THE REDUCTION OF ORGANISATION'S BIODIVERSITY FOOTPRINT WITH SUSTAINABILITY CRITERIA – A CASE STUDY IN PUBLIC PROCUREMENT

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ABSTRACT

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Abstract

Production and consumption activities of human societies have induced several global environmental problems, such as the degradation of natural ecosystems, loss of biodiversity, and climate change. Even though the international community has recognised nature as one of the most important assets for humanity, global biodiversity loss continues and threatens our well-being, health and safety, and economies, not to mention the overall sustainability transition of societies. Food consumption and agriculture significantly impact global biodiversity loss, especially due to their climate change and land use change impacts. Public organisations have a considerable potential to affect their procurements' biodiversity footprint through consumables and commodities including food.

In this thesis, I evaluated the impact of using a sustainability criterion on the biodiversity footprint of public food procurement. I assessed a case organisation, the City of Tampere and its food catering company Pirkanmaan Voimia Oy. The selected criterion aims to increase the share of plant-based main dishes of the total main dishes consumed (in kilograms) to either 30% at a basic level or 50% at a pioneer level. The results show that by adopting and implementing the sustainability criterion, the City of Tampere can lower its biodiversity footprint by 2%. Serving only plant-based protein sources could bring up to an 8% reduction in the overall biodiversity footprint of the city. The study also notes that the protein and energy content of food must be considered to maintain the nutritional values of the main dishes. Especially the main dishes containing red meat, cheese, poultry, and farmed fish were found to have high biodiversity impact intensities. Overall, this thesis provides a new understanding of sustainability criteria's potential to mitigate the environmental impacts of organisations, which can further help governmental institutions set science-based strategic targets for public procurement.

Keywords
Biodiversity footprint, biodiversity loss, food system, sustainable public food procurement, sustainability criteria

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Tiivistelmä Ihmiskunnan tuotantotavat ja kulutustottumukset ovat aiheuttaneet useita globaaleja ympäristöongelmia, kuten heikentäneet ekosysteemien tilaa sekä aiheuttaneet luontokatoa ja ilmastonmuutosta. Vaikka kansainvälinen yhteisö on tunnistanut luonnon olevan yksi ihmiskunnan tärkeimmistä pääomista, maailmanlaajuista luonnon monimuotoisuuden hupenemista eli luontokatoa ei ole saatu pysäytettyä. Luontokato uhkaa ihmisten hyvinvointia, terveyttä ja turvallisuutta, taloudellisen toiminnan ylläpitoa sekä kokonaisvaltaisen kestävyysmurroksen saavuttamista. Ruoan tuotannolla ja kulutuksella on merkittävä vaikutus globaaliin luontokatoon etenkin sen aiheuttaman ilmastonmuutoksen ja elinympäristöjen tuhoutumisen kautta. Julkisilla organisaatioilla on mahdollisuus vaikuttaa omien hankintojensa luontojalanjälkeen, eli luontohaittoihin, esimerkiksi kulutushyödykkeiden, kuten ruoan kautta. Arvioin tutkielmassa kestävyyskriteerin käytön vaikutusta julkisen organisaation luontojalanjälkeen. Tutkimuksen viitekehyksenä toimii Tampereen kaupunki ja sen ruokapalveluita tarjoava Pirkanmaan Voimia Oy. Kestävyyskriteeri tähtää syötyjen kasvispääruokakilojen kasvattamiseen joko 30 % perustasolla tai 50 % edelläkävijätasolla. Tulokset osoittavat, että Tampereen kaupunki voi vähentää kokonaisluontojalanjälkeään 2 % tekemällä kestävyyskriteerin mukaisia hankintoja, eli lisäämällä kasvisperäisiä proteiinilähteitä pääruoissa. Tarjoamalla ainoastaan kasvisperäisiä proteiinilähteitä vähennys Tampereen kaupungin luontojalanjäljessä voisi olla 8 %. Työssä kiinnitetään huomiota lisäksi siihen, että myös ruoan proteiini- ja energiapitoisuudet on syytä ottaa huomioon, jotta pääruokien ravintoarvot säilyvät suotuisina. Korkeat luontojalanjäljen intensiteettilukemat olivat erityisesti annoksilla, jotka sisältävät punaista lihaa, juustoa, kanaa sekä kasvatettua kalaa. Tutkimus tarjoaa kokonaisuudessaan uutta tietoa kestävyyskriteereiden mahdollisuuksista vähentää organisaatioiden ympäristövaikutuksia, mikä voi edelleen auttaa julkishallintoa asettamaan tietoon pohjautuvia strategisia tavoitteita julkisille hankinnoille.	
Asiasanat Luontojalanjälki, luontokato, biodiversiteetti, ruokajärjestelmä, kestävät julkiset ruokahankinnat, kestävyyskriteerit	
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CONTENTS

1 INTRODUCTION

1.1 Life on Earth is under threat

Humanity is living and consuming beyond the planetary boundaries (Hoekstra & Wiedmann, 2014; Steffen et al., 2015; O'Neill et al., 2018; Elo et al., 2023; Richardson et al., 2023), which threatens the diversity of living beings on Earth, that is biodiversity (IPBES, 2019). Biodiversity means life on Earth in its various forms, and it entails all living beings and organisms, their genetic constituents, and the habitats and ecosystems where life spurs (CBD, 2011). Biodiversity loss, however, indicates the decline of that diversity of life, which can mean either loss of species, genetic diversity, or ecosystem diversity on the planet (IPBES, 2019; Ketola et al., 2022).

The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (2023) states that more than 44,000 species are threatened with extinction, covering 28% of all assessed species globally. Approximately only about 23% of terrestrial land areas can be counted as wilderness (Watson et al., 2016). The global biomass of wild mammals has declined by 82% since prehistorical times (Bar-On et al., 2018). Concurrently, the total mammal biomass on the planet is dominated by human and domesticated animal biomass, which covers nearly 95% of the total mammal biomass, leaving only 5% coverage for wildlife mammals on the planet (Greenspoon et al., 2023). Additionally, the mass of all human-produced materials, including building materials such as concrete, steel, and asphalt, equals the mass of all living beings (Elhacham et al., 2020).

Human activities have changed the planet's ecosystems and natural processes at such a rate that scientists have suggested naming this new geological epoch as the Anthropocene (Crutzen & Stoermer, 2000; Crutzen, 2002). Anthropocene emphasises the role of human activities as a major driver behind planetary and biogeochemical changes. Despite the growing knowledge of the severity of ecosystem degradation and loss of biodiversity, The Convention on

Biological Diversity (CBD) reported in 2020 that none of the Aichi targets set to halt biodiversity loss during the 2011–2020 decade was achieved.

Food systems, including the production, distribution, trade, consumption, and waste management of food, are significant contributors to biodiversity loss (Gladek et al., 2017; Mbow et al., 2019; Richardson et al., 2023) and food production is estimated to be responsible for nearly a half of the global biodiversity footprint (Wilting et al., 2017; Bjelle et al., 2021). Therefore, food systems play a crucial role in preventing biodiversity loss, mitigating climate change, and adapting to the inevitable changes these challenges entail (Mbow et al., 2019; IPCC, 2023). Current food systems not only drive biodiversity loss and climate impacts but also threaten human health and well-being (Willett et al., 2019; IPBES, 2019). Staying within planetary boundaries or achieving global sustainability targets cannot be met without substantial changes to production practices and consumption habits of food (Springmann et al., 2018; Clark, Domingo et al., 2020; Richardson et al., 2023).

Biodiversity footprint is a metric for the impacts that an entity, product, or individual has on global biodiversity resulting from the production or consumption of goods and services (IEEP, 2021). The assessment of the biodiversity footprint of an organisation is the first step towards evidence-based mitigation of environmental impacts. To make mitigation decisions based on actual data, it is necessary to have quantitative information about the consumption, and such can be found, for instance, in the accounts of an organisation and trade databases (El Geneidy et al., 2023). The footprint of an organisation or a product is a sum of the footprints of different activities from its operations and supply chain (Hoekstra & Wiedmann, 2014). This is evident especially in food procurement since the production of food products typically accounts for the biggest environmental impacts of the life cycle of food products (Poore & Nemecek, 2018; Clark et al., 2022). Furthermore, consumption information can be linked with different environmental impacts (Marques et al., 2017; El Geneidy et al., 2023). By linking consumption data to environmental impacts, it is possible to assess, which consumption activities have the biggest impact on the environment, and what activities have the biggest potential to mitigate the impact of a certain organisation.

Public organisations can play a key role in mitigating the biodiversity footprint of society due to their significant power and effectiveness in consumption choices and production patterns in procurement processes. In Finland, public procurement is approximately 20% of the total annual gross domestic product (Motiva Oy, 2024a). Public procurement of food products and services has been studied by several scholars (see, for example, Alhola & Kaljonen, 2017; Stefani et al., 2017; Swensson & Tartanac, 2020; Molin et al., 2021; Molin et al., 2024). The use of sustainability criteria during public procurement processes has been acknowledged to enhance sustainability actions in the supply chains of public organisations (Amann et al., 2014; Morley, 2021).

1.2 Aim of the research

In this thesis, I analyse how public procurement sustainability criteria could be used to reduce the biodiversity footprint of an organisation in a Finnish public food procurement context. Public entities are bound to tender out their purchases that exceed a certain monetary threshold, and there's a possibility to set different requirements or criteria for the suppliers that provide the wanted product or service. By setting certain criteria for the procurement, the public entity can ensure that certain matters are considered when the procurement is due. For instance, a public organisation can decide to set sustainability criteria (such as purchasing organically produced food or setting a target for serving plant-based foods in public catering services) for its bidding processes.

The impact of Finnish national procurement criteria on biodiversity loss is yet to be determined. In this thesis, I evaluate the extent to which biodiversity impacts can be potentially avoided by using environment-related procurement criteria. The results of my research aim to support the development of national sustainable public procurement criteria in Finland. Also, the results provide concrete knowledge of how the use of sustainability criteria can reduce the biodiversity footprint of an organisation through its food procurement.

The research questions of this thesis are the following:

1. What is the biodiversity footprint of the main food dishes procured currently in a public organisation?
2. What is the potential impact of the use of a sustainability criterion on the biodiversity footprint of food procurement?

Next, I present a theoretical framework of the research based on a literature review on biodiversity loss and biodiversity footprint assessment with a further examination of the sustainability of food systems and public food procurement. After that, in the data and methodology section, I describe how this research was conducted and how I applied the biodiversity footprint assessment in this thesis. I examine the results in the fifth section, after which the discussion section interprets the results with existing literature. Finally, in the conclusions, I bring together the main outcomes of my thesis.

2 BIODIVERSITY LOSS AND BIODIVERSITY FOOTPRINT

In this section, I explain the significance of biodiversity loss and why biodiversity footprint assessment is essential in reducing the negative environmental impacts, particularly those resulting from consumption.

2.1 Biodiversity loss

Biodiversity and planetary well-being, that is the well-being of both human and non-human species, have declined, especially over the last century (Krausmann et al., 2013; Steffen et al., 2015; Díaz et al., 2019; Kortetmäki et al., 2021). The ecological burden has risen in a way that many countries, especially the Global North, have exceeded the ecological and planetary boundaries (Richardson et al., 2023). At the same time, societies have failed to fulfil the social needs of their citizens (O´Neill et al., 2018; Fanning et al., 2022).

Planetary boundaries are constituted of biophysical and biochemical processes that maintain the Earth system's resilience and offer a safe operating space for humanity and altogether all life on the planet (Richardson et al., 2023). Human activities have led to a situation where six out of nine boundaries are exceeded. These are biosphere integrity, including genetic and functional integrities of species, biogeochemical flows, such as nitrogen and phosphorus flows, climate change, freshwater and land system changes, and novel entities that encompass entities that are not naturally present in the Earth system but are introduced by human activities (Richardson et al., 2023). It is worth noting that the planetary boundaries framework by Rockström et al. (2009) is strongly anthropocentric in the sense that it considers what is safe operating space for humanity and not for the other forms of life on Earth. This is illustrated by the view of biodiversity being one of the boundaries for safe operating space for humanity, but it doesn't take a stance on how much other life can be destroyed before it threatens us.

The Earth is heading towards a human-induced sixth mass extinction of species (Barnosky et al., 2011; Ceballos et al., 2015; IPBES, 2019). It is estimated that the extinction rate of well-known animal species, such as vertebrates, is 100 to 1000 times (Pimm et al., 2014; Ceballos et al., 2015), and for plants 500 times (Humphreys et al., 2019) higher than the natural background rate. This trend is not harmful only to non-human species, but it is deteriorating the well-being and security of human societies as well. Biodiversity is vital for all human activities since our society and economic activities are embedded and based on the well-being of different organisms that uphold the benefits that people and societies obtain from nature, that is, ecosystem services (IPBES, 2019). Biodiversity has an essential role in the production of food and medicine, maintaining water, air, and soil quality as well as microbial ecosystems (WHO & CBD, 2015). Thus, our physical and mental health is fundamentally intertwined with nature.

The societies of the world have recently started to realise the impacts that biodiversity loss has on our societies and economic activities (Dasgupta, 2021; Pouta et al., 2023). Over 50 per cent of the global gross domestic product is dependent on nature and the ecosystem services it provides (WEF, 2024). Accordingly, the World Economic Forum has stated in their most recent risk reports from 2023 and 2024 that risks related to climate change and biodiversity loss are the four most severe risks for humanity in the coming ten years (WEF, 2023; WEF, 2024).

Biodiversity loss is linked to all of the planetary boundaries that have been transgressed. The key direct actions that are drivers that accelerate biodiversity loss include changes in land and sea use, exploitation of natural resources and organisms, climate change, pollution, and invasive alien species (IPBES, 2019; Díaz et al., 2019). The ongoing climate crisis is driving biodiversity loss as the changing climate has already altered and degraded ecosystems, which in turn can accelerate climate change (IPCC, 2022; WWF, 2022; Pörtner et al., 2021; IPCC, 2023). Thus, climate and biodiversity matters must be tackled simultaneously (Pörtner et al., 2021; WWF, 2022; IPCC, 2023). Simultaneously, land and sea use change – especially due to agriculture and animal husbandry – and direct exploitation of natural resources through fishing, hunting, and logging are estimated to be the two most dominant drivers of biodiversity loss (Jaureguiberry et al., 2022). Pollution, climate change, and invasive alien species have significantly smaller impacts on global biodiversity compared to land and sea use and direct exploitation (Jaureguiberry et al., 2022).

However, alongside the direct drivers of biodiversity loss, there are also indirect drivers such as societal values, production practices, consumption habits, and demographic trends that are behind the direct activities that lead to biodiversity loss (IPBES, 2019). Thus, to halt the trends that disrupt the ecosystems, it is essential to focus not only on the direct use of resources but also on the unsustainable consumption patterns and global supply chains that have been recognised to be one of the most important causes behind the environmental problems (Lenzen et al., 2012; Lazarus et al., 2015; Wilting et al., 2017; Dasgupta, 2021; IPCC, 2022; El Geneidy et al., 2023). Hence, the change in consumption habits is a key solution to achieving planetary well-being, where the well-being of all living beings is considered beside human well-being (Kortetmäki et al., 2021; Do et al., 2023).

2.2 Biodiversity footprint assessment

Forerunner organisations are already considering their impact on climate change by, for instance, calculating the carbon footprints of their operation, but similar metrics and indicators for biodiversity loss have mostly been absent in organisations (Bull et al., 2022; El Geneidy et al., 2023). Similarly, it seems that organisations have struggled to recognise the drivers of biodiversity loss that their actions cause, even though climate change and biodiversity loss should be tackled simultaneously (Pörtner et al., 2021; WWF, 2022; IPCC, 2023).

For now, the scientific community lacks a uniform standard for biodiversity footprint assessment, even though several assessment tools and frameworks have been developed (Marquardt et al., 2019; Crenna et al., 2020; Lammerant et al., 2022; UNEP-WCMC et al., 2022; Sanyé-Mangual et al., 2023; TNFD, 2023; Damiani et al., 2023). To get the overall picture of an organisation's biodiversity footprint, it is crucial to evaluate the environmental impacts across its entire operations and global value chains. Similarly, it is important to recognise the most harmful activities on the environment to set clear science-based targets and strategies to mitigate the biodiversity footprint. Overall, the biodiversity footprint assessment needs more information than the carbon footprint assessment (Marques et al., 2017; Verones et al., 2020).

Researchers at the University of Jyväskylä, School of Resource Wisdom have developed methods to calculate the biodiversity footprint of an organisation's procurements (El Geneidy et al., 2021; El Geneidy et al., 2023; Peura et al., 2023; Pokkinen et al., 2023; Pokkinen et al., 2024; Pykäläinen et al., 2024). The method is based on the utilisation of an organisation's accounting data that can be turned into environmental impacts with different global databases, such as input-output or trade-flow databases.

Four elements are needed to calculate consumption-based biodiversity impacts for an organisation: type and amount of consumption, type and amount of driver of biodiversity loss, location of the driver of biodiversity loss, and the actual biodiversity impact caused by the driver in the specific location (FIGURE 1).

