on biodiversity and biodiversity on NJ operations?
- To what extent should NJ hold accountability for such impact?
- What are the biodiversity-related risks of non-actions or ineffective actions for NJ you may foresee?
- How are you aware of biodiversity assessment and goals set by international or national organizations? Should they be integrated into NJ biodiversity assessment, and how?

Sustainability and Biodiversity

- How did the sustainability work start in the company and how is it developed over the years?
- How is sustainability connected to other parts of NJ's operations? How is the decision making related to sustainability usually made?
- To what extent and in what way can biodiversity be integrated in sustainability works in NJ?
- Is sustainability taken into account in selecting suppliers at NJ? How is the partnership with suppliers maintained over time?
- Do you think the expansion of the company is at the expense of positive environmental impact?

Biodiversity roadmap – Existing and Future works

- Which data are available now to support the assessment biodiversity impact and the development of biodiversity works? What else do you plan to keep track of in the future?
- What are the challenges you expect in tackling biodiversity loss? How can they be overcome?
- How can suppliers get involved should biodiversity impact assessment be done?
- To what extent can biodiversity initiatives be collaborative among textile companies?

A.1.2. With NJ's suppliers

Business – Biodiversity relations

- How do you define biodiversity and biodiversity loss with regards to the clothing industry?
- What does the interest in managing biodiversity impact in the company come from? How relevant do you think biodiversity (loss) is in your business operations?
- What are the major impact of your organization on biodiversity you expect to see?
- What are the major impact of biodiversity loss on your operations you expect to see?
- To what extent should your organization and NJ's supply chain overall hold accountability for such impact?
- What are the biodiversity-related risks of non-actions or ineffective actions for your organizations you may foresee?
- Are you aware of biodiversity assessment and goals set by international or national organizations? Do you think those reports should be considered by NJ or your company?

NJ and supplier

- How have you worked with NJ when it comes to environmental works? Does it change over the years and how? Is NJ directly or indirectly involved in these works?
- What do you think of the way NJ facilitates or monitors these activities?
- How do you think NJ regards the importance of sustainability in general and biodiversity in particular?
- In what way do you think NJ and you as a supplier can improve its biodiversity performance? If so, why is it not enacted yet? How can it be bettered?

Biodiversity roadmap – Existing and Future works

- If NJ set up a roadmap on biodiversity on its supply chain, to what extent would you like to be involved? How relevant is it for your operations? Who should be in charge of this?

- What kind of data collected on sustainability or biodiversity are currently available? What else do you plan to keep track of in the future?

A.1.3. With biodiversity specialists

- What are the most critical impact of a textile supply chain on biodiversity (loss) from your perspectives?
- How should space and time be considered in corporate biodiversity management and governance, considering the local specificity of biodiversity and its impact?
- How should the action plan for tackling biodiversity loss on company's level look like to be both scientific, relevant, and easy to use?
- Among the existing frameworks to measure biodiversity impact and develop biodiversity roadmap, which one is the most commonly used ones? Are they also the most effective ones?
- How important is firm size and the nature of the industry in determining the responsibility of biodiversity impact?
- Have you seen an example of best practices in the textile industry or private sectors in general and how does it look like?
- How can different tiers of the supply chain be accounted for in corporate biodiversity assessments and initiatives?
- What are the roles of international organizations and national governments in mainstreaming biodiversity?
- How effective is sustainability and biodiversity certifications in creating leverages and raising awareness on biodiversity loss and sustainable development?
- How should the starting point look like?

Appendix 2: Interview notes

A.2.1. Nudie Jeans' employees

A.2.1.1. The environmental manager

- In the past 1.5 years NJ have been active with climate works, which lead to the creation of material tools among others. Biodiversity came into attention from the last year in textile industry. However, consumers are not highly aware of the issue so the agenda is overall not yet high
- Purpose of biodiversity assessment: knowledge > communications. Not interested in the more "technical aspects" of biodiversity concepts
- Risks of not considering biodiversity: Branding (but consumers may not be aware of biodiversity yet). Vaguely aware of the financial risk
- Raw material stage and wet processing are the most resource-intense stage in the supply chain. Land use change and "insects and bacteria in soil" are also important
- Desirable approach: the simpler, the better (the point of departure should be from human impact on biodiversity and what the company can do, rather than concerning with gene-species-ecosystem hierarchy). Biodiversity should be a part of sustainability assessment where benchmarking is important. Soil and water should be prioritized
- "Scared" to talk about biodiversity. However, she expressed concerns for fully outsourcing the issue to an external party, i.e., a consultancy firm, because that may impede how much the corporate staff can learn about the issue
- The introduction of pro-biodiversity national policies can be impactful on the textile industry, but these policies should be well thought through to ensure an effective implementation. Case in point: chemical tax, which is well intended but not well designed
- Stakeholder engagement on sustainability issues:
    - There can be a clash with design department when it comes to creating new and fresh products seasonally versus sustainable choice of materials and stock quantity, but this is generally not a big problem
    - Fruitful collab with RISE research institutes and universities in ensuring that they follow the right certifications and procedures
    - As a small brand, NJ prefers to participate in smaller networks where the company can assert more influence
    - Building "beyond business" relationships with the suppliers is very important. In particular, credits are given to Chetna/the Indian suppliers for their sustainable practices
    - Everyone in the company can initiate sustainable changes. For instance, certain reuse/recycle processes were started by store staff before being implemented on corporate level. However, in order for positive and effective changes to be made on a company level, a corporate hierarchy approach to decision making is necessary in the long run.
    - Communications with stakeholders regarding sustainability matters have improved in recent years, but overall not as vocal as desirable. NJ wants to make sure that the information they give consumers has been tried and tested within the company

