Material footprint of Flow Festival 2022

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Abstract

Spare time activities are important for balancing modern life, but they cause environmental damage. Activities, such as attending music festivals have a significant impact to an individual's lifestyle material footprint. Material footprint aims to identify general human pressure on nature, and it helps to understand the natural resource use. Producing a mass event, such as Flow Festival, requires large amount of material flows. As the demand for materials continues to increase, so does the environmental impacts from material use. To meet the environmental goals set by the Paris Agreement and to curb natural resource depletion, one solution is to decrease material consumption.

This master's thesis is executed with in co-operation with D-mat ltd and it presents the material footprint calculation of Flow Festival 2022. The thesis includes a literature review that examines the material footprint, the MIPS concept, and material flow accounting. The subsequent research part includes the collection of consumption data, the footprint calculation, and its results. Also, sustainable solutions were created to decrease the material footprint of the festival.

The total material footprint of the festival was 7,780 tonnes which translates to 86 kg per visitor per day, which is more or less equivalent to the daily lifestyle material footprint of an average Finn. There were nine different categories to determine the material footprint, with the visitors category contributing the most at 73.4% of the total material footprint. Other significant categories were food and beverages, stage production, and properties. The study used 'usage by Flow' factors that were partly developed through feedback from relevant experts and partly based on assumptions. Changing these factors could have a significant impact on the study's results.

The study found that the visitors category has a significant influence on the ecological impact of the festival, particularly in regard to their transportation choices. Festival organisers have limited control over visitors' travel choices, but they can effectively reduce other categories, such as by increasing plant-based food offerings at the festival. As the average Finn's material footprint is expected to be reduced to a quarter by 2050, music festivals have a responsibility to reduce their material footprint, and all possible efforts should be made to achieve this. In the future, the sustainable solutions could be utilised for other similar mass events.

Keywords

Material footprint, natural resources, footprint calculation

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Tiivistelmä

Vapaa-ajan aktiviteetit ovat tärkeitä modernin elämän tasapainottamiseksi, mutta niillä on myös negatiivisia vaikutuksia ympäristöön. Aktiviteetit, kuten musiikkifestivaaleilla käyminen vaikuttavat merkittävästi yksilön materiaalijalanjälkeen. Materiaalijalanjälki auttaa ymmärtämään luonnonvarojen käyttöä ja se pyrkii tunnistamaan ihmisen aiheuttaman paineen ympäristölle. Flow Festivalin kaltaisen massatapahtuman tuottaminen vaatii suuren määrän materiaalivirtoja. Materiaalien kysynnän kasvaessa materiaalien käytön ympäristövaikutukset kasvavat. Pariisin ilmastosopimuksen ympäristötavoitteiden saavuttamiseksi ja luonnonvarojen ehtymisen hillitsemiseksi yksi ratkaisu on vähentää materiaalien kulutusta.

Tämä pro gradu -tutkielma on toteutettu yhteistyössä D-mat oy:n kanssa ja siinä esitellään Flow Festival 2022 tapahtuman materiaalijalanjälkilaskelma. Tutkielmaan sisältyy kirjallisuuskatsaus, joka tarkastelee materiaalijalanjälkeä ja MIPS käsitettä sekä materiaalivirta-analyysia. Tutkimusosioon kuuluu puolestaan kulutusdatan keruu ja siinä käydään läpi jalanjälkilaskenta ja sen tulokset. Lisäksi tutkimuksen aikana kehiteltiin erilaisia toimenpiteitä, jotka voivat pienentää festivaalin materiaalijalanjälkeä.

Festivaalin kokonaismateriaalijalanjälki oli 7 780 tonnia, mikä tarkoittaa 86 kilogrammaa kävijää kohden päivässä. Tämä suunnilleen vastaa keskivertosuomalaisen päivittäistä materiaalijalanjälkeä. Materiaalijalanjäljen laskemiseksi määriteltiin yhdeksän eri kategoriaa, joista kävijät-kategorian osuus oli suurin, 73,4 % kokonaismateriaalijalanjäljestä. Muita merkittäviä kategorioita olivat ruoka ja juomat, lavatuotanto ja kiinteistöt. Tutkielmassa määriteltiin festivaalin käyttämille tuotteille ja palveluille käyttöasteet, jotka perustuivat osittain alan asiantuntijoiden kommentteihin ja osittain oletuksiin. Käyttöasteiden muuttaminen voi vaikuttaa merkittävästi tuloksiin.

Tutkielmassa havaittiin, että kävijät vaikuttavat merkittävästi festivaalin ekologiseen vaikutukseen erityisesti kuljetusvalintojen osalta. Festivaalijärjestäjillä on rajalliset mahdollisuudet vaikuttaa kävijöiden matkavalintoihin, mutta he voivat tehokkaasti vähentää muita kategorioita esimerkiksi lisäämällä kasvipohjaista ruokatarjontaa festivaaleilla. Koska keskivertosuomalaisen materiaalijalanjäljen odotetaan pienenevän neljännekseen vuoteen 2050 mennessä, musiikkifestivaaleilla on vastuu pienentää omaa jalanjälkeään, ja tähän olisi pyrittävä kaikin mahdollisin keinoin. Tulevaisuudessa muutkin massatapahtumat voisivat hyödyntää tutkimuksessa kehiteltyjä toimenpiteitä materiaalijalanjäljen pienentämiseksi.

Avainsanat
Materiaalijalanjälki, luonnonvarat, jalanjälkilaskenta

Ohjaajat
Pauli Lappi ja Michael Lettenmeier

Säilytyspaikka

Muita tietoja

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1 Introduction

The purpose of this thesis is to present the material footprint calculation of Flow Festival 2022 and identify the main contributions to the footprint. The focus is on the total material consumption (TMC), which measures the primary material requirement that is related to household consumption (OECD statistics, 2005). The term material footprint (MF) can be defined as the global allocation of raw materials from the starting point until the end of its life cycle. Material footprint aims to identify general human pressure on nature. (Wiedmann et al., 2015, Lettenmeier 2018.) Material footprint provides the total natural resource consumption, but it is still a rather unused approach in the festival industry. However, it can provide a holistic picture of the use of natural resources. (Kolehmainen et al., 2021). Many festivals have calculated their carbon footprint, but in Finland the material footprint has not been calculated for any other festival (Rantanen, 2011; Salomäki, 2020).

1.1 Motivation

The demand of materials is increasing and therefore the use of materials is also rising. One option to meet the environmental targets of the Paris agreement and to reduce natural resource use is to reduce the use of materials. The reduction in material use can be done through material efficiency which has a lot of benefits: can provide savings in production costs, and it can reduce energy emissions. (Karakaya et al., 2021.)

The extraction of natural resources is increasing, and The Intergovernmental Panel on Climate Change (IPCC) has stated that greenhouse gas emissions and material intensity are rising globally, and the current actions are not sufficient to limit the global warming to 1.5°C. Material intensity can be defined as the amount of materials that is needed to produce a product and it can be reduced by material efficiency. This means, for example, that the same product can be produced with less materials. The IPCC report examines the emissions in the industry sector, focusing on the heavy industry. The use of materials is a major driver in the whole industry sector as well as in the event industry, such as the festival industry. Also, the material complexity of products has been increasing due to the demand for new functions in products. (IPCC, 2022.)

The Sustainable Development Goals (SDGs) have been developed by the United Nations as a part of Agenda 2030. The SDGs are related to social, economic, and environmental sustainability. Sustainable Development goal 8 is called “decent work and economic growth” and goal 12 is

called “responsible consumption and production”. (United Nations, 2016.) Lenzen et al., (2022) have implemented the material footprint to measure progress in goals 8 and 12. Goal 8 includes “resource efficiency improvements” and goal 12 includes “sustainable management of natural resources”. Global material extraction has increased drastically between 1970 and 2019. The global material extraction has tripled between 1979 and 2019 and the increase has been 63 gigatons per year.

