INCREASING BIODIVERSITY IN LOGISTICS SITES

Approaches and Economic Benefits of Enhancing Biodiversity On-Site

Lappeenranta–Lahti University of Technology LUT

Master's Programme in Circular Economy, Master's thesis

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ABSTRACT

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76 pages, 2 figures and 11 tables

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Keywords: Biodiversity, real estate, ESG

The aim of this thesis was to examine why biodiversity improvements should be implemented on logistical properties, how biodiversity impact could be evaluated and enhanced on-site and whether there are economic benefits on improving biodiversity on-site.

The biodiversity impact of logistics properties was evaluated by calculating an average biodiversity impact of 77 logistics sites in Finland from land occupation. The calculation was done by LC-IMPACT method. The case study evaluated the biodiversity impact of three logistics sites in Finland in more detail by calculating the current green factor and local biodiversity risk in addition to LC-IMPACT method. Actions to enhance biodiversity on the case sites were explored from Conservation Evidence database. The suitability of the actions into the case sites was examined with information found from literature. Possible economic benefits of enhancing biodiversity on-site were examined through semi-structured interview conducted for four real estate experts.

The average biodiversity footprint of 77 logistics property was 2,55E-11 PDF calculated by the current land occupation. In the case study, it was found that site 3 had most negative impact on biodiversity compared to other case sites 1 and 2. In total, 11 actions to support biodiversity in case sites were identified. The interviews did not result to any significant direct economic benefits from actions of improving biodiversity on-site. However, activities that promote biodiversity can lead to indirect cost savings by helping the company to maintain market position, meet stakeholder requirements, and avoid significant reputational damage.

TIIVISTELMÄ

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Biodiversiteetin parantaminen logistiikkakiinteistöissä

Menetelmät ja taloudelliset hyödyt luonnon monimuotoisuuden lisäämiseksi tontilla

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Tämän diplomityön tavoitteena oli tarkastella miksi logistiikkakiinteistöissä tulisi keskittyä luonnon monimuotoisuutta parantaviin toimenpiteisiin, miten vaikutusta luonnon monimuotoisuuteen voisi arvioida sekä parantaa tontilla sekä millaisia mahdollisia taloudellisia hyötyjä toimenpiteillä voitaisiin saavuttaa.

Logistiikkakiinteistöjen biodiversiteettivaikutusta arvioitiin 77 Suomessa sijaitsevan logistiikkakiinteistön keskimääräisen maankäytön ja LC-IMPACT-menetelmän avulla. Tapaustutkimuksessa tarkasteltiin kolmen logistiikkakohteen biodiversiteettivaikutusta tarkemmin myös laskemalla tontin viherkerroin sekä biodiversiteettiriski BioMAPS menetelmällä LC-IMPACT-menetelmän lisäksi. Mahdollisia biodiversiteettia parantavia toimia kolmessa logistiikkakohteessa etsittiin Conservation Evidence -tietokannasta ja niiden soveltuvuutta tarkasteltaviin logitsiikkakohteisiin tutkittiin kirjallisuudesta löytyvän informaation avulla. Mahdollisia taloudellisia hyötyjä, joita toimet voisivat tuoda kiinteistön omistajille, etsittiin teemahaastatteluiden avulla haastattelemalla neljää eri kiinteistöalan toimijaa.

77 kohteen keskimääräinen biodiversiteettijalanjälki oli 2,55E-11 PDF maankäytön osalta. Tapaustutkimuksen kohteella 3 oli suurin negatiivinen vaikutus luonnon monimuotoisuuteen verrattuna muihin tarkastelussa olleisiin kohteisiin 1 ja 2. Tutkimuksessa identifioitiin yhteensä 11 toimenpidettä, joilla voitaisiin tukea ympäröivän luonnon monimuotoisuutta kohteissa 1, 2 ja 3. Haastattelussa ei löydetty merkittäviä suoria taloudellisia etuja, joita biodiversiteetin parantaminen tontilla voisi tuoda. Luonnon monimuotoisuutta edistävien toimien avulla voidaan saavuttaa epäsuoria kustannussäästöjä kun toimet edistävät yrityksen markkina-aseman säilymistä ja sidosryhmien vaatimuksien täyttämistä sekä auttavat välttämään merkittäviä mainehaittoja.

SYMBOLS AND ABBREVIATIONS

Symbols

BF	Biodiversity footprint	PDF
LP	Light pollution	(mcd/m^2)
Pop	Human population density	Persons/km
T	Traffic intensity	No/km

Abbreviations

BioMAPS	Biodiversity Multi-Scale Assessment of Product Systems
BR	Biodiversity Risk
BREEAM	Building Research Establishment Environmental Assessment Method
CBD	Convention on Biological Diversity
COP	Conference of Parties
CSRD	Corporate Sustainability Reporting Directive
DNSH	Do No Significant Harm
ESG	Environmental, Social and Governance
ESRS	European Sustainability Reporting Standards
EU	European Union
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GVA	Gross Value Added
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
LUI	Land Use Intensity
MTI	Maximum Tolerable Intensity
PDF	Potentially Disappeared Fraction of Species
UN	United Nations

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1 Introduction

Biodiversity refers to diversity of natural habitats, species, and genes in the world. It is crucial for human well-being, since it provides services that maintain and strengthen economies and societies. Biodiversity is essential for the survival and prosperity of all species, including humans. (European Environment Agency 2020.) However, biodiversity is decreasing at an alarming pace and the loss of biodiversity has emerged as one of the most significant risks for humanity in this century. Five major drivers for biodiversity loss globally are land-use change, climate change, pollution, overexploitation, and invasive alien species (Ellen MacArthur Foundation 2021, 14, 44-45). Building sector has a key role in causing biodiversity loss (World Economic Forum 2020a, 5). Building and construction sector accounts to 39 % of global CO_2 emissions and is the largest consumer of natural resources for raw materials. Since the size of the built environment is predicted to double globally by 2050 due to population growth, it is urgent to focus on improving biodiversity and mitigating biodiversity losses caused by built environment. (Ellen MacArthur Foundation 2021, 14, 44-45.)

Climate change mitigation and reducing emissions have been a key target for many companies. The economic benefits of reducing CO_2 emissions are more distinct compared to improving biodiversity, for example cost savings through improving energy efficiency. According to a survey conducted for 26 real estate operators in Finland, 88 % of the operators currently report their direct CO_2-emissions while only 12 % of the operators reports its biodiversity impacts. Although, in the survey, 58 % responded that reporting biodiversity impacts will become relevant in the coming years. (KTI 2024,19.) Thus, biodiversity is clearly an emerging trend in real estate sector in Finland. Therefore, this work focuses on finding ways to improve biodiversity on-site and identifying cost benefits that improvements could bring to the property owner.

Biodiversity loss is strongly linked to climate change (Pörtner et al. 2021, 14), highlighting the need to address this issue as part of corporate environmental responsibility, alongside climate change mitigation efforts. Additionally, land use is a key driver of terrestrial biodiversity loss, making biodiversity loss particularly relevant to companies whose operations involve extensive land use such as in the building sector. Full mitigation of GHG (Greenhouse Gas) emissions is not possible to achieve without considering the crucial role of nature since climate and nature are strongly interconnected. In addition to stabilizing the climate, there is a need for preservation of freshwater resources, land regeneration, securing of healthy ocean as well as protecting biodiversity. These actions are essential for ensuring sustainable well-being and continuation of economic activity. (Science Based Targets Network 2024.)

As stated in the research by Jaysawal et al. (2022), the relevant studies in real estate sector focus more on greenhouse gas emissions of the buildings and on the concept of net zero emissions of buildings. The economic benefits of decarbonization in real estate have also been examined unlike economic benefits of biodiversity improvements (e.g., Echeverria et al. 2023; Issa 2024; Onstwedder 2021). One reason for that may be that there has been significant progress in measuring and valuing the impact of business on climate change but similar efforts regarding to biodiversity have been relatively limited. Nevertheless, methods for assessing biodiversity impacts are currently under development and many are also already available. (Align 2023, 13.)

When considering the relevant research related to the value and impact of biodiversity in built environment, the research is more limited. Ratzke (2023) has been studying the urban environmental and biodiversity value by estimating citizens willingness to pay and Kirk et al. (2021) highlights through a case study the importance of integrating biodiversity considerations into urban development. Opoku (2019) studied the link between biodiversity, built environment and Sustainable Development Goals, and Conceptión et al. (2015) examined how urbanization impacts on the assemblages of species. Gan & Breuste (n.d.) discussed the impact of built environment on biodiversity through a case study. These research studies also propose the ways to support and improve biodiversity in built environment, mostly at the upper strategy level.

However, previous studies have not considered the value of biodiversity in real estate sector in general. Additionally, the ways to promote biodiversity focus either on densely populated urban areas or do not present detail actions how to promote biodiversity on industrial sites. They do not consider the economic value of the actions implemented towards improved biodiversity. This study aims to narrow these research gaps.

1.1. Objective of the research

This research discusses the benefits of improved biodiversity in real estate sector while exploring the ways to improve biodiversity on sites. The objective of this research is to explore methods for assessing biodiversity impact and to identify actions that property owners can implement to enhance biodiversity, the positive value of biodiversity on property, and the potential monetary benefits of these improvements. The goal is to raise awareness on the topic and find motives for property owners to help mitigating biodiversity loss. The research is conducted as a collective case study by examination of possible solutions for improving biodiversity on-site by utilising literature and Conservation Evidence database. Prior to that, average biodiversity footprint for 77 Finnish logistics sites is calculated simply based on land occupation. The land occupation of the building sector is crucial for understanding and addressing its impact on biodiversity loss and forest degradation. In addition, interviews are conducted to study the motives of building owners towards on-site biodiversity improvements, as well as the possible benefits and economic value of these biodiversity actions.

The research questions in this study are:

1. Why should the building owner consider investing in biodiversity on-site?
2. How can the impact of a logistics property on biodiversity be evaluated, and what solutions can be implemented to enhance biodiversity on-site?
3. Could the possible benefits of improving biodiversity on-site be turned into economic value?

1.2. Research scope and structure

This study focuses on logistical buildings in Finland. In this study, logistics buildings include warehouses, distribution centres, and fulfilment centres. The case study focuses on existing buildings; therefore, the subject of inspection is the operation and maintenance phase of building's life cycle. The logistics sites are classified as urban environment in this research. Urban environment refers to area with high population density, and intensive built infrastructure including cities, and suburbs.

The study utilizes case properties of logistical buildings in Finland. First the theory background is presented. Then the methodology of the study is explained in detail. Then the current biodiversity footprint of Finnish logistics sites is studied by calculating the average land occupation of 77 existing logistics sites in Finland. The possible solutions to improve biodiversity on logistical properties are examined through three case properties. The case properties are analysed through available data from the property owners. Literature and Conservation Evidence database is utilised to examine the possible biodiversity improvements on-site. The possible economic value for property owner of improving biodiversity on-site is examined through interviews while also observing the motives behind the biodiversity supporting actions. Finally, conclusions are made through the findings from the case properties as well as from the interviews.

1.3. Limitations

The thesis focuses on biodiversity, which means it covers a wide range of topics. This leads to certain limitations in what the thesis can include. The research is limited to logistics properties in Finland and thus it does not cover all real estate profiles. The evaluation of biodiversity impact is simplified and limited only to land occupation, thus excluding all other impact categories. The case studies simplify the scope and present results on general level. Limited data provided by the asset manager reduces the profundity of the case study. In the interviews, a general opinion on the subject won't be presented. Instead, thoughts from a few real estate experts will be provided, and the conclusions will be based solely on their opinions. The goal of the research is not to cover all frameworks, tools, and solutions, but rather to provide perspective and ideas.

2 Biodiversity in Real Estate Sector

Globally, we are currently producing more materials, food, energy, and waste than ever before, resulting in increased extraction of natural resources. This has led to accelerating economic growth which has improved the human welfare substantially. Despite the impressive growth, there have been major negative consequences for the natural systems that support life on Earth. Due to human activities, 75 % of land environments and 66 % of marine environments have been altered. Ecosystems have decreased considering size and condition by 47 % compared to projected original state. Additionally, around 25 % of plants and animal species are threatened by human activities and around a million species are rapidly becoming extinct. The extensive impact of human activities has resulted in alarming decline in various indicators of ecosystems and biodiversity. (Díaz et al. 2019, 11-12, 24, 28.)

Five major direct drivers for biodiversity loss globally are land- and sea-use change, natural resource exploitation, pollution, climate change, and invasive alien species which have all accelerated since 1970 (Díaz et al. 2019, 12-13). In Finland the main causes for biodiversity loss are forestry, agriculture, construction, pollution, alien species, and climate change (Ruokamo et al. 2023, 5).

Real estate and construction activities are among the most significant direct land occupiers and one of the major significant direct drivers for biodiversity loss on a national level as well as global level (Ruokamo et al. 2023, 5, 8; Díaz et al. 2019, 12-13). Construction sector causes biodiversity loss due to its abundant need of natural resources as well as high production of waste and GHG emissions. (Ellen MacArthur Foundation 2021, 44.) In Finland, the construction sector is responsible for approximately half of the deforestation area. (Assmuth et al. 2022, 8).

