Reducing the water stress inflicted by Sweden’s food consumption on other countries through sustainable food options

-Study focusing on the water stress Sweden inflicts due to coffee and meat import

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Reducing the Water Stress Inflicted by Sweden's Food Consumption on Other Countries through Sustainable Food Options

Master's Thesis in the Master's Programme Infrastructure and Environmental Engineering

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Abstract

This study delves into strategies for Sweden to curtail food imports from water-stressed nations and advance sustainable food production. Initially, we calculate the water footprint of meat and coffee consumption in Sweden, evaluating its impact on both Sweden and its importing countries. The main findings reveal that while Sweden's water stress in 2020 was 3.58%, transitioning to 100% environmentally friendly options, such as producing alternatives to imported coffee and meat within Sweden, resulted in a 0.0214% increase in the country's water stress, thereby increasing Sweden's water stress by a small margin. This would, however, significantly decrease the water stress for other countries which Sweden imports from. The study then explores solutions, emphasizing increased domestic production, water-efficient practices, and consumer awareness. Shifting from meat to plant-based alternatives and opting for sustainable coffee substitutes reduces Sweden's water footprint. The conclusion underscores the significance of transitioning to environmentally friendly options like plant-based meat and chicory plants to foster a resilient and sustainable food system in Sweden while minimizing water stress on other nations.

Key words: Water scarcity, water stress, water consumption pattern, total freshwater withdrawn, water footprint, environmental options.

Contents

1 Introduction

1.1 Background

As the world's population increases so does the need for water. Water is used in all processes involving human activities. The limited freshwater resources and their uneven geographical distribution give the urgency to quantify and identify the appropriation of water (Yang et al., 2013). Food production is a major water consumer (Dinar et al., 2019), and it is important to understand water consumption through food, as well as food production and consumption. In addition, food production is associated with environmental effects, such as soil degradation and eutrophication, and food consumption patterns are associated with high rates of food wastes. Therefore, the world's current food production and consumption habits are not considered to be sustainable (Jurgilevich et al., 2016).

Concepts such as water footprint and virtual water provide a link between the use of water in food production and the trade and consumption of food. According to Yang et al. (2013) the concepts of water footprint and virtual water emerged in the early 1990s and 2000s due to water scarcity increase. Virtual water is defined as the amount of embedded water in a commodity required to produce, package and ship the commodity to consumers and is typically expressed in cubic meters per ton. Water footprint concept is applied more broadly and is an environmental indicator that measures the volume of freshwater used during the production process throughout the whole supply chain expressed in cubic meters or liters.

The concept of efficient food systems is important owing to a broad range of environmental impacts. Increased CO_2 emissions represent 26% of the global greenhouse gas emissions where meat and dairy foods are the majority (University of Oxford, 2022). It is also to be noted that various projections indicate that between 30 and 50 % of the food which is meant for human consumption is wasted at various points throughout the food system (Stuart, 2009). The inefficient food system causes productivity, energy, and natural assets losses, which leads to additional reduction in water resources, an increase in greenhouse gasses and pollution.

The typical dietary patterns of Swedes pose challenges for sustainability both in the short and long term. This stems from their tendency to include meat or other high water footprint foods in their meals, which also significantly contributes to climate change within the food sector (Medveten consumption, 2021). Hence, there's a pressing need for Swedish food habits to transition towards more sustainable alternatives, like vegetarian options, while curbing overall consumption. Presently, the average Swede consumes 800 kg of food and beverages annually, accounting for a quarter of household CO2 emissions (Livsmedelsverket, 2016). Moreover, excessive consumption results in substantial waste, with up to 26% of discarded food still being edible (Swedish Environmental Protection Agency, 2021.a) Additionally, Sweden's water footprint is notably impacted by imported food, which carries a significant virtual water load. Essentially, when Sweden imports food, it also imports the water utilized in food production from other nations. One of the key contributors to Sweden's water footprint from food imports is the consumption of meat and coffee. These two commodities, which have a particularly high water footprint, are imported in large amounts, and account for a significant portion of Sweden's overall water footprint in the food industry (Formas, 2008). Coffee plays a critical role in discussions about water stress, particularly in Sweden, which ranks in the top three in Europe for coffee consumption per capita. This high level of consumption underscores the importance of considering the environmental impact of coffee production, notably its water usage. Given Sweden's substantial consumption, the country indirectly contributes to significant water use globally, which can exacerbate water stress in coffee-producing regions (Statista, 2023). A substantial part of Sweden's food consumption is beef-oriented meats. Water is essential for the production of meat, particularly beef, at every stage of the process, from feeding the animals to growing the feed to processing the meat. Similarly, planting, harvesting, processing, and packaging coffee beans all require significant amounts of water. Meat causes the most considerable environmental damage in the food industry and therefore, other short- and long-term choices must be implemented for consumers as a starting point to start transforming into a circular economy. It is recommended to change the current heavy meat diets to plant-based meats. Plant-based meats use between 47 to 99 % less land, 72 to 99 % less water and emit 30 to 90 % less greenhouse gas than conventional meat. As of today, plant-based meat only makes up for 1% of the retail meat market, and it has the potential to help build a sustainable food supply (Good Food Institute, 2019). Sweden can significantly reduce its water footprint in the food industry by lowering its intake of meat and coffee and move to other sustainable food alternatives (Moberg et al., 2020).

2 Aim and specification of issue

This study aims to assess the water footprint of Swedish food consumption and its impact on water stress in countries where the food is produced, as well as assess potential solutions to reduce this impact. The study will focus on food products that have the most significant impact on water scarcity due to their consumption and high water footprint.

The thesis answers the following research questions.

- What is the water footprint of coffee and meat consumption in Sweden?
- How much does Swedish meat and coffee consumption affect water stress around the world?
- How can this water stress be minimized from a Swedish perspective?

The motivation for choosing the products was mainly based upon the water footprint and due to the high consumption of coffee and meat in Sweden. This gave us an indicator to majorly check on the water footprint of different food products and the consumption pattern in Sweden to evolve this study.

2.1 Scope and Limitations

This report made some limitations in answering the research questions more effectively. These are presented in the points below.

- Focus will be only on food products which have a high water footprint which is in turn relatable to an increase in environmental impacts.
- Some of the countries which had a low export of the products to Sweden will not be studied. Only countries with a large distribution of the chosen products will be studied and their production and import of ingredients needed to produce the products.
- The packaging materials and transportation modes of products will not be studied in detail.

- Focus will be on primary commodities related to food products which are imported the most to Sweden and their significant environmental impact. For instance raw meat and green coffee beans.
- The water footprint is assumed to be after the global average values, they are not calculated in consideration to the country.

3 Background

The concept of a water footprint is pivotal in understanding the hidden water usage behind goods and services. A water footprint measures the total volume of freshwater used to produce goods and services consumed by an individual, community, or business. It encompasses three components: blue water (surface and groundwater), green water (rainwater stored in the soil), and grey water (polluted water). This metric helps in assessing the sustainability of water use in different sectors.

Water trade, often referred to as "virtual water trade," is the exchange of water in the form of agricultural and industrial products. For instance, when a country exports a ton of wheat, it is effectively exporting the water used to grow that wheat. This concept highlights the interconnectedness of global water resources and underscores the importance of considering water footprints in international trade policies.

Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. It is a critical issue that affects billions of people worldwide, leading to water scarcity, deteriorating water quality, and severe impacts on ecosystems. Water stress is exacerbated by factors such as population growth, climate change, and inefficient water use. It often leads to economic losses, conflicts, and health problems making it a crucial focus for sustainable development.

The production of food is one of the most water-intensive activities, accounting for about 70% of global freshwater withdrawals. Different food products have varying water footprints. For example, producing 1 kilogram of beef requires approximately 15,000 liters of water, whereas producing 1 kilogram of wheat requires about 1,500 liters. This disparity emphasizes the need for considering water efficiency in agricultural practices.

Food trade plays a significant role in water distribution. Countries with abundant water resources often export water-intensive crops, while water-scarce regions import these products, thereby balancing global water use. However, this can also lead to water depletion in exporting countries if not managed sustainably.

Adopting sustainable diets is crucial for reducing water demand. Diets rich in plant-based foods generally have a lower water footprint compared to those heavy in animal products. By promoting sustainable agricultural practices, improving water management, and encouraging shifts towards diets with lower water footprints, it is possible to mitigate water stress and ensure a more sustainable use of global water resources.

Two known food categories with a high water footprint that Sweden imports are coffee and meat (Eurostat, 2021). Sweden is recognized as one of the largest coffee-consuming nations globally (Worldpopulationreview, 2023), importing approximately 56,000 metric tons of coffee in 2021. The top four countries from which Sweden imported coffee in 2021 were Brazil, Peru, Honduras, and Germany. Regarding meat imports, Sweden primarily sources it from countries such as Ireland, Germany, Poland, and Italy (Statista, 2021). This indicates that Sweden imports a substantial amount of coffee from countries with warmer climates, which may be necessary for coffee cultivation, while meat imports are less dependent on warm weather.

3.1 Water Footprint

The term "water footprint" describes the total quantity of freshwater consumed for manufacturing and consuming services and products. It measures the quantity of water utilized by people, organizations and nations in indirect and direct ways. Since water is a limited resource and becoming more scarce in many regions of the globe due to global warming, understanding a water footprint is crucial (Singh et al., 2015).

In clarification the water footprint of a product is the total of water impact that resulted in the process that went into production before consuming it. Furthermore, the total water footprint of all the items produced by a system, such as a customer, home, or nation, makes up the system`s water footprint. These ideas can be made clearly by using mathematical equations with specified symbols (Singh et al., 2015).

The water footprint concept consists of 3 different parts, the green water footprint, the grey water footprint, and the blue water footprint. The total amount of rainwater utilized in the consumption and creation of services and products is presented as a "green water footprint", which includes the water used for natural processes like transpiration and evaporation and water utilized by crops and plants for growth. Due to green water not being extracted from a particular resource like blue water, green water is often hidden from view (Singh et al., 2015). The blue water footprint represents the quantity of ground and surface water used in the consumption and creation of products and services, which covers water used for operations, agriculture and drinking. The blue water footprint is the most noticeable component of a water footprint due to water being taken from lakes, rivers, and water bodies (Singh et al., 2015). The grey water footprint is represented as the volume of water needed to reduce contaminants to acceptable levels. That involves the water needed to remove toxins from the air and the water necessary to transport and delude toxins in the water. Although grey water does not directly utilize water, it makes up a significant part of the water footprint because it impacts water availability and quality (Chapagain, 2017). An illustration of the different water footprint can be seen in Figure 1.

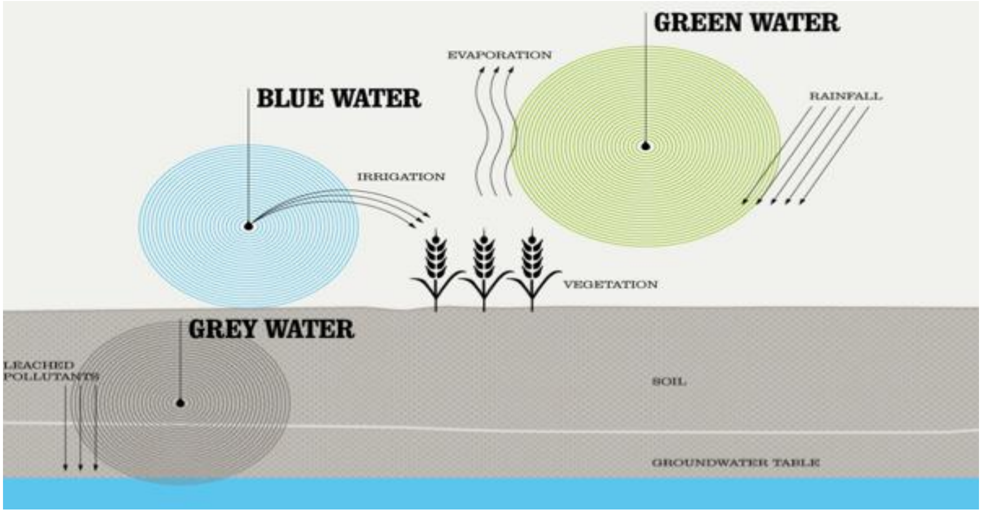

Figure 1. Blue,green and gray water presented as part of the water cycle (Terrascope, N.A).

The equation for calculating the water footprint can be seen in equation 1.

Equation 1: $TWF = GW + BW + GY$
The different abbreviations are explain below:

TWF = Total water footprint to produce a product, measured in L
GW = Total green water used to produce a product, measured in L
BW = Total blue water used to produce a product, measured in L
GY = Total gray water used to produce a product, measured in L

The measurement in order to calculate the water footprint includes both direct and indirect water usage in a variety of activities, including consumption habits, industrial operations, and agricultural output. The comprehensive approach focuses on water consumption trends, potential environmental effects, and how different sectors utilize water in ways that are related to each other (Singh et al., 2015).