In 2021, the government of Finland has composed strategic agenda for circular economy. Circular economy can decrease the natural resource consumption and in Finland the domestic material consumption per person is the largest in Europe. The transition to the circular economy demands a comprehensive change on companies’ and other operators’ attitude and how they make decisions. It is estimated that the consumption of natural resources globally will double by the year 2060. It would mean that the CO_2 emissions from controlling the materials would grow drastically. The processing of materials is a major factor in contributing the global CO_2 emissions and biodiversity loss. Material footprint is mentioned in the strategic agenda and many research institutes cooperate to make scenarios that study the impact of material footprint to the environment and to the economy. (Ympäristöministeriö, 2021).

Spare time activities play a crucial role in balancing the many pressures of modern life. However, as all consumption, they also contribute to the increasing pressure on ecosystems, especially to global warming. Leisure activities, such as attending a music festival make up a significant portion of an individual's lifestyle material footprint. Set by the Paris Agreement in 2016, global warming should be limited to 1.5°C. The idea of the material footprint is to understand the reasons behind global environmental degradation since any material extraction and use always entails related environmental impacts. One of these impacts is climate change from greenhouse gas emissions, measured by the carbon footprint. This is how greenhouse gas emissions and material footprint are related. The material footprint represents also other known and yet unknown environmental problems related to the use of natural resources in general. (Lettenmeier, 2018; Schmidt-Bleek, 2000.) There has been an increase in CO_2 emissions resulting from material production between 1995 and 2015, which has contributed to 23% of global emissions. Material production increases because material demand and consumption have increased. To decrease the global greenhouse gas emissions, material production and therefore consumption have to be taken into account. (The Manufacturer, 2022.)

1.2 Flow Festival and its inputs

Mass events such as Flow Festival require a significant amount of materials, resulting in a range of inputs, outputs, and environmental impacts. Various natural resources, including minerals, biomass, and fossil fuels, are among the inputs considered. Other important inputs include water and soil. The outputs from the festival are also significant, including greenhouse gas emissions, waste, and water pollution. Some examples of environmental impacts include resource depletion and climate change. Other examples of inputs may include energy, labour, and freight traffic. Outputs can include noise pollution, as well as the release of toxic substances. Environmental impacts may also include soil degradation, deforestation, and biodiversity loss.

As this thesis presents the total material consumption, the focus is on the inputs. The material inputs are divided into five categories: biotic resources, abiotic resources, water, air, and earth movement or erosion. Simply, biotic resources are the renewable resources, such as crops and livestock, while the abiotic inputs originate from non-renewable sources, such as minerals and fossil fuels. Earth movement is artificial movement of soil in agriculture and silviculture, but it also includes erosion. (Ritthoff, et al., 2002; Hirvilammi, et al., 2014; Mancini et al., 2012.) In this thesis, only the abiotic and biotic total material inputs (TMI) are considered. In some studies water and erosion are also assessed, but here they are excluded, as they are not the main focus of this study. Calculating the water quantity can lead to distorted results and data on water is often outdated. Also, there is limited data on erosion intensity factors, so including erosion in the calculations would have meant huge additional efforts. (Liedtke et al., 2014; Rinta-Jouppi et al., 2023, p. 11.)

1.3 Research questions

The research questions are:

1. How large was the total material footprint of Flow Festival 2022?

2. Which factors contributed the most to the total material footprint of Flow Festival 2022?

The general pressure of Flow Festival 2022 on nature can be indicated by calculating the material footprint of the festival (Lettenmeier, 2018). By studying which factors are the main causes for the material footprint, actions that can decrease the natural resource consumption can be identified. This

is more discussed in chapter five. Also, it is important to examine which factors can be affected or changed because some factors are hard to change or decrease.

Flow Festival Ltd. and the consultancy D-mat ltd have initiated a project where the material and carbon footprint of Flow Festival 2022 are calculated. This master's thesis is executed as a part of this project, and it is made as a commission to D-mat ltd. Calculating the festival's total material footprint would exceed the scope of a single master's thesis. Therefore, only selected aspects of the calculation are thoroughly presented in this thesis and the focus is on the areas where I made the most significant contributions. However, I was involved in the entire process of calculating the material footprint and collecting data throughout the project. The carbon footprint is excluded from this thesis. Flow Festival Ltd. has calculated and compensated the carbon footprint of the festival since 2009 but this project included the material footprint for the first time.

The structure of the thesis is as follows. In chapter two I will present the theoretical framework, material flow accounting, the MIPS concept, and material footprint as well as literature. Chapter three explains the data of the thesis, and all the products and services required in the festival are presented. Also, the material footprint calculation method is in chapter three. In chapter four, the calculation results are presented and analysed. In chapter five, I will discuss the material footprint of other mass events, sustainable solutions that can decrease the footprint of the festival, and limits of the study. Finally, I will conclude my analysis in chapter six.

2 Theoretical background

This chapter presents the theoretical background. I will start by introducing Material Flow Accounting (MFA), which focuses on the material inputs on national economies. Later, I will present the MIPS concept (Material Input Per Service) and material footprint. All three concepts are different approaches to measuring and analysing material use. I will also review various studies about material footprint.

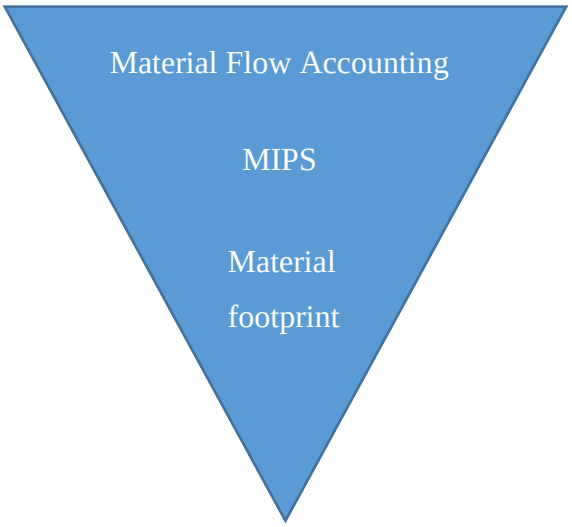

Figure 1: The relation between MFA, MIPS, and MF.

Material Flow Accounting is general theoretical background, and the MIPS concept is based on it. In this thesis, the material footprint is calculated according to the MIPS concept. However, some studies are also limited to the so-called raw-material input (RMI), which also can be called material footprint but does not include unused extraction of materials in its scope. (Lettenmeier et al., 2009; Liedtke et al., 2014.)

MFA accounts for the material flows within an economy or system, from the extraction of raw materials to their final disposal as waste. The MIPS concept, on the other hand, focuses on the material inputs needed to produce a particular service or product. One key difference between MFA and MIPS is that MFA considers all material flows within an economy, while MIPS focuses on the material inputs required to provide a particular service or product. Additionally, MFA is more commonly used at the national or regional level to assess material flows and resource efficiency, while MIPS is more

often used in the context of product or process design. (Krausmann et al., 2017; Schmidt-Bleek, 2000; Schmidt-Bleek, 2009.)

2.1 Material Flow Accounting

Material Flow Accounting is a comprehensive framework that studies the material inputs to national economics, changes in the material stock within in the economic system, and material outputs world-wide (Krausmann et al., 2017). The term economic system can be understood as "a means by which societies or governments organise and distribute available resources, services, and goods across a geographic region or country" (CFI, 2022). Material extraction allows the function of human societies. Historically, the extraction of natural resources remained constant over many years but with industrialisation the use of materials has increased significantly. All extracted materials that flow or move to the economic system are in the end disposed back into nature and the output is waste and emissions and therefore the global CO_2 emissions have also risen drastically during the past few decades.

MFA can be understood by an interrelation between the economy and the environment. Abiotic and biotic resources, water, and air are extracted from nature as inputs, and they are transformed into products for the economy. Finally, the inputs are re-transferred into the nature as outputs, such as waste and emissions. (Hinterberger et al., 2003.)