2.1. The importance of biodiversity

Diverse nature supports ecosystem functioning (Berlinches de Gea et al. 2023). The variety of species within an ecosystem contributes to its resilience and stability, which in turn supports the provision of ecosystem services. Ecosystem services describe the various benefits that nature provides to humans through the combination of living and non-living elements such as soil, minerals, air, water, and the life forms within them. These services include renewable and non-renewable natural resources, as well as functional benefits such as carbon sequestration and plant pollination. (Díaz et al. 2019.) Healthy ecosystems provide us with many self-evident benefits. Plants transform energy from sunlight into usable form for other organisms. Bacteria and other organisms are breaking down organic matter into nutrients, creating fertile soil for plants. Pollinators play a crucial role in plant reproduction, ensuring affluent food supply. Plants and oceans act as carbon sinks and the water cycle is dependent on living organisms. Due to the interrelationships of different living species, the disappearance of one species can cause significant changes in the food chain, and human well-being depends on biodiversity. (European Commission 2020a.) Biodiversity loss threatens these important ecosystem functions. Declining biodiversity threatens adaptability on climate change as well as livelihoods, carbon sequestration, and food security. (IPCC 2022.)

2.2. Climate change & biodiversity loss

Climate change and the degradation of natural habitats are globally pervasive and interlinked issues (Siikavirta et al. 2024, 126). Climate change poses future risks for transformation of ecosystems and loss of biodiversity. Climate change is causing significant biodiversity loss due to increased extreme weather events, including storms, droughts, and heavy rainfall, and rising sea levels. This leads to various impacts on global biodiversity such as species losses through increased diseases and mass mortality events and ecosystem destruction through wildfires and declines in ecosystem services across marine, terrestrial, and freshwater ecosystems. In addition to climate change and increasing greenhouse gas emissions, vague waste treatment, pollutants, oil spills and toxic dumping have had a significant effect on freshwater, soil, and marine ecosystems and on the global atmosphere. The impacts are already noticeable on agriculture, aquaculture, fisheries, and nature's contributions to people. Biodiversity loss will risk livelihoods and food security. (Díaz et al. 2019, 12-13.)

A diverse ecosystem is more resilient to changing climate and is better equipped to recover from disturbances such as extreme weather events. Particularly, diverse forests serve as carbon sinks and storage, playing a crucial role in climate change mitigation. Moreover, biodiversity provides additional benefits such as water purification, flood protection, and erosion control, further emphasizing the connection of nature preservation and climate change mitigation strategies. The measures taken to prevent the biodiversity loss contribute significantly to mitigating and adapting to climate change. Thus, these issues require a comprehensive strategy that considers both aspects. (Siikavirta et al. 2024, 126.)

2.3. Biodiversity consideration in properties

Construction sector is one of the major causes for biodiversity loss. One reason for the biodiversity loss is the high emissions of built environment through linear economy model. Lots of materials are needed and plenty of waste is produced. Over 90 % of global biodiversity loss and water stress is caused by the utilisation, including extraction and processing, of natural resources for which the built environment has also a major responsibility. (Ellen MacArthur Foundation 2021, 14, 44.)

Built environment contributes on 29 per cents of threatened and near threatened species globally. (Ellen MacArthur Foundation 2021, 44-45, World Economic Forum 2020a, 12). In Finland, construction is the third most significant factor causing the threat of species after changes in forest environments and closure of open areas (Hyvärinen et al. 2019, 32). Long-distance transportation of the materials and products leads to the increase of invasive alien species. The urban environment offers a disturbed environment where invasive alien species can compete with native species. Linear design of the built environment increases waste generation. Additionally, urban heat islands and increased light- and noise pollution in urban areas disturb the natural cycles in surrounding ecosystems. (Ellen MacArthur Foundation 2021, 44-45, 48.) The construction sector in the EU consumes around 50% of all material used and produces more than 35% of all waste in the EU, so it is evident that the sector has a large impact on the environment (European Commission 2020b, 11).

In the real estate sector, biodiversity and ecosystem services are crucial for several reasons. Firstly, the sector relies on natural resources for construction materials and energy. Secondly, real estate developments can impact local ecosystems and biodiversity, for example, through habitat destruction or pollution. Thirdly, the quality of the local environment and access to green spaces, clean air, and water can have an impact on real estate values. (Díaz et al. 2019.) Urban areas with abundant biodiversity offer numerous environmental and socioeconomic advantages such as enhanced mental well-being, improved water quality, and increased resilience to climate change impacts. (Ellen MacArthur Foundation 2021, 44.)

According to ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) tool, the successful implementation of real estate development activities, such as acquiring land, constructing buildings, and maintaining properties, relies on various essential ecosystem services. These services include ground water, surface water, bioremediation, filtration of pollutants, reducing light and noise pollution, flood and storm protection, mass stabilisation and erosion control. Many of these ecosystem services are provided by abundant vegetation. (ENCORE 2024.)

2.4. Value of ESG (Environmental, Social, and Governance)

All businesses are dependent of nature, either directly or indirectly through supply chain. Sectors that are highly or moderately dependent on nature, generate a total of 52 % of GDP (Gross Domestic Product) globally accounting to $44 trillion. Construction industry, together with agriculture, food and beverages, is the largest industry dependent highly on nature. The sector is extremely dependent on natural resources and for construction sector it is estimated that nature generates nearly $4 trillion of GVA (Gross Value Added). As a result, the construction sector can suffer from biodiversity loss due to nature's reduced ability to provide ecosystem services. (World Economic Forum 2020b, 13-14.)

On estimation, private sector expended $6.6-13.6 billion per year during 2015-2017 for biodiversity covering biodiversity offsets, sustainable commodities, forest carbon finance, payments for ecosystem services, water quality trading, philanthropic spending, private contributions to conservation NGOs, and private finance mobilized by public development finance. (OECD 2020, 10.) Considering the increasing trend for sustainability topics in private sector, it is probable that the amount spent is even higher these days. The impact of economic activities on biodiversity can be measured through biodiversity footprint that measures the impact of human activity on global biodiversity as a result from production and consumption of goods and services (IEEP 2021, 12).

ESG aspects create value in properties. According to a survey conducted for investors in Europe, 20 % of investors would be willing to pay higher prices to acquire properties that adhere sustainability criteria. Majority of the investors, around 60 %, were willing to pay under 10 % more than for comparable “non-green” asset. However, over 10 % of the investors were willing to pay more than 20 % more. (CBRE 2024a, 24-26.) For occupiers’ point of view, according to a survey conducted for European logistics occupiers, 59 % are unwilling to pay rent premium for green certified facilities. Around a quarter of the respondents would in fact seek discount for non-certified facilities. Occupiers are becoming savvier and demanding about sustainable buildings, making green certifications a standard expectation in prime market rents. Additionally, they are integrating broader sustainability criteria beyond just certifications in their property decision-making processes. (CBRE 2024b, 24-27) Thus, it is evident that neglecting sustainability considerations could lead to higher vacancy rates, resulting in potential value discount for property owners.

RICS (Royal Institution of Chartered Surveyors) has defined guidelines to determine how the application of ESG principles affects to the property and its valuation. In this guideline, the drivers are divided into three categories: Value drivers, risk drivers, and cashflow drivers, according to how the driver affects the property performance. Value drivers include metrics such as energy efficiency, sustainable building design, green certifications, and access to outdoor spaces such as parks and green roofs. Risk drivers include environmental hazards, regulatory compliance, and reputational risk for instance. Cash flow drivers consider for example tenant demand, operating cost, tax incentives and market trends. (Scherrenberg et al. 2024, 7-8.) As we can see from the drivers, many of them could be linked into improvements in biodiversity within the property.

Within this study, RICS published a data list containing ESG indicators that could be relevant when assessing the ESG performance of the property. This data list contains detailed indicators in various categories such as GHG emissions, physical climate risk and material use in the asset. In addition, the data list contains potential indicators that might be relevant in the future. RICS considers biodiversity as a potential indicator for ESG value in the future. This includes measures that can either have a negative or positive impact on biodiversity. Accordingly, biodiversity related data includes land artificialisation, use of pesticides, the size of planted area in the property and existence of biodiversity action plan, beehives, or biodiversity labels. As stated in the document, part of the biodiversity-related aspects may be governed by local regulations while others may be influenced by market conditions. (Scheurwater & Ding 2024, 3, 7-19.)

3 Strategies and Economic Instruments for Biodiversity Conservation

This section introduces the key strategies for biodiversity conservation in Finland, focusing on the relevant frameworks and laws at the national level while also considering relevant global and European initiatives and frameworks that influence in Finland as well. Also, common economic instruments related to improvement of biodiversity are presented shortly. Afterwards, value of ESG aspects on real estate sector are observed through conducted studies and features of green building certifications.

3.1. Convention on Biological Diversity

The biodiversity framework of the United Nations, known as the Convention on Biological Diversity (CBD), is an international legal tool ratified by 196 nations. The framework focuses on preserving biodiversity, ensuring sustainable utilization of its components, and promoting fair sharing of benefits from genetic resources. The CBD covers all levels of biodiversity including ecosystems, species, genetic resources, and related domains like biotechnology. Its governing body is the Conference of the Parties (COP), meeting every other year to review progress and set priorities. The aim of the framework is to promote actions that drive towards a sustainable future. National biodiversity strategies and action plans are essential to the implementation of the framework. (United Nations 2024.)

The United Nations Biodiversity Conference, COP 15, in 2022 created a biodiversity framework that is designed to monitor and promote the preservation and sustainable use of biological diversity. It provides strategic direction and goals for global activities in the protection of natural diversity. The parties involved in the agreement have made decisions regarding new international goals to address the issue of biodiversity and halt the decline of nature. Four long-term goals were agreed upon during negotiations for the year 2050. The first two goals are already part of the existing biodiversity strategy in the EU, which include protecting natural diversity and habitats, improving land and water conditions, promoting sustainable use of biodiversity, ensuring fair distribution of benefits from genetic resources, and incorporating biodiversity into all aspects of society. Achieving these goals is supported by 23 specific objectives that need to be implemented by 2030. (Ministry of the Environment 2024a.)

3.2. European biodiversity strategy for 2030

The biodiversity strategy for 2030 by EU is a detailed, ambitious plan to protect the nature and restore ecosystems. Its objective is to ensure Europe's biodiversity recovery by 2030 and thus increase resilience towards climate change and other threats for society. This is done through specific actions and commitments such as increasing the amount of protected Natura 2000 areas and launching an EU Nature Restoration regulation. (European Commission 2024a.) This biodiversity strategy is part of the EU Green Deal that aims to reduce GHG emissions by at least 55 % by 2030, compared to 1990 levels, and ensure climate neutrality of European Union by 2050 (European Commission 2024b).

3.3. National Biodiversity Action Plan

In Finland, the national biodiversity action plan is currently being prepared. The objective of this action plan is to end the loss of biodiversity by 2030 and to turn the development of biodiversity into a path of recovery. (Ministry of the Environment 2024b.)

Previously, the strategic guidelines of Finland's biodiversity policy were set by the national Strategy for the Conservation and Sustainable Use of Biodiversity “Saving Nature for People” in 2013–2020. Strategy and the goal of the action plan was to stop the biodiversity loss by 2020. Nevertheless, biodiversity in Finland continues to decline. Although there were multiple measures that were completed or implemented, only 10 % of the measures were estimated to have led to a clearly improving development in terms of the theme. All measures were not clear or ambitious enough and therefore the original goal was not achieved. However, it shifted the emphasis of decision-making regarding the use of natural resources towards the cultural and economic values of biodiversity. (Ministry of the Environment 2024b.)

The action plan is currently being prepared and the final content of the regulation is not yet sealed. However, the new action plan being prepared will increase the protection of biodiversity and foster the restoration of degraded ecosystems. The current statements emphasize sustainable planning and construction that minimizes harmful effects on biodiversity. Together with national goals, the new strategy considers the objectives outlined in the UN Convention on Biological Diversity and the EU Biodiversity Strategy. (Ministry of the Environment 2024b.)

3.4. EU Taxonomy

EU Taxonomy regulation is a classification system supporting the EU sustainable finance framework. Taxonomy regulation helps companies and investors to make sustainable investment decisions by determining which economic activities can be considered environmentally sustainable. The regulation contains a comprehensive list of environmentally sustainable activities with specific technical screening criteria for all environmental objectives. (European Commission 2024c.)

The regulation consists of six separate climate and environmental objectives: Climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control and lastly protection and restoration of biodiversity and ecosystems. To be compliant with the regulation, an economic activity must make a substantial contribution to at least one of these environmental objectives and do no significant harm to all the other categories. Additionally, the economic activity must comply with minimum safeguards and technical screening criteria. (European Commission 2024d.)

For building and construction sector, the criteria for protection and restoration of biodiversity and ecosystem as a DNSH (Do No Significant Harm) criteria does not affect the sector other than for construction of new buildings. Thus, it excludes existing buildings. For construction of new buildings, the biodiversity DNSH criteria determines that in order for a new building to be EU taxonomy compliant, the construction should not be located in arable land or cropland with fertile soil and rich below-ground biodiversity, greenfield land with high biodiversity value or a land that includes habitats for endangered species listed on European or IUCN Red Lists, and forest land as defined by national laws or by FAO. (European Commission 2024d.)

3.5. Taskforce on Nature-related Financial Disclosures

TNFD, The Taskforce on Nature-related Financial Disclosures, is an initiative that guides and motivates companies and financial institutions to evaluate, disclose, and act on their nature-related dependencies, risks, impacts, and opportunities. The initiative aims to develop a framework for better understanding and management of nature-related risks. Unlike the similar TCFD (Task Force on Climate-related Financial Disclosures), TNFD focuses especially on the effects of degrading biodiversity and ecosystems on businesses and financial systems. The aim behind the initiative is to offer financial resilience for environmental challenges. (TNFD 2023, 7-8, 15.)