3.2 Water Stress

Water stress is described as insufficient water availability in a particular area to meet the water demand (European Environment Agency, 1999). The disparity between available and needed water is a serious worldwide issue. Water stress may have detrimental effects on ecosystems, agriculture, industry and human beings, as well as the environment. When an area is under water stress, it indicates a lack of water availability to satisfy both the local people and the many businesses that depend on it. Numerous variables, such as climate change, urbanization, unstable water usage, rising population, and ineffective water utilization, may contribute to water stress (Hanumate et al., 2022). The proportion of water extraction to the available resources is an important metric used to measure water stress. A substantial amount indicates that much of the available water is being consumed, which might result in water shortages. There are primarily three degrees of water stress: Low-level, Medium-level, and high-level water stress. Less than 25% of the water resources are withdrawn in low-level water stress. Water is often available and sufficiently serves the demands of the population and the many industries that depend on it. In medium-level water stress, between 25% and 70% of the water resources are withdrawn. Water shortages may occur due to rising demand, leading to pressure on the water supply, which creates opposition between the users. At the stage of high water stress, more than 70% of the water resources are being withdrawn, resulting in severe water shortages, which harm society, the environment, and the ecosystem. This can lead to catastrophic results on the environment, economy, social, and society due to this degree of water stress (FAO, 2018.a). The water stress levels across the world can be seen in Figure 2.

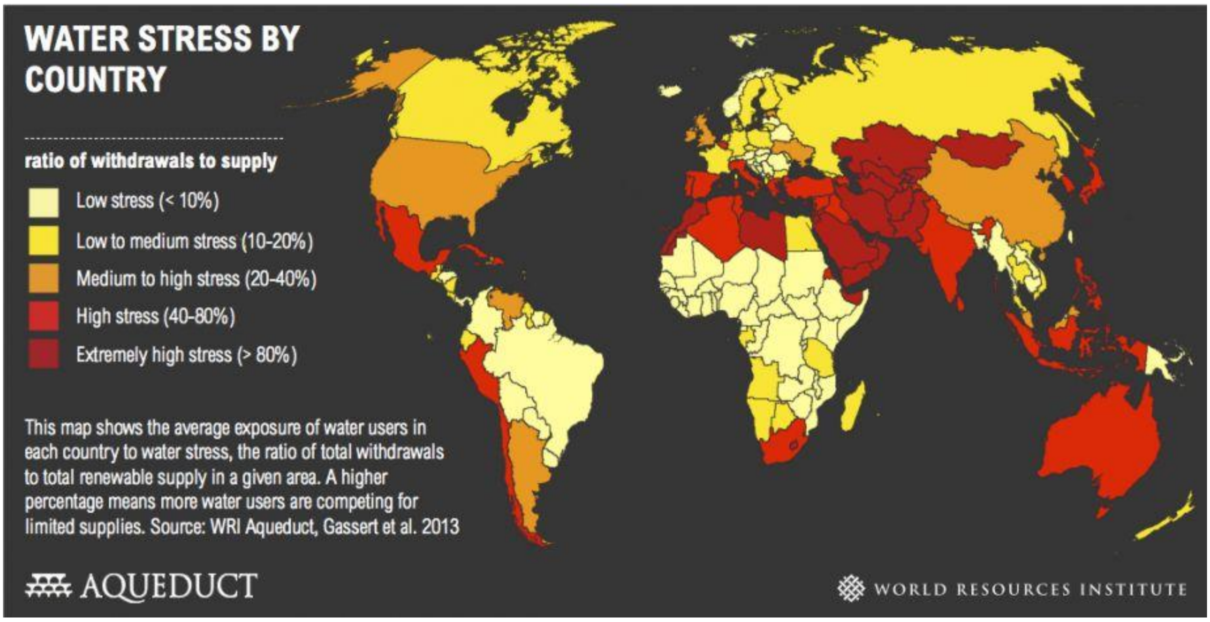

Figure 2. Water Stress in the World (Gebrechorkos & Fathy, 2015).

3.3 Sweden

Sweden, located in northern Europe, has a unique geography, see Figure 3, that influences its water stress and water footprint for food production (Norman et al., 2023). Water stress refers to the scarcity of freshwater resources relative to demand, while water footprint refers to the total volume of water used to produce goods or services.

Sweden generally experiences less water stress than many other parts of the world. This is because the country has a lot of freshwater resources, such as rivers, lakes and groundwater supplies. However, the water stress might differ due to seasonal variations and regional factors. Water stress can be more severe in some areas of Sweden, especially in the south and southeast, during dry seasons or where there is a significant demand for water from industrial, home, and agricultural uses (Johansson, 2023).

Regarding the water footprint from food production, Sweden's geographical position plays a significant role. The nation has a large agriculture industry that demands a significant amount of Sweden's water resources. A large portion of the country's fertile land is located in the central and southern regions, where most of Sweden's agriculture is concentrated. These areas often receive a decent amount of rainfall, reducing the need for treatment and lowering the water footprint of food production. However, irrigation may be necessary in some places during dry years, increasing the water footprint (Grusson et al., 2021).

Additionally, Sweden's environment offers potential for fishing industries and aquaculture, which can reduce the water footprint for food production, with its numerous rivers and lakes and a long stretch of coastline. It is essential to have water for aquaculture, including shellfish and fish farming, to preserve the ecosystem for fish and promote growth (OECD, 2021).

Although Sweden may have quite a low water footprint and water stress compared to other areas, it continues to face problems with water management, such as contamination from industry and agriculture, affecting water quality, and the effects of climate change (WSP, 2021). To decrease water stress and lower the world's water usage for food manufacturing, sustainable water management strategies, such as effective irrigation techniques, resource conservation measures, and pollution control measures, are crucial (WSP, 2021). Sweden's topography generally affects its water footprint and water stress for food production, but other elements, including agricultural methods, water management and climate regulations, all impact the nation's sustainability and water resources. In order to guarantee that water resources are available and sustainable for producing food and other necessities, it is crucial for the country of Sweden, like all other nations, to emphasize appropriate water management techniques (WSP, 2021).

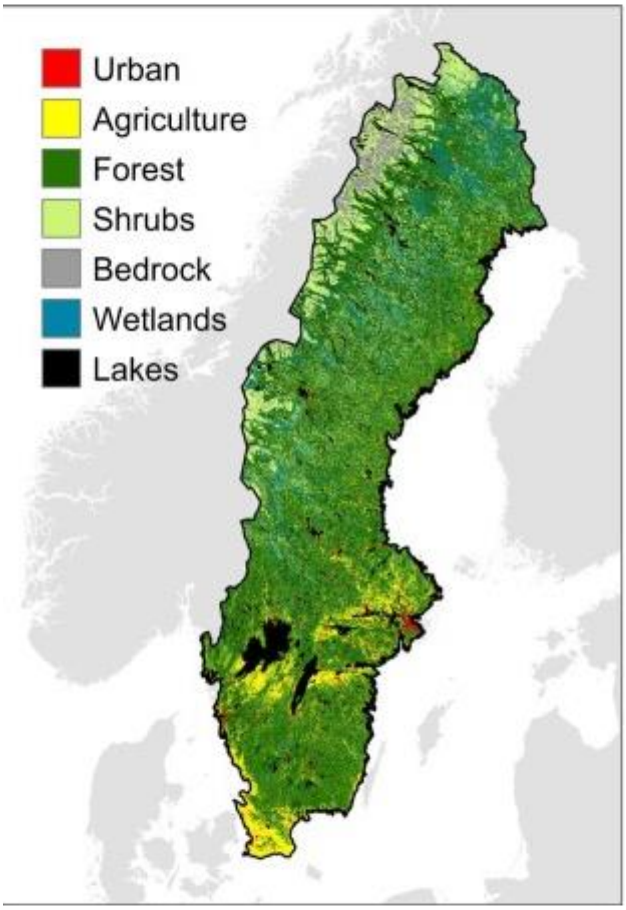

Figure 3. Land cover classes in Sweden (Heuvel et al., 2020).

3.4 Food consumption

Although Sweden has reduced their water consumption and carbon emissions over the years, many studies ignore products intended for final Swedish consumption, which could have increased the total water footprint and carbon emissions over the past years if considered (OECD, 2021). The fact that Sweden imports and consumes a lot of products and services from other nations should be noted since these factors may significantly influence the country's total water footprint. Therefore, it is essential to include the whole life cycle of all goods and services used inside the nation, including imported goods, to appropriately measure Sweden's full water footprint effect. By using an integrative strategy, it is possible to get a more profound knowledge of Sweden's water effect and highlight areas in need of improvement (Johansson, 2023).

As of today, according to (Livsmedelsverrket, 2016), the Swedish people consume around 800 kilos of food and drink per person each year, which leads to a total consumption of 8 000 000 tons of food and drink per year. As the population keeps growing, which will potentially lead to an increasing food consumption, there is a need for an in-depth examination of the related effects on water resources and the environment.

Recognizing the global characteristics of trading and consumption is also crucial. The varied nature of Sweden's environmental footprint is a result of its role as a consumer and importer of products and services from other countries. To correctly calculate the nation's overall environmental effect, it is necessary to take into account the water and carbon emissions generated during the manufacture and shipping of imported goods. If these elements are ignored, the real contribution of the country to global resource use and emissions may not be fully understood (Moberg et al., 2020).

It's crucial to take a comprehensive approach to this problem. The evaluation of Sweden's water footprint must take into account the whole life cycle of all commodities and services used inside the country, including those that are imported. Adopting such a thorough technique will enable a more precise assessment of the nation's environmental effect. This method helps highlight important areas that need immediate attention and action as well as giving lawmakers accurate data (Parekh & Klintman, 2020).

An integrated approach that takes into consideration the different production, distribution, and consumption phases might help to better comprehend Sweden's impacts on the environment. This method enables a complete analysis of the cumulative impacts of both nationally produced and imported commodities, providing insight into the geographical regions with the largest ecological footprint. Such information may direct focused efforts to lessen environmental effect, encourage sustainable behavior, and promote advancements across multiple fields (Johansson, 2023).

3.5 Coffee

Coffee is one of the most consumed beverages around the world. It is mainly produced in subtropical and tropical regions worldwide, although it is grown in most places worldwide. From planting the coffee tree to the gathering, grinding, and ultimately preparing the coffee beans for consumption, the production of coffee includes multiple steps (Febrianto & Zhu, 2023). The quality of water utilized over its life cycle also affects the coffee output. The first step when it comes to producing coffee is planting coffee trees. These kinds of trees need particular climatic conditions, heights above sea levels up to 2000 meters, and fertile soil, among other things (Duszak, 2021). Coffee plants grow the best when the district is in the wet and dry seasons because these are the conditions that coffee beans grow the best. The development of coffee plants relies heavily on water. Sufficient rainfall is required for the plants to get proper growth and a healthy cherry. Although, irrigation methods can be used in areas lacking rainfall to increase the water supply. This requires several methods, including watering systems with sprinklers or drip irrigation, that provide water straight to the plant roots (Caretti, 2016). The coffee cherries get harvested after they have fully grown. This can be done by using either a mechanical or manual method. The ripe cherries get chosen during manual harvesting, which requires

knowledge and skill. As for mechanical harvesting, the cherries get harvested from the trees using special machines. The coffee cherries then get processed after being harvested to separate the bean from the pulp. Afterwards, the beans undergo one of two methods: the dry or wet wash. Both these techniques require water, and the wet wash approach usually requires more water. The cherries get pulped, fermented, and cleaned using the wet wash approach.
Each of these stages requires a substantial quantity of water. The dry technique requires much less water and requires the cherries to be together intact with the pulp (Caretti, 2016). In order to preserve bean quality, water is used during the processing, which involves categorization, grading, and shipping. The water footprint of coffee refers to the total amount of water consumed during its whole life cycle, both indirect and direct. The indirect water usage makes up for water necessary for the inputs used during coffee production, handling, and other onsite operations. Where the coffee is manufactured, including what technique was used, and the efficiency of the water management during the process determines the coffee`s water footprint. Growing coffee can cause water stress and harm the environment in places with high water stress. By implementing sustainable water management methods, like effective irrigation systems, and efficiently using water, it is possible to reduce the water footprint of coffee (Aznar-Sánchez et al., 2018).

3.6 Meat

The term "meat" is typically defined as the animal flesh in a diet. It is an important protein source which can be found in several diets all around the globe. Meat can originate from a wide variety of species of animals, including fish, poultry (turkey and chicken), and mammals (cows, horses, goats, and pigs (Encyclopedia Britannica, 2023).