2.2 The MIPS concept

The MIPS concept was developed by the Wuppertal Institute in 1993 and it is based on material flow thinking and developed to be an indicator of precautionary environmental protection (Schmidt-Bleek, 2000; Schmidt-Bleek, 2009). Wuppertal Institute is a sustainable development research institute that studies ecology, economy, and society (Wuppertal, 2014). The development of the MIPS concept goes back to the 1960s when research stated that environmental problems will not be controlled without dematerialisation. This means that the quantity of material flows that exist from human activity needs to be reduced. (Ayres & Kneese, 1969.) The MIPS concept is developed to calculate the use of resources starting from the point of extraction from nature. All the data that is used in MIPS calculation corresponds to the amount of moved tonnes in nature. The theoretical background for the MIPS concept is based on the Material Flow Accounting (Mancini et al., 2012.)

Material input is the total amount of resources required in the whole life cycle of a product or a service. Service unit refers to the utilisation of a product or service and it can be understood as the benefit that is received by using the material. The service unit cannot be calculated the same way as the material input, and it should be defined separately depending on the product or service. The service unit can be the instance of use of the product or a kilogram of product. (Schmidt-Bleek, 2009; Autio & Lettenmeier, 2002; Cahyandito, 2009.) The MIPS concept was developed to be a basic measure for assessing the resource consumption of products and services. It does not provide detailed information about certain emissions and other outputs, it focuses on the material inputs of products and services. The results are usually presented in kilograms or tonnes, for example kilograms per capita per year (kg/cap/year). (Lähteenoja et al., 2008.)

Material intensity factors are usually used in MIPS calculation, and this is due to avoiding the calculation out of primary data each time. A material intensity factor can be defined as the sum of material inputs that are associated with the unit of consumption, and it is expressed as a ratio to the unit, which could be per kilogram of material or product, per piece of equipment, or per kilometre travelled, depending on the specific characteristics of the item. (Mancini et al., 2012.) The material intensity factors are crucial part of the analysis because the production of different materials require different mass of natural resources (Rahikainen, 2006). Other sources for material intensity factors used in this analysis are from Kotakorpi et al. (2008), Lähteenoja et al. (2006), and Mostert & Bringezu (2019). Also, part of the data used was generated by the research team by using life cycle software and databases. (Rinta-Juoppi et al., 2023. p. 12.)

2.3 Material Footprint

Material footprint is originally based on the MIPS concept, and it measures the total consumption of primary natural resources by humans, taking into account products, activities, and lifestyles. It provides an assessment of the material flows and is often quantified in tonnes or kilograms, such as kilograms per capita per year. Its purpose is to identify the causes of global environmental degradation, as any use of natural resources has an impact on the environment. While the carbon footprint measures greenhouse gas emissions and their effect on climate change, the material footprint provides a broader perspective on the environmental issues associated with the use of natural resources. (Lettenmeier, 2018; Schmidt-Bleek, 2000.) All material input becomes an output sooner

or later and the output can be waste or emissions. This means that by measuring the input, it is possible to get an estimation of the impact potential to the environment. (Ritthoff, et al., 2002.)

The term material footprint has been previously known as the ecological rucksack but the definition of it is similar. The ecological rucksack can be defined as the sum of natural resources moved away from their original place during the entire life cycle of a certain raw material, product, or service. The definition also includes the indirect resource use as well. (Lähteenoja et al., 2008; Ritthoff et al., 2002.)

Material footprint quantifies the demand for material extraction that is driven by household consumption and businesses. Material extractions can be for example biomass, metal ores, and fossil energy materials. (Eurostat, 2022.) Material footprint calculation focuses on the quantity of resources that is required to produce a product or a service. The MIPS concept and material footprint overlap with each other.

2.4 Literature

The natural resource consumption of certain food supply chains has been studied using the MIPS concept and according to it, the volume of the primary materials is crucial. These primary materials are extracted from nature, and they are used or utilised for the economic activities, and it causes pressure on the environment. In the MIPS concept, material input is related to the service unit and according to Mancini et al. (2012) this allows different ways of fulfilling a need to be compared with each other. This means that MIPS can also be defined as ecological price of utility, making it possible to be integrated in the economic analysis.

The material footprint has been studied from various perspectives. The material footprint of nations has been studied by Wiedmann et al. (2015) and the term "material footprint" was defined as the amount of raw materials extracted globally and allocated to the final demand of an economy. While economy-wide studies often use material flow accounting and consider the physical movement of materials, this was not the case in this study. The impacts of increased gross domestic product (GDP) on material consumption were studied and the results showed that when GDP increases, so does material consumption. Karakaya et al. (2021) has studied the material use in the European union and

what the drivers behind it are. Also, in this study the results showed that income has an effect on the material use.

There are also studies on the resource use of private households and in both of these studies, the resource use is expressed in material footprint. The main driver in German households' material footprint is the use of fuel, electricity and whether the household owned a car. Also, social status influences on the material footprint of households. (Teubler et al., 2018.) Similar results can be seen in a study on low-income Finnish households. Households with low-income have lower material footprint than the average Finnish household. (Hirvilammi et al., 2014.) Material footprint studies can also be conducted for specific products, such as electric vehicles. The study showed that most of the material footprint of electric vehicles is due to the battery manufacturing. Also, the electric vehicles considered in this research had a bigger material footprint than conventional vehicles. (Sen et al., 2019.)

Studies on the material footprint of Finnish festivals have not been conducted before but the carbon footprint of many festivals have been previously calculated. Some examples are the carbon footprint studies on Ilosaarirock festival and Provinssi festival. Considering the Ilosaarirock festival, most of the emissions consisted of the travels of visitors and artists. Similar findings were reported in a carbon footprint study of Provinssi festival. Most of the greenhouse gas emissions came from the travels of visitors. (Salomäki, 2020; Rantanen, 2011.) Flow Festival has also calculated their carbon footprint since 2009 but to get a more comprehensive picture of the environmental impacts of the festival, material footprint assessment is required (Rinta-Jouppi et al., 2023. p. 6.).

3 Data and calculation method

The consumption data of Flow Festival 2022 is the basis of the material footprint calculation, and it consists of all the products and services required in the festival. The data is divided into nine different categories and all the categories consist of different products. The data was collected in collaboration with Flow Festival Ltd. and import companies, subcontractors, and suppliers as well as the manufacturers of the products consumed by the festival. The consumption data was mainly collected during the summer months in 2022. The data also includes the material intensity factors received from Wuppertal institute and other sources.

3.1 Consumption data

The consumption data is divided into nine categories: site production, stage production, partner production, properties, organiser logistics, consumption, food and beverages, visitors, and other. Each category has a considerable number of products and services, and they are listed in table 1.

Table 1: Categories and the products and services they include. In bold, what is part of this thesis.

CATEGORY		**Products and services in the category**
1	**Site production**	Infrastructure: fences, fence weights, crowd barriers, diagonal braces, GP-link, concrete roadblocks, trusses, site lights, control systems, miscellaneous, light towers, cables, generators, water pipes, water points, computers and network stations, traffic signs, minor construction, equipment, wood, and screws. Toilets and waste management: garbage bins, waste compactors, demountable platforms, portable toilets, septic tanks, IBC containers, combination containers, toiler stairs, and toilet containers. **Tents** and containers.
2	**Stage production**	Stage structures: GP-links, ballasts, trusses, roof structures, PVC coverings, platform structures, upholstery, masking fabrics, floorings, and mattings. **Stage tents** and containers. Technical infrastructure: Audio; speakers, monitors, mixers, amplifiers, disc drivers, stage boxes, and cables. Video; **LED-screens**, cameras, projectors, control systems, and cables. **Lights; stage lights, control systems, hazers and fog machines**, hazer fluids, cables, chain hoists, trusses, and miscellaneous.
3	Partner production	Partners' structures and freights.

4	Properties	Buildings, constructions, site machinery, ground improvement (turfgrass, crushed stone, large construction equipment), storage buildings, and containers.
5	Organiser logistics	Land and sea freight of items and production, flights of artists and crew transportation (including scheduled and charter flights).
6	Consumption	Fuels, electricity, water consumption, and waste management.
7	**Food and beverages**	**Foods of visitors, artists, and staff: vegan, vegetarian, and fish portions.** Beverages of visitors: alcoholic and non-alcoholic beverages.
8	**Visitors**	Travels and accommodation of visitors.
9	Other	Decorations: upholstery, banderols, matting, and furniture. Merchandise, minor articles: wristbands, passes, and paper products.