3.6. Corporate Sustainability Reporting Directive

Corporate Sustainability Reporting Directive (CSRD) is a directive created by European Union that requires large and listed companies to disclose their social and environmental risks they encounter. The directive obligates organisations to report the information related to their social and environmental impacts. The aim of CSRD is to standardise and enhance the quality of sustainability disclosures and increase transparency among businesses for their sustainability actions. (European Commission 2024e.) The report needs to be conducted in line with the European Sustainability Reporting Standards (ESRS). The ESRS consists of two cross-cutting standards and ten topic-specific standards which are further divided into subcategories. The standards cover wide range of environmental, social, and governance issues, one of them being biodiversity. (European Commission 2023.) ESRS 4 considers biodiversity and ecosystems. It requires companies to report on their impact on biodiversity through performance metrics selected by companies. It also demands companies to set targets related to the topic and create an action plan to complete the targets. (EFRAG 2022.) This improves transparency and accountability. Through the reporting, organisations can identify and manage biodiversity-related risks. The reporting obligation may increase additional motivation for organisations to act to mitigate biodiversity loss.

3.7. Land Use and Building Act

In Finland, currently land use, constructions and activities conducted on them are regulated through Land Use and Building Act (132/1999). The object of it includes ensuring the high quality and interactivity of planning and promoting culturally, ecologically, and socially sustainable development. New Building Act is coming into force in 1st of January 2025. The new act will lighten the administrative burden and bureaucracy, clarify the right of appeal, and clarify issues of responsibility. The act contributes to climate change, promotes circular economy, improves to the quality of construction, streamlines construction, and supports the digitalisation of the built environment. (Ministry of the Environment 2024c.) The new construction law does not consider the protection of biodiversity, even though it was part of the original proposal. However, the new Construction Act focuses on reducing climate emissions. (Finnish Government 2021.)

3.8. Biodiversity offsetting

Biodiversity offsetting is an economic practice aiming for compensating the loss of biodiversity caused by development projects. The instrument is based on the "polluter pays" approach. The compensation is done by creating or restoring natural habitats elsewhere, preferably nearby the emerged project. It involves calculation and implementation of measures to offset the loss of biodiversity caused by human activities. Offsetting is usually aiming for No Net Loss meaning that the economic activity would not deliver any loss to for e.g., natural habitat, species, or ecosystem services. In this case the benefits of the compensation to nature must be equal to the degradation of nature values. The offsetting can also lead to Net Positive Impact, biodiversity net gain, meaning that the offsetting act leads to increased natural values in the area. (Moilanen & Kotiaho 2017, 12, 14-15.)

Offsetting can be executed by conservation, restoration, or enhancement of an area either within the area or in another area, preferably nearby the exploited area within similar natural habitat. The actions required for offsetting depends on the characteristics of the area and the natural habitat. (Nature Conservation Act 9/2023 Chapter 11.) Offsetting actions can include for instance, eradicating invasive alien species or increasing resources for species. Nevertheless, it does not include temporarily transferring species to suitable nearby location during the construction project (Ecosystem Hotel) or protection of an area with similar habitat type, which has no operating pressure. (Moilanen & Kotiaho 2017, 17, 37.) Offsetting act should be implemented before the loss of the natural state occurs (Nature Conservation Act 9/2023 Chapter 11).

It has to be noted that offsetting is considered as the last option to mitigate the losses towards the environment. The order of preference according to the mitigation hierarchy is 1) avoidance 2) minimisation, 3) remediation on-site and 4) biodiversity offsetting off-site (Cares et al. 2023, 2). This is visualised in the figure 1:

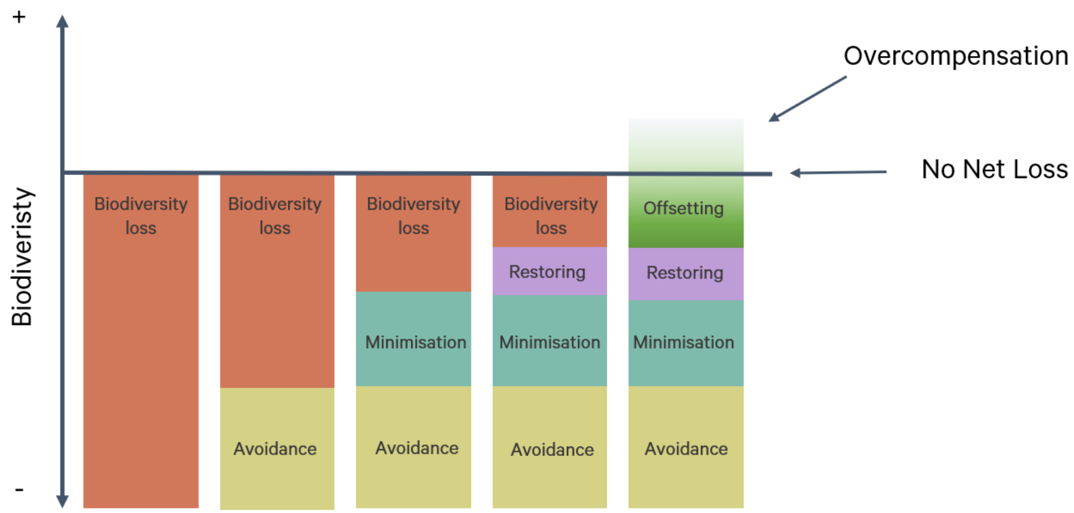

Figure 1. Mitigation hierarchy (Modified from Tinto, R., 2008).

3.9. Payments for Ecosystem Services (PES)

Payments for Ecosystem Services (PES) is a tool that turns externalities into financial incentives for local actors to deliver ecosystem services. It has emerged as a valuable tool for promoting conservation and resource management. The aim of it is that the one benefitting from a local ecosystem should pay for its conservation or restoration. These payments are provided to landowners or farmers who undertake sustainable practices to manage their land and deliver ecological services. This tool is mostly used in low-income areas in biodiversity-rich regions, nevertheless the effectiveness of this tool depends highly on its design. (IIED 2024, Dasgupta 2021, 203).

3.10. Green building certifications

Investors are increasingly favouring environmentally sustainable design and construction methods in order to improve energy and water efficiency and to reduce waste. It is stated that it enhances property value but in addition makes properties more attractive to tenants. Therefore, green building certifications such as LEED (Leadership in Energy and Environmental Design), by U.S. Green Building Council, and BREEAM (Building Research Establishment Environmental Assessment Method), by BRE, are increasing popularity. (Deepki 2024.)

The green building certifications and benchmarks include points that are directly and indirectly effecting on biodiversity. The BREEAM In-Use certificate is a global rating system that evaluates the sustainability of existing, in this case, commercial buildings. It assesses the building's environmental, social, and economic sustainability performance using scientific measures and benchmarks. The certificate provides independent verification of the building's sustainability performance and helps building managers reduce the building's environmental impact and operating costs. It also allows organizations to demonstrate their commitment to sustainability and environmental responsibility. When it comes to BREEAM In-Use certificate, the building has a possibility to gain points when improving biodiversity on-site. These points include increasing the amount of planted area and its ecological features on-site and creating an ecology report or biodiversity management plan. (BREEAM 2020.)

LEED Operations and Maintenance rating system is developed by the U.S. Green Building Council. It is a framework for identifying, implementing, and measuring green building designs, construction, operations, and maintenance. The certificate aims to optimize the use of natural resources, promote regenerative and restorative strategies, and minimize the negative environmental and human health consequences of the building industry. It awards the levels of certification based on the building's environmental performance. Biodiversity improvements can directly impact on the score through various categories such as “Rainwater management”, “Heat island reduction”, “Light pollution reduction” and “Site management plan”. (U.S. Green Building Council 2024.)

“Rakennustiedon ympäristöluokitus” (RTS) is a Finnish environmental classification for construction projects and existing buildings that assesses the environmental impact and indoor air quality of the building’s technical systems and operations as well as EU Taxonomy compliance of the asset. It is a tool for observing the environmental sustainability of buildings throughout their entire life cycle. The classification assesses various categories related to environmental sustainability such as carbon footprint, water use and waste management. Biodiversity aspect is considered through green areas including the size of green areas in the property and stormwater management. The focus of the classification is on environmental sustainability and the examination of social and economic sustainability are given less attention. (Rakennustieto 2024.) This classification is only used in Finland, but it is a practical tool for assessing the environmental sustainability of a building.

The potential to achieve higher building certification score by biodiversity improvements can increase the motivation to conduct biodiversity improvements. In addition to the green building certificates, all frameworks and directives presented aims to mitigate biodiversity loss among other targets such as mitigating climate change and promoting sustainable management practices.

4 Methodology

This study includes different methods to provide data for answering each research question. In this section, the methods are explained in more detail. For research question 1, the land use impact of average logistics site in Finland, and then impact on biodiversity is calculated by using LC-IMPACT method to display possible biodiversity impact of sites via land occupation. Research question 2 is examined through a collective case study. Selected logistics properties' impact on biodiversity is assessed by calculating their current green factor and biodiversity risk in addition to their biodiversity footprint caused by land occupation. Using the Conservation Evidence database and relevant literature, potential solutions to enhance on-site biodiversity are examined and assessed for their suitability to the case sites. For the research question 3, four interviews are undertaken. Insights and experiences from real estate operators related to the topic are analysed and conclusions are made to find out if the possible benefits of improving biodiversity on-site could be turned into economic value.

4.1. LCI-IMPACT calculation

To create a basis for the study, the average impact of logistics sites land occupation for biodiversity is calculated. This is calculated by using LC-IMPACT method. The impact is calculated as a land stress based on the occupied land of 77 logistics property located in Finland. The impact of land transformation and manufacturing and maintenance of the building is excluded. With the help of this simplified biodiversity footprint calculation, it is easier to visualise, how much logistics properties have impact on global biodiversity.

LC-IMPACT is a tool for calculating how a certain driver, in this case land stress, causes global species loss. To measure the amount of biodiversity loss, the functional unit of PDF (Potentially Disappeared Fraction of species) is utilised. PDF is an indicator for the risk of species' extinction. For example, a PDF of 0,01 presents that if the current pressure, such as land use, remains, approximately 1 % of the world's species pool will be at a risk of extinction over time. (Verones et al. 2020). Thus, a lower calculated PDF value indicates less impacts on biodiversity as species loss.

The average biodiversity footprint of logistics sites is calculated from an average biodiversity footprint of 77 assets in Finland. The selected assets are mainly located in the Helsinki area and in Tampere but also some assets are located in different cities such as Turku, Lahti and Jyväskylä. For the calculation, the gross floor areas were received from these assets from a portfolio owner of logistics buildings. The size of the whole property area, the plot size, was estimated either from a local map service or from the MapSite of National Land Survey of Finland. The calculation was conducted based on the estimated plot sizes.

4.2. Collective case study

The collective case study is conducted for three case sites located in Southern Finland. All selected sites are logistics properties. For the case study, the documentation received from the property owner regarding the case sites is considered. This documentation includes detailed plans and ecological reports. Firstly, the current stage of biodiversity on-site is examined with three separate calculation methods: LC-IMPACT, green factor, and local biodiversity risk. After the calculation, the possible actions to support biodiversity is identified from Conservation Evidence database. Lastly, the suitability of the actions to case sites is assessed based on their current state and location. Literature is utilised to support the assessment. The methods are explained in more detail in this section.

4.2.1. Green factor

Green factor measures the proportion of vegetation and other ecologically beneficial surfaces relative to the built-up area being assessed. The blue-green coefficient is a method used to measure green factor at the plot level. The tool serves as a verification tool for designers of urban site plans. For the calculation, site's vegetation, surfaces, and all stormwater structures are detailed based on the site plan. The tool calculates the achieved green factor. The higher the calculated green factor is, the more biodiversity-supportive elements there are in the site. The tool also evaluates, how the site's elements delay stormwater. (City of Turku 2024a.)

Case sites' green factor is calculated by using the Blue-green factor 2.0 - calculation tool from the city of Turku. The tool from the City of Turku is utilized since one of the case sites is located in Turku. The other cities included in the case study, where the case sites are located, do not have their own tool and therefore the calculation tool of Turku is also utilised for these sites. The tool calculates the green factor of the plot or block. It was customized by the City of Turku but is similar with Helsinki's green factor tool. The tool was developed in the international iWater project in 2016-2018 and later updated in 2021 to the version 2.0. (City of Turku 2024a.)

4.2.2. Local biodiversity risk

The local biodiversity risk is calculated through land use intensity (LUI) index value in compliance with Biodiversity Multi-Scale Assessment of Product Systems (BioMAPS) method. The BioMAPS method, is a method designed to evaluate the impacts of land use on biodiversity within Life Cycle Assessment (LCA). The method includes three levels of calculation: Global, regional, and local scales. In this thesis, the calculation is conducted for local scale only since only site level comparison is done. In the method, LUI is calculated by various management parameters that have influence on biodiversity. (Maier et al. 2022.)

The method is created to support decision makers by identifying and helping to prioritise areas with high biodiversity risk. The method provides detailed insights into the impacts of different land use types and management practices on biodiversity. (Maier et al. 2022.) The method is quite new, and it does not yet have clear benchmarks or requirements. However, the method is used to enable comparison of the selected case sites between each other.

In this case, the LUI is calculated by land management in urban areas. The LUI is calculated through six parameters: Artificial nesting sites, traffic, set aside areas, light pollution, sealing intensity and human population density. Usually, the set aside area is calculated separately for terrestrial habitat and aquatic habitat but in this case the latter is excluded since all case sites locates in terrestrial area. Each parameter has their own indicator excluding the artificial nesting sites for which an indicator is not determined. (Maier et al. 2022.) The parameters and their indicators are summarised in table 1.

Table 1. Parameters and indicators for calculation of urban land use index. (Modified from Maier et al. 2022, 124.)