According to (Hoekstra., 2012), around 15,000 liters of water may be needed to produce one kilogram of beef. Many studies prove that different kinds of meat have one of the highest water footprint in the entire food chain. Numerous processes are involved in meat manufacturing, increasing the water footprint. The process starts with the production of crops which are used as feed, such as wheat, soy products, and different types of grains. The water footprint for these commodities is increased by the need for treatment and water supply. Water gets consumed by livestock animals for drinking and health preservation. The animals receive their water through irrigation systems, and the amount of water they receive depends on agricultural methods and the size and type of animal species (Pimentel et al., 1997). Several water-using processes are used in the raising of animals. Water gets used for managing animal waste and washing equipment, floors and barn areas. After the animals are fully grown and mature, they get taken to the slaughterhouses, where they get killed. This is followed by a processing phase in which water is used for washing, freezing, and hygiene. After that, the meat gets packed and delivered to the customers. In the packaging field, water gets used for container cleaning, storing procedures, and shipping. The water footprint of producing meat may vary during the different phases due to the meat type, manufacturing method, water management tactics and the water availability in the region (Pimentel et al., 1997). Some steps can be taken to reduce the water footprint, like increasing feed productivity, optimizing water use for livestock farming, installing water-saving equipment, and advocating sustainable agricultural methods. Furthermore, consuming less meat or switching to other sustainable diets can help significantly lower the total water footprint in the food ecosystem (Holloway & Wu, J, 2019).

The high water demand for meat can exacerbate conditions in areas where water resources are already limited. Additionally, because chemical discharge from fertilizer and feed can contaminate water sources, meat production can pollute and degrade the environment`s water resources (NDSU, 2022).

As shown in table 3.1, the Swedish imports of beef have greatly increased from 4.7% in 1960 to 49.1% in 2013.

Table 3.1 Swedish imports in percentage of the total consumption of the food type (Martin et al, 2016)

Year	**Beef (%)**	**Pork (%)**
1960	4.7	0.8
1970	7.8	8.0
1980	7.9	1.9
1990	8.4	6.2
2001	26.0	10.0
2010	42.1	24.0
2013	49.1	33.2

By changing from the current meat-heavy diets to plant-based diets, Sweden can significantly reduce their water footprint impact on other countries that do not have the same water availability. According to research (Grow Here, 2022), one of Sweden's counties, Västra Götaland, the county can become much more water environmentally friendly, significantly reducing the water stress on other countries, and it has the availability to grow food and feed its population even if the population there would increase by 50%.

3.7 Sustainable food system

The UN Food and Agriculture Organization (FAO, 2023.a) defines a sustainable food system as one that ensures everyone has access to nutritious food while supporting local economies, minimizing environmental impact, and promoting community well-being. A sustainable food system has to cover the entire range of actors and all their activities, such as consumption, production, distribution, aggregation, processing and disposal of food products originating from fisheries, forestry and agriculture. In order to generate food nutrition and security for future generations, a sustainable food system should consider environmental, economic and social dimensions, meaning that it is profitable throughout (economic sustainability), has broad-based benefits for society (social sustainability) and has a neutral or positive impact on the natural environment (environmental sustainability) (FAO, 2018.b).

Sustainable food options consist of a range of food products grown, treated and distributed in ways that support sustainability. The description of sustainable food options can be seen in Table 3.2.

Table 3.2 Sustainable food systems (FAO, 2018.b)

Sustainable food options	**Action**	**Leads to**
Produced locally	Reduce the water footprint linked to food transportation by selecting locally produced vegetables and fruits.	Supports local farmers and helps sustain regional agricultural industries .
Agroecological and organic food	Switching to organic and agroecological farming systems that use pest control and natural fertilizers techniques.	Minimizes the use of chemical-based products and their negative effects on the water quality and environment.
Plant-based diets	Switching to plant-based diets from the current heavy meat diets.	Lessens the negative effects that animal agriculture has on the water environment and the health problems that come with ingesting too much meat.
Sustainable seafoods	Changing to farming seafood from sustainably managed fisheries.	Prevents fish population decline and contributes to the preservation of ocean ecosystems.
Food waste reduction	Reducing food waste or adopting other techniques to decrease it	Cuts on the greenhouse gas emissions, water related emissions and saves on water resources.
Fair trade products	Maintaining fair working conditions and pricing for employees and farmers while purchasing fair trade goods.	Helps to maintain society by promoting social sustainability.

One of the most effective ways to reduce Sweden's water impact on other countries is to promote biodiversity and to transform our food system to one that functions on the principles of a circular economy which is much more sustainable (Pascucci, 2020). The current food system in Sweden could be more sustainable in the long run, especially not for the countries with high water stress which Sweden imports food from. Transitioning into a circular economy will solve these issues, significantly reducing Sweden's water footprint and water emissions. Also, it means heading toward a food system that increases natural capital while allowing nature to thrive. By having stable and healthy soils, water quality, air quality and improved biodiversity, it is possible to achieve regenerative food production, which generates positive outcomes for nature (Pascucci, 2020). This can be implanted in areas by having diverse cover crop varieties, agroforestry, rotational grazing, and cover crops resulting in an agricultural environment more closely resembling natural habitats like forests and native grasslands. It also significantly reduced today's food waste by redistributing edible food and providing it to those in need, while human waste and inedible food by-products are used as raw materials for new goods (Hamam et al., 2021).

Sustainable agriculture, defined as agricultural practices that are mindful of the consequences farming has on an environment, is eating locally. All living things, including ourselves, benefit from farming sustainability since all organisms are immediately touched by what happens to their environment (Pascucci, 2020). By starting to grow food locally, the country of Sweden can significantly reduce its water footprint in those countries which Sweden imports food from, especially those countries with high water stress. By eating locally, people reduce the need for additional water resources. Since water is essential for the development of a product, good irrigation that is sustainable is crucial. Sustainable agriculture and local farming can support the local economy alongside decreasing the water footprint. By consuming food that is produced locally, businesses and neighborhood farmers, people can help local economic development and help support job creation. Locally grown products have a lesser chance of being affected by supply chain distribution, which can reduce the risks associated with depending solely on imported food and increase food security (Ebitu et al., 2021).

Additionally, sustainable agricultural methods also aid in protecting and preserving natural resources, which involves biodiversity and soil. Following and having sustainable agricultural practices to maintain the soil's health and promote biodiversity is crucial for sustaining healthy ecosystems. This is mainly done by minimizing the use of pesticides and dangerous chemicals, primarily since the concern over climate change and its environmental effects has grown, which is one of the main concerns (Ebitu et al., 2021).

In Sweden, local food production and ecological agriculture is a growing movement towards sustainability. This is mainly done through the promotion of organic farming and the adoption of sustainable food policies. The country has set up goals of becoming the first welfare nation free of fossil fuels and has already taken steps towards achieving it. This can create a ripple effect which may set an example and encourage other nations to imitate it by continuing to establish a high priority on local food production and sustainable agriculture, which can lead to a more sustainable future for everybody (Pascucci, 2020). The different areas that have to be covered to have a sustainable food system can be seen in Figure 4.

Figure 4. Toolkit for a sustainable food system (Marrazzo, 2019).

3.8 Water availability to grow local food

The water availability in Sweden is high, and the possibility of growing foods based solely on water is high. The downside of the geographical position of Sweden is the need for more sunlight which limits Sweden's potential for growing vegetables, fruits and other more exotic foods. This limitation forces the Swedish population to import agricultural products from other countries and shift focus to forestry due to the country's climate zones and soil properties. Over the years, the population has risen, and so has the import of raw materials to produce agricultural products and whole foods imports. Whilst the self-sufficient agricultural products have fallen, Sweden has become more reliant on imported foods now than ever. Still, sources point out that Sweden can become more self-sufficient in the agricultural sector for several reasons, such as higher security for the Swedish population of not potentially running out of food but also for battling climate change (Kuylenstierna et al., 2019). Sweden's water availability can be seen in table 3.3.

Table 3.3 Water availability for Sweden

Sweden	Available renewable water resources annually (m^3)
Total renewable groundwater	$20\ 10^9$
Total renewable surface water	$173\ 10^9$
Total renewable water reserves	$174\ 10^9$
Total renewable freshwater resources (TRFR)	$367\ 10^9$

Several variables affect the amount of water Sweden has available for local food production. Sweden's eastern and southern areas typically receive more rainfall than the western and northern sides, with regional variations on how much rain falls across the nation (Olsson et al., 2019). Sweden benefits from various groundwater supplies, wetlands, streams, and rainfall. The assistance of these water sources is crucial for agricultural activity. It is possible to use an underground water supply for irrigation, particularly in regions with limited or irregular rainfall. Effective irrigation techniques can increase the water available for regional food production (Olsson et al., 2019). As of today, Sweden places a high value on environmentally friendly agricultural technologies, such as rainwater harvesting, which reduces waste and maximizes water efficiency (Wenneberg, 2018). These methods assist in ensuring that water resources are utilized effectively, supporting the development of regional vegetation. The possible future impacts of climate change on water supply must be taken into consideration also. Climate change has the potential to cause irregular rainfall patterns, increase the temperature, and a possibility of a rise in extreme weather conditions like dry conditions and intensive rainfall. These changes can impact the water supply, which requires adaptable solutions like better water management techniques and an infrastructure that supports environmentally friendly and sustainable agriculture (Wenneberg, 2018). A water availability map across Sweden can be seen in Figure 5.

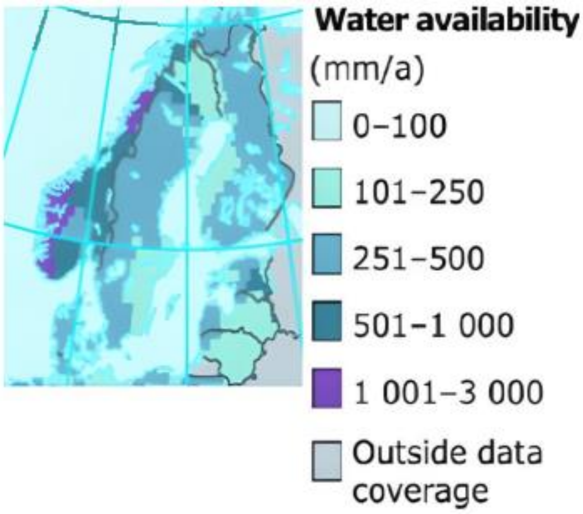

Figure 5. Water availability Sweden (European Environment Agency, 2009).

3.9 Main food imports to Sweden

In order to meet the demands of its population, Sweden has to import a wide range of food products. Since Sweden has one of the highest per capita coffee consumption rates globally, coffee beans are among the most common imported food commodities (Worldpopulationreview, 2023). Sweden imports a wide range of vegetables and fruits due to its short growing seasons, such as bananas, citrus fruits, avocados, peppers and tomatoes. Additionally, to satisfy the population's demands, Sweden also imports poultry and meat such as pork, beef, lamb and chicken. To increase the nation's food supply, chocolate and dairy products, including butter, milk and cheese, are also imported (Cederberg et al., 2019). Sweden due to its physical position along the coasts of the Baltic Sea and the North Sea, Sweden imports a significant quantity of shellfish and fish, mostly from its neighbors Denmark, Norway and Iceland.

Given Sweden's dedication to sustainable growth and responsible consumption, foods with the highest water footprints is an urgent issue. Food products' water footprint describes how much water was used at all the stages of production, including transportation, irrigation and processing. Meat and dairy goods, coffee beans and nuts are some foods with the highest water footprints. Sweden's water footprint is significantly increased due to the importation and consumption of meat and dairy products, with beef being the most water-intensive food. In order to maintain the agricultural land, maintain crops to feed the animals, and supply drinking water for the livestock, beef production requires much water. In addition to irrigation for feed production, equipment cleaning, and animal hydration, dairy production also requires much water. Similarly to other imported foods, coffee beans, one of Sweden's most popular food imports, have a high water footprint, with processing and irrigation using a significant amount of water (Eurostat, 2021).

Some statistical findings from relevant databases are showcased in the tables below, to demonstrate the water footprint of different food categories but also main imports.

Table 3.4 Categories of food from high water footprint to low water footprint

Categories of food	Water footprint (medium value, l/kg)
Fruits	875
Vegetables	2904
Grains	2294
Dairy	3877
Protein foods	15 573
Oils & Solid fats	16 997

Table 3.4 shows the water footprint of common food categories. The three most influential food categories are oils and solid fats, protein foods and dairy products. Table 3.4 in combination with table 3.5 is also one of the reasons for choosing the products that may have the most influential water stress remark.

Table 3.5 Total food import and water footprint for the different food categories for the year 2019 (Eurostat, 2019).

	2019 Import (kg)	Total Water Footprint (m^3)
Vegetables & Fruits	$1.837\ 10^9$	$3.471\ 10^9$
Grains	$643.3\ 10^6$	$1.476\ 10^9$
Dairy	$375.6\ 10^6$	$1.456\ 10^9$
Protein foods	$208.8\ 10^6$	$3.252\ 10^9$
Oil and solid fats	$52.7\ 10^6$	$896.1\ 10^9$

The values shown in Table 3.4 are only appropriate for the different food categories due to unavailable values. For example, Eurostat did not have all appropriate values for all different products in the dairy, grain and oil categories. Therefore, only the medium water footprint is used for these products and, therefore, a rough estimation of the total water footprint. Although this gave us an estimated insight into the food category to choose, together with the medium value of the water footprint in Table 3.5 of the food categories gave us an indication of which food category may have the highest environmental impact through water stress. This indication led us to investigate further Swedish food consumption and specific food types that the Swedish population consumes and has a high footprint and water stress impact. Initially, we chose the year 2019 due to adequately evaluate the import and export of Sweden, and there was a drastic decrease in import and export the years after, probably due to global events such as the covid pandemic and political unrest throughout the globe.