I will provide a more detailed description of the categories and products highlighted in bold, as they are particularly relevant to this thesis. Additionally, I will carefully examine key factors, such as the impact of visitors, which are crucial to the overall results.

The site production category includes the infrastructure of the festival. The festival's infrastructure includes all elements and structures necessary for the event, including for example roadblocks, tents, building structures, gates, water supply, and IT infrastructure, as well as site lighting. (Rinta-Jouppi et al., 2023. p. 16.) One benefit of the MIPS concept is that it focuses, in addition to products and production, on structural aspects such as infrastructure. Unfortunately, the infrastructure is not always possible to change. For example, private households may have no power to change the infrastructure. (Lähteenoja et al., 2008.) However, considering Flow Festival Ltd., it has the power to make decisions and changes about the infrastructure of the festival and therefore there is material reduction potential.

The stage production category consists of stage structures, tents and coverings, technical infrastructure and backstages. Stage structures include for example stage roofs and walls and technical infrastructure consists of audio, video, and light equipment used in the stages. Tents and coverings include the stage tents and backstage consists of different containers.

The food and beverage category includes the consumption of food and beverages of visitors, artists, and staff. Red meat or poultry were not offered at Flow Festival 2022 and all restaurants were required to have at least one vegan portion on their menu. (Flow Festival ympäristöohjelma, 2022.) Consumption category includes energy and water consumption. Waste is also included in this category but in this analysis waste consumption is the waste management. This means that the

material footprint of waste in considered from the waste management aspect. (Rinta-Jouppi et al., 2023. p. 16-20, 26-27.)

The visitors category include the accommodation and travels of visitors. To study them, a survey was conducted for the visitors of Flow Festival 2022. The goal was to get a better understanding of the visitors' behaviour and of the visitors' share in the material footprint. The survey consisted of ten questions and was available in Flow Festival 2022 application during the festival. The response rate varied from 3.6% to 8.8%, meaning that there were at least 1,700 respondents out of 48,000 unique visitors, depending on the question. The overall response rate can be considered low but well sufficient for its purpose. It is important that the survey was conducted because valuable information was achieved which would not have been available on any other ways. One of the most important information received from the visitor survey was related to the travels of visitors. With the survey, information was received about where and how the visitors travelled to Helsinki and how the visitors travelled both to and from the festival area. Also, due to the significant impact of visitors on the overall material footprint of the festival, it was essential to receive the information of the visitors travels via survey. The questions for the survey are given in the Appendix 1.

The consumption data includes a 'usage by Flow' factor for any item that was also used for other purposes than Flow Festival 2022. The factor was calculated by dividing the number of days an item Flow Festival has rented by the number of days the item is rented out during its useful life. For example, the 'usage by Flow' factor is 2.3% for tents while transport and food had a factor of 100%. A 'usage by Flow' factor of 2.3% means that 2.3% of the material footprint for tents were allocated to Flow Festival 2022. Efforts were made to obtain realistic usage values for most products, as the 'usage by Flow' factor significantly affects the material footprint. (Rinta-Jouppi et al., 2023. p. 10, 28-31.)

3.2 Scope and assumptions

The material footprint considers all products and materials used for Flow Festival 2022. The calculation also considers all the activities and services required for organising the festival. At the start of the project, it was determined what was included and excluded from the calculation in order to produce as realistic results as possible. Due to limitations in the available data, including a lack of sufficient information, various assumptions were made. These assumptions can have a significant

impact on the results. For example, how long are the different life cycles of products and how large is the share of their footprint that is allocated to Flow Festival 2022.

Some examples that fall outside the scope of this study include visitor consumption outside the festival area, as well as transportation and accommodation for staff, media, and volunteers. The consumption of food and clothes that occurred outside of the festival area is out of scope, even if the consumption happened because of the festival. Also, the transportation and accommodation of staff, volunteers, and media are outside of the influence of the festival organisers and the impact would be relatively small. A table where all the products and services that are out of scope can be found in the Appendix 3. (Rinta-Jouppi et al., 2023. p. 10.)

3.3 Calculation

In this chapter, the methodology for calculating the material footprint is presented. While some calculations were performed by other members of the project, I was responsible for determining the material footprint for food, tents, some video and light equipment. See the bolded products in table 1.

The material footprint is calculated by multiplying the amount of consumption of, for example, a material, a product, or an activity, by a specific material intensity factor. In the calculation, the total material consumption per festival as well as per person day is considered. First, the material footprint is calculated for each product for its whole life cycle, and then per festival. To calculate the material footprint for the festival, the 'usage by Flow' factor is used as well as the number of products consumed by the festival. Material intensity factors were primarily collected from various sources, including life cycle databases, scientific articles, and other relevant publications. The specific sources for these intensity factors, as well as their use, are listed in detail in the Appendix 4. (Rinta-Jouppi et al., 2023. p. 11.)

Here, the formulas used in the material footprint calculation are presented. The kilogram of the material(s) of the products is multiplied by the material intensity factor(s) of the material. This is done to all the materials in the product, and they are summed together. This means that if there is more than one material in the product, all the materials multiplied by their material intensity factors are summed together.

Also, certain materials have two material intensity factors: one for abiotic and one for biotic materials. While the majority of materials have only a single material intensity factor, which is often abiotic, food ingredients are an example that have both the abiotic and biotic material intensity factors. The calculation requires the summation of both abiotic and biotic material intensity factors. However, often biotic material intensity factor is zero.

Material footprint of a product that uses n numbers of materials:

$$MF = m_1 \times mif_1 + m_2 \times mif_2 \dots + m_n \times mif_n, \quad (1)$$

where m_i is the mass of material i in kilograms and mif_i is material intensity factor of material i. Material intensity factor of material i, $i = 1, \dots, n$.

To calculate the material footprint of a product per festival, the 'usage by Flow' factor and the number of products need to be considered.

$$MF_{festival} = MF \times q \times \delta, \quad (2)$$

where q is the number of products used by Flow Festival and δ is the 'usage by Flow' factor.

To calculate the material footprint for each category, all the material footprints of all the products in the category are calculated and summed together. To get the total material footprint of Flow Festival 2022 the material footprints of all the categories are summed together.

Most of the products that are required and consumed to and for Flow Festival 2022 are rented, meaning that the material footprint of the whole life cycle of the product does not fall for the festival. Flow Festival is just one actor to use the products. Hence the 'usage by Flow' factors are included in the calculation. Some products are single use products, and, in the calculation, their 'usage by Flow' factor is 100%. These include merchandise, food, and beverages. Also, some of the products are owned by Flow Festival Ltd., such as decorations. Their 'usage by Flow' factor is not necessarily 100% if the products are used multiple times or if they are made of recycled materials. (Rinta-Jouppi et al., 2023. p. 10.)

4 Calculation results

The total material footprint of Flow Festival 2022 is presented in this chapter. The footprints of each category are presented individually, with a focus on the parts that I have personally calculated. These include tents and coverings from site and stage production category, technical infrastructure from the stage production category and food from food and beverage category. Nonetheless, I will present all of the results.

4.1 Total material footprint of Flow Festival 2022

The total material footprint of Flow Festival 2022 was 7,780 tonnes and the material footprints for each category can be found in table 2. The number of total visits, or visitor days, was 90,000 and the number of unique visitors was 48,000. From a visitor's point of view, the material footprint is 86 kg per visitor day. The majority of the total material footprint consists of abiotic resources, and they cover 7,520 tonnes, or 96.7% of the total. The biotic resources account for 260 tonnes, or 3.3% of the total material footprint.

Table 2: The material footprint of Flow Festival 2022 for each category.
Source: Rinta-Jouppi et al., (2023) p. 14.