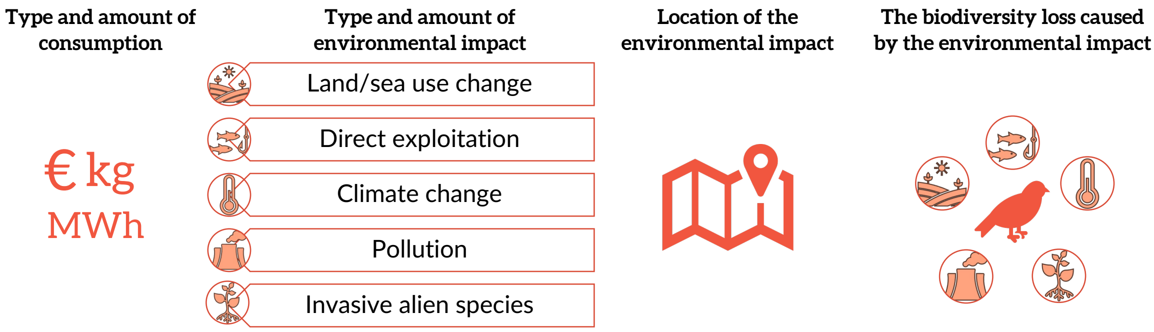

FIGURE 1. Elements needed to assess an organisation's biodiversity footprint (El Geneidy et al., 2023). The list of biodiversity loss drivers is derived from IPBES (2019).

The type and amount of consumption can be derived from different accounting information, such as financial statements. Typically, the accounting information contains information on monetary consumption, but organisations may have data from, for example, their energy consumption in kilowatt-hours, water usage in cubic meters, or food consumption in kilograms.

The commodities that are consumed, for instance, food, are always produced in some location, and production causes different impacts, such as land use change, greenhouse gas emissions, or pollution. The biodiversity footprint assessment is based on the information where the drivers of biodiversity loss, such as land use or pollution, are occurring. It is essential to know whether the biodiversity impact is occurring in an area where the biodiversity and species richness are high or low to determine the size of the impact (Verones et al., 2020).

By procurement, organisations are externalising their negative environmental impacts through their global value and supply chains. The biodiversity footprint assessment takes the global environmental impacts into account by utilising different databases, such as EXIOBASE (Stadler et al., 2018) and LC-IMPACT database (Verones et al., 2020). EXIOBASE is based on an environmentally extended multi-regional input-output (EEMRIO) analysis developed in the field of Industrial Ecology (Marques et al., 2017). More precisely, environmentally extended input-output (EEIO) analysis concentrates on describing the economic flows of traded goods between countries and regions (Leontief, 1970; Marques et al., 2017), as well as counting the total upstream, downstream, and indirect environmental impacts of consumption (Kitzes, 2013).

The impact of a specific driver of biodiversity loss on the biodiversity of a given location can be assessed, for instance, with the LC-IMPACT database (Verones et al., 2020). LC-IMPACT database is based on life cycle assessment (LCA) analysis, which aims to assess the environmental impacts that a product or a service is causing with its total life cycle, typically from raw material extraction to waste treatment (Klöpffer, 1997; Hellweg & Milà i Canals, 2014). LCA uses indicators of environmental impacts, also known as characterisation factors, which indicate how much impact a certain amount of action is causing, for instance, in one year (Marques et al., 2017). The combination of EEIO analysis and LCA is called the hybrid EEIO-LCA methodology, which can be used to calculate the environmental impacts of actions and consumption of an organisation (Nakamura et al., 2016; Crawford et al., 2018; El Geneidy et al., 2023).

LC-IMPACT contains country-specific biodiversity impact factors for different drivers of biodiversity loss (Verones et al., 2020). LC-IMPACT indicates the impact on biodiversity loss as the fraction of the species of the world that are likely to become globally extinct if the harmful activity remains. For short, this indicator is potentially disappeared fraction of species globally (PDF) (Verones et al., 2020). LC-IMPACT combines several scientific studies on the distribution and vulnerability of species and the sensitivity of species groups to different drivers of biodiversity loss (Verones et al., 2020). Moreover, LC-IMPACT covers impact categories on biodiversity, such as climate change, terrestrial acidification, freshwater and marine eutrophication, and land and water stress that are divided into terrestrial, marine, and freshwater ecosystems (FIGURE 2).

More specifically, the indicators of biodiversity loss in terrestrial ecosystems address, for example, the impact of land use change on the environment and habitats, the effect of climate change on species distribution across habitats, and the effect of terrestrial acidification on the abundance of plant species. Similarly, the indicators of biodiversity loss in freshwater ecosystems convey how water usage diminishes the surface area of wetlands, how climate change affects the river flows, and how eutrophication affects freshwater habitats and species. The indicator of biodiversity loss in marine ecosystems indicates the effect that marine eutrophication has on marine habitats and species (Verones et al. 2019). The species that are covered in the impact models of LC-IMPACT include mammals, birds, amphibians, reptiles, butterflies, and vascular plants for terrestrial ecosystems; mammals, birds, amphibians, reptiles, fish, and vascular plants for freshwater ecosystems; and bony and cartilaginous fish, molluscs, echinoderms, annelids, and cnidarians for marine ecosystems (FIGURE 2) (Verones et al., 2020).

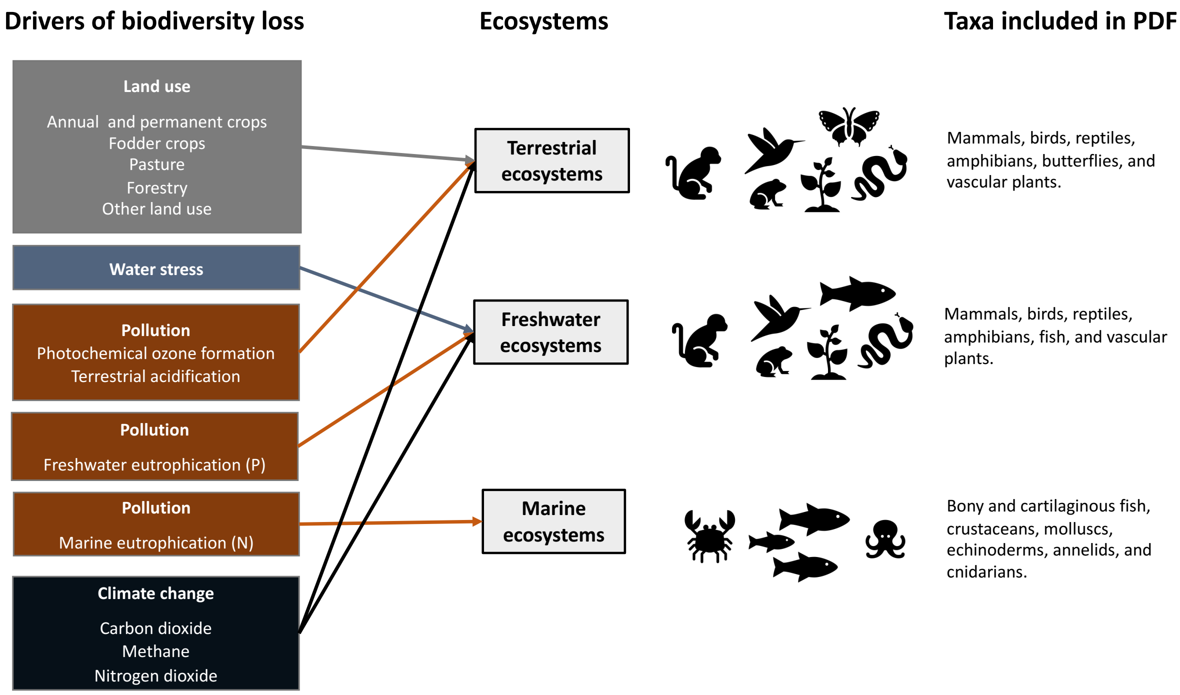

FIGURE 2. Drivers of biodiversity loss for distinct ecosystems and taxa assessed in LC-IMPACT using the biodiversity loss indicator PDF (Verones et al., 2020; El Geneidy et al., 2023).

Verones et al. (2020) do not encourage combining these biodiversity footprints of different ecosystems as such. However, the combination of all three biodiversity footprint values can be formed after weighing each of them (El Geneidy et al., 2023). The weighted values can be derived by utilising the estimated percentage of species abundance among the plant and animal species of the ecosystems (Román-Palacios et al., 2022). Therefore, the biodiversity footprint values of each ecosystem can be combined by multiplying the weight and the weighted values. The result is a global biodiversity impact factor for terrestrial, freshwater, and marine ecosystems. The ecosystem-specific biodiversity footprint values (*BF*) are combined into a single biodiversity footprint by utilising species abundance weights by Román-Palacios et al. (2022). The equation is derived from El Geneidy et al. (2023).

$$BF_{combined} = BF_{terrestrial} \times 0{,}801 + BF_{freshwater} \times 0{,}096 + BF_{marine} \times 0{,}102$$

Country-specific biodiversity impact factors mean that one unit of the driver of biodiversity loss causes different amounts of biodiversity impacts on different countries. This is because the species are not distributed evenly around the globe, and some areas have higher species richness per unit area than others (Myers et al., 2000; Kotiaho & Hovi, 2002; Ceballos & Ehrlich, 2006; Tittensor et al., 2010; Pimm et al., 2014; Schluter & Pennell, 2017; Raven et al., 2020). The biodiversity impact factors are typically greater in areas that have higher species richness per unit area. For instance, areas near the equator, such as Brazil, have greater biodiversity impact factors than Finland. Therefore, the same action, for example, logging 100 m^2 of forest in Brazil, causes a greater impact on the biodiversity (measured as PDF) than the same would do in Finland (El Geneidy et al., 2023). In other words, for the same action, the potentially disappeared fraction of species globally is greater in Brazil than it is in Finland. However, when the same amount of biodiversity loss measures as PDF is caused in Finland and Brazil, then the potentially disappeared fraction of species globally is the same. In other words, when the global species pool is considered as one unit, the biodiversity loss in different locations means the same thing, that is, the share of global species that will potentially be lost, and they can be compared to one another (El Geneidy et al., 2023).

Given its comparable characteristics, the PDF metric can be used similarly to carbon dioxide equivalent (CO_2e) as an indicator of carbon footprint. For this reason, El Geneidy et al. (2023) have proposed that the PDF metric can be referred to as biodiversity equivalent (BDe). From hereafter, I refer to the indicator of biodiversity footprint as BDe. Technically, BDe is still the same indicator as PDF combining the three separately reported ecosystem-specific biodiversity impacts into one by applying weights based on assessed relative species richness.

3 SUSTAINABLE FOOD SYSTEMS

The focus of my thesis is the public food procurement of a Finnish organisation and the use of sustainability criteria to reduce the biodiversity footprint of food services. However, it is crucial to understand that the impacts of food procurement are scattered along the food supply chains, causing global consequences (see, for example, Chaudhary & Kastner, 2016; Bjelle et al., 2021). Overall, food systems are significant contributors to the decreasing diversity of life (Gladek et al., 2017; Mbow et al., 2019; Clark et al., 2022; Bjelle et al., 2021; Jaureguiberry et al., 2022; Richardson et al., 2023). I explore this topic further in this section.

3.1 Global sustainability problems caused by food systems

A food system refers to an entity that incorporates all aspects and processes, inputs, and outputs involved in the production, distribution, trade, consumption, and waste management of food (Nguyen, 2018). The latter can be considered as sub-systems of the food system. Food systems are strongly interconnected to other complex systems, such as energy systems, materials flow, and health systems. Sustainable food systems strive to maintain food security and nutritional needs for present and future generations in a way that the environmental, social, and economic foundations of food systems do not deteriorate (Nguyen, 2018; Béné et al., 2020).

Food security is defined as a state in which all individuals consistently have physical, social, and economic access to an adequate, safe, and nutritious food supply that aligns with their dietary requirements and preferences (FAO, 2001). However, our current agriculture systems fail to provide sustainable, healthy, and secure food systems to all (Willett et al., 2019). To ensure food security for present and future generations, the biodiversity conservation aspects need to be considered (Fischer et al., 2017). Even though food systems are accountable for negative environmental impacts, they are simultaneously facing escalating threats from these changes (Mbow et al., 2019; Springmann et al., 2018; IPCC, 2023), and 30% of the world's population faces severe or moderate food insecurity (FAO, 2023). Yet concurrently, obesity and other diet-related noncommunicable diseases continue to rise (Willet et al., 2019). Health and sustainability aspects in food production and consumption are largely emphasised since food-related health problems in human populations mostly derive from the same sources as environmental problems (Tilman & Clark, 2014; Godfray et al., 2018; Willett et al., 2019; Clark et al., 2019). These sources include especially excessive consumption of red meat since the reduction of meat products has been acknowledged to bring substantial health and environmental benefits (Godfray et al., 2018; Willett et al., 2019; Clark et al., 2019).

To achieve structural changes in food systems, all the sub-systems should be considered (Nguyen, 2018). For instance, Willet et al. (2019) states that achieving a healthy and sustainable food system transformation requires shifts in dietary patterns and food production practices, as well as a reduction in food waste. However, it is acknowledged that the environmental, social, and economic foundations of food systems have trade-offs with one another (Béné et al., 2020). Overall, developing food systems can have a fundamental role in facilitating the sustainability transition, which signifies a long-term, multi-dimensional, and thorough change toward sustainable solutions in production and consumption patterns (Markard et al., 2012; Gladek et al., 2017).

Global agriculture production is strongly linked to exceeding planetary boundaries of biosphere integrity and biogeochemical flows of nitrogen and phosphorus cycles (Campbell et al., 2017). It also plays a significant role in transgressing the planetary boundaries of climate change and has a major role in land system change and freshwater use (Campbell et al., 2017; Springmann et al., 2018). Agriculture occupies approximately half of the land surface that is suitable for growing plants (Gladek et al., 2017; Poore & Nemecek, 2018). According to Wilting et al. (2017), global food consumption is accountable for 40% of the global average biodiversity loss based on the drivers of climate change impact and land use changes. However, the study of Bjelle et al. (2021) estimates food consumption to cover up to 50% of the global average biodiversity loss based on land use changes.

The global sustainability goals cannot be met without significant alterations to the way we produce and consume food (Springmann et al., 2018; Clark, Domingo et al., 2020; IPCC, 2023). This is because the food systems are central to at least 12 of the United Nation's 17 Sustainable Development Goals (SDGs) (Chaudhary et al., 2018). Furthermore, global food systems are directly linked to the Paris Agreement's climate change targets as well as Aichi Biodiversity targets (Clark, Domingo et al., 2020).

The sustainability of the food system is a global issue, and the benefits and harms of food systems are not distributed equally across the globe. This is because the impacts of food procurement are scattered around the world along the food supply chains. Most of the environmental impacts of food consumption come from the early production systems, and for example, only 1–9% of the greenhouse gas emissions of beef come from transportation, packaging, and retail (Poore & Nemecek, 2018). Developed economies and the Global North are responsible for consuming most food products, while the environmental impacts are most visible in the Global South (Lenzen et al., 2012; Chaudhary & Kastner, 2016; Wilting et al., 2017; Springmann et al., 2018; Bjelle et al., 2021; Hentschl et al., 2023). As the global population and income levels continue to rise with higher demand for food production, the negative environmental impacts are expected to rise by 50-90% by 2050 (Springmann et al., 2018). In particular, the growing demand for animal-based food products accelerates biodiversity loss, since livestock and feed production are the primary drivers of tropical deforestation (Gladek et al., 2017) in areas that encompass the biggest biodiversity hotspots on Earth (Raven et al., 2020). The role of dietary choices in achieving sustainable food systems transformation is emphasised because the potential of technological sustainability advancements in agriculture production is considered to be less than those of dietary shifts (Poore & Nemecek, 2018; Springmann et al., 2018).

Food consumption in all Nordic countries has transgressed the planetary boundaries of climate change, cropland, and freshwater use, as well as nitrogen and phosphorus application (Harwatt et al., 2023). In comparison, the current food consumption in Finland transgresses the planetary boundaries of climate change, cropland use, and nitrogen application while nearly exceeding the boundary of water use and phosphorus application (Harwatt et al., 2023). Sandström et al. (2017) discovered that 36% of the total crop consumption in Finland is imported, thus connecting Finland strongly to the global agricultural systems. Over 90% of the land use-related biodiversity impacts took place outside Finland (Sandström et al., 2017). Similarly, 90% of the biodiversity footprint of S Group, one of the biggest food retailers in Finland, was generated outside of Finland (Peura et al., 2023). Food, accommodation, and catering services are listed as one of the most significant categories in the environmental impacts of public procurement in Finland (Kalimo et al., 2021).

Food consumption has a high biodiversity impact per unit of consumption (BDe/€), also referred to as the biodiversity impact intensity (Pykäläinen et al., 2024). Thus, food consumption marks one of the most significant consumption categories in the biodiversity footprint of several studies and organisations. For example, the biodiversity footprint of EU consumption concludes that food products, especially meat, had one of the highest impacts on the overall biodiversity footprint of all the consumption categories (Sanyé-Mengual et al., 2023). Similar results were found by Crenna et al. (2019). The food procurement of the City of Tampere had the biggest biodiversity footprint of all the consumption categories in the city's biodiversity footprint assessment (Pokkinen et al., 2024). Correspondingly, in the biodiversity footprint of the Student Union of the University of Jyväskylä, food products were the most significant contributor to the overall biodiversity footprint of the organisation (Pokkinen et al., 2023). Food consumption contributes nearly half of the overall biodiversity footprint of an average Finnish citizen, and red meat consumption contributes the biggest share of the total biodiversity footprint of food consumption (Ollikainen et al., in press). The comparison between the biodiversity footprints of different protein sources showed that animal-based protein sources had significantly higher biodiversity footprint than plant-based protein sources (Hynönen, 2024). The potential to mitigate the environmental impacts of Finnish food consumption can mainly be achieved by reducing meat consumption (The Ministry of Agriculture and Forestry, 2024).