Parameter	**Indicator**
Artificial nesting/resting/foraging sites	N/A
Traffic	Vehicles (No/km)
Set aside area/terrestrial habitat	Set aside area/total land use area (%)
Light pollution	Artificial sky brightness (mcd/m^2)
Sealing intensity	Imperviousness (%)
Human population density	Persons/km^2

The land use index is a value between 0 and 1, where 0 indicates very low land use and 1 indicates very high land use. The lower the value, the less intensive the land use is which generally correlates to higher biodiversity and healthier ecosystem. (Maier et al. 2022.). The urban land use index is calculated by summarizing the calculated intensities of each parameter as presented in equation 1.

$$LUI_{Urban\ (i)} = \frac{\left(\sum_{i=1}^{n} \frac{LP(i)}{LP(MTI)} + \frac{Se(i)}{Se(MTI)} + \frac{Pop(i)}{Pop(MTI)} + \frac{T(i)}{T(MTI)} + \frac{Set\ aside(i)}{Total\ area(i)}\right)}{n} \qquad (1)$$

, where

LUI $_{Urban}$ (i) = LUI index for urban at location i

MTI = Maximum Tolerable Intensity

LP (i) / LP (MTI) = Intensity of light pollution at location i

SE (i) / Se (MTI) = Intensity of sealing at location i

Pop (i) / Pop (MTI) = Intensity of human population density at location i

T (i) / T (MTI) = Intensity of traffic at location i

Set aside (i) / Total area = Intensity of set-aside area at location i

n = number of parameters

The Maximum Tolerable Intensity (MTI) corresponds to benchmark value used for the calculation of intensity of each parameter (Maier et al. 2022.). The method does not directly give MTI values for each parameter. The indicator values used were searched from local databases considering the guidance of the method for determining the indicators. In this case study, the biodiversity risk score is calculated to enable the comparison of case sites between each other. Therefore, the benchmark values chosen for each parameter, were as regional as possible. The MTI is calculated by summarising the average value of the indicator with average standard deviation. However, in this study, the MTI was only determined as average value of the indicator without standard deviation since average standard deviation was not available.

The traffic intensity for each site was calculated from the data of Statistics Finland. The traffic performance of 2023 was evaluated based on the municipality in which the site is situated. As a benchmark value, 1 218 million car-kilometres was used for all sites. This number represents the traffic performance of a Finnish municipality, which is the largest in the country. In this case, the number is Vantaa's traffic performance in year 2023. (Statistics Finland 2024a.)

Sealing of each site was calculated as a proportion of the sealed area in relation to the total area of the plot. The value is calculated as a percentage, and it is used directly as an intensity value. Set-aside area in each site was calculated as a proportion of set-aside in relation to the total area of the plot. The intensity value is determined based on the percentage of set-aside area as presented in table 2. The larger the set-aside area, the lower the intensity value. Since there was limited data available in the case study, set-aside area was assumed from site plans. All plantings as well as meadows were assumed to include only native, biodiversity supportive species and thus considered as set aside area. Lawns were not considered as set-aside area but were considered as imperviousness surface together with planted areas and meadows. Gravel was considered as sealed area since the impact on biodiversity is similar to completely sealed surface.

Table 2. Set-aside area and its corresponding intensity value. (Modified from Maier et al. 2022, 128.)

Set-aside area (%)	**Intensity value**
0	1
5	0.9
10	0.8
15	0.7
20	0.6
25	0.5
30	0.4
35	0.3
40	0.2
45	0.1
50	0

The artificial sky brightness of each site was searched from the Light Pollution Atlas 2022 providing information of artificial night sky brightness based on satellite data (Light pollution Atlas 2022). The data includes only artificial light excluding natural light. Common benchmark value is determined for all sites since the intensity of artificial light pollution remains unaffected by geographical location. The MTI used for light pollution was 0.174 mcd/m^2 which corresponds to typical natural night sky background brightness (Falchi et al. 2016). The intensity for lighting pollution is calculated as ratio between artificial brightness to natural brightness expressed as a percentage increase of artificial lighting over the natural lighting level.

Intensity of human population density was calculated from the data of Statistics Finland. It was calculated similarly as traffic intensity; the population density in 2023 in each site's municipality was compared to the benchmark value of a Finnish municipality with highest population density in 2024. The benchmark value used was the population density of Helsinki, which was 3 144,4 persons/km^2 in 2023. (Statistics Finland 2024b.)

The urban land use intensity index considers all presented parameters equally since it is not clear which metric is more relevant than the other. The calculated intensity index indicates the land use intensity. High land use intensity in urban areas indicates a high level of human activity and development, which can significantly impact on local biodiversity. The lower the calculated intensity index is, the less impact the site has on local biodiversity.

The local urban biodiversity risk is calculated from urban land use intensity index as presented in equation 2.

$$BR\_locLUI_{Urban\,(i)} = -54{,}133 * LUI^2 + 119{,}07 * LUI - 14{,}51 \qquad (2)$$

The biodiversity risk translates the calculated LUI indexes into a form that the results are also comparable between different land use types. In this case study, all sites are classified as urban, so the calculation of the biodiversity risk is not necessary but still conducted for possibility of later comparison. High biodiversity risk value indicates areas where critical biodiversity is at significant risk of being lost due to various factors. Low biodiversity risk indicates lower likelihood of species loss and more balanced natural environment. Sites with lower biodiversity risk values are better at supporting diverse species and maintaining ecological functions.

4.2.3. Exploring the actions for supporting biodiversity on-site

Conservation Evidence is a database created in the University of Cambridge, UK with collaborators, offering information on the effects of conservation actions. The database is utilised since it is based on scientific literature and therefore the found results can be considered as reliable. The aim of this database is to provide synopses of evidence to analyse the effectiveness of various actions that can be implemented to conserve natural characteristics such as a given species group or habitat to overcome a particular conservation challenge. The database complies and presents the information from scientific studies that examine the impact and effectiveness of conservation actions. (Conservation Evidence 2024a.)

The actions are classified by their overall effectiveness to six categories: Beneficial, likely to be beneficial, trade-offs between benefits & harms, unknown effectiveness, unlikely to be beneficial and likely to be ineffective or harmful. The classifying is based on the action's effectiveness, certainty of the evidence, and potential harm, including possible negative side effects of the action. A panel of experts scores the actions based on the evidence collected. The higher the score, the more beneficial the action is. For an action to be categorized as beneficial, it must have effectiveness and certainty score of 60 % or more and it must have a harm score less than 20 %. For action to achieve "likely to beneficial" category, it must have 40 to 60 % score from certainty and effectiveness and a harm score less than 20 %. See table 3 for scoring matrix and interpretation of the scoring. (Conservation Evidence 2024b.)

Table 3. Scoring matrix for overall effectiveness of the action. (Modified from Conservation Evidence 2024b.)

Overall effectiveness		**Effectiveness**	**Certainty**	**Harm**
Beneficial		> 60%	> 60%	< 20%
Likely to be beneficial	Criteria 1 or	> 60%	40% to 60%	< 20%
	Criteria 2	40% to 60%	> 40%	< 20%
Score interpretation		0% = not effective 100% = highly effective	0% = no evidence 100% = high quality evidence	0% = none 100% = major undesir-able effect

Actions to improve local biodiversity were searched from the database. The database currently includes 3 690 actions. To find the actions, best suited for the environment of logistics properties in Finland, actions were filtered by country, habitat, action category and keywords. Three filter combos were used for this study. In two of the searches, the country observed was Finland. This means that only actions that have also relevant studies conducted in Finland were included. In the third search, no country filter was used. In the first search the actions were additionally filtered to artificial habitats since logistics properties are classified as an artificial habitat. The search resulted to 22 actions in total. In the second search, in addition to the country filter, a keyword "urban" was added to filter the actions. This resulted to nine actions in total.

To widen the scope, a third search was made. This search was limited by both filters presented abode, keyword "urban" and artificial habitat. As a difference, the search was not limited to studies conducted in Finland. The country was not filtered. Additionally, conservation category was limited to bird, reptile, terrestrial mammal, bar, butterfly and moth, amphibian, peatland, forest, farmland, bee, and grassland conservation, soil fertility and natural pest control. Conservation categories left out were categories focused on marine habitat or habitat or species group irrelevant for assets located in Finland. These excluded categories were for example marsh and swamp conservation, marine fish conservation and primate conservation.

These filters were selected since they seemed most suitable for the scope of this study. Since the study focuses on logistics building, urban areas and artificial habitats describes the best these sites. At first the study was limited to research also conducted in Finland to find the best actions to be beneficial in Finland. The third search was conducted without the country filter to find even more actions. However, the third search needed to be limited with other filters due to abundant number of results. Therefore, the third search included other filters described previously.

4.3. Semi-structured interviews

Research question 3 is examined through semi-structured interviews since there is a lack of data related to the topic. The interview involved four individuals representing different companies in the logistics sector. Main topics and questions were sent in advance, but the structure of the conversation formed freely as the interview progressed.

4.3.1. Interview structure

In a semi-structured interview, the conversation is guided by certain pre-selected themes and related follow-up questions. Semi-structured interviews allow for further clarification and immersion to given predetermined questions. The order in which the questions were presented varied depending on the natural flow of the conversation. The purpose of the interviews is to explore the motivations and willingness of property owners to invest in biodiversity, as well as to identify the specific actions companies have undertaken to achieve their biodiversity objectives.

The following questions and topics were sent to the interviewees in advance:

1. How does the company prevent biodiversity loss?
2. What measures have already been taken in the company's properties and what plans are there in the future to prevent biodiversity loss and improve the biodiversity of the surrounding environment of building properties?
3. What benefits have these possible measures brought?
4. How does biodiversity and these measures affect the economic value and costs in the company's properties?

The collection and analysis of research data was carried out through interviews with four real estate professionals representing their companies. The companies interviewed owned or managed logistics real estate. In one company, property management was the main part of their business. In the other three, the company's business is focused elsewhere, but logistical properties are owned to support the core business. These interviews provided different perspectives on the development of biodiversity in properties. The interviews were carried out as individual interviews, where the company's experiences and actions to take biodiversity into account in the property, the company's motivation to develop biodiversity, the possible benefits, and considerations that activities promoting biodiversity have brought, and the future outlook on the topic were discussed. The interviews were carried out in August and September in 2024. The interviews were conducted in the Microsoft Teams service, and they were recorded with a permission to ensure that the important points are extracted from the interview and that the focus is not distracted by writing notes during the interview. The interviews lasted an average of 30 minutes. All interviews were held in Finnish. The important findings, presented later in this study, are translated into English.

4.3.2. Interviewee backgrounds

The following experts from four different companies were interviewed. The profiles of the interviewees and their companies is presented in table 4.

Table 4. Interviewed experts and company profiles.

	Title	Representative company
Expert 1	Project manager	Company 1: Nationwide company, occupies both owned and leased properties
Expert 2	Construction manager	Company 2: Nationwide company, occupies both owned and leased properties
Expert 3	Head of asset management	Company 3: Global company, real estate investment and management
Expert 4	Property manager	Company 4: Global company, occupies both owned and leased properties

4.3.3. Analysation of the interviews

The content of the interviews was analysed using qualitative content analysis. Qualitative content analysis is a method for analysing qualitative data, focusing on identifying themes and patterns within the data to reveal insights about specific topics, themes, and subjects. It involves systematically coding data from various sources, such as interviews, to draw broader conclusions and to create a clear description of the phenomenon under study. The aim is to move from concrete data points to more abstract concepts, providing a rich, in-depth understanding of the content. (Vuori 2021.)

4.4. Summary of the methods

Each research question is examined through different methods. LC-IMPACT calculation creates the basis for this study and tries to describe the current situation. In the case study, current situation is calculation with LC-IMPACT method together with green factor and biodiversity risk. After that, the possible actions to support biodiversity on-site are explored from Conservation Evidence database. To conclude, the suitability of the found actions to the selected case sites is assessed based on the location and the current state of the sites. Lastly, an interview is conducted to explore the possible benefits of biodiversity improvements. Figure 2 summarises the used methods and data for each research question in this study.

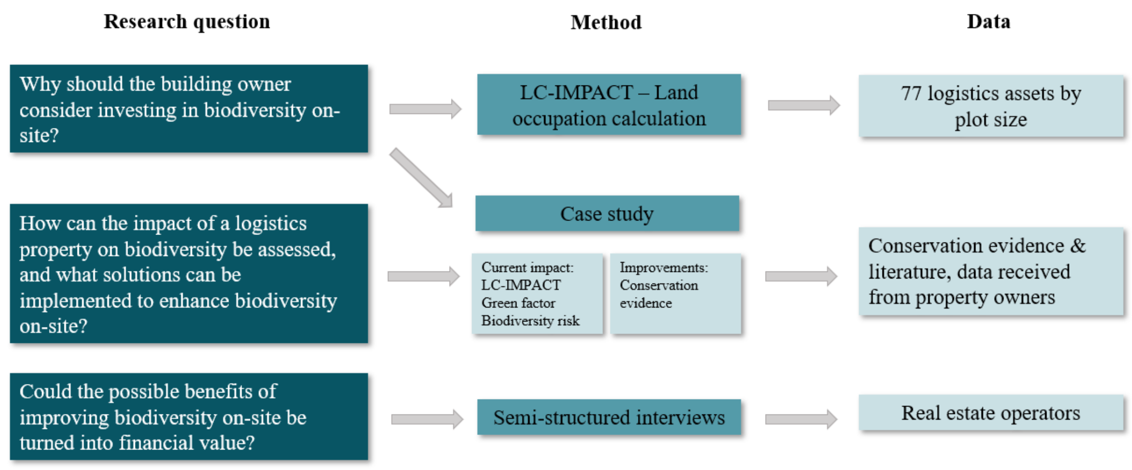

Figure 2. Research method for each research question.