CATEGORY		**MATERIAL FOOTPRINT**	**MATERIAL FOOTPRINT**	**%**
		t/festival	kg/visitor/festival	
1	Site production	182	2	2.3
2	Stage production	350	4	4.5
3	Partner production	220	2	2.8
4	Properties	362	4	4.6
5	Organiser logistics	142	2	1.8
6	Consumption	185	2	2.4
7	Food and beverages	570	6	7.3
8	Visitors	5,712	63	73.4
9	Other	59	1	0.8
TOTAL		**7,780 t**	**86 kg**	**100 %**

The material footprints of different categories are notably high. The reason behind this is that the material footprint includes multiple types of material resources, such as ores and mining, earth excavation for infrastructure, fossil fuels, and biomass. (Rinta-Jouppi et al., 2023. p. 14.) To provide

an understandable perspective to the material footprint value of 7,780 tonnes, it is equivalent to approximately 3.8 million car kilometres. Additionally, the material footprint of the festival per visitor day, which is 86 kg, is approximately equivalent to the lifestyle material footprint of an average Finn for one day. (Akenji et al., 2021; Kotakorpi et al., 2008.)

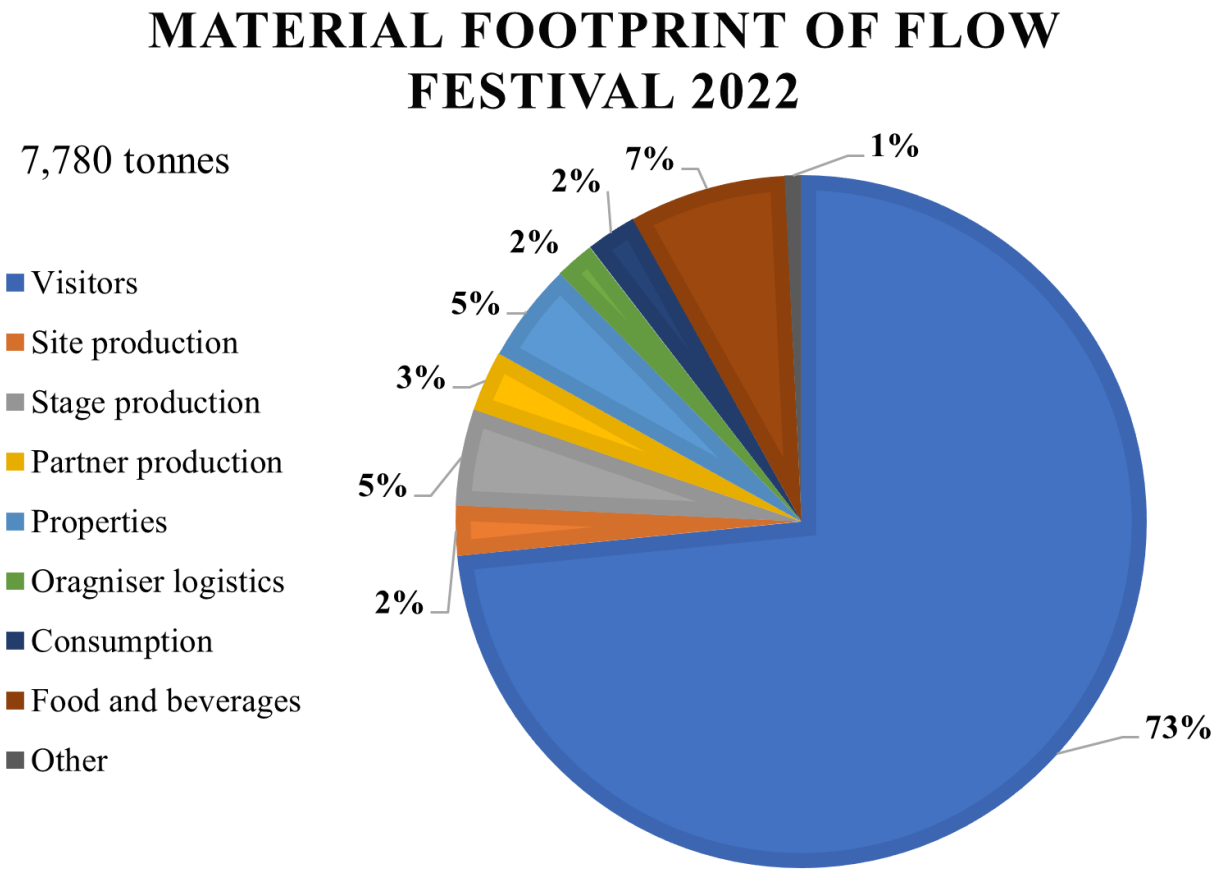

Figure 2: Material footprint of Flow Festival 2022 (t/festival).

The visitors category accounts for 73.4% of the total material footprint, making it the largest contributor to the footprint. Figure 2 shows that the material footprint of all other categories combined is less than the material footprint of the visitors category. The reason for the visitors category's large share of the total material footprint is the significant amount of travels by both domestic and international participants. The material footprint of train travels is notably high, primarily due to the construction requirements and lower usage rates compared to other transportation modes, such as roads. For this analysis, intensity factors specific to Finland were used since the usage rate of train

travel is lower in Finland than in Central Europe. This is relevant given that most of the train travels because of Flow Festival 2022 occurred in Finland. (Rinta-Jouppi et al., 2023. p. 29.) The large share of visitors to the total footprint is a common outcome for festivals and other spare time activities, where high footprints from visitors' travels are typical. (Häkkinen et al., 2000; Autio & Lettenmeier, 2002; Luoto et al., 2008; Veuro et al., 2008.)

4.2 Material footprints of site and stage production

The site and stage production combined forms 6.8% (532,000 kg) of the total material footprint of Flow Festival 2022. The stage production category has the third largest material footprint, 350,000 kg, and the material footprint of site production is 182,000 kg. The material footprints of tents and technical infrastructure, such as light and video equipment are presented next.

4.2.1 Material footprint of tents

The majority of tents in the festival area are part of the site production category, including food and bar service tents, cloakrooms, and the main gate. However, certain tents, such as venue tents, are in the stage production category. The tents are assumed to be on average 83% aluminium and 17% PVC plastics, with aluminium being the material in the tent structure, and PVC used for the tent covers. The assumption is based on comments from relevant experts. Neither material is particularly material intensive, but the overall amount of aluminium used in tents is quite large. (Rinta-Jouppi et al., 2023. p. 16-20.)

The tents vary in sizes and serve a different purpose in the festival area, but all the tents have on average the same material share. For example, one of the festival tents weighed 1,676 kg, with 1,390 kg (83%) being aluminium and 286 kg (17%) made up of PVC plastic. To calculate the material footprint of the tents and their covers, the weight of the aluminium (1,390 kg) was multiplied by the average material intensity factor for aluminium (18.98 kg/kg). Similarly, the weight of PVC (286 kg) was multiplied by the material intensity factor for suspended PVC, which is 3.33 kg/kg. From this, the material footprint of a tent that weights 1,676 kg and uses two materials can be written the same way as formula (1):

$$1{,}390\ kg \times 18.98\ \frac{kg}{kg} + 286\ kg\ \times 3.33\ \frac{kg}{kg} = 27{,}300\ kg, \quad (3)$$

where 1,390 kg is the amount of aluminium, 18.89 kg/kg is the material intensity factor of aluminium, 286 kg is the amount of PVC plastics, and 3.33 kg/kg is the material intensity factor of PVC plastics.

Again, the material footprint of Flow Festival 2022 is considered and therefore the number of tents used by Flow Festival and the 'usage by Flow' factor is needed, such as in formula (2):

$$27{,}300\ kg \times (5 \times 0.023) = 3{,}140\ kg, \quad (4)$$

where the 5 is the amount of tents that weigh 1,676 kg and 2.3% is the 'usage by Flow' factor. The material footprint of these tents used by Flow Festival 2022 is 3,140 kg.

The tents are rented and therefore the 'usage by Flow' factor is not 100%, but it is assumed to be 2.3%. This assumption is based on experts contacted. The calculation is done to all the tents that are used by Flow Festival and the material footprints are summed together. The total material footprint of the tents in the site production category is 27,500 kg, being 15% of the overall material footprint of the site production category. Some venue tents fall into the stage production category, and they cover 9% of the overall material footprint of the category. The material footprint of the tents and their covers in the stage production is 32,100 kg. Tents and coverings have moderate material footprint in both site and stage production category due to their low 'usage by Flow' factor.