3.2 The environmental impacts of food products

The environmental impacts of different food products have been studied extensively (Aleksandrowicz et al., 2016; Clark & Tilman, 2017; Crenna et al., 2019; Clark et al., 2022; Poore & Nemecek, 2018; Read et al., 2022; Hentschl et al., 2023; Taylor et al., 2023). It is evident that animal-based food products have a consistently high impact on the environment due to their significant impact on greenhouse gas emissions, land use change, pollution, and freshwater usage (Godfray et al., 2018; Springmann et al., 2018; Crenna et al., 2019).

The energy flows in food chains lose a certain amount of energy at each trophic level due to the metabolism of living organisms. For example, only 10% of the energy content of grass consumed by a cow is transferred to and stored in its body. Thus, the energy-to-protein efficiency ratio, that is the amount of energy needed to produce a certain amount of protein, in meat production is more inefficient than in plant-based protein sources, such as soybeans, peas, or beans (Sabaté & Soret, 2014). Similarly, on average, meat production produces more emissions per unit of energy per kilogram compared to plant-based foods due to energy loss at each trophic level (Sabaté & Soret, 2014; Godfray et al., 2018).

Meat production is a large source of methane emissions, which has a higher global warming potential compared to carbon dioxide emissions (Godfray et al., 2018; IPCC, 2023). The land conversion of natural habitats to agricultural grasslands or grazing is one of the most significant direct drivers of biodiversity loss (Jaureguiberry et al., 2022). For example, the South American rainforest areas have faced the biggest deforestation rates during the recent thirty years (FAO, 2020). Concurrently, the South American rainforest areas are one of the biodiversity hotspots on Earth (Raven et al., 2020). Approximately 71% of land use change has been for cattle ranching, and an additional 14% land use change for crop plants for animal feed (de Sy et al., 2015). FAO estimates that by 2050 meat consumption will rise globally by 76% from the base year 2012. This rise is due to a doubling of poultry consumption, increasing beef consumption by 69%, and increasing pork consumption by 42% (Alexandratos & Bruinsma, 2012).

Clark and Tilman (2017) estimated the environmental impacts of ruminant meat products to be 20-100 times higher than plant-based food per kilocalorie of food produced based on the indicators of greenhouse gas emissions, land use, energy use, acidification potential, and eutrophication potential. Whereas eggs, dairy, pork, poultry, and seafood have 2-25 times higher environmental impacts compared to plant-based food (Clark & Tilman, 2017). Similarly, Poore and Nemecek (2018) found that especially beef has high greenhouse gas emissions and land use change impacts.

3.3 The impact of dietary changes

Dietary changes to more sustainable dietary patterns, such as vegan or vegetarian diets, can have the potential to globally reduce the GHG emissions and land use of the current average diets by 70–80%, and water use by 50% (Aleksandrowicz et al., 2016). Similarly, among popular dishes worldwide, vegan and vegetarian options have significantly lower biodiversity footprints compared to those containing meat (Cheng et al., 2024). Matej et al. (2024) examined options for reducing the food-related biodiversity footprint of the city of Vienna and found that diets with fewer animal products could reduce the footprint of the city by 21–43%. However, if the recommended caloric intake is maintained the reduction of biodiversity footprint could be 9% (Matej et al., 2024). Harwatt et al. (2017) examined the effects of replacing beef consumption with beans, considering both calorie and protein intake. They concluded that a diet based on beans could reduce the total GHG emissions by 74% and free up 42% of the area of cropland in the US. Saarinen et al. (2017) conducted an LCA evaluation on the climate change impact combined with nutritional values of food, that comply with the national nutrition recommendations (National Nutrition Council, 2014). They found that climate change impacts per mass unit of individual nutrients were high among beef, mutton, shrimp, rainbow trout, and cheese products, whereas the lowest impacts were among domestic Finnish fishes and peas (Saarinen et al., 2017).

Dietary changes towards more plant-based food consumption, combined with the preservation of soil carbon storage in Finnish farmlands, could result in a 30–40% reduction in the carbon footprint of the current Finnish diet (Saarinen et al., 2019) or additionally reduce 48% of the agricultural and 34% of the overall food system climate change impacts compared to the average Finnish diet (Risku-Norja et al., 2009). This shift would simultaneously enhance the nutritional quality of the average Finnish diet (Saarinen et al., 2019).

When evaluating the environmental impacts of food consumption, it is essential to also consider the nutritional values of various diets and food products (Saarinen et al., 2019; Willett et al., 2019). The National Nutrition Council of Finland compiles the Finnish nutrition guidelines, the primary objective of which is to improve public health through nutrition. The recommendations are utilised, for instance, in political guidance, monitoring, planning, and communication (National Nutrition Council, 2014). The national nutrition recommendations are derived from the Nordic nutrition recommendations (Blomhoff et al., 2023), and an updated version of the Finnish national nutrition recommendations will be developed during the year 2024. The Nordic nutrition recommendations recognise that there are many ways to compile a healthy diet but highlight the importance of prioritising a plant-based diet rich in vegetables, fruits, berries, legumes, potatoes, and whole grains. They also encourage the consumption of fish and nuts, moderate intake of low-fat dairy products, and restricted consumption of red meat, white meat, and processed meats such as sausages, ham, or dried meat (Blomhoff et al., 2023).

Nevertheless, the current average diet in Finland fails to meet the national nutrition recommendations, exposing citizens to nutritional deficiencies and associated health-related risks (Valsta et al., 2018). Especially the intakes of protein, fat, and saturated fatty acids are too high (Valsta et al., 2022), which implies that the current average diet in Finland is too heavily based on meat consumption compared to the national nutrition recommendations (Valsta et al., 2018). Women are estimated to exceed the recommended protein intake by 4-19% and men by 18-25% (Valsta et al., 2022). Nearly 70% of the protein intake comes from animal-based protein sources (Valsta et al., 2018). On the other hand, the intake of carbohydrates and fibre was below the recommended level, which implies that the average diet should consist more of vegetables and cereals, for instance (Valsta et al., 2022). Concurrently, 70-90% of men and 20-40% of women exceed the maximum recommended meat and processed meat consumption of 500g per week (Valsta et al., 2022), whereas only 14% of men and 22% of women consume enough vegetables, berries, and fruits (Valsta et al., 2018).

Although the consumption of red meat in Finland has decreased, this change has increased, especially the consumption of poultry products, while the reduction in milk consumption has been accompanied by increased consumption of cheese and other dairy products (Kaljonen et al., 2022). Recently, these results have been acknowledged, and The Ministry of Agriculture and Forestry states in its final report of the meat sustainability criteria working group that meat consumption should be replaced primarily with plant-based proteins (Ministry of Agriculture and Forestry, 2024).

The need for further incentives for citizens to obtain healthier and better dietary options for the environment is highlighted. Therefore, a holistic sustainability transition in Finnish food consumption requires the combination of diets that are beneficial for human health and simultaneously environmentally sustainable (Lehikoinen & Salonen, 2019). The shift to healthy diets, which are mostly plant-based, is needed to achieve the transition to a more environmentally sustainable society (Tilman & Clark, 2014; Clark, Macdiarmid et al., 2020).

Complying with the national nutrition recommendations could improve personal health while simultaneously reducing the environmental impacts of food consumption (National Nutrition Council, 2014; Kaljonen et al., 2022). However, while shifting dietary habits to be more in line with the current national nutrition recommendations would reduce the environmental impacts of food consumption, the change would not be enough to lower the environmental impacts to a level where critical planetary boundaries, such as biodiversity loss, climate change, cropland use, and nitrogen applications would not be transgressed (Harwatt et al., 2023). There is a need for bigger reductions in meat, dairy, and egg consumption with food waste reduction and improvements in farming practices (Clark, Macdiarmid et al., 2020). Thus, stronger integration of environmental aspects within the nutrition recommendations is needed to guide public organisations towards more sustainable and healthier food consumption (Huan-Niemi et al., 2020).

Since most of the protein intake comes from animal-based protein sources (Valsta et al., 2018), there is a concern about whether the plant-based diet can uphold adequate protein intake and maintain healthy diets. Therefore, scholars suggest that the shift towards healthier and more environmentally sustainable food consumption is mainly a matter of protein transition from meat-based to plant-based protein sources (see, for example, Aiking & de Boer, 2020; Hoehnel et al., 2022). Additionally, some studies have concluded, that plant-based protein sources might not replace and reduce meat consumption, but consumers might be eating more protein instead (Hartmann & Siegrist, 2017).

Saarinen et al. (2019) studied the nutritional values and compositions of different dietary options, where they compared the current average Finnish diet to, for example, a vegan diet. The idea was to construct an optional diet that meets national nutritional recommendations (National Nutrition Council, 2014). The current Finnish diet, which falls short of meeting the nutrition recommendations, energy intake comes mainly from cereals and grains (23%), milk products (19%), oils and fats (16%) and meat products (13%). The protein intake consists of meat products (30%), milk products (28%) and cereals and grains (18%) (Saarinen et al., 2019). The optional vegan diet, which complies with the national nutrition recommendations, would gain its energy intake from cereals and grains (50%), beans, legumes and nuts (23%), and vegetable oils (9%), whereas the protein intake would come from cereals and grains (46%), beans, legumes and nuts (42%), and other vegetables (6%) (Saarinen et al., 2019).

3.4 Drivers of dietary changes

While my research is a case study of an organisation, the individuals inside the organisation or the customers can have a difference considering the dietary changes in the organisation. Thus, understanding the underlying causes of individual preferences in food consumption is important to facilitate the sustainability transition of the food system (Godfray et al., 2018). A decision to consume certain food products is shaped by several complex social and cultural values and cues, as well as societal norms, influences, and political contexts (Godfray et al., 2018; Lehikoinen & Salonen, 2019).

When considering the dietary change from meat products to plant-based food, there are several individual-level behavioural and society-level policy barriers (Sabaté and Soret, 2014). Behavioural change and food selection involve conscious and non-conscious processes (Marteau, 2017). Human behaviour is partly driven by the non-conscious automatic process, which is an emotion-driven system, and partly by the conscious process, which is reflective and reason-driven (Marteau, 2017). Meat consumption is usually seen as a natural, necessary and normal part of the diet, and the human decision-making process may unconsciously prioritize meat products in food selection situations (Godfray et al., 2018). Also, personal characteristics and identity can be shaped by dietary decisions, which has been evident, especially in meat consumption among men (Hartmann & Siegrist, 2017; Godfray et al., 2018). Hartmann and Siegrist (2017) concluded that consumer awareness of meat production's environmental impacts is relatively low, and the incentives for people to reduce their meat consumption is an understudied field.

The policy barriers related to dietary changes, however, are primarily associated with public acceptance of change and the effectiveness of nudging incentives (Nissinen et al., 2015; Marteau, 2017). More precisely, these involve the lack of price incentives, excessive marketing of products that are harmful to health and the environment, lobbying power of, for example, food industries trying to influence policymaking, and information gaps that reduce public acceptability (Marteau, 2017). Similarly, subsidies and taxation that do not support environmental and health benefits play a major role in policy barriers (Saarinen et al., 2019). This is evident, for example, in the price of meat products that do not cover the environmental nor the health impacts they cause in society (Godfray et al., 2018).

Marteau (2017) suggests that values are not always the most efficient driver for behavioural change, meaning that even though a person would support pro-environmental values, the behaviour does not necessarily comply with them. Concurrently, the excessive reliance on voluntary efforts to enhance sustainable consumption has been proven to work weakly (Nissinen et al., 2015). Therefore, drastic changes in human behaviour and food preferences are complex and time-consuming processes, underscoring the government's responsibility to drive sustainable dietary change.

The dietary change requires a mix of behavioural policy instruments, such as regulation, incentives, nudging, and guidance from national and international food policies (Sabaté & Soret, 2014; Nissinen et al., 2015; Godfray et al., 2018; Huan-Niemi et al., 2020). For example, the actions to support sustainable dietary changes include stronger integration of environmental criteria into public catering and national nutrition recommendations, enhancing food education, combining environmental and health-based taxes and subsidies, and setting clearer and more ambitious environmental targets for public food service providers (Nissinen et al., 2015; Saarinen et al., 2019). Social norms and individual behavioural patterns can change, but this process requires the support of various societal actors (Huan-Niemi et al., 2020). These actors include local and national governments, private sector entities, and civil society organisations, that have distinct roles in organising and facilitating the sustainable food system transition (Béné et al., 2019; Clark, Macdiarmid et al., 2020).

3.5 Sustainable public food procurement

Governmental and public organisations are significant procurers that have the power to influence consumption choices through their procurement processes. In public procurement in Finland, the state, municipalities, or joint municipal authorities make supply or service contracts with external suppliers (Ministry of Economic Affairs and Employment of Finland, 2024). In Finland, the net cost of public procurement is 35-50 billion euros annually (Kivistö & Virolainen, 2019), making the public sector one of the biggest procurers in the Finnish markets (Kalimo et al., 2021). Public food procurement is approximately 350 million euros annually (Finfood, 2023).

Public procurement in Finland follows the Act on Public Procurement and Concession Contracts (1397/2016) which is based on the procurement directives of the European Union (Directive 2014/24/EU). According to the Act on Public Procurement and Concession Contracts (1397/2016) 2 § subsection 2 the Act "seeks to enhance … sustainable procurement". Additionally, the Act on Public Procurement and Concession Contracts (1397/2016) 94 § states that public organisations should take the whole life cycle of the product or service into account when making procurement decisions. Also, the EU directive on public procurement (Directive 2014/24/EU) states in subsection 74 that "public purchasers need to allow public procurement to be open to … achieve objectives of sustainability" and in subsection 91 that "Directive clarifies how contracting authorities can contribute to the protection of the environment and the promotion of sustainable development".

The Finnish Ministry of Finance (2023) has created a Handbook on Government Procurement, which aligns with both national and EU public procurement laws and directives, as well as with the United Nations' Sustainable Development Goal 12, Target 7. This target aims to "promote sustainable public procurement practices in accordance with national policies and priorities" (United Nations, 2024). The Handbook mentions, for instance, the role of public procurement in supporting sustainable food systems and promoting biodiversity (Ministry of Finance, 2023).

Sustainable and green public procurement, along with the use of sustainability criteria, is also recognised as a key tool for addressing biodiversity loss in the EU's biodiversity strategy (European Commission, 2020). The national biodiversity strategy of Finland will be announced in the year 2024, and it is based on the EU's biodiversity strategy (Ministry of the Environment, 2024). In addition, ecological sustainability is identified as one of the key targets in Finland's joint national strategy for public procurement (Ministry of Finance, 2020).

Public food procurement can be seen as a powerful and efficient policy instrument facilitating the transformation towards more sustainable food systems and diets (Nissinen et al., 2015; Saarinen et al., 2019; Boyano Larriba et al., 2019; Swensson & Tartanac, 2020; Huan-Niemi et al., 2020). Public food procurement can play a crucial role in helping cities and municipalities achieve their environmental and climate change targets (Alhola & Kaljonen, 2017). For example, the public school system in Finland can support the sustainable transitions of just food systems by exposing children to sustainable food options (Kaljonen et al., 2022). The national nutritional recommendations (National Nutrition Council, 2014) and the recommendations for school meals (National Nutrition Council, 2017) are guiding public food services. Public food services provide 2 million meals daily (Saarinen et al., 2019), from which 900,000 meals are served to children (Kaljonen et al., 2022). For instance, the catering company Pirkanmaan Voimia Oy serves 14 million meals annually across daycare centres, schools, hospitals, and nursing homes (Pirkanmaan Voimia Oy, 2024). Thus, public food services have a crucial guiding and teaching role for the citizens (Kaljonen et al., 2022), but they also have a guiding impact further along the food supply chain through their procurement processes (Huan-Niemi et al., 2020).

Sustainable public procurement is a process, where public authorities aim to achieve a balance between the environmental, social, and economic sustainability aspects while procuring goods and services (Berg et al., 2022). Another similar concept is green public procurement, which aims to reduce the environmental impacts of public purchases, for example, by comparing the life cycle impacts of different goods and services (European Commission, 2024). The importance of sustainability criteria across different product categories in tendering processes is widely acknowledged as crucial for fostering sustainable public procurement. (Berg et al., 2022). The sustainability criteria can facilitate the transition toward responsible consumption patterns and the overall sustainability transformation of our society (Huan-Niemi et al., 2020).

3.6 The use of sustainability criteria in public food procurement

Several literature reviews on public food procurement have shown that sustainability discourse circles around locally and organically produced food, and they tend to address all three pillars of sustainability (environmental, social, and economic) with the main emphasis on the social aspects (Stefani et al., 2017; Swensson & Tartanac, 2020; Molin et al., 2021; Molin et al., 2024).

Swensson and Tartanac (2020) highlight the potential of inclusive public food procurement, which prioritises purchasing goods or services from vulnerable supplier groups, such as local smallholder farmers. This approach can positively influence water and land use, nature conservation, and climate change mitigation at the local level. Morley (2021) discovered that sustainable food procurement strategies can enhance the implementation of more sustainable practices among food suppliers as well as increase their knowledge about sustainability in the food sector. Similar findings have been found by Amann et al. (2014), stating that by integrating sustainability criteria in public tendering, public procurement guides suppliers to engage with sustainability practices. However, sustainability criteria in the bidding process do not always result in more sustainable practices, as public organizations rarely conduct monitoring or verification once the tendering process is complete. Even when monitoring is in place, there is often no effective mechanism to enforce consequences for suppliers who fail to meet all sustainability requirements (Palmujoki & Vartianen, 2020).

In the context of sustainable public food procurement, environmental sustainability has been mainly understood to address the potential benefits of certain types of foods, for instance, organic and local food, and their perceived sustainable outcomes, which included climate change mitigation, reduced impacts on the environment, less pollution or toxicity, resource consumption, and food waste (Molin et al., 2021). However, these associations have been hypothetical, and not always based on any actual environmental assessments, such as LCAs (Molin et al., 2021). Thus, the consensus on how sustainability is defined, and what is sustainable remains unclear among the various actors in public food procurement (Molin et al., 2024). Some sustainability aspects might be contradictory to one another, for example, locally produced food may not always be the most environmentally sustainable option (Molin et al., 2024).