5 The average biodiversity impact of logistics sites in Finland

The average biodiversity impact of logistics sites in Finland is calculated based on the average land occupation of 77 logistics sites in Finland. The impact was calculated by LC-IMAPCT method explained in more detail in section 4.1.

The ecoregional characterization factor for land occupation in these areas is 6,08E-16 PDF/m^2 excluding the assets located in Turku where the ecoregional characterization factor is 9,29E-16 PDF/m^2. This means that the assets located in Turku have a larger negative impact on global biodiversity compared to other assets in the portfolio located outside of Turku, due to the higher ecoregional characterization factor. The biodiversity footprint of land occupation was calculated by multiplying the property area with the ecoregion level characterization factor.

The total gross floor area of the selected logistics properties was 1 220 633 m^2. The average property size was 15 852 m^2. The total estimated plot area was 3 122 637 m^2 where the average plot size was 40 554 m^2. 198 600 m^2 of the total plot area was located in Turku, and 2 924 037 m^2 outside of Turku and thus calculated with different characterization factor. When multiplying the average plot size with the ecoregion level characterization factor, the average biodiversity footprint (BF) can be calculated as presented in equation 3.

$$BF, avg = \frac{\sum_{i=1}^{n} Area * Ecoregion\ level\ characterization\ factor}{n} \quad (3)$$

$$BF, avg = \frac{2\,924\,037\ m^2 * 6{,}08 * 10^{-16}\frac{PDF}{m^2} + 198\,600\ m^2 * 9{,}2 * 10^{-16}\frac{PDF}{m^2}}{77}$$

$$= 2{,}546 * 10^{-11} PDF \approx 0{,}0255\ nPDF$$

Based on the calculations, the average biodiversity footprint of a logistics property is 2,55E-11 PDF calculated by the current terrestrial land occupation. Therefore, it can be estimated that the average logistics property causes 2,55E-11 % of global species pool to be at a risk of extinction.

Since the biodiversity footprint calculation is simplified, only including the land occupation, the only parameters considered are location and plot size. In this calculation, a larger plot size results in a higher biodiversity footprint. Different locations have different ecoregions, which in turn have different characterization factors for the calculation. The characterization factors in Finland are relatively similar, even with two different ecoregions. However, when comparing to the world average characterization factor of 6,71E−15 PDF/m^2, the factor for Finland is smaller (6,08E-16 PDF/m^2 and 9,29E-16 PDF/m^2). This means that land occupation in Finland has around 11 times smaller biodiversity footprint for the same plot size compared to the world average. For example, if the sites were located in the Iberian sclerophyllous and semi-deciduous forests in Spain, the footprint would be larger since the factor for that ecoregion is 1,37E−14 PDF/m^2. The impact in Spain, in that ecoregion, is around 23 times higher than in Finland. In comparison, if the sites were located in northern Norway, in the ecoregion of Scandinavian montane birch forest and grasslands with a characterization factor of 4,33E−16 PDF/m^2, the biodiversity footprint and therefore the impact on biodiversity would be around 1.4 times lower.

The influence calculated for logistics site in Finland on biodiversity is relatively low, but considering this impact is only for one logistics plot so the impact of all logistics properties, or all properties is more significant. If the transformation of the land was included, the impact would be even higher. This validates the reason why properties' biodiversity should be given attention. As noted in the calculations, although Finland is a large country in terms of area, the ecological characterization factor is the same in most parts of Finland. More specific factors, depending on the habitat type, would provide a clearer picture of the impact of land use on biodiversity in the area. More accurate factors would improve the comparability of individual plots in terms of the biodiversity impact.

6 Current state of case properties

The aim of the case study was to calculate the current impact of the selected case sites on biodiversity as well as to find out actions to improve biodiversity on-site and examine the potential benefits of the actions if implemented. The case study was conducted for three existing logistical properties. Each property was studied individually.

6.1. Site 1 - Property description

The first site, “Site 1”, located in Southwest Finland is a distribution centre containing some office space. The building comprises of 2 floors and the gross floor area is around 12 000 m^2. The plot area is approximately 32 000 m^2. The property was constructed in 2021 into a woodland.

The asset is located next to a nature conservation area, as a part of Natura 2000 network. The surrounding area is mainly woodland with some logistics properties. (City of Turku 2024b.) The environment was considered during the construction of the asset and the site already has elements that support biodiversity. During the construction, parts of the green surfaces and some trees were preserved, and various new plantings were made. According to the property manager, rotten wood has been left on the plot and few insect hotels has been installed. Additionally, according to the site plan, at least 8 small birdhouses were attached to the trees during the construction phase. The building also utilises renewable energy by installed solar PV panels on the roof and a ground source heating system.

6.1.1. Existing ecological values

Biodiversity impact from land occupation by LC-IMPACT method for site 1 can be calculated as follow:

$$Biodiversity\ footprint\ (Site\ 1) = 32\,000\ m^2 * 9{,}2 * 10^{-16} \frac{PDF}{m^2} = 2{,}944 * 10^{-11} PDF \approx 0{,}029\ nPDF$$

The footprint of the site is larger than the average calculated footprint from land occupation of logistics sites in Finland due to higher characterization factor of the ecoregion.

According to the site plan and photographs provided by the property owner and aerial map from the city of Turku, the site has versatile green elements in relation to other case sites presented in this study (City of Turku 2024b). For the calculation of the green factor, a meadow area was estimated to be 1 870 m^2 in total. Lawn area was estimated to be approximately 370 m^2 and gravel surface around 5 360 m^2. A preserved ground vegetation was estimated as 3 190 m^2. 191 preserved and 200 planted trees were calculated to locate on the plot. Bushes were estimated to cover 200 m^2 of the plot. Perennial and other small plantations were estimated as 200 m^2. Insect hotels and rotten woods of the plot were also included on the calculation. A stormwater infiltration well with a volume of 130 m^3 was identified from the site as well.

The green factor of the property is estimated to be 1,4 based on the calculations conducted with the green factor calculation tool. According to construction control by City of Turku §8, the target green factor for industry and warehouse area is 0,5 (City of Turku 2024c). Therefore, the site's green factor already achieves the target. According to the calculation in the tool, the permeable surface area in relation to the total area of the plot is 34,3 %. This means that in relation to the total area of the plot, the plot has 34,3 % vegetation surfaces and solutions that delay stormwater.

The site is also assessed through the calculation of land use intensity index as described more detailed in chapter 6.1.2. The traffic intensity and human population density were calculated based on traffic intensity and human population density in Turku. The light pollution was obtained directly from the location of the site. Set aside area and sealing intensity were calculated based on the site plan. The values used in the calculation of land use intensity and biodiversity risk are presented in table 5.

Table 5. Values used in calculation of land use intensity and biodiversity risk in site 1.

Parameter	**Indicator**	**Site 1**
Atificial nesting/resting	N/A	
Traffic	Vehicles ((milj) no km)	278,0
	MTI ((milj) no km)	1 218
Set aside area/terrestrial habitat	Set aside area/total land use area (%)	21,52
	Intensity value	0,6
Light pollution	Artificial skybrightness (mcd/m^2)	5,17
	MTI	0,174
	Intensity value	0,30
Sealing intensity	Imperviousness (%)	0,62
Human population density	Human population density (persons/km^2)	821,80
	MTI	3 144,4

The urban land use intensity index for site 1 (s1) is calculated as follows:

$$LUI_{Urban\,(s1)} = \frac{\left(\sum_{i=1}^{n} \frac{LP(s1)}{LP(MTI)} + \frac{Se(s1)}{Se(MTI)} + \frac{Pop(s1)}{Pop(MTI)} + \frac{T(s1)}{T(MTI)} + \frac{Set\ aside(s1)}{Total\ area(s1)}\right)}{n}$$

$$LUI_{Urban\,(s1)} = \frac{\left(0{,}30 + 0{,}62 + \frac{821{,}8}{3144{,}4} + \frac{278}{1218} + 0{,}60\right)}{5}$$

$$LUI_{Urban\,(s1)} = \frac{(0{,}30 + 0{,}62 + 0{,}26 + 0{,}23 + 0{,}60)}{5} = 0{,}402 \approx 0{,}40$$

Local urban biodiversity risk is then calculated from land use intensity:

$$BR\_locLUI_{Urban\,(s1)} = -54{,}133 * LUI^2 + 119{,}07 * LUI - 14{,}51$$

$$BR_{locLUI\,Urban\,(s1)} = -54{,}133 * 0{,}402^2 + 119{,}07 * 0{,}402 - 14{,}51 = 24{,}617 \approx 24{,}6$$

The urban biodiversity risk for site 1 is then 24,6.

6.2. Site 2 – Property description

The second site is a distribution centre located in Southern Finland, in Nurmijärvi. The building is constructed in 2023 and the gross floor area is around 25 000 m^2. The plot area is approximately 51 000 m^2. The property utilises ground source heat and there are solar PV panels installed on the roof. The site is constructed to a waste land. The area is zoned as a workplace area surrounded by nature, mainly woodland. The site is not located on a ground water area. The closest nature conservation, Natura 2000, area is located within 1 kilometre from the site. (City of Nurmijärvi 2024.) According to the ecologist report provided by the asset manager, the ecological value of the site was very low even prior to construction.

The yard area is currently mainly asphalt and gravel and it includes some meadow area and planted vegetation. According to the asset manager, meadow has been planted on-site instead of conventional lawn due to easier maintenance. As confirmed by the asset manager, the yard area is fitted with a few insect hotels. The site is equipped with a stormwater pool of approximately 205 m^3 according to the site plan.

6.2.1. Existing ecological values

Biodiversity impact from land occupation by LC-IMPACT method for site 2 was calculated as follow:

$$Biodiversity\ footprint\ (Site\ 2) = 51\ 000\ m^2 * 6{,}08 * 10^{-16}\frac{PDF}{m^2}$$

$$= 3{,}101 * 10^{-11} PDF \approx 0{,}031\ nPDF$$

The footprint of the site is larger than the site in Turku due to larger plant area. The green factor of the site was calculated using information from the site plan, ecological report and photos received from the property owner together with an aerial map from the city of Nurmijärvi (City of Nurmijärvi 2024). The meadow area is estimated to cover a total of 7 300 m^2 within the yard. Additionally, there is an estimated 250 m^2 of lawn on the site. The remaining yard area is assumed to be asphalt or gravel. Furthermore, approximately 102 small trees and 66 m^2 of bushes are estimated to be located on the property. The stormwater pool and insect hotels on the site were also included in the calculations.

According to the green factor calculation tool, the permeable surface area in relation to the total area of the plot is 21,5 % which is lower compared to site 1. The green factor of the site is estimated to be 0,43. The city where the site is located does not yet have any requirements for the green factor or permeability of the plot. However, this value is still lower than for example the requirement by city of Turku for logistics sites.

The site is also assessed through the calculation of land use intensity index. The traffic intensity and human population density were calculated based on traffic intensity and human population density in Nurmijärvi. The light pollution is based on the exact location of the site. Set aside area and sealing intensity were calculated based on the site plan. The values utilised in the calculation of land use intensity and biodiversity risk are presented in table 6.

Table 6. Values used in calculation of land use intensity and biodiversity risk in site 2.

Parameter	**Indicator**	**Site 1**
Atificial nesting/resting	N/A	
Traffic	Vehicles ((milj) no km)	423
	MTI ((milj) no km)	1 218
Set aside area/terrestrial habitat	Set aside area/total land use area (%)	18,05
	Intensity value	0,7
Light pollution	Artificial skybrightness (mcd/m^2)	2,89
	MTI	0,174
Sealing intensity	Imperviousness (%)	0,79
Human population density	Human population density (persons/km^2)	123,7
	MTI	3 144,4

The urban land use intensity index for site 2 (s2) is calculated as follows:

$$LUI_{Urban\ (s2)} = \frac{\left(\sum_{i=1}^{n} \frac{LP(s2)}{LP(MTI)} + \frac{Se(s2)}{Se(MTI)} + \frac{Pop(s2)}{Pop(MTI)} + \frac{T(s2)}{T(MTI)} + \frac{Set\ aside(s2)}{Total\ area(s2)}\right)}{n}$$

$$LUI_{Urban\ (s2)} = \frac{\left(0{,}17 + 0{,}79 + \frac{123{,}7}{3144{,}4} + \frac{423}{1218} + 0{,}7\right)}{5}$$

$$LUI_{Urban\ (s2)} = \frac{(0{,}17 + 0{,}79 + 0{,}04 + 0{,}35 + 0{,}7)}{5} = 0{,}408 \approx 0{,}41$$

Local urban biodiversity risk is then calculated from land use intensity:

$$BR\_locLUI_{Urban\ (s2)} = -54{,}133 * LUI^2 + 119{,}07 * LUI - 14{,}51$$

$$BR_{locLUI\ Urban\ (s2)} = -54{,}133 * 0{,}408^2 + 119{,}07 * 0{,}408 - 14{,}51 = 25{,}028 \approx 25{,}0$$

The urban biodiversity risk for site 2 is then 25,0.

6.3. Site 3 – Property description

Site 3 is a logistics property located in Southern Finland, in Kerava. The building is constructed in 2020 and it includes a distribution centre part and a cross-dock centre part. The gross floor area of the building is approximately 18 000 m^2 and the plot area is around 42 000 m^2. The site is zoned as a technical maintenance area. The surroundings are mainly industrial properties and residential areas with few buffer green areas. The property is not located on a groundwater area. (City of Kerava 2024a.) The yard area is mostly covered with asphalt and only limited green features are present. The property utilises geothermal heat. The roof is equipped for solar panels but there are no panels yet.