According to an extensive literature review and these tables above, one food category and one food product stood out due to their high water footprint and high consumption patterns. These foods were particularly notable because of alternative solutions that can significantly reduce their water footprint and the water stress they impose. Additionally, these foods are popular among consumers. Further details are provided in Appendices 4 and 5, where coffee is highlighted in its own category regarding

Swedish consumption patterns. Although coffee beans are technically included in the vegetable category, their significant environmental impact necessitates separate research.

The findings on the most suitable and impactful foods that Sweden imports, exports and produces are categorized for the three most recent years available in Eurostat. These tables show the total amount of most consumed meats imported/exported and produced in Sweden; coffee is the following food product. Due to categorizing them by different meats, as shown in the appendix; they have different water footprints and impact the water stress differently. The third step is to check the import trade and which country Sweden affects the most by importing. The fourth step is to check how much Sweden affects its water stress by producing these types of food.

Table 3.6 Export/import and production of foods in Sweden (Eurostat, stats for year 2019) in kg

	Import Quantity (kg)	Export Quantity (kg)	Production Quantity (kg)
Total Meat	208 817 600	56 681 100	626 160 600
Coffee (not roasted coffee, not decaffeinated)	110 918 500	2 591 900	-

Table 3.7 Export/import and production of foods in Sweden (Eurostat, stats for year 2020) in kg

	Import Quantity (kg)	Export Quantity (kg)	Production Quantity (kg)
Total Meat	180 951 491	56 875 047	560 454 400
Coffee (not roasted coffee, not decaffeinated)	109 766 800	1 312 500	-

Table 3.8 Export/import and production of foods in Sweden (Eurostat, stats for year 2021) in kg

	Import Quantity (kg)	Export Quantity (kg)	Production Quantity (kg)
Total Meat	188 584 543	66 140 528	337 381 307
Coffee (not roasted coffee, not decaffeinated)	96 715 100	1 053 200	-

The tables 3.6 to 3.8 shows the total import, export and production of the products chosen, whilst also advocating for the greater picture of how much of these product are circulated in Sweden, these values are used as an foundation to further differentiate for instance the difference meat during later stages, these tables also describe if the products are produced in Sweden, for instance coffee is not produced in Sweden and therefor Sweden is totally reliable on the production of other countries.

Table 3.9 Consumption gathered from Eurostat, kg/year per individual

Eurostat	2019	2020	2021
Meat	75.7	66.1	44.1
Coffee (not roasted coffee, not decaffeinated)	10.5	10.43	9.2

Findings on Swedish consumption are presented below. The database from 'Jordbruksverket' shows the Swedish consumption per person of food categories coffee and meat. The specific data researched were limited to three consecutive years, 2019, 2020 and 2021 and are shown in more detail in appendixes.

Table 3.10 Consumption, kg/year per individual (Jordbruksverket, 2022)

	2019	2020	2021
Meat	81	79	80
Coffee	8	7	5

It is important to note that table 3.9 shows the consumption of the Swedish population for all meats; the values above gathered from Eurostat in table 3.11 represent only the most imported meat types and usually the most consumed, therefore the values from Jordbruksverket and Eurostat do not correlate precisely. The same is for coffee, the values gathered from Eurostat is the total amount of non roasted coffee beans that in time is roasted in Sweden, the non-roasted coffee beans amount to an higher value than the Swedish population actually consumes and that is because after it is roasted in Sweden, it is exported in greater amount than roasted coffee beans, if the values are gathered as roasted coffee beans it is introduced as Sweden is producing them on Eurostat, which gives a false indication of how much coffee Sweden imports but also produces.

Sweden imported mostly coffee and meat from countries such as Germany, Ireland and Brazil. Appendix 3 provides a list of the main exporter to Sweden for the selected products, as well as their relative contributions to the much meat and coffee that came from which country.

There is also an important perspective to understand that different kinds of meats impact the environment differently therefore the different meat kinds are to be categorized with their respective water footprint. Table 3.11 describes water footprint of different meats in liters per kilogram, they do not take into account from which country and to packaging and transport, therefore these values are moderately given due to the water footprint of a certain product can vary due to the country it is produced. Table 3.11 is used to later on calculate the water footprint for the different meat types and coffee.

Table 3.11 The respective meat and coffee and their water footprint (Marie, 2022; Marie, 2023).

Different meat types and coffee	Water footprint (l/kg)
Pig meat, swine	5 988
Bovine meat	15 415
Sheep meat, Goat	8 763
Horses	51 779
Chicken, Turkey	4 325
Coffee beans (not roasted)	15 897
Plant-based meat	200
Chicory plant	387

3.10 Food waste in Sweden

Throughout the world, there is a serious problem with food waste, which impacts the environment and the economy. Food waste is a concern in Sweden because Sweden is the country producing the most food waste compared to Scandinavian countries (Nordic Council of Ministers, 2017). According to the Swedish Environmental Research Institute (2021.b), 133 kilos of food go to waste per person in Sweden yearly, which equals 1.3 million tons of food. In addition to causing economic loss, food waste increases Sweden's overall water footprint due to the resulting higher food needs; it also contributes to additional environmental issues, such as increasing Sweden's greenhouse gas emissions. Considering the situation is so essential, the Swedish government has aimed to decrease food waste in Sweden by half by 2030 (Livsmedelsverket, 2018). One of their main strategies to achieve this target is to reduce food waste at the source. This requires managing the leading causes contributing to food waste, such as weak planning, over-purchasing, and overproduction of food (Livsmedelsverket, 2018).

Sweden has several non-profit initiatives in place to cut down on food waste. One of those initiatives is called "Maträddarna", a group that gathers food not sold by supermarkets and offers it to people in need (Claesson & Isbring, 2019). The Swedish Environmental Protection Agency has started a project called, "Klimaträtt" teaming up with different organizations, schools and several municipalities, where the goal is to reduce food waste in schools by educating kids on food waste and giving them the tools to manage food waste. Through the initiative, schools get resources and instructions on how to prepare, plan, and deliver nutritious meals that are environmentally friendly. The initiative also advises schools to let students participate in the preparations of meals and to teach them why it is essential to value minimizing food waste and making sustainable food choices (Swedish Environmental Protection Agency, 2021.b).

3.11 Sustainable diets

A sustainable diet is one that promotes health and well-being, minimizes environmental impact, and supports food security and biodiversity. While a plant-based diet is one form of sustainable eating that focuses on reducing the environmental impact and overall water footprint, see Figure 6, sustainable diets can also include responsibly sourced animal products. In recent years, plant-based diets have gained popularity due to their health advantages and the growing concern for climate change and sustainability (Pascucci, 2020).

Several plant-based foods, such as vegetables, fruits, seeds, whole grains and nuts, comprise a vegetarian diet. The essential nutrients which human beings need to thrive, vitamins, minerals, fiber and protein, are included in these meals. Meat can be swapped out with plant-based meats and based on protein-rich products like beans, lentils, and tofu. By adopting foods that are locally produced, less processed, and organic, one may decrease the environmental effect of food production. Consuming locally produced foods helps the region's economy and reduces transportation emissions. Organic food can be produced without using hazardous pesticides and fertilizers, which could reduce water and soil pollution. Foods which have undergone little processing need fewer resources and less energy to manufacture, which reduces their water and carbon footprint (Pascucci, 2020).

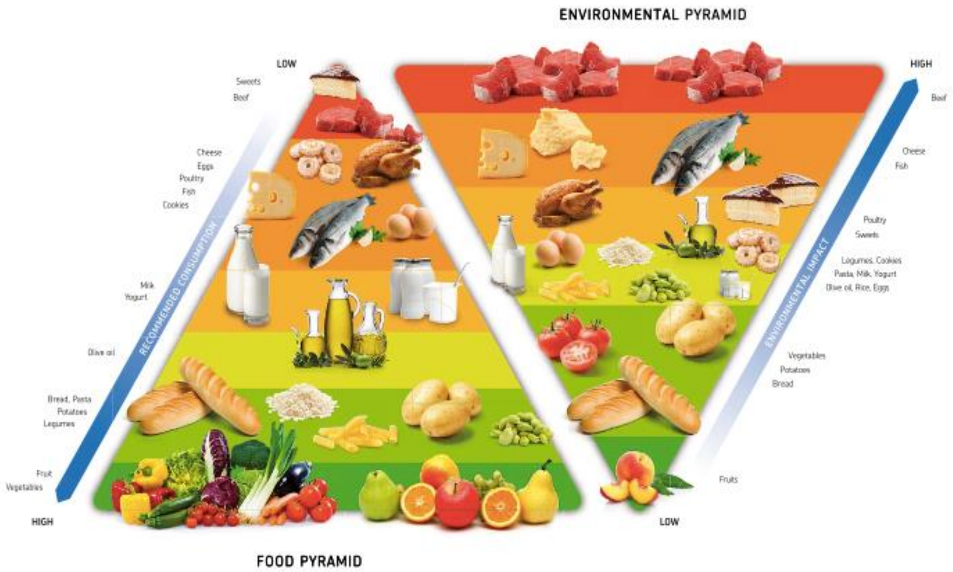

Figure 6. Environmental food pyramid (Ruini et al., 2015).

A vegetarian, sustainable diet provides multiple health benefits along with being compassionate to the earth. According to (Thomas et al., 2023), eating a plant-based diet may lower a person's risk of developing chronic illnesses, including diabetes, heart disease and cancer. Furthermore, plant-based foods have lower saturated fats and cholesterol levels, which can benefit the heart.

Sweden is a good fit for locally producing and growing plant-based diets. It emphasizes the utilization of fresh, in-season ingredients, resulting in an ideal choice for individuals trying to lessen their water footprint and environmental impact (Swedish Environmental Protection Agency, 2021.b).

As seen in Figure 6 above, there are several categories of food that significantly alter the environment at varying degrees. Figure 6 explains to a greater extent the difference between the food categories and their impact on the environment. Whereas the most significant impact of food production is meat, coffee and cacao products when upon more profound research on only the water footprint of these products, it becomes clear that these food products are the most harmful regarding water stress issues.

4 Methodology

The methods used to answer the research questions are presented in this section. The approach includes multiple methods, each serving a specific purpose in this research. This section is structured to ensure clarity and understanding of the analytical process.

To aid in understanding the work process, a comprehensive figure (Figure 7) that visually depicts the step-by-step progression of the used methodologies. This figure serves as a roadmap, providing a clear overview of the interconnected methodological steps that guide this study.

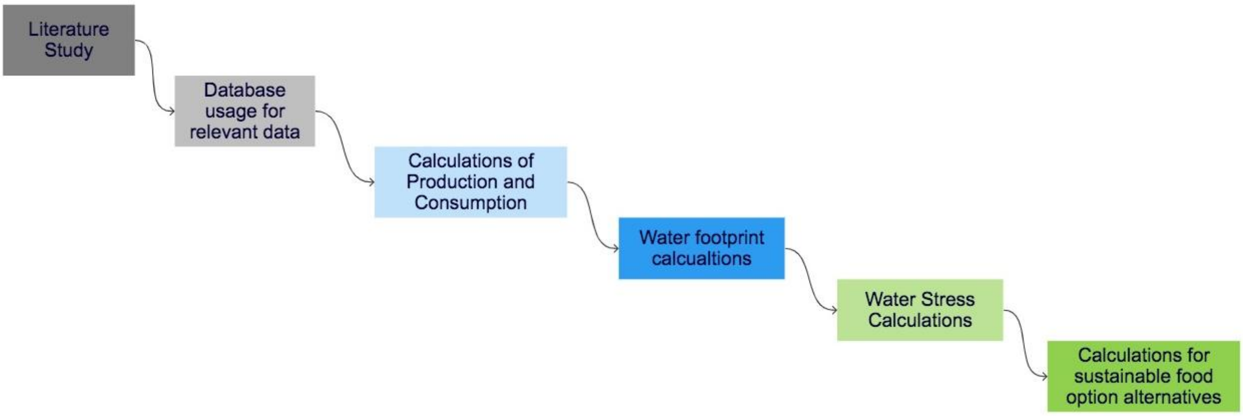

Figure 7. Methodological process.

The methodologies can be broadly categorized as following:

1. **Literature study**: The research was initiated by conducting an extensive review of existing literature to establish a strong foundation for this study. The comprehensive literature review made it possible to identify trends, key concepts, and gaps in the field.
2. **Database usage for relevant data**: A crucial element for this study involves the development and application of relevant data. This step forms the backbone of our calculations and allows us to assign appropriate weights to various factors, ensuring a robust analysis of production and consumption data.
3. **Calculations of Production and consumption**: Detailed calculations of production and consumption patterns are essential for the research. Processed data related to these aspects, considering various variables and factors that influence them.
4. **Water footprint Calculations**: Central to our research is the assessment of water footprint associated with different aspects of the study. We employed established methodologies to quantify water usage and to our chosen variables.