The impacts of public procurement on the environment have been examined in various guidebooks and reports in Finland. The guidebook for sustainable food procurement by Motiva (2023) emphasises the need for more transparent and traceable supply chains that can assist in making more accurate life cycle analyses based on the country or region of origin of the food products and further help to make more sustainable procurement decisions. According to the guidebook for sustainable food service procurement (Ministry of Agriculture and Forestry, 2021), the core components of environmentally sustainable food services include effective menu planning, responsible food procurement, and minimizing food waste.

Gaia Consulting Oy examined with Pellervo Economic Research (PTT) ry and the Ministry of Agriculture and Forestry the consideration of biodiversity aspects in food procurement in Finland and how the public food procurement and sustainability criteria could enhance the target of reducing negative biodiversity impacts (Gaia Consulting Oy & PTT ry, 2022). They also analysed the economic impacts of the use of sustainability criteria. Any additional criteria can bring higher costs to the procurer compared to the situation where the procurement is done solely based on price factors (Gaia Consulting Oy & PTT ry, 2022). Including sustainability criteria in the procurement is no exception. The lowest price is often the most important factor for winning the tender contracts and sustainability aspects are regarded as secondary obligations in the procurement. This traditional procurement culture can be short-sighted, and the long-term expenses could prove to be higher when considering the total life cycle costs of a product or service (Alhola, 2012; Alhola & Kaljonen, 2017; Swensson & Tartanac, 2020). However, it is worth noting that if the environmental criteria were included in tender calls, the weighting for the criteria is usually low, mostly below 10%, making it possible to win the contract without fulfilling the environmental criteria (Alhola, 2012).

The EU directive on public procurement (Directive 2014/24/EU) sets explicit requirements for the procurement process but does not take a stance on what should be procured. The principle of free trade is emphasised in tendering, thus any additional criteria in the bidding process may be viewed as discriminatory if they are considered too restrictive, which could lead to legal issues (Kalimo et al., 2021). On the other hand, adding sustainability factors in tendering could eventually drop unsustainable suppliers from the market, or formulate new markets for more sustainable suppliers (Amann et al., 2014). However, public organisations might still avoid using criteria as a means of managing legal risks (Alhola, 2012). Similarly, the use of sustainability criteria can place an additional burden on public organisations if they are required to demonstrate and verify their application to avoid potential legal issues (Gaia Consulting Oy & PTT ry, 2022). Conversely, too restrictive public procurement legislation could lead to inefficient decisions and set harmful barriers to innovative procurement (Kalimo et al., 2021). Nonetheless, it is an important question whether the sustainability aspects should still be weighted more in the

EU directive on public procurement and subsequently in national legislation (Alhola, 2012).

The joint report of the Ministry of Agriculture and Forestry and Motiva Oy (2023) conducted a survey about sustainability criteria among public organisations that procure food or food services in 2022. The results showed that 59% of public organisations have strategic targets related to ecological sustainability, biodiversity or climate change mitigation in food procurement and food services. However, usually, sustainability strategies are ambiguous and do not concentrate on singular sustainability criteria (Alhola & Kaljonen, 2017). On average, the most important sustainability criteria that public organisations have used with food procurement are nutritional criteria (43%), food safety (38%), environmental and climate-related criteria (29%), animal safety and wellbeing (23%), and social sustainability (16%) (Ministry of Agriculture and Forestry & Motiva Oy, 2023). Even though the use of sustainability criteria has increased over the last decade, their quality has remained the same (Kalimo et al., 2021). There are also indicators that the voluntary adoption of environmental and climate-related criteria has not yet become a primary focus for public organisations when integrating specific requirements into their tendering processes (Ministry of Agriculture and Forestry & Motiva Oy, 2023). Currently, 43% of food services provide plant-based vegan or vegetarian meals as a daily main dish option, while 26% offer them once a week, indicating an increase in the availability of plant-based foods and protein sources over time (Ministry of Agriculture and Forestry & Motiva Oy, 2023).

Public procurement, guided by various handbooks and legislation, can be challenging for the buyer organisation, which would benefit from greater strategic support in their tendering processes (Alhola & Kaljonen, 2017). Simultaneously, fulfilling the tendering requirements can be challenging, particularly for small suppliers. Thus, it is also crucial to increase market dialogue with suppliers (Alhola & Kaljonen, 2017). The procurer's knowledge of product or service-specific tendering issues, including sustainability impacts, legal aspects, technical features, and overall market know-how, is crucial for conducting successful public procurement (Alhola, 2012; Swensson & Tartanac, 2020; Molin et al., 2024). The values and expertise of the procurer can significantly influence procurement decisions and the application of sustainability criteria (Swensson & Tartanac, 2020; Ministry of Agriculture and Forestry, 2024). Moreover, top-level management within organisations must be committed to sustainable public procurement practices (Alhola & Kaljonen, 2017). The purchasing process should also consider the unique characteristics and capacities of each organisation, recognising that different organisations have varying limits and resources when making procurement decisions (Berg et al., 2022).

Overall, achieving sustainable public food procurement necessitates comprehensive improvements within the catering industry from menu planning to effective tendering processes. This requires support from key stakeholders, including suppliers, procurers, and organisational management (Alhola & Kaljonen, 2017; Berg et al., 2022). Additionally, policymakers at the governmental level play a crucial role in shaping public food procurement practices by establishing the frameworks that guide the tendering processes (Swensson & Tartanac, 2020).

The theory behind sustainable food systems, dietary changes, public food procurement, and sustainability criteria are crucial to understanding the context of the use of sustainability criteria that I research in my thesis. In the next section, I combine the theories of biodiversity footprint assessment and sustainable public food procurement by explaining how I evaluated the impact of using the sustainability criteria on the biodiversity footprint of a public organisation.

4 DATA AND METHODOLOGY

In this section, I explain what kind of data and methodologies I used in my thesis. My thesis is a quantitative case study that typically examines one or a few examples to explore a broader phenomenon (Williams et al., 2022). I evaluated how sustainability criteria used in public procurement can reduce the biodiversity footprint of food consumption and contribute to lowering the overall biodiversity footprint of an organisation. The biodiversity footprint assessment method that I applied in this thesis is developed by the Biodiversity Footprint Team of the University of Jyväskylä (University of Jyväskylä, 2024; El Geneidy et al., 2023; Pokkinen et al, 2024; Pykäläinen et al., 2024; Peura et al., 2023; Pokkinen et al., 2023). I used artificial intelligence tools, such as ChatGPT 3.5 and Grammarly, to improve the grammatical accuracy and fluency of this thesis.

4.1 Data and scope of the research

The City of Tampere was a pilot organisation for this evaluation and the research was based on the biodiversity footprint assessment of the City of Tampere, which was conducted by Pokkinen et al. (2024). In the biodiversity footprint assessment of the City of Tampere, the focus was on the administrative department's procurement impacts. Thus, this study examined the biodiversity footprint of public organisation's procurement with the viewpoint of a procurement unit's possibilities to mitigate the footprint. Further limitation was made to narrow the scope of this thesis to food consumption and food services. The data used in this evaluation is derived from Pokkinen et al. (2024) study of the biodiversity footprint of the City of Tampere. More in detail, the food procurement of the city is made by Pirkanmaan Voimia Oy, which provides food and catering services for day-care centres, schools, and hospitals (Pirkanmaan Voimia Oy, 2024). The biodiversity footprint analysis of food products was based on the kilogram-based accounting data from the city, which covered the food products procured by Pirkanmaan Voimia Oy in 2022.

The Finnish government's Sustainable Development Company Motiva Oy has developed several procurement-related responsibility criteria in cooperation with the Natural Resources Institute of Finland and the Ministry of Agriculture and Forestry (Motiva Oy, 2024b). The criteria focus on mitigating the environmental impacts of different products and services, such as food products. For instance, they encourage public entities to increase the serving of plant-based foods in public canteens and cafeterias, or by purchasing organically produced food. Food products were selected as the scope of this research also because the sustainability criteria created by Motiva Oy have several criteria related to food and food services, that focus on enhancing the diversity of nature. By spring 2024, the criteria bank of Motiva contained 49 diversity of nature-related procurement criteria (Motiva Oy, 2024b). Since the biodiversity footprint assessment method must be evaluated based on specific product and service categories, the number of the criteria rises to 72 in the category of food and food services (Motiva Oy, 2024b). The subcategories within the food and food services category include for example, grains and grain products, dietary fats and vegetable oils, and milk and dairy products. However, I limited my study to one criterion only which is related to food services. The criterion is the following (free translation from the original criterion in Finnish):

> The share of plant-based main dishes of the total eaten main dishes (in kilograms) must be either 30% at a basic level or 50% at a pioneer level [kasvipohjaisten pääruokien osuus syödyistä pääruokakiloista tulee olla 30% perustasolla ja 50% edelläkävijätasolla] (Motiva Oy, 2024c).

I selected the criterion for my analysis because it focuses on increasing the overall share of plant-based food consumption in public organisations. I also chose this criterion because, as was stated earlier, decreasing meat-based food consumption has one of the most significant impacts on environmental impacts from food consumption (see, for example, Poore & Nemecek, 2018; Crenna et al., 2019; Clark et al., 2022; Taylor et al., 2023) but also has several benefits for people's health (Willett et al, 2019). Decreasing meat consumption is also listed as one of the targets by Nordic nutrition recommendations (Blomhoff et al., 2023).

4.2 Method for assessing the biodiversity footprint of food products

The biodiversity footprint assessment of food products for the City of Tampere (Pokkinen et al., 2024) was based on the research by Poore and Nemecek (2018), which identifies 42 food product categories and their associated drivers of biodiversity loss per kilogram of food. The study of Poore and Nemecek (2018) combines several LCA-based studies and databases, and they have built a multi-indicator global database on the environmental impacts of food products based on a meta-analysis of 570 studies. Their dataset covers approximately 38,700 commercial farms from 119 countries, which compose almost 90% of global protein and calorie consumption (Poore & Nemecek, 2018). The data set includes five environmental impact indicators: land use, freshwater use, greenhouse gas emissions, acidification, and eutrophication emissions. The assessed system covers the environmental impacts of food production's supply chain from farming to retail, covering the inputs and outputs of the production, such as fertiliser use, irrigation, machinery, and soil and climatic conditions for crop production, pasture management, feed processing, energy use of housing, on-farm emissions, and manure management for livestock or aquaculture systems as well as the energy and water use of processing, material use of packaging, and energy use of retail of the products (Poore & Nemecek, 2018).

In the case of the City of Tampere, the biodiversity impact factors that were derived from the study of Poore and Nemecek (2018) by Pokkinen et al. (2024) were land use (m^2/kg) and greenhouse gas emissions (CO_2 eq/kg) for terrestrial ecosystems. Land use and greenhouse gas emissions were the only drivers that could be currently considered in the kilogram-based biodiversity footprint assessment of food products. More work is needed to harmonize and combine the biodiversity impact factors by Poore and Nemecek (2018) and the LC-IMPACT database (Pokkinen et al., 2024), thus the number of the drivers of biodiversity loss can be increased in the future. The biodiversity footprint metric used in this study is biodiversity equivalent (BDe), which is derived from the indicator of potentially disappeared fraction of species (PDF) (Verones et al., 2020; El Geneidy et al., 2023).

In the evaluation of the biodiversity footprint of the City of Tampere, some product categories were added to the analysis alongside the initial categories of Poore and Nemecek (2018). For instance, new categories were produced based on estimates of the raw material ingredients and their compounds in the products. This way, it was possible to get more accurate results for specific products that were common in the dataset, for instance, pork-beef minced meat was estimated to contain 50% of pork and 50% of beef. Similarly, the same kind of category combinations were made for products that contain a mix of pig and poultry or pig, beef and poultry meat (Pokkinen et al., 2024).

Food products were divided into animal-based and plant-based products due to simplifying the interpretation. Additionally, plant-based foods were further divided into annual and perennial crops (FIGURE 3). The land use for plant-based food products was assumed to occur in the country of origin, as specified in the dataset provided by Pirkanmaan Voimia Oy. With animal-based products, animal grazing was assumed to occur in the country of origin. Nevertheless, the cultivation of annual crops, that is fodder plants, was assigned to more than one country based on the EXIOBASE database (Stadler et al., 2018) and the Pymrio tool (Stadler, 2021). This was done because it was assumed that fodder cultivation generates a significant share of the biodiversity footprint of animal-based products (Poore & Nemecek, 2018) and because fodder is typically imported from all over the world (Sandström et al., 2017; Pokkinen et al., 2024). The kilogram-based impact factors of the drivers of biodiversity loss (m^2/kg or CO_2 eq/kg) were combined with country-specific values for the biodiversity impact factors of the LC-IMPACT database (BDe/m^2 or CO_2 eq BDe/kg CO_2 eq). This way the results were the product and country-specific biodiversity impact factors in the form of biodiversity footprint per kilogram of food product (BDe/kg) (FIGURE 3).

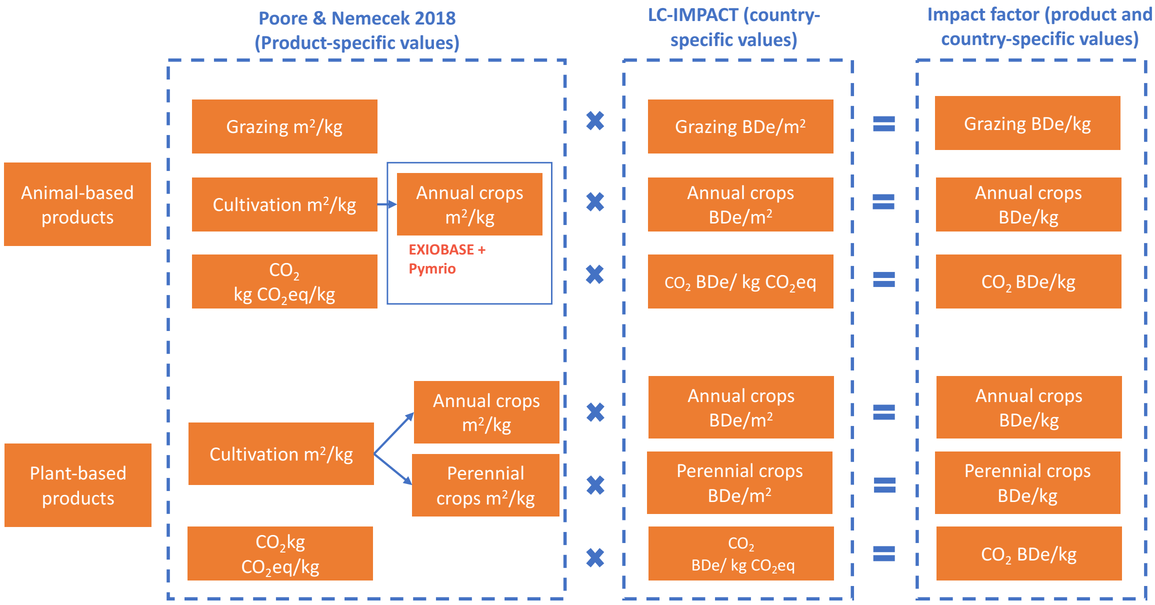

FIGURE 3. A graph illustrating the method and data sources in assessing the biodiversity footprint of food products (Pokkinen et al., 2024).

I compared the results of this study to the overall biodiversity footprint of the City of Tampere (Pokkinen et al., 2024). Thus, it is necessary to acknowledge the other methodologies of biodiversity footprint assessment. The biodiversity footprint assessment of the city was a combination of monetary, energy (in kilo-watt hours), kilometre and kilogram-based methodologies utilising data from Ecoinvent, EXIOBASE and LC-IMPACT, that were applied in different consumption categories. For example, with energy use the calculation was based on consumption by kilo-watt hours (kWh), water consumption by cubic meters (m^3), and services by monetary value in euros (Pokkinen et al., 2024).

4.3 Categorization of the food products as main dishes and assumption in the data

The categorisation of the food products for my analysis was based on the study of Poore and Nemecek (2018) and Pokkinen et al. (2024). The above-mentioned criterion divides the main dishes into two categories: meat-based dishes and plant-based dishes. Thus, the criterion does not distinguish between vegetarian and vegan diets. However, studies imply, that a vegetarian diet can have a significantly higher impact on the environment compared to a vegan diet, especially if the main protein sources are substituted with cheese (Clark et al., 2022; Cheng et al., 2024; Matej et al., 2024). Therefore, for this evaluation where I examined the impact of the use of the criterion on the biodiversity footprint, and the potential to mitigate the footprint, the separation between vegetarian and vegan diets was justifiable. A lacto-ovo vegetarian diet is defined as a diet where a person does not eat meat or fish but does consume egg and milk-based foods (National Nutrition Council, 2016). A vegan diet is defined as a diet that allows strictly only plant-based foods and protein sources (National Nutrition Council, 2016).

The main dishes were determined based on the primary protein source of the meal. Hence, this evaluation consisted of three main dish categories: meat-based protein sources, lacto-ovo vegetarian protein sources, and purely plant-based vegan protein sources (TABLE 1). In short, I refer to them as meat-based, vegetarian, and vegan dishes. The meat-based dishes were defined based on protein sources of bovine beef meat, pig, poultry, lamb, fish, crustaceans, or meat-based convenience food. Vegetarian dishes were determined by milk, cheese, or egg-based protein sources that can be categorised as the main protein source of the meal, such as vegetable patties that contain egg or cheese, or vegetable convenience food. Similarly, dishes were determined to be vegan if the protein source was soy-based protein products, beans, lentils, peas, and other vegetable-based products that can be categorised as the main protein source of the meal (TABLE 1). The above-mentioned categories were selected from the product-specific accountancy data provided by Pirkanmaan Voimia Oy.