6.3.1. Existing ecological values

Biodiversity impact from land occupation by LC-IMPACT method for site 3 was calculated as follow:

$$Biodiversity\ footprint\ (Site\ 3) = 42\ 000\ \ m^2 * 6{,}08 * 10^{-16}\frac{PDF}{m^2}$$
$$= 2{,}5536 * 10^{-11} PDF \approx 0{,}026\ nPDF$$

The footprint of the site is around the average footprint of a logistical site located in Finland, as calculated in chapter 5. The green factor for site 3 was calculated based on the information provided in site plan and photographs provided by the property owner as well as aerial photos sourced from the city of Kerava (City of Kerava 2024a). Lawn area was estimated to be 764 m^2. Gravel was estimated to cover around 2 500 m^2 from the yard area. Additionally, around 200 bushes and small trees were assumed to locate on the site. No separate stormwater management structures were identified.

According to the green factor calculation tool, the permeable surface area in relation to the total area of the plot is 8,24 % which is substantially lower compared to site 1 and 2. The values are calculated based on property's site plan. The green factor of the property is estimated to be 0,12. The City of Kerava, where the asset is located, does not currently have any requirements for green factor for properties but in a new building regulation is coming in 2025 and according to the proposal, in the future at least 30% of the property's area should be planted and permeable surface material (Keravan kaupunki 2024). Since this plot only have 8 % of permeable surface, it would not fulfil this requirement.

The land use intensity index was calculated based on the traffic intensity and human population density in Kerava. The light pollution is based on the exact location of the site. Set aside area and sealing intensity were calculated based on the site plan. The values used in the calculation of land use intensity and biodiversity risk are presented in table 7.

Table 7. Values used in calculation of land use intensity and biodiversity risk in site 3.

Parameter	**Indicator**	**Site 1**
Atificial nesting/resting	N/A	
Traffic	Vehicles ((milj) no km)	176
	MTI ((milj) no km)	1 218
Set aside area/terrestrial habitat	Set aside area/total land use area (%)	1,82
	Intensity value	1,0
Light pollution	Artificial skybrightness (mcd/m^2)	6,39
	MTI	0,174
Sealing intensity	Imperviousness (%)	0,92
Human population density	Human population density (persons/km^2)	1 245,5
	MTI	3 144,4

The urban land use intensity index for site 3 (s3) is calculated as follows:

$$LUI_{Urban\ (s3)} = \frac{\left(\sum_{i=1}^{n} \frac{LP(s3)}{LP(MTI)} + \frac{Se(s3)}{Se(MTI)} + \frac{Pop(s3)}{Pop(MTI)} + \frac{T(s3)}{T(MTI)} + \frac{Set\ aside(s3)}{Total\ area(s3)}\right)}{n}$$

$$LUI_{Urban\ (s3)} = \frac{\left(0{,}37 + 0{,}92 + \frac{1247{,}5}{3144{,}4} + \frac{176}{1218} + 1{,}0\right)}{5}$$

$$LUI_{Urban\ (s3)} = \frac{(0{,}37 + 0{,}92 + 0{,}40 + 0{,}14 + 1{,}0)}{5} = 0{,}565 \approx 0{,}57$$

The intensity of light pollution is 1,0 since the intensity value calculated is higher than 1 and 1,0 is the maximum value for intensity. Local urban biodiversity risk is then calculated from land use intensity:

$$BR\_locLUI_{Urban\,(s3)} = -54{,}133 * LUI^2 + 119{,}07 * LUI - 14{,}51$$

$$BR_{locLUI\,Urban\,(s3)} = -54{,}133 * 0{,}565^2 + 119{,}07 * 0{,}565 - 14{,}51 = 35{,}496 \approx 35{,}5$$

The urban biodiversity risk for site 3 is then 35,5. This is significantly higher value compared to sites 1 and 2. Th is means that the critical biodiversity in the area has a higher likelihood of being lost compared to sites 1 and 2.

6.4. Summary of calculations for sites 1, 2 and 3

The biodiversity impact of the sites was evaluated by calculating the biodiversity footprint through terrestrial land occupation as well as by green factor and biodiversity risk calculation. Table 8 summarises the results of the calculations for sites 1, 2 and 3.

Table 8. Summary of calculated biodiversity footprint, green factor, land use intensity index and biodiversity risk for site 1, 2 and 3.

	Site 1	**Site 2**	**Site 3**
Biodiversity footprint (nPDF)	**0,029**	**0,031**	**0,026**
Green factor	**1,4**	**0,43**	**0,12**
Traffic	0,23	0,35	0,14
Set aside area/terrestrial habitat	0,60	0,70	1,00
Light pollution	0,30	0,17	0,37
Sealing intensity	0,62	0,79	0,92
Human population density	0,26	0,04	0,40
Land use intensity index (urban)	**0,40**	**0,41**	**0,57**
Local biodiversity risk	**24,6**	**25,0**	**35,5**

As the table 8 presents, site 2 has the largest impact on biodiversity measured by biodiversity footprint of land occupation. This is due to significantly higher plot size compared to sites 1 and 3. Site 3 has the lowest green factor due to limited green elements in the plot area. The green factor for site 1 was compliant for the recommendation of City of Turku where the site is located. Even though cities, where sites 2 and 3 are located, do not require certain level of green factor, the green factor of these sites could be improved since the green factor is lower than the recommendation made by City of Turku for example. The green factor of the site can be improved by increasing the planted areas as well as improving the stormwater management systems.

For land use intensity index and local biodiversity risk, site 3 has clearly larger intensity and risk value. This results from limited set-aside areas and high sealing intensity. Additionally, the site is located in a city with higher population density as well as higher light pollution level. Sites 1 and 2 are quite on a same level with land use intensity and biodiversity risk. Even if site 1 has significantly more various green elements on site, site 2 benefits from low human population density of the city and low light pollution level. The property owner cannot influence on the area's population density or traffic intensity, but the property owner can decrease the sealing intensity and increase the proportion of set-aside areas on the site and thereby reduce the local biodiversity risk.

As can be summarised, site 2 has the largest negative impact on biodiversity, but site 3 has the least green elements and elements that support biodiversity. Therefore, site 3 should be considered the most regarding biodiversity improvements due to high biodiversity risk and low green factor by increasing the amount of set-aside areas and biodiversity supportive elements as seen with for example site 1.

7 Enhancing local biodiversity

In this section, some strategies to improve biodiversity in logistics sites is presented. The strategies were found from the conservation evidence database. The search resulted to 90 actions in total. When observing only actions that are classified as beneficial or most likely to be beneficial, the search was left with nine actions from the first search, four from the second and 28 from the third search. From this, only one action was found from all searches and three actions from two searches. The filters used and number of actions found is summarised in table 9.

Table 9. Summary of the three separate searches in Conservation Evidence database. (Conservation Evidence 2024c.)

	Filters	**Results**	**Number of beneficial actions**
Search 1	• Country: Finland • Habitat: Articifial	22	9
Search 2	• Country: Finland • Keyword: Urban	9	4
Search 3	• Keyword: Urban • Habitat: Articifial • Category: Only relevant categories for case properties selected	90	28
Total			36

In total there were 36 actions that could fit to logistics properties in the case study and be beneficial or most likely to be beneficial. The actions found are presented in table 10.

Table 10. Results of the three independent searches in Conservation Evidence database. (Conservation Evidence 2024c.)

*Includes studies conducted in Finland.

	Action	**Effectiveness**	**Number of studies**	**Category**	**Search number**
1	Install barrier fencing and underpasses along roads	Beneficial	55	Terrestrial mammal conservation	3
2	Install overpasses as road/railway crossing structures for bats	Likely to be beneficial	4	Bat conservation	3
3	Install rope bridges between canopies	Beneficial	10	Terrestrial mammal conservation	3
4	Install signage to warn motorists about wildlife presence	Likely to be beneficial	6	Terrestrial mammal conservation	3
5	Install tunnels/culverts/underpass under roads	Likely to be beneficial	25	Terrestrial mammal conservation	3
6	Keep cats indoors or in outside runs to reduce predation of wild mammals	Likely to be beneficial	1	Terrestrial mammal conservation	3
7	Leave headlands in fields unsprayed (conservation headlands)	Beneficial	57*	Farmland conservation	1
8	Leave overwinter stubbles	Likely to be beneficial	20*	Farmland conservation	1
9	Maintain bat roosts in road/railway bridges and culverts	Likely to be beneficial	2	Bat conservation	3
10	Maintain species-rich, semi-natural grassland	Likely to be beneficial	22*	Farmland conservation	1
11	Manage vegetation using livestock grazing	Likely to be beneficial	6	Terrestrial mammal conservation	3
12	Plant grass buffer strips/margins around arable or pasture fields	Beneficial	69*	Farmland conservation	1
13	Plant nectar flower mixture/wildflower strips	Beneficial	104	Farmland conservation	3
14	Prevent mammals accessing potential wildlife food sources or denning sites to reduce nuisance	Likely to be beneficial	2	Terrestrial mammal conservation	3

	behaviour and human wildlife conflict				
15	Provide artificial dens or nest boxes on trees	Beneficial	30	Terrestrial mammal conservation	3
16	Provide artificial nesting sites for falcons	Beneficial	22*	Bird conservation	2, 3
17	Provide artificial nesting sites for owls	Beneficial	18*	Bird conservation	2, 3
18	Provide artificial nesting sites for raptors	Likely to be beneficial	9	Bird conservation	3
19	Provide bat boxes for roosting bats	Likely to be beneficial	44	Bat conservation	3
20	Provide education programmes to improve behaviour towards mammals and reduce threats	Likely to be beneficial	2	Terrestrial mammal conservation	3
21	Provide or retain set-aside areas in farmland	Beneficial	54*	Farmland conservation	1
22	Provide supplementary food for birds or mammals	Likely to be beneficial	25*	Farmland conservation	1
23	Provide supplementary food for songbirds to increase reproductive success	Likely to be beneficial	37*	Bird conservation	2, 3
24	Reduce fertilizer, pesticide, or herbicide use generally	Beneficial	47*	Farmland conservation	1
25	Release captive-bred individuals to re-establish or boost populations in native range	Beneficial	31	Terrestrial mammal conservation	3
26	Release translocated mammals into fenced areas	Beneficial	24	Terrestrial mammal conservation	3
27	Remove vegetation by hand/machine	Likely to be beneficial	20	Terrestrial mammal conservation	3
28	Restore/create species-rich, semi-natural grassland	Beneficial	71*	Farmland conservation	1
29	Retain existing bat roosts and access points within developments	Likely to be beneficial	3	Bat conservation	3
30	Scare or otherwise deter mammals from human-occupied areas to reduce human-wildlife conflicts	Likely to be beneficial	10	Terrestrial mammal conservation	3

31	Translocate raptors	Beneficial	7	Bird conservation	3
32	Translocate to re-establish or boost populations in native range	Beneficial	64	Terrestrial mammal conservation	3
33	Undersow spring cereals, with clover for example	Likely to be beneficial	18*	Farmland conservation	1, 2, 3
34	Use collar-mounted devices to reduce predation by domestic animals	Beneficial	5	Terrestrial mammal conservation	3
35	Use holding pens at release site prior to release of translocated mammals	Likely to be beneficial	35	Terrestrial mammal conservation	3
36	Use vaccination programme	Beneficial	7	Terrestrial mammal conservation	3

The table presents actions that can be taken to conserve biodiversity in artificial habitats and in urban environment in Finland. The actions are categorized by their effectiveness, the number of studies that support their effectiveness, the category of conservation they contribute to, and in which search were the action listed in the database.

In total, there are 21 categories available in the first 2 searches and 9 categories in third search for the actions based on the habitat the actions are affecting to (Conservation Evidence 2024c). As we can see from the results, the actions fall on to only four categories: farmland conservation, terrestrial mammal conservation, bat conservation, and bird conservation. This may be mostly due to the limitations to urban and artificial habitats. Other reason may be that there is not enough evidence to make conclusions on the beneficially of the actions. Overall, these actions presented in Table 10 could be beneficial for biodiversity conservation in logistics properties presented in the case study. It is important to consider that actions that could fit for biodiversity conservation in logistics property may be excluded from the results due to the limited search and definition of application criteria. The suitability of the actions into the case sites are examined in chapter 8.

8 Assessing the Suitability of Biodiversity Measures to Case Sites

Considering the biodiversity enhancing actions presented earlier in section 4, multiple actions could support biodiversity also on the presented case sites. In this section, the possible implementation of these actions into case sites 1, 2 and 3 is examined. All actions found in chapter 7 are not observed. Actions that would be most suitable for the case sites are only examined in more detail. The suitability of the actions is considered based on the nature and location of the case sites as well as the threat of species possibly present in the locations. Also, the ease of the implementation of the actions was also considered from the point of view of the property owners.

Restoring and creating species-rich, semi-natural grassland would be most likely a suitable action for logistics sites. According to the 2019 Red List of Finnish Species the number of traditional biotopes, including open fields, heaths, and various fresh and moist meadows as well as heathlands and leafy meadows, has decreased during the 20th century more than 99% and the quality has significantly weakened. All traditional biotopes in Finland are classified to be endangered or critically endangered. (Hyvärinen et al. 2019, 90.) Therefore, it would be worth considering either establishing a meadow area on the plot or, alternatively, a green roof.

Most of the presented logistical sites have large plot areas that could be suitable to fit a small meadow. Site 3 is the only site not having solar panels on the roof so a conventional green roof could be considered there. In logistics buildings, dry meadow or moss-lichen cover is the least maintenance-intensive and lightest green roof solution. Dry meadow green roof or meadow area on the plot could support endangered traditional biotopes and additionally reduce the risk of flooding and provide aesthetic pleasure. (Klemola 2013, 33.)