5. **Water Stress Calculations**: Understanding the level of water stress is a critical component of our investigation. We utilized specific calculations to assess water stress in the context of our study, providing valuable insights into sustainability and resource management.
6. **Calculations for sustainable food option alternatives:** Our research extends to the evaluation of the alternative food options. Through careful calculations and comparative analysis, the effects of various dietary choices could be achieved.

Figure 8 illustrates how the chosen products were investigated in each step that was taken and divided from start to finish. This illustration can be used as a guide together with the methodologies to get a better understanding of every step that was done in the study. As this section continues, a more detailed breakdown of each method, outlining the specific procedures, data sources, and assumptions underpinning our research will be explained.

Figure 8: Illustration of the chosen steps taken to determine the water stress of chosen products and the change of water stress due to solutions.

4.1 Literature study and information search

At first, a comprehensive literature search was conducted to gather information regarding issues on water footprint and water stress. This process involved collecting data from various sources, including books, online journals, and articles. The search strategy included using common keywords such as "food products," "water footprint," "water stress in countries," and "food consumption in Sweden" to narrow down relevant sources.

The literature study began with defining the concept of the water footprint, followed by identifying Sweden's import and export partners concerning food products. Detailed research and analysis highlighted the water footprint of coffee and meat products due to their significant import frequency and high water demands. The research then delved into the manufacturing processes and pathways of these products from different exporting countries.

To obtain data on Sweden's imported products and identify significant import and export partners, databases such as Eurostat were utilized. These databases provided valuable insights into the top countries exporting to Sweden, guiding further investigation. The next step involved more profound studies on the water stress levels in countries from which Sweden imports coffee and meat.

These in-depth studies examined relevant data and reports on water availability, usage patterns, climate conditions, and agricultural practices in the selected countries. By assessing the water stress levels, the research aimed to understand the environmental impact and sustainability of producing and exporting coffee and meat to Sweden. This analysis helped evaluate the potential water-related risks associated with the supply chain of these products, aiding in the formulation of strategies and policies to promote sustainable trade practices and mitigate environmental risks.

Understanding the water stress levels in the countries of origin was crucial for assessing the environmental implications of Sweden's imports. This comprehensive analysis provided a foundation for developing strategies to ensure sustainable trade and minimize environmental impacts.

4.2 Relevant databases

Several databases were utilized to gather relevant data for calculating the specific water stress caused by food consumption patterns in Sweden. The objective was to understand water availability in specific countries, analyze food import and export, and gather food production data. The following databases were used:

* Eurostat: A wide range of statistics can be accessed from the statistical database Eurostat. It was used to gather data on import and export, enabling researchers to study the dynamics of the food trade. Eurostat displayed the values in kg/year, this was later used in our study to calculate the Total freshwater withdrawal (TFW), by utilizing the water footprint (WF).

* Aquastat: This database is owned by the Food and Agricultural Organization of the United Nations (FAO). This database provides precise data for all countries on water usage, water resources, and irrigation practices worldwide. The authors used Aquastat to gather information on water availability in various nations and to evaluate any possible water stress related to food production from the chosen food types. Aquastat gives values on total renewable freshwater resources (TRFR) in the unit m^3/year.

* eFlows: eFlows is a database that provides data linked to environmental flows, quantity, and quality of water required to sustain ecosystems and their biodiversity. The authors were able to determine the impact of water consumption in food production and its possible repercussions on ecosystems with this database, which offered information on the environmental water requirements of certain areas or rivers. The main values given by eFlow was the environmental flow requirement (EFR), the unit used was m^3.

Utilizing these databases, the authors could compile essential information on water resources, import and export patterns, and food production methods. This information was essential for calculating the water stress and water footprint from Sweden's food consumption habits and comprehending the environmental effects of food production and importation. The Environmental Flow Requirement (EFR) and Total Freshwater Withdrawal (TFW) statistics were retrieved from previously stated databases. While the TFW refers to the quantity of freshwater extracted for diverse uses, including agriculture, industry, and residential usage, EFR represents the water required to sustain ecosystems and retain their biodiversity.

4.3 Gathering of import-export flow and consumptions pattern data

Import and export data were gathered from the Eurostat database for the products and ingredients most commonly used by Swedish consumers in regards to products with the highest water footprint per kilogram of food product. The leading importers and exporters were identified. The gathering of data aimed to allocate weights to the various products and ingredients based on their importance and frequency of use among Swedish consumers. By identifying the leading importers and exporters, this could provide valuable insights into the supply chain dynamics and help prioritize focus areas for further analysis. During this stage, different factors were considered such as the volume of imports and exports. By analyzing the data on the imported products to Sweden, the researchers could determine their significance in the overall import and export landscape. Researchers assigned weights to the products and ingredients based on their total import and export volume. This involved calculating the percentage contribution of each product to the overall trade, considering both import and export values for each country. The ability to identify essential trading partners, comprehend market patterns, and assess the eventual effects of trade policies and disruptions were all made possible using this information. This stage helped allocate resources for more study and analysis. Researchers could look more deeply into the unique supply networks, environmental effects, and sustainability aspects of these products by concentrating on the products and substances with the highest water footprint in relation to the amount of imports. Production in Sweden was also looked into if we were to produce the products domestically in relation to understanding how much it would add to Sweden's water stress. By gathering data which could pinpoint where higher import and export volumes were made it easier to make strategic decisions by pointing out areas where water stress was a problem and, from there, develop more sustainable, environmentally friendly strategies. It thoroughly assessed the import and export scene, giving the authors the information they needed to make wise choices and promote more sustainable food strategies for Sweden.

4.4 Calculation of production and consumption through import and export values

The next step focused on calculating the production and consumption values through import and export data. The following assumptions were made to facilitate these calculations:

Equation 2: $Import + production = Consumption + Export$

This assumption implies that the total imports and domestically produced goods are equal to the overall consumption of a specific product. Additionally, the consumption is further influenced by the amount of that product being exported.

Using these presumptions and the available import and export statistics, the authors attempted to calculate the consumption rates of the chosen food products. This estimate gave insights into the dynamics of trends and helped to understand the national demand for food products. Data on domestic production was merged with import and export statistics taken from the Eurostat database to complete the calculations. The import value indicated the amount of the product imported to Sweden, whilst the export value indicated the quantity of the product exported from Sweden. The domestic production value accounted for the amount of the product manufactured within Sweden. By adding the import and production values and subtracting the export value, the authors could estimate the total consumption of the product. By employing this method, the authors could get a comprehensive insight into the consumption trends and patterns for the chosen food products. This allowed the authors to analyze the effects of trade policies, determine if import reduction or local production incentives were necessary, and find opportunities for sustainable food strategies. The water footprint of food products and Sweden's food import as well as Sweden's consumption pattern can be seen in the tables from 3.4 to 3.11. These tables constructed through literature study and databases such as Eurostat were a large part of the foundation that was later used to calculate water stress.

4.5 Calculation for the total water footprint

In order to calculate water stress which is consequently created by Sweden's import from its partners regarding coffee and different meat types, the total water footprint of those products has to be calculated by utilizing equation (2) shown below. By gathering information such as the water footprint to produce a specific product from reliable sources such as reports and databases, together with data on the amount imported from these countries, extracted from the database Eurostat, the total water footprint could be calculated of that specific product which is imported to Sweden. This was done for every different meat product which Sweden imported as well as for the coffee beans.

Equation 3:
$TFW = (P \times WF)$

$\text{TFW} = \text{Total freshwater withdrawn for the specific product in total, measured in liters}$
P = Quantity of product, measured in kg
WF = The water footprint of the specific product, measured in liters/kg.

This equation was used to determine the overall TFW related to the production of different meats and coffee in the countries from which Sweden imported these items. This information enabled the authors to understand Sweden's influence on TFW on different countries related to importing these products and the possibility of calculating the water stress inflicted in those areas.

4.6 Calculation for water stress

Water stress in individual countries is calculated using Equation (3). The data was obtained from online databases, as mentioned earlier (IWMI, 2023);

Equation 4: $Water\ Stress\ (\%) = \frac{TFW}{(TRFR - EFR)} \times 100$

Total freshwater withdrawn (TFW)
Total renewable freshwater resources (TRFR)
Environmental flow requirements (EFR)

Data from the Water Data Portal's database were used to determine the environmental flow needs of selected nations. This database is a valuable resource to obtain the water requirements that ecosystems have in order to preserve ecosystems. By combining this data, the authors were able to examine the environmental effects of water use and determine the possible degrees of water stress in various nations. Additionally, information on the total renewable freshwater resources accessible in various nations was gathered using the Aquastat database (FAO, 2023.b). This extensive database supplied information on the amount and accessibility of surface water and groundwater resources. The degree of water stress in nations of interest was determined by merging the data on total renewable freshwater resources, environmental flow requirements and total freshwater withdrawal. This estimate evaluated the stability between water supply and demand, highlighting nations where water supplies may be constrained or in danger of running short. Understanding the sustainability of water usage, especially in the context of food consumption patterns, required the calculation of water stress. In order to inform plans and policies aiming at encouraging sustainable water management practices and reducing possible water-related dangers, it enabled the authors to identify nations with high levels of water stress. The resulting outcomes provide insight into which nations are significantly under water stress and how Sweden's food imports from these countries relate to their water stress. These results opened the door to investigating long-term solutions for developing a sustainable Swedish food system and addressing the problems by reducing Sweden's food imports from affected countries, lowering its water stress impact on affected nations.

Equation 4 is used to calculate the water stress inflicted by Sweden’s import of food from other countries. In that case, the total freshwater withdrawn (TFW) is calculated by multiplying the water footprint of relevant products (liter/kg) by the total amount of product imported by Sweden just as equation 3 shows. The obtained TFW from equation 3 is then put in equation 4 with the variables shown in equation 4 that are acquired by databases such as eFlow and Aquastat. This displays the water stress as a direct consequence to produce that product, this is then compared with the total water stress in the country to assess the significance of Swedish import and consumption in that country.

4.7 Calculation for different food option alternatives

In the last step, in order to come up with new alternatives, a calculation of Sweden's current water stress levels had to be done, and from there, a calculation of how much of its food production makes up for the total water stress levels, this is achieved by conducting data from the databases mentioned earlier. Firstly, the total water footprint of the Swedish food production of the researched products was calculated by utilizing equations 2&3. After that, steps were repeated to calculate water stress from the countries Sweden initially imported the products with the same principles used to calculate the Swedish water stress from its food production. By studying the water stress calculation results, the authors could study different sustainable alternatives that could be analyzed and implemented as an alternative instead of heavily relying on importation. After the different alternatives were studied, new calculations were constructed to see how much the water stress levels could be reduced. Firstly, the new alternatives' total water footprint was calculated using the equation (2&3). Secondly, together with information such as TFW, TRFT, and EFR, the new alternatives' water stress levels could be calculated to see how much the water stress levels could be reduced.

5 Results

This section provides results for the total freshwater withdrawal (TFW) for meat and coffee and the water stress induced by Sweden's import of these products.

5.1 Water footprint

Tables 5.1 to 5.6 present the different TFW to produce selected products. Values are provided for coffee and different types of meat from identified countries. The values were obtained for 2019-2021 to potentially identify a trend.