The drivers of biodiversity loss considered in the main dish categories were derived from Pokkinen et al. (2024). For meat-based and vegetarian dishes, these drivers included land use (cropland and pastures) and climate change, while for vegan dishes, they involved land use (cropland) and climate change (TABLE 1).

TABLE 1. Categorisation of food products and the drivers of biodiversity loss for each main dish category.

Main dish categories	Protein sources	Drivers of biodiversity loss
Meat-based	Bovine, pig, poultry, fish (farmed), crustaceans (farmed), lamb and mutton, beef and pig, beef, pig and poultry, pig and poultry, meat-based convenience food, cheese protein sides 50%, milk-based protein sides 50%.	Land use as cropland (m^2/kg) and pasture (m^2/kg), climate change (CO_2e/kg).
Vegetarian	Egg and milk-based proteins, cheese protein sides 50%, milk-based protein sides 50%, vegetarian convenience food.	Land use as cropland (m^2/kg) and pasture (m^2/kg), climate change (CO_2e/kg).
Vegan	Tofu, soy products, root vegetables, oatmeal, wheat-based protein, peas, other vegetables, beans and lentils.	Land use as cropland (m^2/kg), climate change (CO_2e/kg).

The separation between vegetarian and vegan dishes was made based on the ingredients in the products. Some of the vegan dishes were re-categorised because they were originally categorized as vegetarian food that includes the land use as pasture impact. For example, a plant-based patty was categorised as a vegan root vegetable, if the main ingredient was carrot, beetroot or other similar root vegetable, and if the product did not contain any animal-based ingredients, such as egg or dairy products. In this way, the categorisation of the food products was slightly more accurate in this evaluation than it was in the original biodiversity footprint assessment of the City of Tampere conducted by Pokkinen et al. (2024).

Additionally, certain milk, cheese and plant-based products that can be categorised as part of the main dish protein sources were added to the evaluation to get more accurate results. These products included, for example, milk and plant-based cooking creams and grated cheese, which are usually eaten with the main protein source of the dish. Especially in vegetarian dishes, milk and cheese products can be added to the main dish to increase the protein intake of the food. However, cooking creams and grated cheese can also be added to meat-based dishes. Therefore, these protein sources were divided into the main dish categories as follows: cheese and milk products were divided 50/50 for meat-based and vegetarian dishes (TABLE 1). Vegan plant-based cooking creams were oat-based in this data; thus, these products were categorised as vegan dishes (TABLE 1).

4.4 Protein and energy contents of main dishes

In order to consider the nutritional values of the main dishes, the protein content (g/kg) and energy content (kcal) were calculated. The Finnish Institute for Health and Welfare maintains the national Food Composition Database Fineli, which contains nutrition information on different food products and dishes (Finnish Institute for Health and Welfare, 2024a). Protein and energy contents were derived from the database by searching for similar food products and main dishes that matched the food consumption accountancy data of Pirkanmaan Voimia Oy. Since some protein source sub-categories include multiple food products or dishes, average values for protein and energy contents were taken from the most common items within these categories. For example, the protein and energy contents of soy products were calculated as the average values of soy sausages and minced soy. The protein and energy contents were harmonized to equal the kilogram-based food consumption data. For example, energy contents were announced in kilojoules, which were converted into kilocalories by Fineli's conversion factor (1 kilojoule equals 0.239 kilocalories) (Finnish Institute for Health and Welfare, 2024b).

4.5 Calculation and its assumptions

Certain assumptions were made when calculating the increase of plant-based dishes. The equations that I used in this research are explained below. I did the calculations in Microsoft Excel.

4.5.1 Calculating the biodiversity footprint

The main equation I used in this research was for calculating the biodiversity footprint given the mass of a main dish category (meat-based, vegetarian or vegan). The equation is derived from the basic equation for calculating biodiversity footprint equivalent (*BDe*) values:

$$BDe = BDe_{kg} \times M, \tag{1}$$

where units of the variables are BDe_{kg} = biodiversity impact intensity (BDe/kg) and M = mass (kg). Since the purpose of this research was to compare how much the resulting biodiversity footprint value changes when the share of vegetarian food is increased, it can be inferred that the total mass of main dishes does not change. By dividing the main dishes into two categories, the following equation is formed:

$$M_{total} = M_{vegetarian} + M_{meat} \qquad (2).$$

With this equation, the first equation can be expanded to the following form:

$$BDe = BDe_{kg,vegetarian} \times M_{vegetarian} + BDe_{kg,meat} \times M_{meat} \qquad (3).$$

The aggregated biodiversity impact intensity (BDe_{kg}) factor for the categories is unknown, but it can be derived from the factors of the individual items inside a category. For example, if there were two items in the vegetarian category, tofu and beans, the aggregated factor for the category could be derived as follows:

$$BDe_{kg,vegetarian} = BDe_{kg,tofu} \times S_{tofu} + BDe_{kg,beans} \times S_{beans} \qquad (4).$$

In this equation, S_{tofu} and S_{beans} represent the shares of these products in the category. For example, if 50% of the vegetarian food was tofu, in this case, both values of S_{tofu} and S_{beans} would be 0.5. More generally, this can be represented as a sum of i biodiversity impact intensities (BDe_{kg}), times their share in the respective category (S):

$$\sum_{i=1}^{n} S_i BDe_{kg,i} \qquad (5).$$

Applying the sum equations to equation 3 gives the following:

$$BDe = M_{vegetarian} \sum_{i=1}^{n} S_i \, BDe_{kg,i} + M_{meat} \sum_{j=1}^{k} S_j BDe_{kg,j} \qquad (6).$$

In this example, vegetarian dishes (*i*) are summed *n* times and meat-based dishes (*j*) are summed *k* times. Finally, with the help of equation 2, it is possible to reduce the number of unknown variables in the equation to one, and arrive at the final solution:

$$BDe(M_{vegetarian}) = M_{vegetarian} \sum_{i=1}^{n} S_i \, BDe_{kg,i} + (M_{total} - M_{vegetarian}) \sum_{j=1}^{k} S_j BDe_{kg,j} \qquad (7).$$

In this example, the equation is used for calculating the biodiversity footprint equivalent (*BDe*) value given the mass of the vegetarian food, but it might as well be used for meat or any other two categories. An important observation is that this equation only works when there are two categories. For this reason, the categories were always grouped into two when calculating the results. The shares (S_i) are assumed to stay constant. In other words, when the mass of a category changes, the change in mass is divided evenly across different products.

I applied the above-mentioned equation further by calculating the difference between two biodiversity footprint values to find out the impact of increasing the share of vegetarian dish mass:

$$BDe(M_{current\ situation}) - BDe(M_{target\ situation}) \qquad (8).$$

Here, the target situation can be, for example, the mass of vegetarian dishes according to the criterion. Applying equation 7, it is possible to calculate certain levels of biodiversity footprint for the dishes. This way, I can set a clear mitigation target for the biodiversity footprint that the dishes should reach.

$$BDe(M_{vegetarian}) = M_{vegetarian} \sum_{i=1}^{n} S_i \, BDe_{kg,i} + (M_{total} - M_{vegetarian}) \sum_{j=1}^{k} S_j BDe_{kg,j} \qquad (9)$$

$$BDe = M_{vegetarian} \sum_{i=1}^{n} S_i \, BDe_{kg,i} + M_{total} \sum_{j=1}^{k} S_j BDe_{kg,j} - M_{vegetarian} \sum_{j=1}^{k} S_j BDe_{kg,j}$$

$$BDe = M_{vegetarian} \left(\sum_{i=1}^{n} S_i \, BDe_{kg,i} - \sum_{j=1}^{k} S_j BDe_{kg,j} \right) + M_{total} \sum_{j=1}^{k} S_j BDe_{kg,j}$$

$$M_{vegetarian} = \frac{BDe - M_{total} \sum_{i=1}^{n} S_i BDe_{kg,i}}{\sum_{i=1}^{n} S_i BDe_{kg,i} - \sum_{j=1}^{k} S_j BDe_{kg,j}}$$

Because the values used in the calculation were either high in kilograms or small in biodiversity equivalent (*BDe*) values, I expressed the kilograms in tons and *BDe* values as nano *BDe* ($nBDe = BDe * 10^9$).

4.5.2 Calculating the protein and energy contents

With the same assumption that the shares of individual products do not change, also the change in protein content when the number of plant-based dishes is increased can be calculated with the following two equations:

$$Prot(M_{vegetarian}) = M_{vegetarian} \sum_{i=1}^{n} S_i \, Prot_{kg,i} + (M_{total} - M_{vegetarian}) \sum_{j=1}^{k} S_j Prot_{kg,j} \quad (10).$$

Here, *Prot* represents the protein content and $Prot_{kg}$ protein content per kilogram of the dishes. Finally, I calculated the difference between the two protein content values to find out the impact of increasing the share of vegetarian dish mass:

$$Prot(M_{current\ situation}) - Prot(M_{target\ situation}) \quad (11).$$

The same logic can be further applied to the energy content of dishes.

5 RESULTS

In this section, I present the results of my analysis. First, I introduce the current situation of food procurement in the City of Tampere in relation to the sustainability criterion. Secondly, I demonstrate the main dish categories in the quadrant illustration. Then, I illustrate the impact of increasing the plant-based dishes on the biodiversity footprint of main dishes along with the changes in protein and energy contents. Lastly, all the presented biodiversity footprint results are compared with the total biodiversity footprint of food procurement and the overall biodiversity footprint of the City of Tampere.

5.1 Current situation in relation to the criteria

In 2022, food consumption contributed 20 % (108 nBDe) of the total biodiversity footprint of the City of Tampere (540 nBDe) (Pokkinen et al. 2024). Food consumption was also the single most significant consumption category compared to the other categories, such as heat consumption, construction and electricity consumption. The most significant contributors to the biodiversity footprint among the food products were red meat (37 nBDe, 34%), dairy products (24 nBDe, 24%) and poultry (11 nBDe, 11%). All meat products combined contributed 44% of the total biodiversity footprint of food consumption. However, the most consumed product categories were vegetables (1 708 tons, 27%), cereal products (1 501 tons, 24%) and dairy products (1 352 tons, 21%). While red meat is the largest contributor to the biodiversity footprint, its consumption (157 tons) comprises only 2% of the total food consumption.

In 2022, the City of Tampere purchased nearly 827 tons of food products that were categorised as protein sources in main dishes. Of the total number of main dishes, 550 tons were meat-based, while 280 tons were vegetarian, including 170 tons of purely vegan dishes (FIGURE 4). Meat-based dishes generated 89% (60 nBDe) of the total biodiversity footprint of main dishes, whereas vegetarian dishes contributed 11% (7 nBDe), of which pure vegan dishes generated 7% (5 nBDe). In FIGURE 4, the orange bar represents each category's share of the total consumption volume of the dishes in kilograms, whereas the blue bar represents the biodiversity footprint in BDe. As explained in the data and methodology section, vegan dishes are embedded as part of vegetarian dishes but are also presented as a separate category to differentiate the biodiversity impacts inside the vegetarian dish category, even though the criterion itself does not separate vegan food from vegetarian ones.

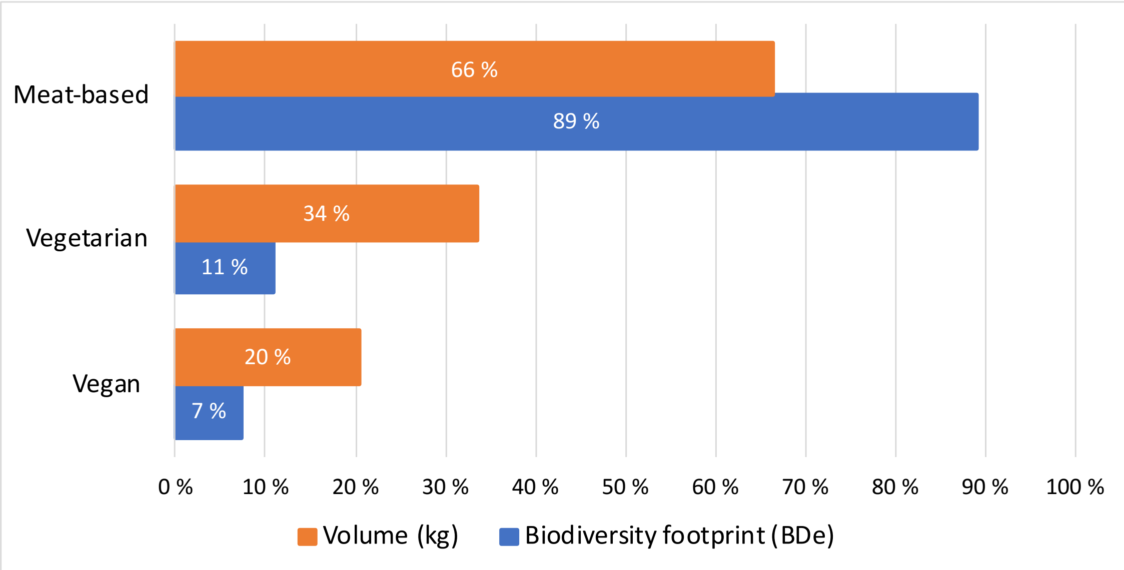

FIGURE 4. The volumes and biodiversity footprints of meat-based, vegetarian, and vegan dishes purchased by the City of Tampere in 2022.

When comparing the current number of vegetarian dishes to the basic (30%) and pioneer (50%) levels of the criterion, it can be noticed that the vegetarian dishes reached a total of 34% of the main dishes. Therefore, the results show that according to this evaluation, the vegetarian dishes exceeded the basic level criterion of 30% by four percentage points (FIGURE 5). However, to reach the pioneer 50% level of the criterion, the number of vegetarian dishes should increase by 16 percentage points. In FIGURE 5, the blue colour illustrates the share of vegetarian dishes out of the total main dishes purchased by the City of Tampere in 2022. The orange colour indicates the criterion level, either at the basic level of 30% or the pioneer level of 50%.

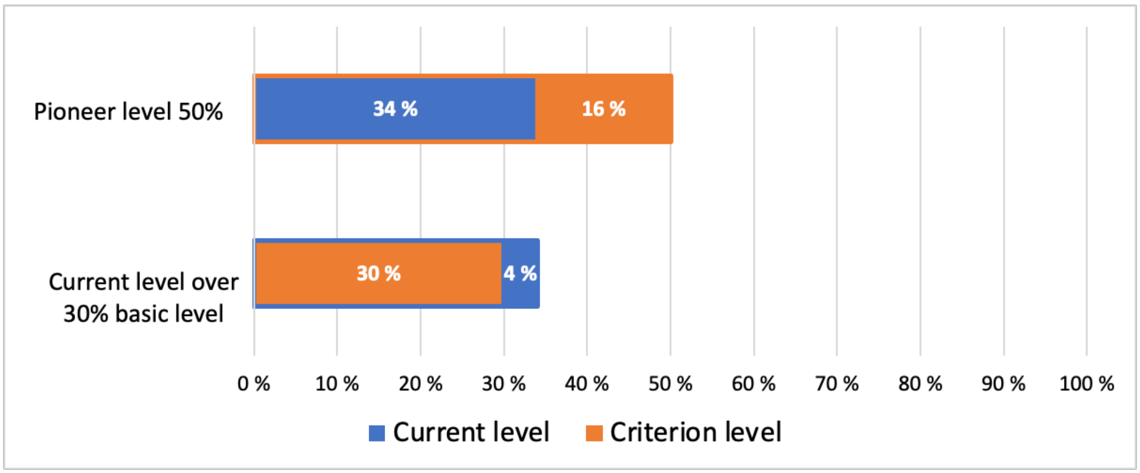

FIGURE 5. The share of vegetarian dishes out of the total number of main dishes in relation to the criterion.

According to this evaluation, vegan dishes represented 20% of the total number of main dishes (FIGURE 6). If the criterion were set for vegan dishes instead of the current vegetarian dishes, with targets of 30% and 50%, the proportion of vegan dishes would need to increase by 10 percentage points to reach the basic level of 30% and by 30 percentage points to achieve the pioneer level of 50%. In FIGURE 6, the blue colour illustrates the share of vegan dishes out of the total number of main dishes purchased by the City of Tampere in 2022. The orange colour indicates the criterion level, either at the basic level of 30% or the pioneer level of 50%.

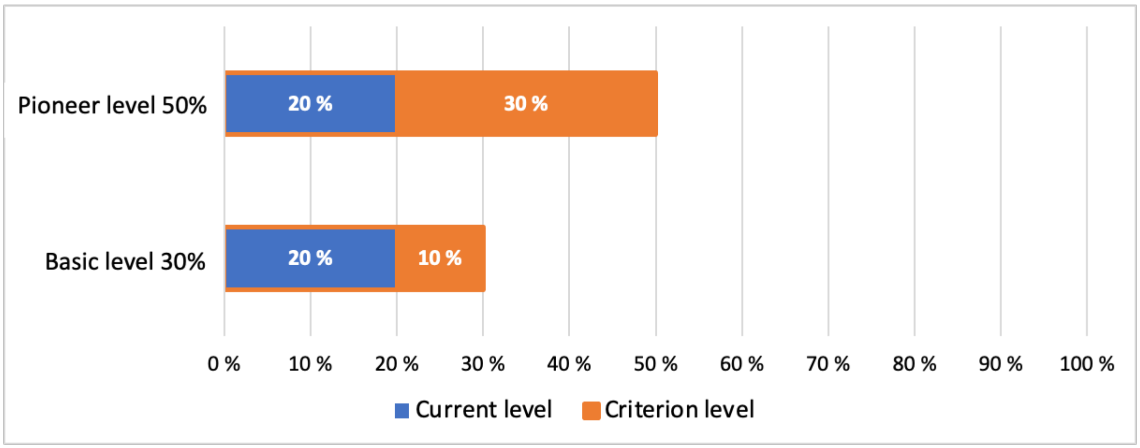

FIGURE 6. The share of vegan dishes out of the total number of main dishes in relation to the criterion.