Although all the other case properties already have solar panels on the roof, it would still be feasible to install green roofs. Contrary to general belief, a green roof can also be installed on the roof together with solar panels on racks. These solutions are not mutually exclusive, but rather complement each other. The green roof cools the surface while improving the efficiency of the solar panels. The output of solar panels often decreases as the temperature increases. Therefore, the cooler their temperature is, the better. By comparing neighbouring buildings, the green roof was found to keep the temperature of the roof and its structures even significantly cooler in warm weather than a traditional roof. It has been shown that a green roof can increase the efficiency and energy production of a traditional rooftop solar panel system. According to one study, a green roof increased the long-term yield of solar panels by 3,6 % on average. (Irga et al. 2021, 76.)

Green areas on sites could be enhanced by planting nectar flower mixture or wildflowers. The flower plantings provide resources for bees and other pollinators. Increased insect populations may attract more birds to the area by increased food sources. Planting flower strips to sites are widely examined topic with numerous beneficial results. The effectiveness of the action is classified to 100 % in Conservation Evidence database, which means that the action has resulted completely effective, and it has consistently produced the desired results in every studied reviewed (104 studies) without any significant failures. Thus, by improving existing and possible future green areas with flowers, the area's biodiversity could most likely be effectively improved. Increasing the proportion of set-aside areas would have a positive impact on previously calculated green factor values as well as land use intensity and biodiversity risk values.

Site 1 is located next to a main road with heavy traffic and high speeds. Currently, there is no barrier or fence along the road. Therefore, it might be justified to install a barrier or a fence in the plot area between the building and the main road. Sites 2 and 3 already have a fencing around the plot so the action is not relevant in those sites. According to Conservation Evidence database and the study results, installing roadside barrier or fencing together with underpasses, reduced collision between mammals and vehicles. This promotes biodiversity together with road safety. The studies focused especially on the cumulative benefit of installing both, the fencing, and the underpass. The impact of fencing alone has not been examined that much. Nevertheless, one study, conducted in Portugal, found that fences are generally more effective than passages in reducing collision between wildlife and vehicles thus maintaining animal populations. According to that study, partial fencing of the road can be almost as effective as full fencing in reducing collision. (Ascensão et al. 2013, 36.) However, the separate effect of fencing and passages has not been studied in Finland. Research is needed since building owners cannot influence on road passages. Installing road passages for mammals should be done during the construction of new roads. Therefore, building owners can only consider fencing their plots.

Providing artificial nesting for falcons in the site could enhance local biodiversity by supporting existing falcon populations and by offering natural pest control by reducing rodent numbers. In Finland, from falcons, only Eurasian hobbies and kestrels are observed in southern Finland. Both species have currently a vital population. However, this measure could also be extended to other raptors. According to the 2019 Red List of Finnish Species, especially the golden eagle has benefited from conservation work. At the moment, for example, the pallid harrier is classified as highly endangered, so its protection measures could also be justified in case sites, as observations of the bird in question have been made in all these areas. (Hyvärinen et al. 2019.) In practice this artificial nesting could mean shelters that can be either small, medium, or large. Boxes that are protected from the prevailing weather are more likely to be occupied compared to boxes that are more exposed to the weather. Installed nests should preferably locate further away from forest edges, roads, and inhabited houses, and closer to grassy ditches. (Conservation Evidence 2024c.)

A study conducted in Finland concluded that the nests are more successful in the absence of larger owls. As stated in some of the studies, smaller nests are more occupied but on the other aspects of the design are not that important. According to information provided by Laji.fi, from owls, mainly six different owl species have been observed within 5 km in all case sites (Laji.fi 2024). From these, eagle owl, Eurasian pygmy owl, and boreal owl are either near threatened, vulnerable or endangered (Hyvärinen et al. 2019, 565). Eagle owl thrives also in more urban environment, but Eurasian pygmy owls and boreal owl live only in forested environments (NatureGate 2024). Therefore, it would be justified to add artificial nests for eagle owls in sites 1, 2 and 3. A competent ecologists would be needed when considering the installation of artificial nesting sites.

Related to the actions of providing artificial nests to various bird species, mammals could also be protected with the help of artificial nests either by artificial dens or nest boxes on trees. This action has been studied across the world in 30 studies and it has resulted to be 65 % effective. As confirmed in the Red List of Finnish Species, the natterer's bat, nathusius's pipistrelle, and the European polecat are species of traditional biotopes and built environments that are endangered or vulnerable (Hyvärinen et al. 2019, 576). According to the findings in Laji.fi, European polecat have been observed in each case properties. Only 1-5 Natterer's bat individuals were observed within 3 kilometres from the case site. Only site 3 should focus on also conserving nathisiu's pipistrelle, since site 1 did not have any observations near and site 2 had only 1 observation. Site 3 had 25 individuals observed within 3 km from the site. (Laji.fi 2024.) It would therefore be justified to create suitable nesting places for at least nathisiu's pipistrelles in site 3. Nesting places for European pole-cats would be needed but logistics properties may not be the best location for nesting sites due to vehicle manoeuvring. Also in this case, a competent ecologists should evaluate the suitability of the nesting sites further.

The action "Provide bat boxes for roosting bats" goes together with providing nesting sites for mammals. In addition to bats presented before, there are a few other bat species lives in Finland such as whiskered bat and northern bat. However, nathisiu's pipistrelle and nat-terer's bat are the only bat species that are endangered or vulnerable. Therefore, the recom-mendations presented in the action of creating nesting sites for mammals aligns with this action as well. Providing artificial nesting sites for bats, birds and mammals would all impact positively on previously calculated green factor of the site.

The action of retaining existing bat roots and access points within developments should be considered especially in site 3 in case of refurbishment work since bats are observed near the property area. This action means that during demolition work it's important to avoid destroying hiding and foraging areas crucial for bats. These areas should be identified through surveys during project planning. Preserving hollow trees is essential for bats, as well as for many other species. Additional bat boxes can be installed to provide resting places for the species. (Finnish Environment Institute 2022.)

Providing supplementary food for mammals or birds have been studied to be 90 % effective action to support biodiversity. The studies collectively indicate that supplementary food pro-vision generally increased certain metrics of farmland bird abundance, breeding success, and overwinter survival, though the effects varied by species, region, and other factors. Addi-tionally, some studies found no clear benefits or even negative effects on specific aspects such as breeding abundance or fledging rates, highlighting the complexity of responses to supplementary feeding. Supplemental feeding is likely to have a positive effect on the pop-ulation if food availability limits either survival or reproduction.

Providing extra food can be advantageous for birds during winter, particularly in regions with severe winters (Jokimäki et al. 2016). Feeding birds during winter helps many winter-ing birds survive until spring. For example, great tit, Eurasian blue tit and Eurasian tree sparrow have increased over the past decades, partly due to winter feeding. Vulnerable white-backed woodpecker, which has been observed within 3 km from all case sites, would also benefit for supplemental feeding. (Birdlife Finland 2024, Laji.fi 2024.) During winter bird feeding, it's crucial to support species that are threatened while being mindful not to disproportionately benefit those that are thriving due to human activities (Haapasalo, 2022.)

Even if it is beneficial for biodiversity to provide artificial nesting sites for birds, bats and mammals, the implementation of these actions should be carefully considered. In logistics sites there are a lot of vehicles manoeuvring which can cause collision between vehicles and mammals. The tenants of the property do not necessarily want unwanted animals to breed on the property, as they can get into the interior of the building and thereby damage, for example, assets stored in the property. The placement of possible artificial nesting sites and organisation of supplementary feeding should be carefully considered in case of implementation.

The food provided can bait varmints that spread diseases such as rats and mice, or other animals that can damage the building such as squirrels (City of Helsinki 2024). When providing extra food for mammals, the feeding must be well planned. For example, the city of Vantaa, the neighbouring city of site 2 and 3, recommends feeding birds and hedgehogs only together with systematic controlling of rats and mice. (City of Vantaa 2024.) Feeding mammals might be more beneficial to be perform outside of densely populated areas. Feeding of game helps the animals to survive through winter. By placing feeding stations strategically, it can also minimize damage to agriculture, forestry, and reduce collision with vehicles. Hunters typically feed small deer, hares, and partridges (Suomen riistakeskus 2024).

Mammals in urban and residential areas can conflict with humans in various ways, such as digging through garbage, damaging gardens, spreading diseases, showing aggression, or causing traffic hazards. Communities often feel the need to tackle these problems by preventing mammals from entering these spaces. Successful non-lethal solutions could minimize the need for lethal control of these species. (Conservation Evidence 2024c.) According to a study conducted in Turku, were site 1 is located, a red fox has been the most observed medium-sized carnivore in the urban area. Also, raccoon dogs and badgers were reported as seen in the urban area. All three species were observed in gardens. Red foxes and raccoon dogs were also often observed in the roads. Badgers were mostly encountered in forests.

These carnivores spread to urban area possibly due to abundance of food sources. (Kauhala et al. 2015, 25, 30-31.)

The city of Kerava, where site 3 is located, informs residents to prevent rats in properties by organising the waste management so that rats or other animals cannot get into the waste container or composter containing biowaste. Additionally, the city guides to stop supplemental feeding of birds in case of rats in the property and recommends to never feed the birds directly from the ground. (City of Kerava 2024b.) The neighbouring city Vantaa recommends not to feed mountain goats to avoid collision with vehicles and damage to gardens. This is valuable information also related to the action of providing supplementary food for birds or mammals in all case sites.

In total, 11 actions could be implemented for the case sites based on the search in Conservation Evidence. These actions are beneficial, or likely to be beneficial and should not cause major harm to the nature according to the rating matrix. These results can be trusted since the actions are based on various studies which are further evaluated by the panel of experts of Conservation Evidence. However, it must be noted that some of these actions did not include any research made in Finland. Thus, the research conclusions of the actions are considered from studies conducted in various places and nature types. Therefore, it can be assumed that the actions could be beneficial conducted in Finland as well. The actions proposed for implementation to the case sites are presented in table 11.

Table 11. Summary of identified actions to support biodiversity on case sites. (Conservation Evidence 2024c.)

	Action	Number of studies	Effective-ness	Certainty	Harms	Implementa-tion site
1	Install barrier fencing and underpasses along roads	55	72 %	70 %	0 %	1
2	Plant nectar flower mix-ture/wildflower strips	104	100 %	75 %	N/A	All
3	Provide artificial dens or nest boxes on trees	30	65 %	70 %	0 %	3
4	Provide artificial nesting sites for falcons	22	65 %	65 %	0 %	All
5	Provide artificial nesting sites for owls	18	65 %	66 %	5 %	All
6	Provide bat boxes for roosting bats	44	70 %	60 %	0 %	3
7	Provide supplementary food for birds or mam-mals	25	90 %	50 %	N/A	All
8	Provide supplementary food for songbirds to in-crease reproductive suc-cess	37	51 %	85 %	6 %	All
9	Restore/create species-rich, semi-natural grass-land	71	100 %	73 %	N/A	All
10	Retain existing bat roosts and access points within developments	3	77 %	60 %	0 %	3
11	Scare or otherwise deter mammals from human-occupied areas to reduce human-wildlife conflicts	10	50 %	70 %	0 %	All

As presented in table 11, in total 11 different actions could be considered as suitable to implement on the case sites 1, 2 or 3. The actions found included mostly actions related to terrestrial mammal conservation, bird conservation or farmland conservation. The actions 3, 4, 5 and 6 are similar actions for providing nesting sites to birds and mammals. Actions 7 and 8 are supportive actions for actions 3, 4, 5 and 6 but can be also conducted individually.

Even if all sites, especially site 1, are located close to nature, it is important to support biodiversity also on-site. Integrating ecological elements into the sites helps reducing habitat fragmentation and facilitates species movement within the area. These elements can serve as ecological corridors, enhancing connectivity. Additionally, they support local ecosystem services such as pollination and water filtration. (Environment.fi 2024.) Green roofs and plantings contribute by binding carbon dioxide and mitigating the heat island effect, thereby supporting biodiversity through climate change mitigation (Irga et al. 2021, 3).

Most of the actions presented in table 11 could be considered as low-threshold actions. The most demanding action to implement to the case sites would probably be creating species-rich, semi-natural grassland or installing fences alongside roads. It has to be noted that the beneficiality of farmland conservation actions are examined mostly in farmland habitats. Also, no costs of the actions were considered. This case study was conducted with limited data from the case sites. However, the actions could be beneficial also in the habitat of case sites, but more detailed research related to suitability of the actions should be conducted in case of implementation. An ecologist or other qualified expert is recommended to develop a more precise plan in case of installing any artificial nesting boxes and feeding stations or when conducting other recommended measures.

9 Economic benefits of improving biodiversity on-site

This section presents the findings from interviews related to economic benefits of improving biodiversity on-site. The aim of the interviews was to examine the possible benefits of improving biodiversity on-site and if they can be turned into economic value. The interviews explored motivation and mindsets towards biodiversity improvements, with a focus on examining the experience of real estate owners and investors related to the benefits of improving biodiversity on-site. First the experience on conducted biodiversity improvements are presented. Then the possible economic benefit is examined through identified challenges and benefits and the motivation behind the conducted actions. Finally, the conclusions are made from the interviews.

9.1. Actions taken by the companies

Companies 1 and 2 had done more actions related to biodiversity improvement. Company 3 had only conducted limited biodiversity actions, and company 4 had conducted no actions on biodiversity. Company 1 has focused on careful site selection and on effective stormwater management. They explored pollinator-friendly initiatives such as placing flower meadows on logistics sites. Company 1 has also considered leaving ecological corridors in yard areas and also even ecological compensation in a construction project but has yet not conducted these.