Table 5.1 TFW due to coffee import to Sweden from different countries for the years 2019-2021

Unroasted coffee, not decaffeinated, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Brazil	$662.991\ 10^6$	$670.066\ 10^6$	$630.367\ 10^6$
Peru	$230.989\ 10^6$	$174.496\ 10^6$	$149.136\ 10^6$
Honduras	$176.627\ 10^6$	$174.496\ 10^6$	$144.523\ 10^6$
Kenya	$68.469\ 10^6$	$70.318\ 10^6$	$62.592\ 10^6$

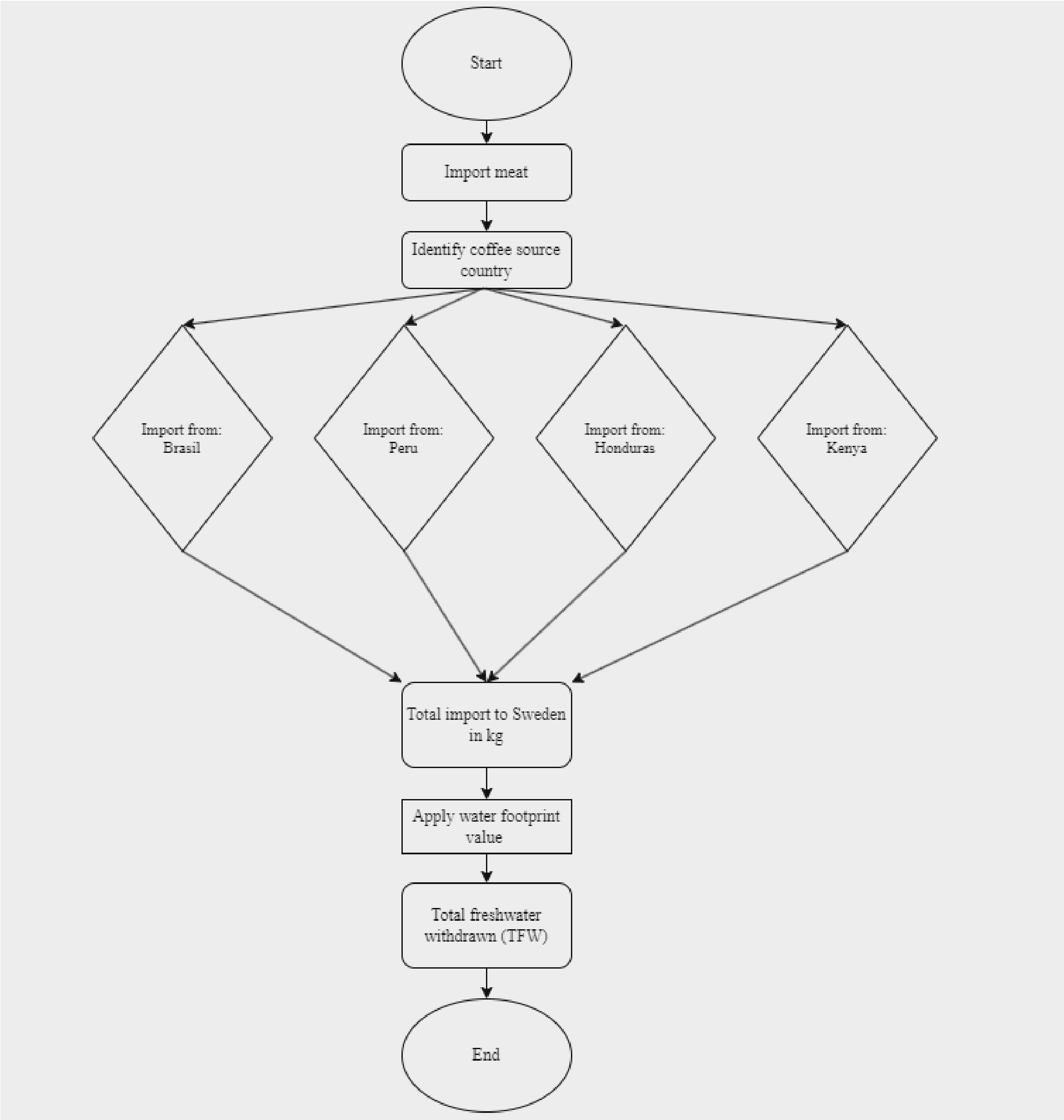

Figure 9. Simple flowchart of unroasted coffee import to Sweden.

Figure 9 shows the process thought of acquiring the TFW, the flowchart works well with table 5.1, displaying the different countries and the TFW results to import coffee to Sweden.

Table 5.2 TFW due to swine meat import to Sweden from different countries for the years 2019-2021

Swine meat, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Germany	$185.266\ 10^6$	$131.138\ 10^6$	$147.127\ 10^6$
Denmark	$74.290\ 10^6$	$77.859\ 10^6$	$78.698\ 10^6$
Poland	$56.621\ 10^6$	$52.039\ 10^6$	$49.381\ 10^6$
Finland	$35.480\ 10^6$	$24.323\ 10^6$	$6.480\ 10^6$

Table 5.3 TFW due to poultry meat import to Sweden from different countries for the years 2019-2021

The water footprint on poultry meat, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Denmark	$158.552\ 10^6$	$142.264\ 10^6$	$148.121\ 10^6$
Netherlands	$33.280\ 10^6$	$32.470\ 10^6$	$42.058\ 10^6$
Germany	$20.998\ 10^6$	$20.125\ 10^6$	$17.572\ 10^6$
Poland	$12.152\ 10^6$	$10.103\ 10^6$	$14.155\ 10^6$

Table 5.4 TFW due to bovine meat import to Sweden from different countries for the years 2019-2021

The water footprint on bovine meat, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Ireland	$288.328\ 10^6$	$284.126\ 10^6$	$314.586\ 10^6$
Netherland	$228.793\ 10^6$	$175.171\ 10^6$	$171.541\ 10^6$
Poland	$175.597\ 10^6$	$162.958\ 10^6$	$147.844\ 10^6$
Denmark	$128.237\ 10^6$	$84.140\ 10^6$	$106.043\ 10^6$
Germany	$117.943\ 10^6$	$109.331\ 10^6$	$162.437\ 10^6$

Table 5.5 TFW due to sheep and goat meat import to Sweden from different countries for the years 2019-2021

The water footprint on sheep and goat meat, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Ireland	40.779 10^6	39.621 10^6	38.300 10^6
Netherland	16.384 10^6	18.708 10^6	14.384 10^6
New Zealand	12.356 10^6	14.617 10^6	12.776 10^6
Germany	5.599 10^6	3.738 10^6	3.754 10^6

Table 5.6 TFW due to horse meat import to Sweden from different countries for the years 2019-2021

The water footprint on horse meat, total freshwater withdrawn (TFW) (m^3)			
	2019	2020	2021
Italy	2.289 10^6	6.229 10^6	-
Finland	3.754 10^6	1.036 10^6	-
Belgium	3.159 10^6	3.019 10^6	-

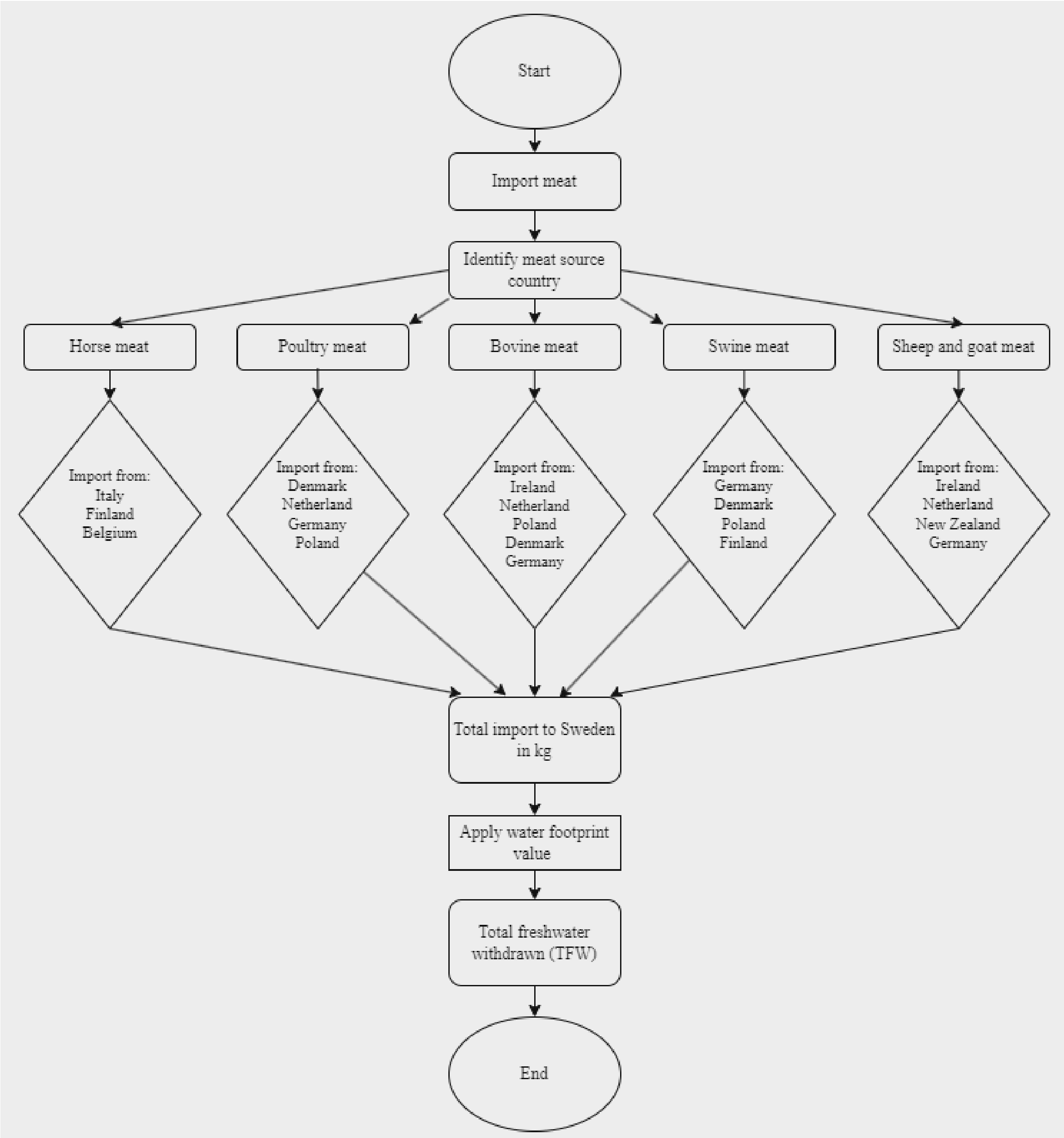

Figure 10. Simple flowchart of different meat imports to Sweden.

Table 5.2 to 5.6 describes the TFW acquired to produce the different meats for import to Sweden, the flowchart in figure 10 displays the process thought to acquire the different TFW from different countries as well as different meat types. These tables are the groundwork for equation 4 and equation 3 is utilized to get these values.

Table 5.7 shows the total water withdrawn when it comes to both products combined from one country.

Table 5.7 The TFW from different countries for the years 2019-2021, including both coffee and all sorts of meat (m^3).

The combined total freshwater withdrawn to import all kind of meat and coffee (TFW total)			
	2019	2020	2021
Brazil	662.991 10^6	670.066 10^6	630.367 10^6
Peru	230.989 10^6	174.496 10^6	149.136 10^6
Honduras	176.627 10^6	174.496 10^6	144.523 10^6
Kenya	68.469 10^6	70.318 10^6	62.592 10^6
Germany	340.1 10^6	264.332 10^6	274.496 10^6
Ireland	329.107 10^6	323.747 10^6	352.886 10^6
Netherland	278.457 10^6	226.349 10^6	227.983 10^6
Poland	244.37 10^6	214.997 10^6	211.38 10^6
Denmark	361.079 10^6	304.263 10^6	332.862 10^6
Italy	2.289 10^6	6.229 10^6	-
Finland	39.234 10^6	25.359 10^6	6.480 10^6
Belgium	3.159 10^6	3.019 10^6	-
New Zealand	12.356 10^6	14.617 10^6	12.776 10^6

5.2 Water stress

The data collected to calculate the water stress of the products chosen are down below in the appendix, here are the results of Sweden's import of the major meats and coffee from different countries.

Table 5.8 Water stress: Freshwater withdrawal as a proportion of available freshwater resources for the year of 2020 (United Nations, 2020)

Water stress	(%)
Sweden	3.58
Brazil	1.48
Peru	7.18
Honduras	4.62
Kenya	33.24
Germany	33.50
Ireland	21.64
Netherland	16.80
Poland	30.00
Denmark	26.40
Italy	29.81
Finland	7.11
Belgium	51.58
New Zealand	8.05

The table 5.8 shows the water stress of the countries from which Sweden imported the chosen products most from, these values represent the water stress in regard to the total freshwater withdrawn for all processes in those specific countries in regard to environmental flow and with the renewable water resources available in those countries. Table 5.9 shows the percentage of which Sweden's import of chosen products adds to the processes of which require freshwater resources which in term adds to the total amount of the existing water stress. Due to two quite different products in terms of import quantity and in difference of where they are imported it is quite easy to differentiate them on table 5.9, the top four countries on the table represent only coffee import and their water stress while the rest represent meat import and their water stress.

Table 5.9 The water stress inflicted by Sweden's import of the chosen products of year 2019,2020

Water stress Sweden inflicts on countries	2019 (%)	2020 (%)
Brazil	0.006	0.006
Peru	0.007	0.006
Honduras	0.130	0.128
Kenya	0.107	0.109
Germany	0.096	0.075
Ireland	0.351	0.345
Netherland	0.128	0.128
Poland	0.323	0.284
Denmark	2.581	2.18
Italy	0.001	0.002
Finland	0.019	0.012
Belgium	0.014	0.013
New zealand	0.022	0.026

5.3 Solutions

For Sweden to transform its current non-sustainable food system into a sustainable one, changes in the food supply chain have to be implemented. As of today, Sweden is heavily reliant on other countries to provide food to its inhabitants. The Swedish high meat and coffee consumption is not sustainable; therefore, new sustainable alternatives have to be implemented. Due to meat being one of the highest water footprint foods, new alternatives can be implemented where the transition from today's regular meat habits to alternative sustainable meat options is crucial. Plant-based meat could be one of many solutions. Studies which have been done by the (Good food institute, 2019) have shown that changing to plant-based meat from traditional meat could reduce the water footprint by up to 99%. This would reduce the high water footprint of beef (15 000 kg/L) to plant-based beef, which could be 22 kg/L. Implementing these changes could remove Sweden's reliance on heavy meat importation, where the nation could produce plant-based meat locally instead. If this were to be implemented, Sweden would have the capability to make this transition with its current water availability.