5.2 Main dishes in quadrant illustration

A quadrant illustration can be used to visualise the biodiversity impact intensity (here in FIGURES 7a and 7b in BDe/kg in the vertical axis) in relation to the volume of the procured items (here in FIGURES 7a and 7b in kg in the horizontal axis). The illustration helps in determining which consumed items have the greatest potential to reduce the biodiversity footprint of food consumption. The upper FIGURE 7a represents the full picture, whereas the lower FIGURE 7b is targeted at the product categories, that are situated in the bottom left-hand corner of the upper figure. The quadrant illustration was conducted for the main protein sources of the dish purchased by the City of Tampere in 2022.

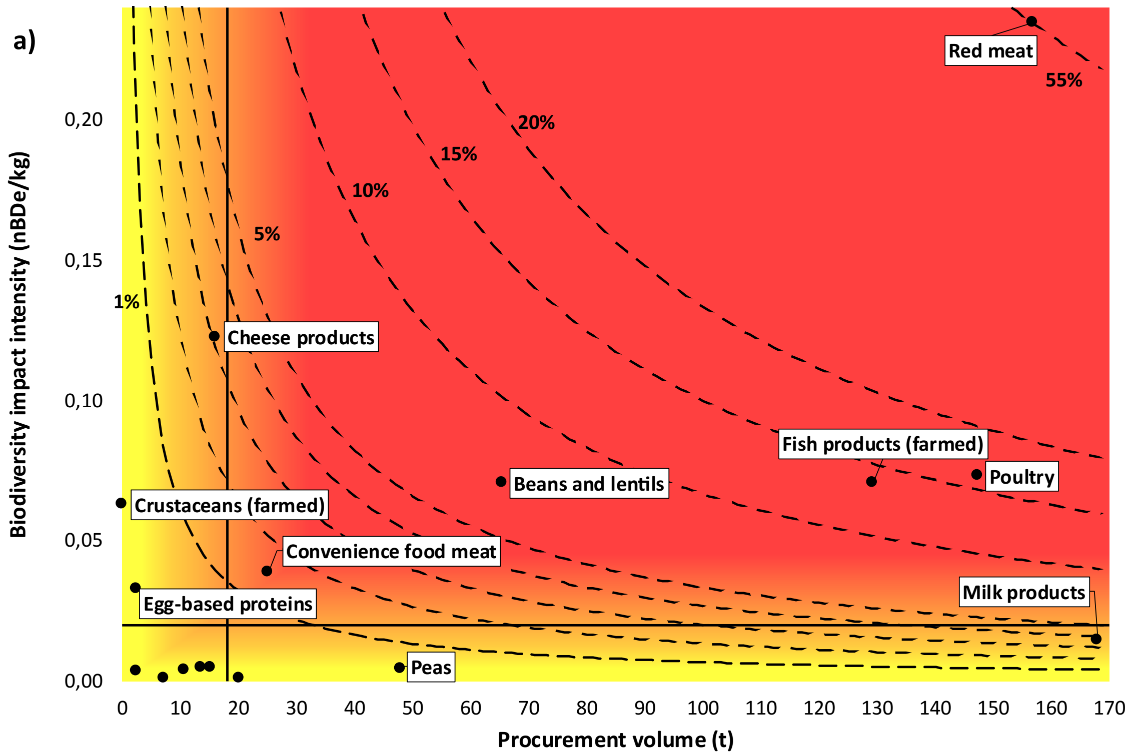

FIGURE 7a. Quadrant illustration of the main protein sources of the dishes purchased by the City of Tampere in 2022.

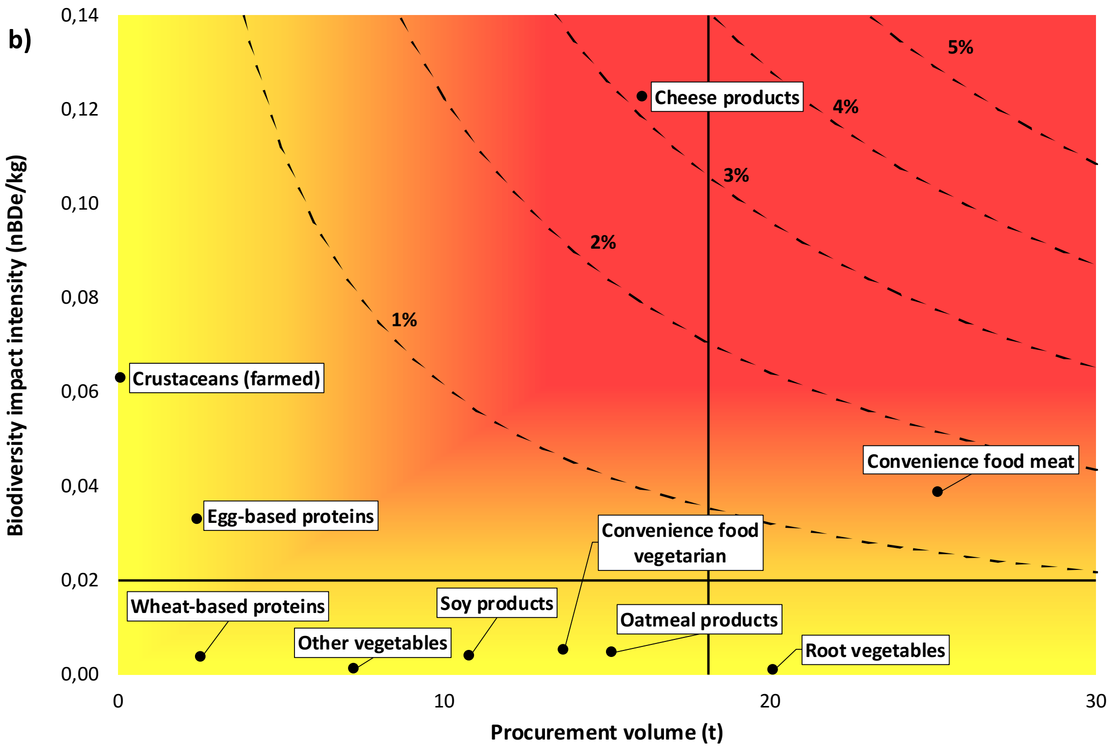

FIGURE 7b. Quadrant illustration of the targeted main protein sources of the dishes.

The four squares in the quadrant are formed by the median values of the mass of purchased main dishes and biodiversity impact intensities of the dishes. The median volume of purchased main dish products is 18.11 tonnes, and the median biodiversity impact intensity is 0.02 nBDe per kilogram (FIGURES 7a and 7b).

The food products that are situated in the top right-hand corner of the quadrant are red meat, farmed fish products, poultry, beans and lentils, and meat convenience food. These categories have the best potential for reducing biodiversity impacts because they are purchased in large volumes and have a high biodiversity impact intensity (nBDe/kg). The mitigation potential could be reached from categories with high biodiversity impact intensity, such as cheese products and farmed crustaceans, by changing the products to less harmful ones, that is, to products that have lower biodiversity impact intensity. The biodiversity impact intensity of milk-based protein sources is below the median value, but they are purchased in large volumes (FIGURE 7a). The consumption of milk-based products could be also changed to less harmful plant-based options to reduce the biodiversity footprint. In conclusion, there are two ways of reducing the biodiversity footprint of consumption: one is to lower the consumption and the other is to change it to less harmful products, that is, products with lower biodiversity impact intensity.

The colour gradient from yellow to orange to red in the figures represents the realised overall biodiversity footprint of the consumption as a function of the biodiversity impact intensity and the amount of consumption. Each of the consumed products falls somewhere on the colour gradient. The dashed lines in the figure represent threshold values that indicate the shares of the absolute total biodiversity footprint. Similarly, with the colour gradient, the threshold values are a function of biodiversity impact intensities and procurement volumes. Thus, the threshold values help to understand the magnitude of the colour gradient. The protein sources of red meat constitute just over 55% of the total absolute biodiversity footprint of the main dishes (FIGURE 7a). Similarly, poultry products account for 15 to 20%, while farmed fish products make up 10 to 15% of the total absolute biodiversity footprint. Half of the product categories contribute less than 1% to the total absolute biodiversity footprint of main dishes. These include, for example, root vegetables, oatmeal products, soy products, and wheat-based protein sources. (FIGURE 7b).

5.3 Impact of dietary changes on biodiversity footprint

The biodiversity footprint of main dishes was analysed when the number of vegetarian or vegan dishes was increased either to basic (30%) or pioneer (50%) levels of the criterion (FIGURE 8). The biodiversity footprint values were also calculated for the situations where only vegetarian, vegan, or meat-based dishes are served when the current total mass of food is held constant. To evaluate the change in the nutritional values of the dishes, the biodiversity footprints of the needed mass of vegetarian or vegan dishes were calculated, while keeping the current protein and energy contents of main dishes constant (FIGURE 8). In the figure, the horizontal axis depicts the mass of vegetarian, vegan, or meat-based dishes in tonnes. Similarly, the vertical axis presents absolute biodiversity footprint values in nBDe. Vegetarian dishes are shown only at the pioneer 50% level, as their mass exceeded the basic 30% level of the criterion. The dashed lines represent the linear change of the biodiversity footprint of main dishes when the mass of vegetarian, vegan, or meat-based dishes changes, but the total mass of dishes is kept constant.

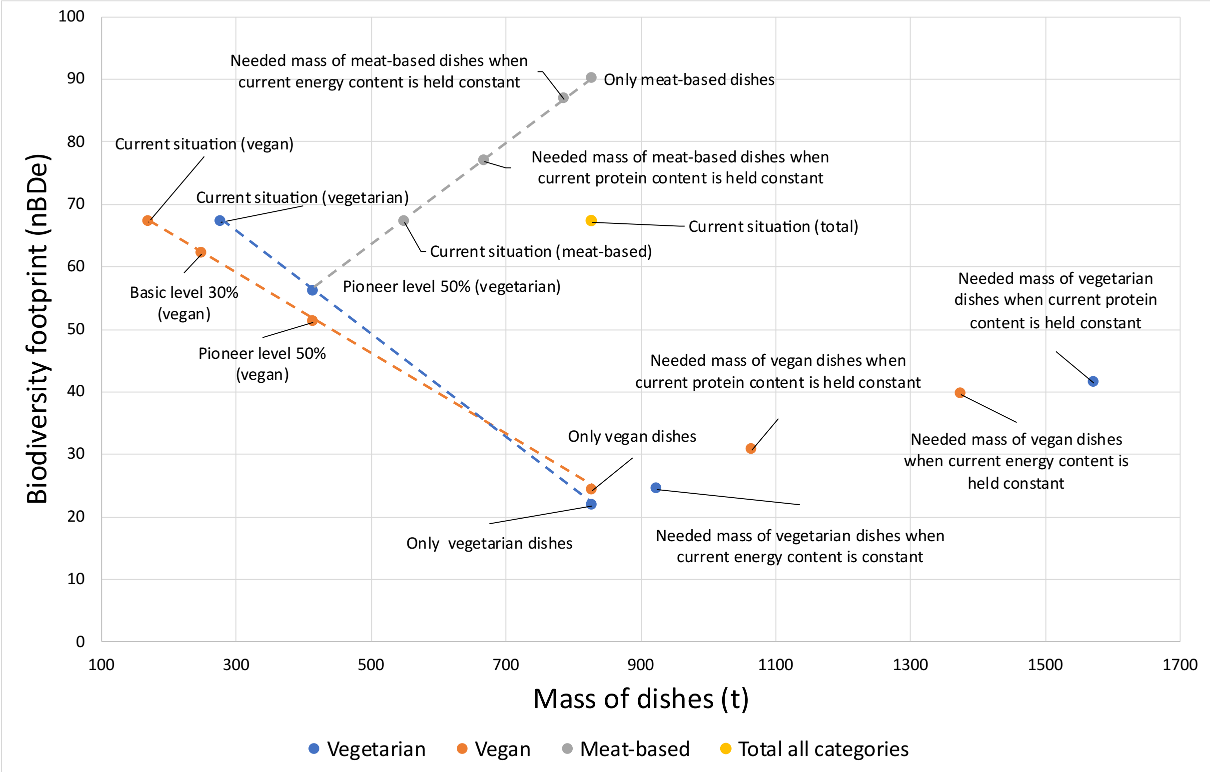

FIGURE 8. Change in the biodiversity footprint of main dishes when the mass of main dishes changes.

The results show that the decrease in the biodiversity footprint of main dishes followed the increase in the mass of vegetarian or vegan dishes. Similarly, the change in protein and energy contents of the main dishes complied with the reduction in biodiversity footprint achieved by increasing vegetarian and vegan dishes. The smallest biodiversity footprint (22 nBDe) was achieved by serving only vegetarian dishes. However, the biodiversity footprint of vegan dishes is only slightly higher (24 nBDe). The pioneer level biodiversity footprint of the criterion was, nevertheless, lower when calculated with vegan dishes (51 nBDe) compared to vegetarian dishes (56 nBDe). The highest biodiversity footprint was generated when only meat-based dishes were served (90 nBDe). Thus, the highest biodiversity footprint of main dishes was about fourfold compared to the lowest biodiversity footprint.

The result showing the smallest biodiversity footprint for vegetarian dishes is somewhat surprising. It is important to keep in mind that the results of this study are limited to the protein sources that were categorised as part of the main dishes, which was an assumption based on the criterion. The categorisation of food products as the main protein sources of the dish excluded many products that could be used in the lacto-ovo diet to compensate for meat consumption. For example, only 18% of the purchased cheese products were categorised as the main protein source of vegetarian dishes. These were, for example, grated cheese because they are usually used as part of main dishes. Additionally, the vegetarian category consisted of only 3% cheese. The most dominant vegetarian food product was cooking cream, which accounted for 30% of the vegetarian category and significantly reduced the biodiversity footprint of the main dish category. I discuss the results in more detail in the discussion section.

To efficiently lower the biodiversity footprint of food, the criterion should focus directly on lowering the footprint instead of the changes in the mass of food. This way, clear targets for reducing the biodiversity footprint could be set to, for instance, 10, 30, or 50% of the current situation. Then, it is possible to calculate the needed mass of vegetarian food to reach the reduction targets of biodiversity footprint. This is shown in FIGURE 9, which illustrates the increase in the mass of vegetarian dishes when the biodiversity footprint is lowered. The calculation was done with the reduction targets of the biodiversity footprint of main dishes from 10 to 50% (FIGURE 9). The results show that if the biodiversity footprint of main dishes is reduced by 50%, the mass of vegetarian dishes should be about 2.5-fold compared to the current situation. Additionally, the 50% reduction in the biodiversity footprint of main dishes requires 65% more vegetarian dishes than the 50% pioneer level of the criterion.

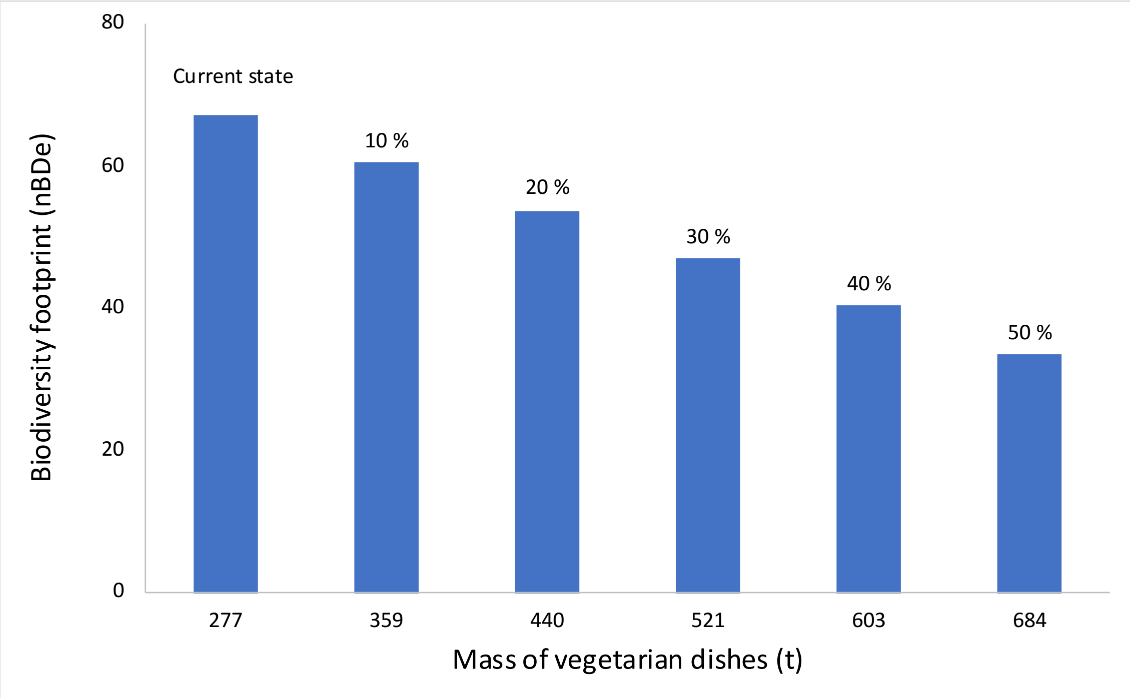

FIGURE 9. Reduction of biodiversity footprint of main dishes when the mass of vegetarian dishes is increased.