A.2.1.2. The product developers

- Biodiversity knowledge: Stated that biodiversity is the “variety”, the “connection”, but not much beyond that. Related biodiversity to water, energy, and chemicals. Express uneasiness when more questions about biodiversity were asked
- Biodiversity impact usually concentrate in upstream stage of the supply chain
- Decisions related to sustainability should be initiated on an executive level
- Small companies are more flexible to change, but less power to steer suppliers
- Building relationships w supplier takes a lot of time and efforts. It takes around one year to build a solid partnership with discussions online and offline. Over the years, more suppliers try to be innovative in a sustainable way under the pressure from the society. Case in point: dry denim
- Green washing issues can pop up if other clothing firms are not onboard with sustainability. Case in point: companies follow Better Cotton Initiatives (BCI) although it’s not as green as it appears; NJ’s scandal with sun-blasting jeans
- It is possible to make a product that looks good and IS sustainable. Many consumers choose NJ for the look, not the sustainable part. However, sustainable materials are not the same as technically optimal ones
- Production stocks are made in the form of collections, whose specific quantify is derived from past sale numbers. Leftover clothes can be resold next season(s) with minimal degradation in quality, but being relevant in style is also important
- Doesn’t know much about sustainability in general, but emphasize the willingness to learn about it in the company

A.2.2. The suppliers of Nudie Jeans

A.2.2.1. Chetna Organic representatives, the Indian cotton supplier of Nudie Jeans

- Biodiversity is mainly about agro-biodiversity and ensuring balance, such as in the forest, to build long-term diversity. In practice for Chetna, this specifically includes the use of non-GMO seeds, organic farming, intercropping (such as with lentil and cotton for nitrogen fixation), and the use of mixed crops and border crops.
- Climate change, like the increase in the frequency and intensity of drought and changing seasonal patterns, makes the cost of production increase and cost of cultivation decrease, so building knowledge is imperative.
- There is little demand for organic produce in the market, no premium pricing in domestic market. Organic farmers don’t receive subsidies that regular farmers do, and it is increasingly difficult to get a hand on non-GMO seeds.
- Biodiversity impact
    - Critical risk mainly revolves around the reduction in seed diversity due to the preference for monocropping, the prevalence of GMO seeds and low productivity of local seeds among other things. Seed conservation program is underway at Chetna, via the collection, multiplication, and distribution of disappearing seeds to farmers.
    - Soil is sampled and measured to assess quality annually.

    - Land reclamation is also an important part of environmental management at Chetna.
- Biodiversity assessment scheme should be controlled by the facilities and should be a part of sustainability reporting. However, brands should monitor certifications and guidelines.
- Ecosystem level is of the most interest to Chetna. Specific important elements include seed, soil health, organic carbon, Percentage of Beneficial Pest and Proteins content.

A.2.2.2. Agrona representative, the Turkish cotton supplier

- Cotton is a strategic agricultural product in Turkey as it is the only country with cotton plantations in the West, the sixth biggest cotton producer in the world, and one of the few countries with an integrated manufacturing system for cotton. Agrona is one of the largest cotton producers in Turkey and has 2200 farmers under their system from 2010. For farmers, staying in the organization has cooperative benefits (avoid middle men, convenient to sell all products, cotton and food, to one supplier).
- Aim to produce organic, water-saving cotton on the field. Supervision is done by 6 people control system in the beginning, mid and end of the seasons.
- Data on land and soil are collected. The use of water drippers with attached calculators makes it easier to collect accurate info on water use. Knowledge on land is collected qualitatively by asking farmers.
- Traceability via cotton labelling system is developed and applied to their cotton supply.
- Environmental goals: 100% renewable energy and 40% water use reduction via dripping water system by 2025.
- The pandemic make consumers aware of sustainability and traceability issues. Spending 10-20% extra on raw materials is usually not a big problem for retailers because that increase would not amount significantly to end products *and* there can be positive branding values.
- Droughts and the prevalence of insects are the main (future) environmental issues. Drought is countered by the use of water drippers and indirectly with solar energy in the warehouse.
- The use of non-GMO cotton seeds are important, especially as GMO seeds are illegal in Turkey.