4.2.2 Material footprint of technical infrastructure

In addition to stage tents, the stage production category also includes technical infrastructure such as audio, video, and light equipment. Flow Festival 2022 consumed significant amounts of advanced technical device, such as speakers, LED-screens, and stage lights. The differences in the material footprints of audio, video, and light equipment is mostly caused by their 'usage by Flow' factors and the amount of the equipment.

The material information of various electrical appliances, such as LED-screens or stage lights were mostly received by field experts. However, the material footprint of these devices is heavily determined by the amount of logical integrated circuits and their share is quite small in the weight of the whole device, even minor adjustments in their quantity or material intensity can significantly impact the total material footprint of the device. Obtaining detailed material information of the

electrical devices is often extremely challenging or nearly impossible in many cases. Therefore, in cases where more detailed modelling of an electrical appliance was not feasible or practical, the appliances were modelled as an "average consumer electrical appliance" in the calculation. (Rinta-Jouppi et al., 2023. p. 18.) The material footprint of different technical equipment can be calculated using formulas (1) and (2). However, information about the material composition of technical products is classified and cannot be explained in detail here.

From the technical infrastructure, lights have the smallest material footprint comparing to audio and video even if the pure mass of lights is the largest. The mass of lights is 63 tonnes, 36 tonnes for video, and 30 tonnes for audio. The differences in their footprints are due to different amounts of advanced technology, and lights have the least of this technology. Cables, chain hoists, and trusses constitute the majority of the lights, and they have relatively small material intensities. Also, the weighted average 'usage by Flow' factor for video equipment is nearly twice that of audio or lights.

The stage production category constitutes a significant portion of the festival's footprint. Excluding the visitors category, it accounts for 17% of the total material footprint. This is also a category where festival organisers can have more control. Although the limited availability and rapid pace of development of festival-specific technologies, organisers have the final say in procurement decisions. (Rinta-Jouppi et al., 2023. p. 35.)

4.3 Material footprint of food

The material footprint of Flow Festival 2022 for the category food and beverages is 570,000 kg covering 7.3% of the total material footprint of the festival and making it the second-largest contributor of the categories. From the 570,000 kg, 320,600 kg comes from the food. The material footprint (kg/festival) of food consumed by visitors is 288,200 kg, which is 51% of the total footprint of this category. For staff members the material footprint of food is 29,000 kg per festival and the material footprint of the artists is 3,400 kg. (Rinta-Jouppi et al., 2023. p. 26.)

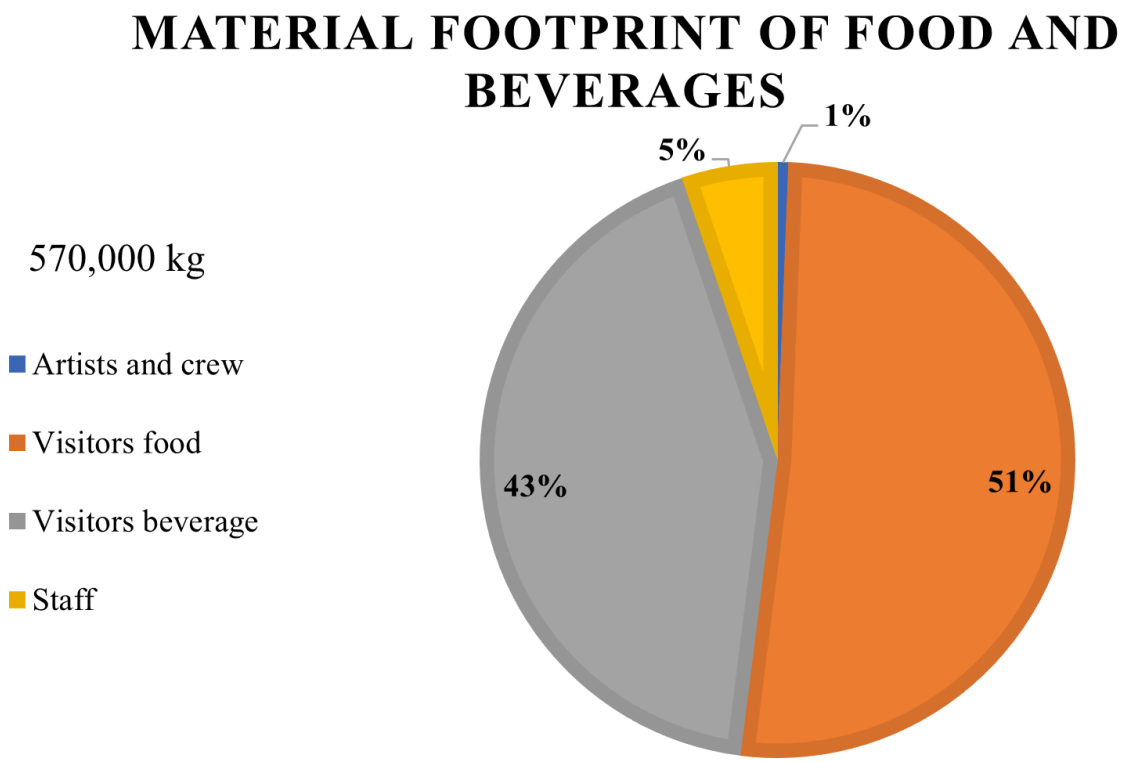

Figure 3: Material footprint of food and beverages category.

During Flow Festival 2022, red meat and poultry were not part of the menus, meaning visitors, staff, and artists did not consume them. The food sold during the festival was vegan, vegetarian, and fish, resulting in a smaller material footprint than the 2019 festival when red meat and poultry were available. Of all the sold food in the festival 2022, 50% was vegan.

To calculate the material footprint of food, it was necessary to estimate the food portions. The portions were built on average meals (Finnish Food Authority, 2022; Flow Festival, 2022). The portions were divided into three: vegan[1], vegetarian[2], and fish[3] portions. The meals are assumed to weigh on average 400 grams and no utensils or plates are included in the material footprint of the portions, but their impact is added to the total footprints of the category.

[1] The size of the vegan portion is 400 grams, and the share of soy protein was 130 g, vegetables 120 g, carbohydrate 130 g, and fat 20 g.
2 The size of the vegetarian portion was 400 grams, and the share of soy protein was 100 g, vegetables 150 g, carbohydrate 100 g, fat 10 g, cheese 20 g, and milk 20 g.
3 The size of the fish portion was 400 grams, and the share of fish protein was 100 g, vegetables 150 g, carbohydrate 100 g, fat 10 g, cheese 20 g, and milk 20 g.
Sources: Finnish Food Authority and Flow Festival

In the case of food and beverage category, the products, food portions, do not have materials, but they have different ingredients, and they have different material intensity factors. The vegan portion has six ingredients, vegetarian and fish portions have eight ingredients. Food ingredients have both abiotic and biotic resources and therefore they have two material intensity factors.

The material footprint of vegan portion is written as the formula (1):

$$0.13\ kg\ \times \left(1.1\frac{kg}{kg} + 1.3\frac{kg}{kg}\right) + 0.04\ kg\ \times \left(7.0\frac{kg}{kg} + 1.0\frac{kg}{kg}\right) + 0.04\ kg \times \left(0.29\frac{kg}{kg} + 1.7\frac{kg}{kg}\right)$$
$$+ 0.13\ kg \times \left(1.3\frac{kg}{kg} + 1.4\frac{kg}{kg}\right) + 0.04 \times \left(8.0\frac{kg}{kg} + 1.0\frac{kg}{kg}\right) + 0.02 \times \left(8.3\frac{kg}{kg} + 20\frac{kg}{kg}\right) = 2\ kg, \quad (5)$$

where 0.13 kgs are the amounts of wheat flour and soy protein, 0.04 kgs are the amounts of cucumber, tomato, and potato. 0.02 kg is the amount of fat. The multipliers inside the brackets are the abiotic and biotic material intensity factors.