5.4 Impact of dietary changes on protein content of food

As mentioned earlier, the changes in protein content of the main dishes were calculated either by keeping the total mass of food constant or by maintaining the total protein content constant while the mass of the main dishes varied. FIGURE 10 illustrates these changes in more detail. In the figure, the change in protein contents of main dishes is illustrated in different levels for vegetarian, vegan, and meat-based categories, when the total mass of food is kept constant: current protein content for all the categories, protein content when the mass of vegan or vegetarian dishes is increased to the basic (30%) or pioneer (50%) levels of the criterion, and protein content if only vegetarian, vegan, or meat-based dishes are served. Additionally, the needed mass of only vegetarian, vegan, or meat-based dishes was calculated, while the current protein content of the main dishes was held constant. In the figure, the horizontal axis depicts the mass of dishes in tonnes. Similarly, the vertical axis presents protein content in tonnes. The dashed lines represent the linear change in the protein content of main dishes when the mass of vegetarian, vegan, or meat-based dishes changes, but the total mass of dishes is kept constant.

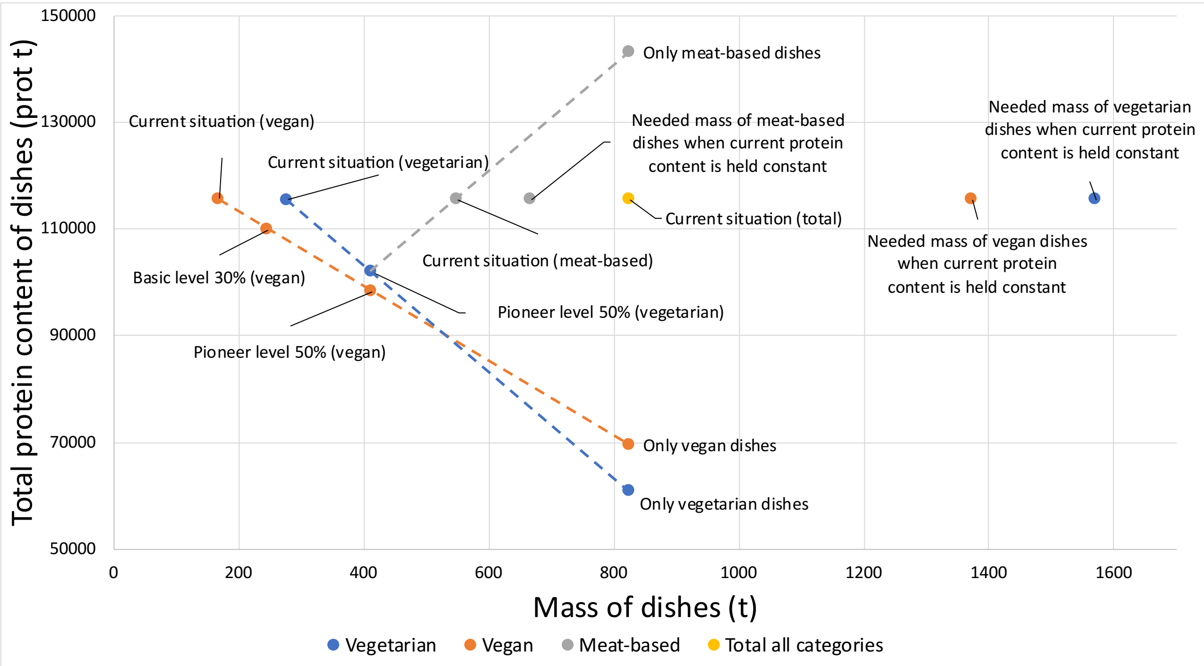

FIGURE 10. Change in the protein content of main dishes when the mass of dishes varies, while either the total mass of food or the total protein content remains constant.

The results show that the increase in vegan or vegetarian dishes comes with a risk of lowering the protein content of the dishes. With vegetarian dishes, the drop of protein content from the current situation (approximately 115 400 tonnes of protein per 280 tonnes of food) to the point where only vegetarian dishes are served (60 700 tonnes of protein per 830 tonnes of food) is steeper than the protein content drop from the current situation of vegan dishes (115 400 tonnes of protein per 170 tonnes of food) to protein content where only vegan dishes are served (69 500 tonnes of protein per 830 tonnes of food). Hence, the lowest protein content level is at the point where only vegetarian food is served when the current total mass of food is held constant. The highest amount of food is at the point where the needed mass of vegetarian dishes reaches the point where the current protein content is kept constant (115 400 tonnes of protein per 1 572 tonnes of food). The point where only meat-based dishes are served when the total food mass is held constant (830 tonnes) has the highest amount of protein content (143 000 tonnes of protein). The low protein content results with vegetarian dishes can be explained by the product content of the category. As mentioned earlier, vegetarian dishes are composed of 30% cooking creams, which have relatively low protein content compared to beans, lentils, and peas, which are separated to vegan dishes. As a result, the vegetarian category has a lower protein content per kilogram compared to vegan dishes, where the proportion of protein-rich foods is higher.

5.5 Impact of dietary changes on the energy content of food

Further nutrition evaluation was done with the energy content of the main dishes. As in the protein content calculations, the energy content changes were calculated either by keeping the total food mass constant or by maintaining the total energy content constant while the mass of the main dishes varied (FIGURE 11). These are illustrated in different levels for vegetarian, vegan, and meat-based categories when the total mass of food is kept constant: current energy content for all the categories, energy content when the number of vegan or vegetarian dishes is increased to the basic (30%) or pioneer (50%) levels of the criterion, and energy content if only vegetarian, vegan, or meat-based dishes are served. Also, the needed mass of only vegetarian, vegan, or meat-based dishes was calculated, while the current energy content of the main dishes was held constant. In the figure, the horizontal axis depicts the mass of the main dishes in tonnes. Similarly, the vertical axis presents the energy content level in tonnes of kilocalories. The dashed lines represent the linear change of energy content of main dishes when the mass of vegetarian, vegan, or meat-based dishes changes, but the total mass of dishes is kept constant.

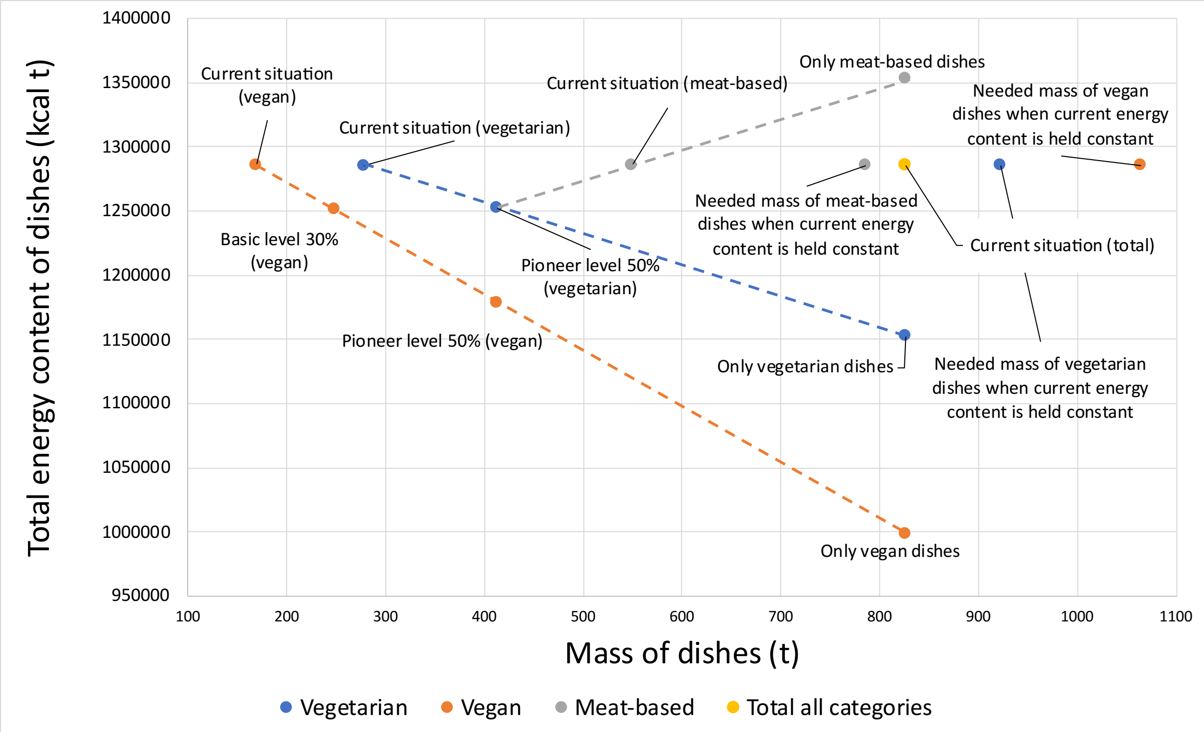

FIGURE 11. Change in the energy content of main dishes when the mass of dishes varies, while either the total mass of food or the total energy content remains constant.

Correspondingly with protein content, the increase of vegetarian or vegan dishes lowered the energy content of main dishes. With vegetarian dishes, the drop of energy content from the current situation (approximately 1.29 million tonnes of kilocalories per 280 tonnes of food mass) to the point where only vegetarian dishes are served (1.15 million tonnes of kilocalories per 830 tonnes of food) is gentler compared to the vegan dishes that is illustrated with the dashed lines (FIGURE 11). Thus, the lowest energy content level is at the point when only vegan food is served. The highest amount of food is at the point where the needed mass of vegan dishes reaches the level where the energy content is kept constant (1.29 million tonnes of kilocalories per 1 065 tonnes of food). Therefore, the results indicate that vegan dishes have lower energy content per kilogram compared to vegetarian or meat-based dishes. Similarly, with protein content, the point where only meat-based dishes are served when the current total mass of food is kept constant (830 tonnes) has the highest amount of energy content (1.35 million tonnes of kilocalories).

5.6 Impact of dietary changes on the overall biodiversity footprint of the City of Tampere

To track the impacts of the increase of vegetarian and vegan dishes on the current biodiversity footprint of the City of Tampere, it was necessary to compare the biodiversity footprint value results. These comparisons are shown in the TABLE

2. In the first column, the different actions are listed, such as the biodiversity footprint of main dishes if the number of vegetarian dishes was increased to the pioneer level of the criterion. The table also depicts the biodiversity footprint values for situations where only vegan or vegetarian dishes are served, with varying protein and energy contents. The comparisons of these different actions were made with the current biodiversity footprint of the main dishes, with the values presented in the second column and the percentages in the third column (TABLE 2). The fourth and fifth columns contain the comparisons with the current biodiversity footprint of the total food products, including every food product purchased by the City of Tampere in 2022. The last two columns present the comparisons of these actions to the total biodiversity footprint of the City of Tampere.

TABLE 2. Comparison of the biodiversity footprints of main dishes and their impact on the overall biodiversity footprint of all food products and the City of Tampere.

State or action	Biodiversity footprint of main dishes (nBDe)	Change in the biodiversity footprint of main dishes (%)	Biodiversity footprint of food products (nBDe)	Change in the biodiversity footprint of food products (%)	Biodiversity footprint of Tampere (nBDe)	Change in the biodiversity footprint of Tampere (%)
Current state	67		108		540	
Basic level 30% (vegan)	62	8 %	102	5 %	535	1 %
Pioneer level 50% (vegetarian)	56	17 %	96	10 %	529	2 %
Pioneer level 50% (vegan)	51	24 %	92	15 %	524	3 %
Needed mass of vegetarian dishes in current protein content	41	38 %	82	24 %	514	5 %
Needed mass of vegan dishes in current energy content	40	41 %	80	26 %	512	5 %
Needed mass of vegan dishes in current protein content	31	54 %	71	34 %	503	7 %
Needed mass of vegetarian dishes in current energy content	24	64 %	65	40 %	497	8 %
Only vegan dishes	24	64 %	65	40 %	497	8 %
Only vegetarian dishes	22	68 %	62	42 %	495	8 %

The results show that the biggest reduction in the biodiversity footprint occurs when only vegetarian food is served. The second-best reduction would be achieved when only vegan dishes are served or when the needed mass of vegetarian dishes reaches the level of current energy content. The reduction that could be achieved with vegetarian dishes at the pioneer level of the criterion is 17% with the biodiversity footprint of main dishes, a 10% reduction in the biodiversity footprint of all food products, and a 2% reduction in the total biodiversity footprint of the City of Tampere. If the criterion would also be set with vegan dishes, the biodiversity footprint reduction with basic level criterion could be 8% in main dishes, 5% in all food products, and 1% in the total biodiversity footprint of the City of Tampere. With vegan dishes at the pioneer level of the criterion, the biodiversity footprint reduction could be 24%, 15% and 3%, which marks a bigger reduction compared to vegetarian dishes at the pioneer level of the criterion.

6 DISCUSSION

In this section, I interpret the main findings of the research. First, I discuss the impact of using the sustainability criterion in the public food procurement process on the biodiversity footprint of the case organisation. I also compare the results with findings from other studies and examine the limitations of this research, offering suggestions for the use of sustainability criteria.

6.1 Interpretation of the results

In this study, I assessed the impact of using a public procurement sustainability criterion during the purchasing process on the biodiversity footprint of a public organisation. The studied criterion aims to increase the share of plant-based main dishes of the total eaten main dishes in kilograms, either to 30% or 50%. The main findings revealed that if a public organisation is using the studied sustainability criterion of the 50% target during its food procurement process, the biodiversity footprint of food procurement will be 10% lower compared to the current biodiversity footprint. This would also result in a 2% reduction of the total biodiversity footprint of the public organisation.

Meat-based dishes had the highest biodiversity footprint (60 nBDe, 89%) compared to lacto-ovo vegetarian (7 nBDe, 11%) or purely plant-based vegan dishes (5 nBDe, 7%), which were separated from the vegetarian category. Especially red meat, such as beef, lamb, and pork, contributed the biggest share (55%) with poultry (slightly over 15%) of biodiversity footprint compared to plant-based main protein sources of the dish, from which six out of seven vegan protein sources contributed less than 1% of the total biodiversity footprint of main dishes protein sources. The high biodiversity footprint of red meat is due to the land use as cropland and pasture, as well as the climate change impacts that are high, especially with ruminant livestock, which is a significant source of global methane emissions (Poore & Nemecek, 2018; Godfray et al., 2018). For similar reasons, cheese products had the second-highest biodiversity impact intensity (0.12 nBDe/kg) after red meat (0.23 nBDe/kg).

Corresponding results with mine have been found by Sanyé-Mengual et al. (2023), who compared different LCA methods to assess the biodiversity footprint of EU consumption. They concluded that food products, especially red meat (beef and pork), contributed most of the biodiversity footprint of all consumption categories with every LCA method they compared. The overall impact of meat was associated with livestock production impacts on land use and climate change – that were the assessed impact categories in my research – but also with acidification and photochemical ozone formation due to air transportation (Sanyé-Mengual et al., 2023). Crenna et al. (2019) conducted a more detailed LCA-based assessment of the biodiversity footprint of food consumption in the EU using the ReCiPe database versions from 2008 and 2016. Red meat (beef and pork) contributed a total of 44% of the biodiversity footprint of the total EU food consumption (Crenna et al., 2019). In addition, poultry generated the second highest results with 8–13% of the total biodiversity footprint, cheese generated 7% and eggs 4–5% (Crenna et al., 2019). Cheng et al. (2024) compared the biodiversity footprint of popular main dishes around the world with three biodiversity indicators: species richness, threatened species richness and range rarity by converting natural habitat to cropland or pastureland. Their results indicate that dishes containing meat had a higher biodiversity footprint compared to vegetarian or vegan dishes (Cheng et al., 2024).

Hynönen (2024) compared the biodiversity footprint of different protein sources and found that red meat generates most of the biodiversity footprint, followed by cheese and poultry, whereas vegan protein sources, such as peas and tofu, have the lowest impact. Also, Ollikainen et al. (in press) assessed the biodiversity footprint of consumption of an average Finnish citizen, showing that ingredients that are commonly used in lacto-ovo vegetarian dishes, such as cheese, milk products and eggs, have higher biodiversity footprints compared to the vegan options. Both Hynönen (2024) and Ollikainen et al. (in press) used the same biodiversity footprint assessment method, adapted from El Geneidy et al. (2023), that I applied in this research.

However, differing from the studies of Hynönen (2024) and Ollikainen et al. (in press), the results of my research indicate that vegetarian main dishes have a relatively low biodiversity footprint, even compared to vegan options. As explained earlier, this is due to the categorisation of food products as the main protein sources of the dish. Milk-based cooking creams, which have a relatively low biodiversity footprint, were the most dominant product in the vegetarian category, with a 30% share of the category, followed by beans and lentils (24%), peas (17%), and root vegetables (7%). Cheese made up only 3% of the vegetarian category, and just 18% of the total number of purchased cheese products could be categorised as vegetarian main protein sources, which significantly lowers the biodiversity footprint of the vegetarian category. According to FIGURE 7a, the biodiversity impact intensity of cheese products was the second highest after red meat.