A.2.3. Biodiversity specialists

A.2.3.1. The biodiversity consultant at Metabolic

- Climate change receives more attention than biodiversity when it comes to sustainability issues, and this can be because
    - The Paris Agreement on Climate change has teeth for all actors, including private sectors, while biodiversity agenda has not witnessed an event of similar traction.
    - Emission accounting is relatively more simple than biodiversity accounting.
- The increasing interest of fashion industry to consider biodiversity in their ESG may be largely contributed by Kering’s works.

- In order to assess biodiversity impact and develop works to mitigate the risks of biodiversity loss, the starting point should be materiality assessment and supply chain mapping. After that, pilot projects like regenerative farming can be set up in certain sites that NJ's suppliers are based. SBTs provide a good step-wise approach for that.
- The lack of data is to be expected, and it is important to know which data is available and can be available (especially spatial data), and think about how to initiate the works despite this data incompleteness.
- Financial risks with biodiversity loss can be hard to foresee, and the pressure to maintain reputation as a green brand can only go so far. It is the company that needs to be internally motivated to get the balls rolling.

A.2.3.2. The journalist and author on organic cotton

- India has various endemic cotton species thanks to its diverse agro-climatic conditions. Cotton was a subsistence crop before the advent of British rule. The Industrial Revolution introduced steam power and new technology for ginning and spinning. Britain did not want to rely on America for cotton and so it turned to India for supplies, especially during the American civil war. Cotton as a result became a cash crop and land for food was diverted to grow this fibre.
- At present, the national policy does promote organic farming but cotton farmers rarely take it up as they feel the yields will be less. Unless there is a strong economic incentive, farmers would be reluctant to switch to organic farming. The policy does not create enough incentives for organic cotton farming as well as the conservation of local seeds. Very few farmers and regions grow organic cotton in India. Most of them are tied to organisations or groups which export or give them a higher price.
- Long fiber staple versus short fiber staple: While Indian or desi cotton is short stapled, the cotton mills in England set up after the Industrial Revolution were geared to using longer stapled cotton grown in America. Hence, Britain encouraged Indian farmers to grow the longer stapled American varieties. Meanwhile, Indian cotton is usually characterized by the shorter cotton fiber which is more suited to hand weaving and very fine muslins were woven from this type of cotton.
- The introduction of genetically modified (GM) cotton seeds in India in 2002 was mainly to counter the large expenditure on pests on cotton, but that has social and environmental implications, as follows:
    - GM cotton is mainly hybrid and requires more water and fertilisers. However, while GM cotton was intended to counter a single pest on cotton- the American bollworm, there was a surge of secondary pests like the white fly and the pink bollworm. As a result, farmers spent more on controlling these pests and incurred heavy expenses.
    - Seed guardianship and propagation is no longer with farmers as it has been for the most part of human history, when farmers own seeds and select and breed plants The Bt cotton patent is owned by Monsanto (now Bayer) and agro-chemical giants control production and marketing. The seeds are costly and farmers often borrow to buy them. There is a proliferation of illegal seed companies as well. Farmers, especially small-holder, are in a more vulnerable

state as they are heavily in debt which they often cannot repay. Furthermore, the traditional knowledge that farmers have on seed multiplication and plant breeding becomes largely un-utilized.
    - The use of hybrid, GM seeds which are now grown on over 96% of the cotton area in India, has introduced a uniformity in cotton and severely hampered the seed biodiversity.
- Main changes to the cotton businesses that has impact on sustainability and biodiversity:
    - The economic system of the textile business becomes centralized and mechanized. This thus changes the power dynamics of the value chain in such a way that put farmers at the receiving end and the seed company and mills and brands in a profiting situation.
    - The transition from multicropping to monocropping agricultural systems in India. Farmers traditionally often grow cotton with food crops like pulses. But as cotton provides more income, many farmers switch to monocropping cotton, with heavier use of fertilizers, which poses a threat to food security. Farmers incur heavy debts and crops also fail due to erratic monsoon. Repeated crop failure, heavy debt and low incomes are among the driving factors for farm suicides in India, mainly among cotton farmers.
- While certifications and the formation of farming cooperatives that aim to enhance market power and provide technical trainings for organic farming help conserve the economic and technological feasibility of organic farming, having national regulations that incentivizes organic farming system is of critical importance in the long run.