The material footprint of vegan portion is 2.0. The calculation considering the vegan portions sold during the festival can be written as in formula (2): $2\ kg \times (50{,}000 \times 1) = 100{,}000\ kg$, where 50,000 is the number of sold vegan portions and the 'usage by Flow' factor is 100% because food portion is a single use product. The total material footprint of vegan portions is approximately 100,000 kg.

The material footprint of vegetarian portion is 2.7 kg and when the amount of vegetarian portions sold during the festival is considered, the formula can be written as in formula (2): $2.7\ kg \times (31{,}000 \times 1) = 83{,}700\ kg$, where 31,000 is the number of sold vegetarian portions in the festival, the 'usage by Flow' factor is 100% and 83,700 kg is the material footprint of sold vegetarian portions sold during the festival.

The material footprint of fish portion is 3.2 kg and when the amount of fish portions sold during the festival is considered, the formula can be written as in formula (2): $3.2\ kg \times (21{,}000 \times 1) = 67{,}200\ kg$, where 21,00 is the number of sold fish portions in the festival, the 'usage by Flow' factor is 100% and 67,200 kg is the total material footprint of sold fish portions sold during the festival. The sold portions and the material footprint of portions can be found in table 3.

Table 3: Footprints and amounts (rounded) for meals consumed by visitors in 2022.
Source: Rinta-Jouppi et al., (2023) p. 27.

PORTION TYPE	NUMBER OF PORTIONS CONSUMED	MATERIAL FOOTPRINT PER PORTION
Vegan	50,000	2.0 kg
Vegetarian	31,000	2.7 kg
Fish	21,000	3.2 kg
Meat	0	4.8 kg
Total	**102,000**	

The differences between the material footprints of different portions can be explained by the material intensity factors. The material intensity factor for butter, cheese and milk is higher than vegan fat for example. (Rinta-Jouppi et al., 2023. p. 27.) The material intensity factors of food ingredients can be seen in Appendix 2.

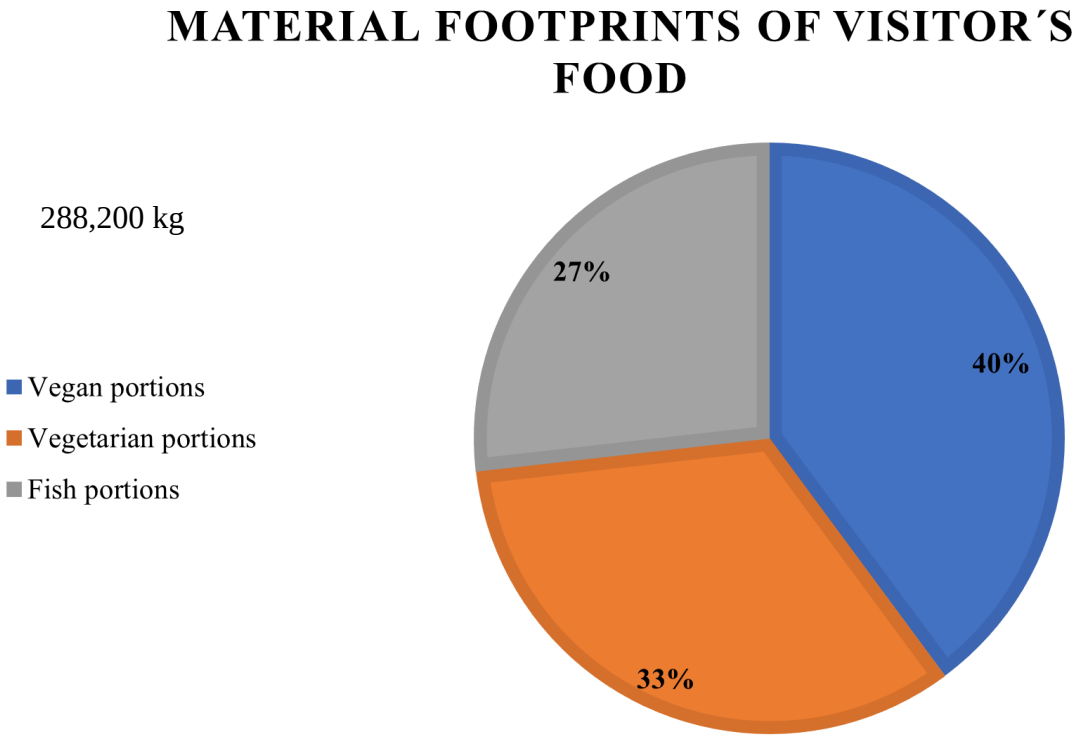

Figure 4: Material footprint of different food portions consumed by visitors.

The material footprint of vegan portions is the biggest, but this can be explained by the sold portions. Vegan portion were the most sold portions of all the three. When the material footprints of single portions are examined, table 3 shows that the material footprint is smallest for the vegan portion, the biggest for fish portion and vegetarian portion is between them.

5 Discussion

In this section I will examine other mass events and their environmental impacts. For the London 2012 Olympic Games and Paralympic Games the carbon footprint has been calculated and material flows have been analysed in other mass events held in Finland. Also, I will examine the possible actions that can be done to decrease the material footprint of the future Flow Festival. and. Finally, I will discuss the limits of the study and more about the MIPS concept and what it does not consider.

5.1 Comparison to other mass events

The material flows of Helsinki 2005 World Championship in Athletics have been analysed in a master's thesis and the focus were on the amount of the temporary structures and also on the material consumption of disposable structures. The material flows of mass events are often significant because the temporary structures, such as tents and stages are built only for the one event. Even a more important environmental impact of the event is travels. The travels of the visitors was almost ¾ of the total material footprint. Typically, the greatest and the most negative environmental impact of mass events generally is often caused by car traffic. Temporary structures are important factors in mass events; however, the environmental impacts are not as significant as the impacts are from the travels of visitors. (Rahikainen, 2005.)

Similar results can be seen in other mass events as well. Transport was one of the main contributions in emissions and natural resource use in the London 2012 Olympic Games and Paralympic Games. In a study of the natural resource consumption in World Championship in skiing in 2001 in Lahti, travels were also the main single contributor in the natural resource consumption. Transport covered 41.7% of the material flows of the mass event. (International Olympic Committee, 2018; Neopoli oy, 2001.)

5.2 Decreasing the material footprint of the festival

Different sustainable solutions have been proposed that can decrease the material footprint of Flow Festival 2022. This can be done by decreasing the consumption or the material intensities of the products consumed. These sustainable solutions are made specific for Flow Festival. When considering the sustainable solutions, the visitors category has been left out from the total material footprint. This is to emphasise the size of each category and the impact of the solution on it, without

being heavily influenced by the visitors' footprint. Since it is more challenging for organisers to influence the visitors category, it is reasonable to consider the other categories separately without the visitors category's effect.

One sustainable solution is for the category food and beverages. Red meat or poultry portions were not sold at Flow Festival 2022, and it has decreased the material footprint compared to the festival held in 2019. Further reductions in material footprint can be achieved by increasing the share domestic vegetarian and vegan food and reducing overall food and beverage consumption. For example, a complete shift to 100% vegan food at the festival could reduce the material footprint by 55,000 kg. Additionally, if 50% of alcoholic beverages were switched to soft drinks, the material footprint reduction would be 41,000 kg.

In the stage production, the largest share of the material footprint is dedicated to the structures and equipment used for audio, video, and lighting. Although the materials used for the structures are not necessarily material intensive, they are consumed in significant quantities, while the electrical appliances are very material intensive. To decrease the material footprint in this category, one can either minimise the number of items used or select items with longer lifetimes. This approach will result in a smaller 'usage by Flow' factor allocated to Flow Festival. (Rinta-Jouppi et al., 2023. p. 37-43.)

Sustainable solutions related to the visitors were also created. The visitors cause most of the total material footprint of the festival by travelling to the festival area. Understandable, the reason behind the large footprint is the large number of visitors attending the festival. However, the transport plays an important role as well. Reducing the travelled distances or the material intensities of the transportation lead to a decreased material footprint.