Also, the separation between vegetarian and vegan dishes brought difficulties in interpreting the results since the vegan dishes were embedded in the vegetarian category to answer the criterion. In total 61% of the food products in the vegetarian category could be separated into vegan dishes, meaning that together they dominated the vegetarian category. Beans and lentils contributed 39% of the vegan category, whereas peas contributed 28% and root vegetables 12%, meaning that these products had a higher proportional share in the vegan category than in the vegetarian category. In this study, especially beans and lentils have relatively higher biodiversity footprints compared to cooking creams, contributing to the higher biodiversity footprint of vegan dishes compared to vegetarian dishes. Nevertheless, with a lacto-ovo vegetarian diet, the main protein source of the dish is often something else than cooking creams, for example, cheese or eggs. It is also worth noting that in this research oatmeal-based cooking creams had lower biodiversity impact intensity values than milk-based cooking creams, meaning that if milk-based cooking creams were replaced with oatmeal cooking creams, the biodiversity footprint of food could be smaller.

I also assessed the impact of using the sustainability criterion on the protein and energy contents of the dishes. The results of this study show that when the studied sustainability criterion of the 50% target is used, the protein content of main dishes is 12% lower and energy content is 3% lower than without the use of the criterion. Therefore, if the organisation aims to maintain the current protein and energy contents of the main dishes, the mass of vegetarian main dishes would need to be nearly six times higher than it currently is to maintain the protein content, and three times higher to maintain the energy content. It is important to note that both protein and energy contents are crucial and should be met simultaneously. Correspondingly, Saarinen et al. (2019) studied optimal nutrition compositions and concluded with similar results that in vegan diets or in diets that consume less meat than the average diet in Finland, the quantity of the consumed food needs to be higher to comply with the national nutrition recommendation.

However, determining the appropriate nutritional value level in this study is challenging, as the calculations were based on the total protein and energy content of the main protein sources of dishes rather than individual meals. This study did not include other main food products, such as potatoes and cereals, or the side food products, such as salads, bread, or drinks that would be crucial to compiling a nutritious and healthy plant-based meal. Especially in vegan diets a healthy meal is constructed from several different protein sources that could be compiled during the day with different meals. Also, customers who eat the food in catering services usually eat only one meal, meaning that it is typically one of the two recommended warm meals per day. Even though one meal can contribute a significant portion of the total food consumption per day, with nutritional intake the overall diet marks whether an individual's protein or energy intake is on the recommended level.

Catering companies typically do proper menu planning based on nutrition recommendations to maintain the quality and nutritional values of the food and not just increase the meals they are already serving, which is now assumed in the calculations of this study. Correspondingly, it can be assumed that the food served by Pirkanmaan Voimia already aligns with the nutritional recommendations to some extent. Thus, the biodiversity footprints were calculated in the situations where only vegetarian and vegan dishes were served, while their masses were increased to match the current protein and energy contents of the main dishes. If only vegetarian dishes were served while maintaining the current protein and energy contents, the biodiversity footprint of the City of Tampere could be reduced by 5–8%. With vegan dishes, the reduction of the biodiversity footprint of Tampere could be 5–7%. Corresponding results were found by Matej et al. (2024), who studied how the total biodiversity footprint of the City of Vienna can be lowered by 5-9% by increasing plant-based foods in average diets and by complying with recommended caloric intake. Interestingly, Matej et al. (2024) adjusted diets to align with recommended caloric intake by reducing the number of calories, suggesting that the average diet contains an excessive number of calories. It was not possible to evaluate whether the customers of Pirkanmaan Voimia consume excessive protein or calorie intakes from the food they are served.

It is also important to note that in this research, I evaluated the nutritional content of food based on weight, which varies significantly depending on the type of food. For example, cooking creams have relatively low protein content per kilogram because the product is in liquid form. This could explain why the results showed that vegetarian dishes had the lowest protein content per kilogram, as the category was predominantly made up of cooking creams.

Nevertheless, the current average Finnish diet has several deficiencies (see, for example, Valsta et al., 2018; Kaljonen et al., 2022) and especially the protein and meat intake are estimated to exceed for both men and women (Valsta et al., 2022), and fall short with carbohydrates (Saarinen et al., 2019). Saarinen et al. (2019) recommend various diets that align with nutritional recommendations while also reducing meat consumption. With protein transition from meat-based protein sources to more sustainable options, the diversity of plant-based protein sources is important (Hoehnel et al., 2022). Other studies have found a correlation between more nutritious food products and smaller environmental impacts (Tilman & Clark, 2014; Saarinen et al., 2017; Godfray et al., 2018; Willett et al., 2019; Clark et al., 2019; Clark et al., 2022) that further encourage the shift towards more plant-based diets.

6.2 Limitations in data and methodologies

As in all research, this study also has limitations that need to be considered when interpreting the results. Here, I further discuss the limitations regarding data selection, criteria, and the biodiversity footprint assessment methodology.

6.2.1 The data

I categorised the main dishes based on the kilogram-based accounting data of Pirkanmaan Voimia. Thus, the categorisation might not be as accurate as the actual main dishes served. Also, the consumption data does not provide information on how the food products were presented or served by the catering service. Some food products categorized as vegan protein sources in this study may have been served as part of main dishes that also included vegetarian or meat-based ingredients, meaning the served food would not have been entirely vegan. For more detailed results, the assessment should be done with more accurate menu details of the main dishes. Nevertheless, the product categorisation in this thesis was done more accurately than in the original biodiversity footprint assessment of the food products of the City of Tampere.

One important aspect that affects the biodiversity footprint of food products is their country of origin since the environmental impacts vary, for example, based on the environmental conditions or species richness of the region where the impact is directed (Verones et al., 2020). This has been evident in the studies of Sandström et al. (2017), Peura et al. (2023), Pykäläinen et al. (2024) and Pokkinen et al. (2024), where the global distribution of biodiversity footprint often has the greatest impact outside of Finland, and mainly in areas where species richness is high. One option to lower the biodiversity footprint is to favour food produced in low-biodiversity areas (Peura et al., 2023). The study of Hynönen (2024) shows that overall protein sources produced in Finland have relatively lower biodiversity footprints because the local species richness is not that high in Finland compared to many other countries. Also, Matej et al. (2024) found that relocating food production from abroad to Austria would reduce the City of Vienna's biodiversity footprint by 5-21%. However, all plant-based protein sources had a significantly lower footprint than any of the animal-based protein sources produced in Finland, indicating that the greatest reduction in biodiversity footprint is still achieved by shifting towards plant-based diets (Hynönen, 2024). Also, it is necessary to acknowledge that even though the species richness is not relatively high in Finland, the local land use practices are still important for the viability of local species and ecosystem functions and thus provide ecosystem services for local people (Peura et al., 2023).

In this study, the original production country of certain food products or their raw materials may be inaccurate. The country of origin for some of the products has been listed as Finland, although the product may have been only packed in the listed country. For example, most soy products have been listed as produced in Finland. This way, the study may give incomplete results on certain products. Soy production has been particularly controversial due to its potential to cause deforestation, especially when it is produced in areas like the Brazilian rainforests (Saarinen et al., 2019). However, in Finland, most of the human-consumed soy comes from Europe (Koistinen, 2020), and most of the soy produced in fragile rainforest areas or other regions with rich biodiversity is used to feed livestock, mostly poultry (Saarinen et al., 2019). Many plant-based protein sources, for example, horse bean, quinoa, hemp, flax seeds, and peas, are rich in amino acids and could be cultivated in Finland but are currently underutilised (Saarinen et al., 2019). Thus, if a public catering organisation wants to favour local food production but avoid animal-based protein sources, there are several nutritionally rich options for locally produced plant-based protein sources.

6.2.2 The criterion

The selected criterion sets certain limitations to the evaluation. Pirkanmaan Voimia Oy is a catering service provider, and their kilogram-based consumption data encompasses all the food products purchased across the entire organisation. The criterion, however, focuses on the main dishes that are eaten in a specific public catering organisation, meaning that the criterion focuses on a slightly different thing because the amount of purchased food is not the same as the amount of eaten food. Food can be, for instance, discarded, which can affect the kilogram-based amount of eaten food compared to the purchased food. Therefore, the findings of this study indicate the impact of increasing plant-based protein sources on the biodiversity footprint of food; however, due to the consumption-based data, the results do not directly address the criterion. This may have distorted the results of the current situation, as it shows that plant-based main dishes currently make up more than 30% of the total meals purchased. In this regard, a more thorough evaluation would need more accurate data about the eaten main dishes. Nonetheless, 43% of Finnish food services provide plant-based vegan or vegetarian meals as a daily main dish option, with an additional 26% offering them once a week (Ministry of Agriculture and Forestry & Motiva Oy, 2023). Thus, the results of this study may fall into this scope regardless of not directly responding to the criterion.

The criterion focuses solely on the main dishes, excluding the other foods provided by catering services. The protein sources of the main dishes evaluated in this research contributed to 13% of the total food consumption of the City of Tampere and 62% of the biodiversity footprint of food products. Thus, a significant portion of the consumed food was excluded from the evaluation. A more comprehensive evaluation of the footprint's mitigation potential would need to consider all the other food products served.

The sustainable level of an organisation's food consumption remains unclear, as does the extent to which the biodiversity footprint should be reduced through more sustainable consumption practices. With a biodiversity footprint, there is yet no unambiguous optimal level that could be considered sustainable. It is uncertain whether the biodiversity footprint reduction potential provided by the sustainability criterion is sufficient for an organisation or its sustainability targets. Shifting dietary habits to align more closely with current national nutrition recommendations would reduce the environmental impacts of food consumption. However, this change alone would not be enough to lower the environmental impacts to a level that avoids transgressing critical planetary boundaries, such as climate change, cropland use, and nitrogen applications (Clark, Macdiarmid et al., 2020; Harwatt et al., 2023). Thus, stronger integration of environmental aspects within the nutrition recommendations is needed to guide public organisations towards more sustainable and healthier food consumption (Huan-Niemi et al., 2020), which would further support the overall sustainability transition of our societies and halt the progression of biodiversity loss and climate change.

The criterion itself may not be sufficient to lower the biodiversity footprint of food products at the sustainable level, but it can be one of multiple actions. Food waste, along with the necessary shift toward plant-based diets, stands as one of the major challenges to achieving sustainable food systems (Saarinen et al., 2019; Kortesoja et al., 2022; Read et al., 2022). One of Matej et al. (2024) biodiversity footprint reduction scenarios included halving food waste, which would lead to a 5% reduction of the biodiversity footprint of the City of Vienna. Additionally, seasonal and organically produced food may have positive biodiversity impacts (Gaia Consulting Oy & PTT Oy, 2022), but their overall biodiversity footprint should be further investigated. Thus, it is reasonable to state that employing multiple criteria simultaneously is essential to achieving a significant reduction in the biodiversity footprint of food consumption.

6.2.3 The methodology

Besides the biodiversity footprint calculation methodology used in this study, other methods have been developed as well (Crenna et al., 2020; Lammerant et al., 2022; Damiani et al., 2023). Methodology for biodiversity footprint calculation is under development and currently it can assess only certain aspects that have been estimated on a reasonable level. The method does not recognise variations within product categories or differences in production methods, such as the distinction between organically and conventionally produced foods. In this study, the biodiversity footprint of food products was assessed only in terrestrial ecosystems. For example, Peura et al. (2023) calculated the biodiversity footprint also for marine and freshwater ecosystems with monetary consumption information. Their results show that all meat products have significant impacts on those ecosystems as well, even though the monetary-based calculation may not be as accurate as the kilogram-based assessment. However, other protein sources, for instance, fish products were found to generate high impacts on marine ecosystems, and dairy products on freshwater ecosystems (Peura et al., 2023). Thus, if impacts to other ecosystems were added to the kilogram-based biodiversity footprint assessment, the results could be different.

This research considers only climate change and land use as drivers of biodiversity loss in the biodiversity footprint assessment of food consumption. Even though they are estimated to be the biggest contributors to the biodiversity footprint of food (Poore & Nemecek, 2018; Verones et al., 2020), other drivers of biodiversity loss, such as pollution, phosphorus emissions and water usage should be considered to produce more accurate evaluations. These factors would allow calculations to include the impacts on freshwater and marine ecosystems, providing more holistic information on the global impacts of food consumption.

The calculation method developed to assess the impact of the use of the criterion introduces certain limitations to the research. The calculation assumed that within the main dish categories, such as vegetarian dishes, the share of individual products will not change, although the total number of vegetarian dishes is increased. In other words, the shares of each product inside the main dish category are assumed to stay constant, and only the mass of a category changes, dividing the change in mass evenly across different products. In this regard, the calculation is limited to the current scenario, focusing solely on the food products identified as main dishes within the dataset. Consequently, while the calculation may not be ideal for planning more plant-based menus, it provides a practical starting point for an organisation aiming to reduce the biodiversity footprint of its food consumption.

6.3 Future suggestions and research

Overall, the sustainability criteria should be designed in a way that makes it practical for the buyer organisation. For now, the use of sustainability criteria is voluntary, and biodiversity-related criteria are applied only moderately in public tendering processes (Ministry of Agriculture and Forestry and Motiva Oy, 2023). Several barriers to the use of sustainability criteria have been identified, for example, by Alhola (2012), Alhola and Kaljonen (2017), Swensson and Tartanac (2020), Molin et al. (2021; 2024) and Berg et al. (2022). Thus, the potential of public procurement to drive organisational sustainability is underutilised, and the procurement process requires further development.

As previously noted, the criterion does not distinguish between vegan and vegetarian main dish options; instead, both are grouped under plant-based main dishes. Nonetheless, I wanted to bring forth the differences between these categories and encourage public organisations to form the criterion in a way where vegan and vegetarian options have separate target levels. For example, public organisations could take a stance by offering only vegan food and thus encourage and accustom people to consume more plant-based options. An alternative approach for the criterion could be to focus more on increasing the availability of plant-based options compared to meat-based ones. For instance, the criterion could have three target levels, one for each main dish category: 70% vegan, 20% vegetarian and 10% meat-based dishes. According to this research, a significant reduction in the biodiversity footprint of an organisation is not feasible without decreasing meat consumption and transitioning more to plant-based options.

I argue that the criterion should be more ambitious and explicitly set a target for mitigating the biodiversity footprint, as it currently addresses this issue only indirectly through the increase in plant-based food consumption. Additionally, the current pioneer-level criterion results in only a marginal reduction of the organisation's overall biodiversity footprint (2%) and the footprint of food (10%) and main dishes (17%). In this regard, a calculation based on the biodiversity reduction target (FIGURE 9 in section 5.3.) was made to provide a simpler calculation method for organisations to evaluate the needed increase of plant-based main dishes to reach the desired reduction in biodiversity footprint. The calculation provides a clear mass quantity of vegetarian-based main dishes required if the organisation aims to reduce its biodiversity footprint by, for example, 50%. The calculation according to the biodiversity footprint reduction could work as the initial step for organisations to start their footprint reduction process. Further planning would have to be done with the nutritional values of the meals, but this could be a longer process for organisations. This kind of calculator could be an option to highlight the original points of the criterion, one of which is the enhancement of biodiversity (Motiva, 2024c).

This study evaluated the potential of a single sustainability criterion to mitigate the biodiversity footprint. Additional biodiversity footprint assessments should be conducted using other sustainability criteria developed by Motiva (Motiva, 2024b) to gain a more comprehensive understanding of their effects on the biodiversity footprint of public organisations. Also, a broader discussion on whether the use of criteria or which combination of criteria can best support a public organisation in achieving its sustainability targets is necessary, as this was not evaluated in this research.

Further development is needed also with the biodiversity footprint assessment of food products. Now the estimates are based on country-specific averages, but more accurate results can be achieved with producer-specific LCA analysis. Public organisations could steer the science-based sustainable public food procurement by encouraging producers in their supply chains to conduct LCA analyses on their products and shifting tendering processes from price-based to sustainability-based competition.

Rather than placing the burden of dietary change solely on individuals, public organisations have a significant opportunity to influence citizens' behaviours, habits, and customs by offering and nudging more sustainable and healthier options (Sabaté & Soret, 2014; Godfray et al., 2018; Huan-Niemi et al., 2020). Public catering services could execute this opportunity by incorporating science-based targets for more sustainable and healthier food in their menu planning. It is also feasible to align the sustainability and health aspects of food with customer preferences. Transitioning to more sustainable and healthier dietary patterns requires coordinated, science-based efforts also from private suppliers and governmental bodies, which establish incentives and frameworks for public procurement (Clark, Macdiarmid et al., 2020). Public organisations should take a pioneering role in driving the overall sustainability transition within society.

7 CONCLUSIONS

Academia emphasises the need to transition from animal-based protein sources to plant-based alternatives to promote health and support the overall sustainability transition. Public organisations hold a significant potential to nudge citizens towards this change, with one effective tool being the use of sustainability criteria in public procurement processes.

In my Master's Thesis, I evaluated the impact of the use of sustainability criteria on the biodiversity footprint of public food procurement. The evaluation was made with a case organisation, the City of Tampere, and its food catering company, Pirkanmaan Voimia Oy. The selected criterion aims to increase the share of plant-based main dishes in the total number of main dishes consumed, setting targets of 30% or 50%. In this study, the main dishes were determined by the main protein source of the food, such as beef, fish, or beans. The biodiversity footprint impact calculations were based on the methodology of El Geneidy et al. (2023) and utilised the biodiversity footprint assessment of the City of Tampere conducted by Pokkinen et al. (2024). Also, the changes in protein and energy contents of main dishes were estimated according to the increase in plant-based dishes since the nutritional values of food are essential, especially when providing public food services to schools, hospitals and daycare centres.

The results indicate that by using the criterion, an organisation can reduce its biodiversity footprint. The criterion should, however, be applied using science-based decisions in menu planning to achieve substantial reductions in biodiversity footprint while ensuring the dishes meet nutritional recommendations. Through this thesis, I aim to encourage public organisations to actively incorporate sustainability criteria into their procurement processes by providing concrete insights into the biodiversity footprint reduction potential of a criterion that has not been studied before.

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Silja Tuunanen

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