Additionally, the development of plant-based foods is steadily happening, making plant-based options more environmentally friendly and sustainable over time. Suppose the transition were to happen today with the current technology; in that case, Sweden has the potential, with its current water availability, to produce and provide the meat demand for its inhabitants, which is required. Additionally, chicory coffee, date seed coffee, Kentucky coffee tree, and roasted barley coffee have been shown to be great alternatives to the current coffee product (Indzere et al., 2018). These alternative coffees are plant-based and require significantly less water, requiring around 2.5% water of the regular coffee bean amount, and the ingredients are roots, seeds, and grains instead of the traditional coffee beans. It also is less reliant on warm weather and can be grown in colder conditions, which aligns with Sweden's weather patterns. There are multiple types of coffee plants, and most of them thrive the best in warm weather but can be grown under most weather conditions. One option is to cultivate winter chicory, a plant capable of thriving in cold conditions down to -35°C, allowing year-round production in Sweden. The plant has a storage lifespan from 3 years up to 8 years with good care, making it possible to grow all year around in Sweden and store for years ahead.

5.3.1 Solution 1; Chicory plants

Solution 1 for coffee, Chicory plants: 50% of normal coffee beans are imported and 50% are chicory plants produced in Sweden for the original values of imported coffee beans displayed in table 5.10.

Table 5.10 Hypothetical production of chicory plants in Sweden, if half of the total amount of the imported coffee beans for the year of 2020 are instead chicory plants produced in Sweden.

2020	TFW (m^3)	TRFR (m^3)	EFR (m^3)	Water stress (%)
Half of the imported coffee is produced In Sweden and is made of Chicory plants	21.4 10^6	367 10^9	71.423 10^6	0.0058
Brazil, Peru, Honduras, Kenya				0.003, 0.003, 0.064, 0.055

Table 5.10 indicates a clear and quite significant decrease in water stress for the countries which Sweden would have imported from in this hypothetical solution, as this is hypothetical, if Sweden would produce chicory plants half of the amount it imported, the water stress would increase approximately 0.0058% for Sweden, by using chicory plants Sweden would from its perspective drastically reduce water stress on other countries but also drastically reduce it domestically. This table also verifies that if we would start with 25% chicory-based coffee on imported coffee, the other countries that export to us would be affected by ¼ of the original water stress mentioned in table 5.9 and Sweden would be affected by half of that water stress described in table 5.10.

To be able to transition from the coffee beans that Sweden imports from other countries into fully growing and producing their own coffee, it is important to be realistic. Start aiming to first reduce the importation by 25% less coffee and instead produce that in Sweden with sustainable options is a good start for the beginning of transitioning into a sustainable food system. This could be aimed and achieved after a couple of years which could be set up as a short-term goal. Thereafter for the mid-goal terms, the aim could be 50% sustainable option and then lastly 100% sustainable coffee option. Additionally, by educating consumers about why it is important to lower the food waste, it can potentially be reduced over the years which will additionally reduce the need for food import and production, leading to a lower water usage overall.

5.3.2 Solution 2; Plant based meat

Table 5.11 Hypothetical production of plant-based meats in Sweden, if half of the total amount of the imported and produced types of meat for the year of 2020 are instead plant based meats only produced in Sweden.

2020	TFW (m^3)	TRFR (m^3)	EFR (m^3)	Water stress (%)
Plant-based meat Sweden only on imported meats	18.095 10^6	367 10^9	71.423 10^6	0.0049
Germany, Ireland, Netherland, Poland, Denmark, Italy, Finland, Belgium, New Zealand				0.0375, 0.175, 0.064, 0.142, 1.09, 0.001, 0.006, 0.0065, 0.013

Table 5.11 shows the new water stress level in Sweden if half of the meats that it imports instead get produced in Sweden with plant-based options which have a water footprint of 200 L/kg. This is a hypothetical solution where half of the original meat products still gets imported and the other half instead gets produced in Sweden. If half of the imported meats were instead to be produced in Sweden with plant-based meat, then Sweden's water stress would have an additional increase of 0.0049 %. By switching to plant-based meats, the water stress levels can greatly be reduced in both other countries and Sweden would have a minimal increase in contrast to producing normal coffee beans, in Sweden itself the difference would be 46 times less in water stress by producing plant-based meats.

5.3.3 Solution 3; Food waste on imported meats and Chicory plant 100 % on imported coffee

According to the Swedish Environmental Protection Agency (2021.a) 26% of foods get thrown away as waste and 12% are still edible. To conclude an effective food system and to aim for the environmentally friendly agenda, we constructed an hypothetical solution if the food system were to reach a higher efficiency, we calculated that if 10% is still edible the population is still eating 10% of the meats and not throwing them away, how much would we affect the water stress, this is shown in table 5.12.

Table 5.12 Combining food waste and Chicory plant and the difference it would have on Sweden and the countries that Sweden imports from.

2020	TFW (m^3)	TRFR (m^3)	EFR (m^3)	Water stress (%)
Sweden	42.480 10^6	367 10^9	71.423 10^6	0.0116
Germany, Ireland, Netherland, Poland, Denmark, Italy, Finland, Belgium, New Zealand				0.0075, 0.0345, 0.0128, 0.0284, 0.218, 0.0002, 0.0012, 0.0013, 0.0026

5.3.4 Solution 4: Sweden's water stress if it only produces coffee and meats and does not import at all, these two products are 100% produced by environmentally friendly options, chicory and plant-based meats.

The table below presents the water stress Sweden would be experiencing if it produced the foods chosen in the initial imports. This is a hypothetical assumption that it is possible to grow and produce regular coffee in Sweden in order to know how it would affect Sweden's water stress. Table 5.13 shows the new water stress results if Sweden would produce these foods by environmentally friendly options such as plant-based meat and chicory coffee. The environmental options lead to a decrease in water stress to all other countries we would initially import from, but if Sweden would produce these products by environmental options it would still be quite low of a change to Sweden's water stress but it would be noted.

Table 5.13. Sweden's water stress if it produces the amount of coffee and meat it imports but with environmental friendly options (plant based meats and chicory plant) for year 2020

2020	TFW (m^3)	TRFR (m^3)	EFR (m^3)
Sustainable food options	78.670 10^6	367 10^9	71.423 10^6

If the values on table 5.13 are calculated, Sweden's water stress will be affected by a value of 0.0214 % by using environmentally friendly options for coffee and meat and would not require Sweden to import coffee or meat.

6 Discussion

6.1 Different scenarios and solutions

With this in mind we constructed on the result headline above, different scenarios on how Sweden would be affected and proved that Sweden would not be severely affected and would probably unburden in regards to water stress in a couple of countries which we import these products from. These scenarios were constructed only on the basis of the imported part, not the production part of Sweden, in relation to check, how much we would affect just these countries and how much Sweden could produce without affecting its water stress too severely. One of the results which did stick out the most came from the country of Denmark which can be seen in table 5.9.

Upon doing a deeper analysis of the factors underpinning Sweden's influence on Denmark's water stress, an interesting discovery becomes unveiled, centered around the importation of bird-type meats. Remarkably, a substantial 64% of Sweden's imported bird-type meats play a direct role in amplifying the impact of high water stress between these two nations. This intricate interconnection extends its stands into the realm of pork meats, where 19.3% of the total imports contribute to Sweden's impact of water stress in Denmark. These two prominently imported meat categories, characterized by a notably high water footprint, collectively constitute nearly 2.5% of Denmark's overall 26% water stress level. Astonishingly, this translates to an influential 1/10 of the total water stress, underscoring the significance of these specific imports in shaping Denmark's water stress landscape. Unraveling this intricate web of connections emphasizes the need for a nuanced understanding of the impact of trade practices on environmental dynamics. By spotlighting the role of these highly imported meat products, which significantly contribute to water stress, the discussion gains depth and clarity. This awareness paves the way for targeted strategies, sustainable alternatives, and collaborative efforts aimed at mitigating the water stress challenges faced by Denmark, thereby fostering a more environmentally resilient future.

6.2 Additional solution to reduce water stress in contrast to our study

Sweden needs to adopt a comprehensive strategy to decrease its reliance on food imports from water-stressed nations and promote sustainable food production. This approach involves boosting domestic food output while minimizing the impact on water-stressed countries by promoting water-efficient agricultural practices, embracing sustainable farming techniques, and refining food systems. By integrating these strategies, Sweden can establish a resilient and sustainable agricultural system that ensures both food security and environmental sustainability now and in the future.

To achieve a fully sustainable food system, Sweden could initiate a socio-technical transition focused on reducing imports, particularly of water-intensive products like meat and coffee, in favor of prioritizing local and sustainable food production. This transition requires a deliberate and coordinated transformation in how water resources are managed, encompassing infrastructure development and changes in social behaviors and norms. It involves shifting away from unsustainable water management practices towards more effective and sustainable methods.

This transformation necessitates implementing new water-management techniques and infrastructure, such as improved water purification systems, efficient irrigation methods, and advanced water monitoring systems. Leveraging these innovations can optimize water usage and enhance efficiency.

Addressing sociocultural and lifestyle aspects is crucial, including advocating for sustainable water habits, increasing public awareness about water-related issues, and fostering behavioral changes at the individual, societal, and institutional levels. Education and community involvement are vital in promoting an environmentally friendly mindset and encouraging sustainable water usage.

Li et al. (2022) found that electro-culture, a new agricultural technique using mild electrical impulses, enhances plant growth efficiency and reduces water usage. This method promotes better water absorption, nutrient uptake, and soil nutrient availability through electrochemical processes. By minimizing the need for fertilizers and improving plant resilience to drought, electro-culture shows promise for sustainable agriculture and water conservation. Further research is needed to fully understand its effectiveness and long-term impacts.

The focus in this report has been on scenarios and options demonstrated above in the results for improving water usage and efficiency, with particular emphasis on reducing food waste and exploring environmental alternatives such as chicory for coffee and plant-based meats.

6.3 Raise awareness

One potential strategy for altering consumer buying patterns is to raise awareness about the unintentional water consumption associated with certain products. This could be achieved by labeling products with their water footprint and providing educational materials to inform consumers. By making informed choices, consumers can contribute to sustainable water usage. This could also lower the Swedish consumers' food waste which is the highest in the Nordic countries, 26 %, where half of it is still edible when being thrown to waste. This would significantly reduce the Swedish water footprint, lowering its impact on countries with high water stress and reducing the amount of food Sweden has to import, especially for the high water footprint foods. Also, educating consumers about reducing their food consumption and minimizing their food waste are keys to reducing their water footprint. This was put to the test in the result part of 6.3.3 **solution 3** in combination with chicory plant for coffee, this would mean that in theory if Sweden's food system is as efficient as it can be we would import 10% less meat and that would lessen our water stress impact on other countries, but not as much as we would like. While 10% is quite an amount if put up in the perspective of combining many different solutions together, it would still be insufficient in contrast to the perspective of only comparing plant based meat solutions to food waste.

6.4 Coffee cultivation

In the short term, it is advisable for water-stressed countries from which Sweden imports coffee to adopt climate-smart coffee practices. These practices involve implementing sustainable and adaptable methods for coffee cultivation that address climate change impacts and water management issues. They aim to mitigate the environmental impact of coffee farming, increase the resilience of coffee plantations to climate-related risks, and ensure the long-term viability of the coffee industry. Policymakers, local farmers, and international funders must work together to increase the adaptation of climate-smart coffee production techniques in a coordinated manner in order to strengthen and protect the socio-ecological system connected with coffee cultivation and the related regional, landscape and worldwide advantages. One solution which, according to us, was the most straightforward and most realistic was to produce coffee using environmentally friendly options such as chicory plants, which also is resilient and can grow in Sweden. We included the Chicory plant in several solutions due to it reflecting good results which didn't affect Sweden's current water stress by much and can be 100% implemented in Sweden. This would lead to the water stress Sweden affected the 4 major exporting countries of coffee (Brazil, Peru, Honduras and Kenya) to Sweden in table 6.5 would be non-existing or drastically reduced, this can be seen in **solution 1** and **solution 4**. In solution 4 we did not only check the imported products as in solution 1 to solution 3, but we also checked the amount Sweden produced for the year 2020 and imported an combined them to see if Sweden completely for the year of 2020 would have been producing coffee and meat by environmental friendly options and how much that could affect Sweden's water stress.

6.5 Transitioning to plant-based meat

Transitioning from meat imports to plant-based meat alternatives produced locally gives Sweden opportunities to reduce its water footprint and develop a more sustainable food system given the massive amount of water needed for livestock, meat production, and animal feed, which has an enormous impact on water resources. Sweden could significantly lower its water consumption and help foster sustainable development by lowering its reliance on meat imports and instead adopting plant-based alternatives. Meat replacements made from plants often use much less water, making them more water efficient and sustainable. Vegetarian meat substitutes often contain plant-based nutrients like grain which require much less water. As of today, plant-based meat only makes up for 1% of the retail meat market, and it has the potential to help build a sustainable food supply (Good Food Institute, 2019).