A.2.3.3. The program officer at SIWI

- Water plays a key role in maintaining ecosystem health. Unlike carbon emissions, water cycle has local specificity and initiatives to assess and tackle water impact must take this into account. Also for this specificity, water and biodiversity offsetting is often tricky.
- While the degree to which companies from different industries address water issues to a large extent depend upon how material it is to them. The degree to which companies address the impact they have on the environment is often dependent on other factors.
- For metrics and frameworks that companies follow to assess their environmental impact (especially water impact), the assumptions, points of reference and system scopes behind what is reported should be paid attention to. For instance, initiatives can have varying absolute and relative impact, or the assessment differs on product level and company and supply chain level. In addition, it is imperative to be thoughtful about to whom and under what aim the disclosure of non-financial information is for.
- It is not sufficient to only consider water consumption in water impact assessment. The cycle and type of water need to be taken into account.
- At present, climate change receives more attention from both public and private sectors, compared to water and biodiversity. Pressure from the financial sector on these latter issues is thus vital to better connect sustainability data and business data, and to raise awareness on the topics.

- The starting point for companies can be to understand their materiality impact, with transparency and acknowledgement of the importance of sustainability as an integrated part of their business, and their specific responsibility. Lobbying is useful to promote wider changes.

Appendix 3: Ranking of Environmental Information Visibility

This appendix comprises the calculations for each supply chain level, behind the MRV-based ranking explained in the Methodology (section 3.2.2), and in Table 6 of the Findings. The Excel file can also be accessed in the attached file named "NJ Environmental Data Availability Ranking_Nhu Anh Phan".

Tier 1: Raw Material

Raw material	**monitor**	**report**		**verify**	**sum**
	data collected & measured	environmental goals present	information disclosed	certifcations & internal verification conducted	
material origin	1	1	1	1	4
material quality	1	1	1	1	4
material composition	1	0	0	0	1
material volume	1	1	1	1	4
recycled content	1	0	0	1	2
recyclability	0	0	0	0	0
water use	1	1	1	0	3
wastewater management	0	0	0	1	1
chemical use	1	1	1	0	3
hazardous chemicals	1	1	1	1	4
energy use	1	1	1	1	4
emissions	1	1	1	1	4
waste handling	0	0	0	0	0
soil health	1	0	1	1	3
ecosystem health	0	0	0	0	0
LUC	0	0	0	0	0

Tier 2: Processing & Manufacturing

Processing & Manufacturing	**monitor**	**report**		**verify**	**sum**
	data collected & measured	environmental goals present	information disclosed	certifcations & internal verification conducted	
material origin	1	0	0	0	1
material quality	1	1	1	1	4
material composition	1	0	1	0	2

material volume	1	1	1	1	4
recycled content	1	1	1	1	4
recyclability	0	0	0	0	0
water use	1	1	1	1	4
wastewater management	1	0	0	1	2
chemical use	1	0	0	1	2
hazardous chemicals	1	1	1	1	4
energy use	1	1	1	1	4
emissions	1	0	1	1	3
waste handling	0	0	0	0	0
soil health	0	0	0	0	0
ecosystem health	0	0	0	0	0
LUC	0	0	0	0	0

Tier 3: Distribution & Logistics

Distribution & Logistics	**monitor**	**report**		**verify**	**sum**
	data collected & measured	environmental goals present	information disclosed	certifcations & internal verification conducted	
material origin	1	0	0	0	1
material quality	0	0	0	0	0
material composition	0	0	0	0	0
material volume	1	1	1	1	4
recycled content	0	0	0	0	0
recyclability	0	0	0	0	0
water use	0	0	0	0	0
wastewater management	0	0	0	0	0
chemical use	0	0	0	0	0
hazardous chemicals	0	0	0	0	0
energy use	1	0	1	0	2
emissions	1	0	1	1	3
waste handling	0	0	0	0	0
soil health	0	0	0	0	0
ecosystem health	0	0	0	0	0
LUC	0	0	0	0	0

Tier 4: Retail

Retail	monitor	report		verify	sum
	data collected & measured	environmental goals present	information disclosed	certifcations & internal verification conducted	
material origin	1	1	1	1	4
material quality	1	1	1	1	4
material composition	1	1	1	1	4
material volume	1	1	1	1	4
recycled content	1	1	1	1	4
recyclability	1	1	0	0	2
water use	1	0	0	1	2
wastewater management	0	0	0	0	0
chemical use	0	0	0	0	0
hazardous chemicals	1	1	1	1	4
energy use	1	1	0	0	2
emissions	1	1	1	1	4
waste handling	1	1	1	0	3
soil health	0	0	0	0	0
ecosystem health	0	0	0	0	0
LUC	0	0	0	0	0

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DIVISION OF ENVIRONMENTAL SYSTEMS ANALYSIS
CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden
www.chalmers.se

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