Encouraging visitors to travel by train or bus instead of by car would significantly reduce the material footprint of the festival, particularly since many who arrived by car or by taxi could have used public transportation instead. To make bus or train travel more appealing, Flow Festival Ltd. could collaborate with public transportation provider to offer festival ticket holders discounts on certain routes or include a public transportation ticket to the festival ticket. The material footprint of the festival would significantly decrease if all car and taxi travels were replaced with public transportation.

If 50% of car driving to Helsinki from other places in Finland was switched to bus and train, material footprint reduction potential would be 170,000 kg which would be 2.2% from the total footprint of the festival. Also, if 50% of taxi and car rides inside Greater Helsinki switched to public transport, the material footprint could be reduced by 143,000 kg, or by 1.8%.

5.3 Limits of the study

Most of the material intensity factors used in the footprint calculation were from Wuppertal institute from 2014. Since the factors have been published about nine years ago, they may have changed throughout the years. Some of the intensity factors were modelled during the project for the calculation.

The 'usage by Flow' factor has a significant impact on the total material footprint and efforts were made to ensure that the factor is as realistic as possible. However, the 'usage by Flow' factors used are partly based on assumptions and although these assumptions were well reasoned during the project, any changes to them could still have a significant impact on the results.

While the MIPS concept is a useful approach to study the material inputs needed to produce a service or product, it has its limits. MIPS is focused on the material flows and the natural resource consumption as a whole and therefore it does not consider specific environmental impacts, nor it tells anything about their toxicity. Also, the material flows provided by the MIPS concept do not directly consider the area required in the production nor the direct impact to biodiversity. When it comes to the soil movement category, in the MIPS concept, it is not possible to separate the environmental impacts soil movement has. For example, it does not consider whether the soil is moved from an area that is valuable and protected or from an area human have modified. (Hirvilammi, et al., 2014; Mancini et al., 2012.)

6 Conclusion

This thesis presented the material footprint calculation of Flow Festival 2022. The material footprint of the festival amounted to 7,780 tonnes. This equals to 86 kg per visitor per day, which is approximately equivalent to the daily lifestyle material footprint of an average Finn. Nine different categories were assessed to determine the material footprint of Flow Festival 2022. The visitors category, including travel and accommodation, was the biggest single contributor to the total material footprint of the festival amounting to 5,712 tonnes or 73.4%.

Other significant categories, with shares ranging from 350 tonnes to 570 tonnes from the total material footprint were stage production, properties, and food and beverages. The food and beverages category was the second largest contributor to the total material footprint of the festival and it amounted to 570 tonnes, or 7.3% of the total footprint. However, the impact of the visitors category to the total material footprint is significant: the material footprint of the visitors category was larger than the material footprint of all other categories combined.

The material footprint is calculated by multiplying the amount of consumption of a material by a material intensity factor. The material footprint calculation in this thesis is solely based on the MIPS concept. The 'usage by Flow' factors used in the project are party based experts contacted and partly based on assumptions, which, if altered, can have a significant impact on the results.

The results of the visitors category reveal that the ecological impact of a festival is significantly influenced by the decisions made by its visitors, particularly in regards to their transportation choice. Similar results can be seen in previous studies on mass events. While festival organisers have limited control over visitors' travel choices, there are other categories that can be effectively reduced by the organisers. Sustainable solutions can decrease the material footprint of the festival and one sustainable solution is to increase the proportion of plant-based food offerings at the festival.

Finally, as spare time activities, such as attending a music festival make up a significant portion of an individual's lifestyle material footprint and as the average material footprint of Finns is expected to decrease to a quarter by 2050, music festivals must take responsibility for reducing their footprint and efforts should be made to achieve this goal.

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8 Appendices

Appendix 1: Visitor survey questions and the amount of answers.
Source: Rinta-Jouppi et al., (2023)

QUESTION		ANSWERS
1	Where are you travelling from?	1707
1.1	If from outside of the Great Helsinki region: How are you arriving to Helsinki?	1701
2	How did you arrive to the Flow Festival area?	4233
2.2	If you used public transport: What type of public transport ticket did you use?	4233
3	How did you leave the Flow Festival area?	3971
4	Where did you stay during the Flow Festival?	3616
5	What’s your main diet?	2137
6	Do you drink alcohol?	4218

Appendix 2: Material intensity factors.
Source: Wuppertal institute 2014.

Production inputs	Specification	Material intensity		Unit	Other information
		Abiotic material	Biotic material		
Aluminium	average	18.98		kg/kg	Europe
Polyvinyl chloride; PVC		3.33		kg/kg	Europe
Bread	wheat flour	1.1	1.3	kg/kg	Finland
Cucumber		7	1	kg/kg	Finland
Potatoes		0.29	1.7	kg/kg	Finland
Soy		1.3	1.4	kg/kg	Finland
Tomato		8	1	kg/kg	Finland
Colza oil		8.3	20	kg/kg	Finland
Rainbow trout		2.8	4.7	kg/kg	Finland
Butter		9.8	25	kg/kg	Finland
Cheese		11	29	kg/kg	Finland
Milk		1.1	3	kg/kg	Finland

Appendix 3: List of items that are out of scope.
Source: Rinta-Jouppi et al., (2023).

OUT OF SCOPE	SPECIFICATION
Visitor consumption outside the festival area	The consumption of food, beverages, and clothing that occurred outside of the festival area is out of scope due to a lack of available data and the difficulty in determining responsibility for such consumption.
Area without Flow Festival	The area where the festival is organised was previously mainly used for energy production in a power plant. A significant part of the area has contaminated soil, and that means that residential use of the area would be possible only at very high efforts and costs. Because of this, building up the area for its original purpose is out of the scope. However, efforts such as ground improvement that were made for utilizing the area for Flow Festival, are within the scope of the project.
The artists' own equipment and everything the artists brought to the area	It was not possible to receive comprehensive data over this equipment. Also, their impact can be assumed relatively small because they are mostly reused at other events, and their amount can be considered relatively small in comparison to the equipment and structures set up by the festival's organisers – both are considered in the calculations.
Staff, volunteers and media transportation and accommodation	They are outside the influence of the festival organisers and, in addition, relatively small compared to the transportation and accommodation of artists and visitors.
Communication and marketing	They were considered of small relevance in relation to the other aspects of the festival. Also, sufficient data is difficult to gather.
Artists' and some products' travel from the festival to their next destination	During the summer season, some artists and some festival equipment travel from festival to festival. Therefore, the artists' transportation from Flow to their next destination was left out of scope to avoid double counting. The same applies for rented products if they went straight away to their next renter.
Transport from factory and disposal of rented items	The scope includes transportation of rented items from storage, other venues or elsewhere, to Flow festival site, but doesn't include the original shipping from factory, or the end-of-life disposal. These once-in-a-lifetime activities have negligible impact on the whole footprint, especially with technical devices, where material requirements are high, biological decomposition doesn't happen, and recycling efforts usually take place.
Some minor scale consumption	Where the footprints of products had to be calculated on the basis of the materials they contain without ready-made calculations or consumption data from elsewhere, some aspects have been omitted due to missing data, e.g. production energy or minor material components such as coatings. When sufficiently precise data was not available, some minor scale consumption has been left out of the calculations. The biggest of these are ten art installations at the festival area.

Appendix 4: Sources and their main purposes in the footprint calculation.
Source: Rinta-Jouppi et al., (2023).le

SOURCE	CATEGORIES AND ITEMS APPLIED ON
Wuppertal Institute material intensities Wuppertal Institute (2014)	All categories: • most of the material intensity factors
KotiMIPS-research Kotakorpi et al. (2008)	Visitor accommodation: • material intensities Food and beverages: • alcoholic beverages material intensities
LiikenneMIPS-research Lähteenoja et al., (2008)	Organiser logistics: • material intensities for different transport modes Visitor travels: • material intensities for different transport modes
Research article on material intensities of basic elements Mostert & Bringezu (2019)	All categories: • material intensities of more specific elements
Experts contacted	Especially stage production: • specific material compositions and use days for different items