Company 2 clearly has the most experience in biodiversity-enhancing activities among these four companies. Company 2 is currently conducting ecological compensation in an ongoing construction project. The new logistics property is also getting an extensive stormwater treatment system where stormwater is filtered even down to microplastics. They are continuously focusing on energy efficiency and adaptability on their properties. The company also highlights that the site location as well as its altitude is well considered when selecting the site. These actions will mitigate climate change and therefore indirectly help preventing biodiversity loss. The interviewee declares that a biodiversity roadmap is being developed.

Company 3 and company 4 had limited experience on biodiversity actions on-site. Company 3 addressed that the focus on sustainability sector is improve collection of consumption data. They had only one site were the stakeholder group received instructions to increase biodiversity by leaving the grassy meadow as a meadow and adding an insect hotel there. The sign shared information about the topic. Company 4 had no experience on biodiversity actions. They are more focused on energy efficiency and producing renewable energy on-site.

9.2. Source of motivation

As a motivation, companies highlight various aspects. All the companies addressed the importance of stakeholder requirements and adapting to the market would act or already acts as a motivation to do actions related to biodiversity improvement. In addition to the requirements set by law, stakeholders, and the market, companies 1 and 2 are aiming to be beyond compliance and through that be more future proof. Company 1 highlighted that sustainable values are deeply ingrained in the organisation.

Expert 1 noted that the driver is not necessarily mitigating biodiversity loss but adapting to the market. They state that the primary motivation is to avoid negative consequences, such as poor value development if no action is taken. They highlight that for instance, certifications and proof of sustainable activities have now become baseline requirements rather than value enhancer.

Company 2 finds improving biodiversity as an opportunity rather than an obligation. According to the expert, their tendency is not to wait until they must act, but rather to be a pioneer and learn from experience. The expert believes that currently voluntary actions may well become mandatory in the future, for example ecological compensation. Therefore, pioneering increases future proofness.

9.3. Identified challenges

The interviewees brought out various challenges regarding to biodiversity improvements on-site. The challenges include lack of awareness and knowledge on possible solutions, investment justification and lack of clear benchmarks and metrics. Additionally, for many businesses, real estate is not their primary focus, and the majority of their biodiversity impact consists of activities other than their real estate holdings.

Company 1 highlighted that the actual implementation of the measures is challenging in practice despite the awareness of the problem. Company 2 also finds the implementation challenging but is aware that pioneering requires experimentation and success in new initiatives often involves trials and errors. According to company 3, indirect benefits and lack of clear benchmarks and metrics for biodiversity are the main barriers since it is difficult to justify investments for investors without these. Company 4 also find justifying of costs difficult. They also lack awareness and targets regarding to the topic.

9.4. Identified benefits

Despite the challenges, various benefits were found. The benefits included not only benefits directly from biodiversity improvements on-site, rather more benefits in general from sustainable actions. Benefits included a range of reputational and operational advantages. Company 1 highlights cost savings from energy efficiency, avoiding penalties, maintaining property value, staying competitive, futureproofing, and reducing maintenance costs by preserving natural areas. Company 2 focuses on gaining experience for future projects, meeting potential business, or financing needs, creating a positive image for investors and customers, positive public relations, maintaining property value, avoiding reputational risks, and appealing to responsible employees and applicants. Company 3 emphasizes positive public relations, raising awareness, potential mental well-being benefits for area users, maintenance cost savings by preserving natural areas, and meeting investor criteria when selling properties. Company 4 notes the importance of responding to customer demands.

Expert 2 has observed that employees are eager to promote sustainability, which is evident in their recruitment process. According to the expert, more often, especially young jobseekers consider the employer's sustainability values important. Beyond workforce, these sustainable actions also enhance the company image among investors and customers. Even if these benefits are more connected to sustainable actions in general, biodiversity improvements can promote a company's reputation and bring the company closer to stakeholder requirements, in the same way as other types of sustainable actions.

9.5. Other emerged issues

Company 1 has been proactive in implementing responsibility measures ahead of requirements, with a focus on emission reduction, reporting, and certifications, primarily driven by financial cost optimization. Company 2 acknowledges that while considering sustainability in construction projects may be slightly more expensive, investments in energy efficiency solutions are beneficial in the long term. Company 3 faces a lack of stakeholder pressure, leading to a free rider problem where individual efforts are ineffective without collective action. According to expert 3, certifications should emphasize biodiversity actions more, or such actions should be demanded by investors. Company 4 notes that perspectives on sustainability may vary depending on whether one is a real estate investor or a real estate owner with no intention of leasing or reselling in the near future.

9.6. Conclusions and summary of the interviews

The companies' attitudes, knowledge and experience related to the subject varied greatly. According to company profiles, the perspective on the subject is different; A real estate management company is a background player who prioritise the appearance of properties compared to others, but the company's brand itself is not that important. In contrast to listed companies or those targeting consumers, focus on maintaining their brand and major damage to reputation must be avoided. The contrast in attitudes is large as one company is actively working on a biodiversity roadmap with ambitious goals, while the other company either does not consider biodiversity important or lacks knowledge and implementation in their operations. Companies setting ambitious targets for biodiversity actions tended to find more benefits on improving biodiversity, whereas others saw limited or no benefits and questioned the need for such efforts. Additionally, many experts pointed out that real estate is only a small part of their business, so the impact of the real estate is minor and therefore only limited actions have been conducted. To conclude, company 1 and 4 are clearly taking proactive steps beyond regulatory requirements or market demand, company 4 focusing mainly on energy-efficiency and carbon neutrality and company 1 also considering biodiversity. Company 2 clearly integrates sustainability and biodiversity into its broader strategy seeing it as a business opportunity while company 3 primarily focuses on meeting regulatory demands and only responding to stakeholder requirements with limited proactive biodiversity actions.

As a summary, none of the experts could actually name economic benefits or any measurable value related to biodiversity improvements on site. Only indirect benefits were identified. Many can connect energy efficiency improvements to cost savings, but do not know any direct economic benefits of improving biodiversity on site. Rather, experts believe that the benefits of biodiversity improvements can be achieved by indirect cost savings while maintaining the market presence, meeting stakeholder demands, and avoiding significant reputational damage.

Furthermore, an expert highlighted that the company's commitment to biodiversity measures has indirect economic implications: By maintaining a positive reputation among investors and shareholders, the company's economic value is indirectly influenced. Many emphasized that sustainability issues, including biodiversity measures, are increasingly becoming a fundamental market requirement, or will soon become one. The only direct cost saving, which was mentioned by two experts, is that costs can be saved to a small extent if the yard area of the plot is left in its natural state instead of being maintained. However, this is a minor saving in relation to the total maintenance costs of the property. This lack of direct economic benefits was to be expected, as the subject in general is challenging to measure and the actions can rather reduce future risks and not directly reduce operational costs in the property.

During the interviews, it became evident that biodiversity is still an unknown topic for many. Companies are in a vastly different positions in relation to awareness of biodiversity loss. Assimilating the topic can be difficult, especially in cases where the investor does not directly benefit. Consequently, it becomes difficult to justify additional costs without measurable returns for investors. One expert pointed out that companies would probably invest more in the development of biodiversity in the future if there was a simple common measure and benchmark for it. By utilizing appropriate benchmarks and measurement units, investors would have the ability to demand specific standards for the subject property. For instance, if a certain level of biodiversity is desired, corresponding measures should be undertaken to secure funding. Another expert also pointed out that although there may not be direct economic benefits at the moment, the situation may change very quickly when these issues become requirements for business operations or are mandatory for obtaining funding.

10 Discussion

The study included multiple research methods. This is mainly because biodiversity as a topic is relatively new topic in real estate. Only limited research is conducted specifically to fit in real estate management. There is a lack of unified, all-encompassing method for calculating current biodiversity state on sites. In general, the methods for measuring biodiversity are incomplete. Thus, also research of economic perspective of biodiversity is limited. This study included many different research methods to combine these existing incomplete methods and to get the best possible answer to the research questions. This section provides a more in-depth discussion of some limitations and identified challenges.

None of the conducted calculations are all-encompassing assessments of the current state of the property's biodiversity. Therefore, it was reasonable to conduct several calculations to determine the site’s current impact on biodiversity.

The biodiversity footprint for the logistics assets were simplified in this study due to limited resources as well as limited data. The biodiversity footprint, and the impact of land occupation on biodiversity depends on the location of the asset. If the complete biodiversity footprint of the assets was calculated, many other parameters would impact on the result. With complete calculation of logistics properties biodiversity footprint, benchmark data could be created, and logistics sites could be comparable. As highlighted in the interview part of this thesis, there is a lack of measures in biodiversity of real estate. With more research, biodiversity footprint could become a measure among other calculations conducted in this study, such as biodiversity risk.

The unified biodiversity risk calculated in this thesis is relatively new method and has not yet been widely implemented. Currently, the results are comparable between the case properties, but a broader comparison to other properties cannot be conducted. The result can be considered reliable, because the reference values for the calculation were searched using the same methods, although the benchmark values for intensities needed to be determined to be suitable for Finland.

The standard deviation could not be utilized when calculating the reference values. Additionally, all parameters are equally weighted in the calculation because the relative importance of each metric is unknown, and one parameter is excluded due to the lack of a suitable metric. Despite this, the calculation incorporates various factors affecting biodiversity, providing a valuable comparative perspective on the current biodiversity impact of the property. The result can be considered reliable, because the reference values for the calculation were searched using the same methods, although the benchmark values for intensities needed to be determined to be suitable for Finland.

In the future, the method could be enhanced by incorporating additional parameters and assigning weights to more critical factors. To achieve this, it is essential to determine which categories are most relevant for maintaining biodiversity. For instance, it should be investigated whether human population density is as significant as designated set-aside areas when assessing the risk of biodiversity loss. The current parameters, such as traffic and light pollution, fits well for urban properties, and property-specific factors, such as sealing intensity, make different properties more comparable and highlight the varying risks within the same areas. In the future, the method could be further developed or adopted more broadly. Additionally, the calculation could be designed to account for the unique characteristics of different property types. In the future, this method would possibly suit for benchmarking the assets as well.

The actions found feasible on this research are likely to be limited. This thesis did not consider all the actions presented as beneficial in Conservation Evidence database, instead some filtering was made due to limited resources for this study. The database might not include all the possible actions that could improve biodiversity. Additionally, some actions presented in Conservation Evidence might be filtered out in this thesis due to lack of evidence, even if the action would probably be beneficial. This is because the database categorises actions as "unknown effectiveness" if the action does not have enough evidence and research yet.

With more research, more actions can be found in the future. The research could be applied in the future to different property types in different environments. Additionally, biodiversity actions could be searched for either in a more widely used database or alternatively from other sources or by other methods. With the development of biodiversity calculation tools and methods, it would be possible to make a more accurate assessment of the properties impacts on biodiversity. Furthermore, by utilising different methods for searching the actions, more suitable actions could be found.

The implementation of the actions in the case study was considered with limited data from the case sites. Thus, there is no guarantee that these actions found on this study will be suitable for the selected case sites. To integrate found actions to the case sites, more detailed research related to the suitability of the actions should be conducted. With access to full property data, the suitability of the actions could be examined in more detail. Additionally, actions such as providing supplementary food for species can be controversial. The action may be beneficial for biodiversity but may not necessarily appeal to property users. More research could be done in the future to examine the best practices to support local species without disrupting the activities of the property users.

The research did not reveal any major economic benefits from improving biodiversity on-site. There is no clear evidence on the economic benefits of biodiversity improvements but as can be derived from the presented actions, many of the actions do not require large investments either. However, there is not enough knowledge and experience yet among the real estate operators. The sample size of the interview was limited due to finite research resource. Thus, important knowledge on the subject may have remained outside the results.

The methods utilised in this study could be taken into more detailed level if more data and more resources for the study were available. However, this study provides theoretical background as well as benchmark calculations for future studies, which could be further detailed with additional data and resources.

11 Conclusions

The aim of this thesis was to explore why biodiversity should be considered in logistics sites, how it can be evaluated and improved on-site, and the potential economic benefits for property owners from investing in biodiversity improvements on site. The topic was examined by assessing the impact of logistics sites on biodiversity, exploring the actions of biodiversity improvement as well as conducting a semi-structured interviews for four real estate experts. Research findings provided answers to the research questions and identified challenges in addressing these issues.

As a result, it was found that the land occupation of logistics sites has an impact on biodiversity. The larger the plot area, the more significant the negative impact on biodiversity is. Biodiversity risk on a logistics site can be mitigated by increasing the amount of permeable surface on the plot as well as increasing set-aside areas. Green factor of the plot can be increased by adding green elements on the plot.

As was seen from the calculations, site 3 has currently most negative impact on biodiversity whereas site 1 performed relatively well compared to sites 2 and 3. Thus, improvements proposed should primarily focus on site 3. Various beneficial actions for improving the biodiversity on-site were found. The case sites could support areas' biodiversity by increasing the size of planted area. Providing artificial nesting sites and supplementary food would be beneficial but needs to be considered carefully in case of implementation. By executing these actions, the biodiversity risk and green factor calculated in section 6 could also be improved. However, the suitability of the actions to each site needs to be examined in more detail in case of implementation.

As can be concluded from the interviews, currently there are no direct economic benefits related to improving biodiversity on-site. The companies considering biodiversity in their actions understand the benefit through creating a positive brand image for investors and customers. Minimal maintenance costs savings can also be achieved by preserving natural areas within the site. Based on the interviews, the most significant reason for not implementing measures to improve biodiversity is the lack of consistent biodiversity metrics and benchmarks.

Based on the results, it is essential to elaborate the methods for assessing the biodiversity impacts of properties. It would be important to develop metrics that allow property owners to benchmark their properties in terms of biodiversity. This would help to drive real estate operators to consider biodiversity among other sustainability issues and potentially create a competitive market advantage, leading to economic benefits for operators who incorporate biodiversity considerations into their properties.

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