Furthermore, switching to plant-based meat substitutes corresponds with Sweden's larger environmental objectives, which may aid in reducing climate change, protecting natural resources, and establishing more moral and humanitarian methods. Sweden could take many steps to ease the transition, encouraging plant-based diets, educating people about the adverse effects of meat production on the environment, developing plant-based alternatives and pushing sustainable consumption. Therefore, cooperation between the Swedish consumers, government and agricultural sector is crucial. Due to these general facts above about plant-based meats and the low water footprint of plant based meats, we decided to implement them on several solutions.

7 Conclusion

Promoting a sustainable and responsible food system requires addressing multiple interconnected aspects, including advocating for a vegetarian, sustainable diet, addressing the water footprint of food production, and promoting sustainable coffee practices in water-stressed countries. Coffee production, known for its water-intensive nature, often exacerbates water scarcity issues in countries facing high water stress. The negative impacts of coffee farming on the environment and water resources can be mitigated by implementing climate-smart coffee practices, which focus on sustainable and flexible methods. These practices consider the challenges of climate change and poor water management techniques, offering a path towards more sustainable coffee production.

In 2019, Sweden's total water footprint for meat and coffee consumption was 2,749 million cubic meters. While this had minimal impact on water stress in Sweden and other countries, Denmark experienced a notable increase in water stress by nearly 10%, primarily attributed to the substantial meat imports. By utilizing plant-based sustainable options for meat and coffee, Sweden's water stress on other countries could be greatly reduced, up to 96%.

The water-intensive nature of traditional meat production can be mitigated by embracing plant-based meat alternatives. These alternatives offer a more environmentally friendly option, requiring less water, improving agricultural irrigation productivity, minimizing water waste in the food supply chain, and aligning with eco-friendly farming methods. While Sweden demonstrates a commitment to sustainable development through the implementation of sustainable farming techniques and efforts to reduce water consumption in the food production industry, challenges still need to be addressed, particularly regarding the importation of water-intensive foods that hinder sustainable goals.

Electroculture, an emerging agricultural technique, uses low-level electrical impulses to enhance plant growth, reduce water usage, and improve nutrient uptake. While electroculture shows promise in promoting sustainable agriculture, further research is needed to fully understand its effectiveness and long-term impacts. This is not proven in our report.

In conclusion, a comprehensive approach encompassing various aspects of sustainability is necessary to achieve a more sustainable and responsible food system in Sweden. By embracing sustainable practices, advocating for change, and addressing the interconnected issues of water usage, diet choices, and coffee production, Sweden can pave the way for a brighter and more sustainable future. In short, we concluded to start small and begin reforming some of the major food categories, we understood that products such as meat and coffee have quite a high water footprint and found alternatives to these products that could be produced in Sweden. We concluded that by going 100% on environmentally friendly options such as chicory plant and plant based meats we could drastically reduce water stress we inflict on other countries but also drastically reduce it domestically. Solution 4 gives an insight on how much we would affect Sweden's water stress if we would go 100% environmentally friendly and we would not significantly increase Sweden's water stress. Sweden’s water stress for the year 2020 was 3,58 % and solution 4 gave an additional water stress of 0,0214% which is quite much if checked in the right perspective but it would also mean Sweden does not inflict any water stress to other countries in regards to coffee and meat.

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Appendixes

Appendix 1, Export, import and production for coffee during the years of 2019-2021 in kg.

Table X1 Export/import and production of foods in Sweden (Eurostat, stats for year 2019) in kg

	Import	Export	Production
Not roasted coffee, not decaffeinated	110 918 500	2 591 900	-

10,5 kg per person per year = jordbruksverket value is 8 kg from graph, but that is on roasted and prepared coffee, if that is checked with eurostat the value for the Swedish consumption is indeed 8 kg per person per year.

Table X1 Export/import and production of foods in Sweden (Eurostat, stats for year 2020) in kg

	Import	Export	Production
Not roasted coffee, not decaffeinated	109 766 800	1 312 500	-

10,43 kg per person per year = jordbruksverket values 7 kg from graph but that is on roasted and prepared coffee, if that is checked with eurostat the value for the Swedish consumption is indeed 7 kg per person per year.

Table X1 Export/import and production of foods in Sweden (Eurostat, stats for year 2021) in kg

	Import	Export	Production
Not roasted coffee, not decaffeinated	96 715 100	1 053 200	-

9,2 kg per person per year = jordbruksverket values 5-6 kg from the graph, but that is on roasted and prepared coffee, if that is checked with eurostat the value for the Swedish consumption is indeed 5-6 kg per person per year.

Appendix 2, Export, import and production of meat categories in Sweden for the years 2019-2021.

Table X2.1 Export/import and production of foods in Sweden (Eurostat, stats for year 2019) in kg

	Import	Export	Production
Fresh or chilled carcases, half-carcases and quarters with bone in, of beef and veal	1 249 600	4 900	40 647 600
Fresh or chilled cuts, of beef and veal	45 106 700	6 570 500	129 552 300
Frozen carcases, half-carcases, quarters and cuts, of beef and veal	29 467 100	409 300	9 574 000
Fresh or chilled carcases, half-carcases and cuts, of lamb or sheep	3 256 400	7 800	3 492 800
Frozen carcases, half-carcases and cuts, of lamb or sheep	6 124 600	111 100	4 665 400
Meat of goats, fresh or chilled	31 200	0	0
Frozen meat, of goats	0	0	0
Meat of horses and other equines, fresh or chilled	55 800	0	-
Frozen meat, of horses and other equines	147 100	8 900	0
Fresh, chilled or frozen edible meat and offal (including meat and offal of rabbits, hares and game; excluding frog legs, and meat and offal of poultry, bovine and equine animals, swine, sheep and goat)	943 300	480 900	-
Pig fat free of lean meat; fresh; chilled; frozen; salted; in brine or smoked (excluding rendered)	37 700	5 975 000	-
Frozen whole Chicken and turkeys	5 833 400	3 185 400	3 103 800
Frozen cuts of turkey and chicken	37 759 400	9 050 500	66 096 500
Fresh or chilled whole chicken and turkey	1 625 000	25 900	17 571 300

Fresh or chilled cuts of turkey and chicken	10 171 500	13 171 500	36 196 600
Prepared or preserved meat of swine: hams and cuts thereof (excluding prepared meals and dishes)	-	-	19 017 500
Prepared or preserved meat of swine: shoulders and cuts thereof, of swine (excluding prepared meals and dishes)	-	-	214 700
Prepared or preserved meat, offal and mixtures of domestic swine, including mixtures, containing < 40 % meat or offal of any kind and fats of any kind (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	-	-	5 146 500
Fresh or chilled pig meat (including fresh meat packed with salt as a temporary preservative; excluding carcases and half carcases, hams shoulders and cuts thereof with bone in)	50 181 300	9 107 600	165 541 300
Frozen pig meat (excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	12 369 600	6 851 800	591 000
Pig meat salted, in brine, dried or smoked (including bacon, 3/4 sides/middles, fore-ends, loins and cuts thereof; excluding hams, shoulders and cuts thereof with bone in, bellies and cuts thereof)	2 694 500	137 200	18 301 200
Fresh or chilled carcases and half-carcases, of pig meat (including fresh meat packed with salt as temporary preservative)	846 600	101 500	-
Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat	916 800	1 481 300	-

(including fresh meat packed with salt as a temporary preservative)			
Frozen carcases and half-carcases, of pig meat	10 300	0	-
	208 817 600	56 681 100	626 160 600
			75.7 kg per person per year, Eurostat had most values for the different meat types, still an lower value is expected due to not all meat types are included just the important ones.

Table X2.2 Export/import and production of foods in Sweden (Eurostat, stats for year 2020) in kg

	Import	Export	Production
Fresh or chilled carcases, half-carcases and quarters with bone in, of beef and veal	1 240 495	10 218	38 589 200
Fresh or chilled cuts, of beef and veal	39 611 035	8 017 731	129 662 800
Frozen carcases, half-carcases, quarters and cuts, of beef and veal	25 600 277	433 136	13 804 400
Fresh or chilled carcases, half-carcases and cuts, of lamb or sheep	3 539 700	6 131	3 099 000
Frozen carcases, half-carcases and cuts, of lamb or sheep	6 148 802	102 905	-
Meat of goats, fresh or chilled	11 160	0	-
Frozen meat, of goats	2	0	0
Meat of horses and other equines, fresh or chilled	29 123	699	26 000
Frozen meat, of horses and other equines	185 674	28 883	0
Fresh, chilled or frozen edible meat and offal	605 286	375 543	875 000

(including meat and offal of rabbits, hares and game; excluding frog legs, and meat and offal of poultry, bovine and equine animals, swine, sheep and goat)			
Pig fat free of lean meat; fresh; chilled; frozen; salted; in brine or smoked (excluding rendered)	3 947	5 981 556	12 483 000
Frozen whole Chicken and turkeys	4 965 209	4 028 064	1 870 800
Frozen cuts of turkey and chicken	36 317 758	9 552 270	67 975 300
Fresh or chilled whole chicken and turkey	2 035 608	53 280	17 200 200
Fresh or chilled cuts of turkey and chicken	7 975 357	15 927 234	42 546 600
Prepared or preserved meat of swine: hams and cuts thereof (excluding prepared meals and dishes)	-	-	17 440 300
Prepared or preserved meat of swine: shoulders and cuts thereof, of swine (excluding prepared meals and dishes)	-	-	1 482 900
Prepared or preserved meat, offal and mixtures of domestic swine, including mixtures, containing < 40 % meat or offal of any kind and fats of any kind (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	-	-	5 563 600
Fresh or chilled pig meat (including fresh meat packed with salt as a temporary preservative; excluding carcases and half carcases, hams shoulders and cuts thereof with bone in)	40 323 990	7 043 919	151 634 700

Frozen pig meat (excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	8 983 227	5 184 429	9 123 500
Pig meat salted, in brine, dried or smoked (including bacon, 3/4 sides/middles, fore-ends, loins and cuts thereof; excluding hams, shoulders and cuts thereof with bone in, bellies and cuts thereof)	2 364 349	101 256	17 774 200
Fresh or chilled carcases and half-carcases, of pig meat (including fresh meat packed with salt as temporary preservative)	459 548	753	-
Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat (including fresh meat packed with salt as a temporary preservative)	546 069	27 030	6 321 100
Frozen carcases and half-carcases, of pig meat	4 875	0	22 981 800
	180 951 491	56 875 047	560 454 400
			66,1 kg per person per year, not all meat types are included only the demand important ones, a lower value than retrieved from jordbruksverket is expected

Table X2.3 Export/import and production of foods in Sweden (Eurostat, stats for year 2021) in kg

	Import	Export	Production
Fresh or chilled carcases, half-carcases and quarters with bone in, of beef and veal	1 473 335	2 168	-
Fresh or chilled cuts, of beef and veal	41 353 401	6 209 581	-
Frozen carcases, half-carcases, quarters and cuts, of beef and	28 081 856	651 686	13 100 800

veal			
Fresh or chilled carcases, half-carcases and cuts, of lamb or sheep	2 996 177	3 354	-
Frozen carcases, half-carcases and cuts, of lamb or sheep	5 607 627	103 604	2 745 800
Meat of goats, fresh or chilled	23 464	11	0
Frozen meat, of goats	4 741	24	0
Meat of horses and other equines, fresh or chilled	29 541	12	-
Frozen meat, of horses and other equines	200 566	23 456	0
Fresh, chilled or frozen edible meat and offal (including meat and offal of rabbits, hares and game; excluding frog legs, and meat and offal of poultry, bovine and equine animals, swine, sheep and goat)	700 889	427 185	-
Pig fat free of lean meat; fresh; chilled; frozen; salted; in brine or smoked (excluding rendered)	3 065	7 813 354	-
Frozen whole Chicken and turkeys	5 917 119	4 378 163	1 586 700
Frozen cuts of turkey and chicken	38 925 594	8 365 891	71 690 600
Fresh or chilled whole chicken and turkey	1 922 651	3 515	19 246 900
Fresh or chilled cuts of turkey and chicken	8 940 578	19 929 239	47 976 507
Prepared or preserved meat of swine: hams and cuts thereof (excluding prepared meals and dishes)	-	-	18 336 900
Prepared or preserved meat of swine: shoulders and cuts thereof, of swine (excluding prepared meals and dishes)	-	-	-

Prepared or preserved meat, offal and mixtures of domestic swine, including mixtures, containing < 40 % meat or offal of any kind and fats of any kind (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	-	-	5 764 900
Fresh or chilled pig meat (including fresh meat packed with salt as a temporary preservative; excluding carcases and half carcases, hams shoulders and cuts thereof with bone in)	37 865 955	6 879 771	150 184 900
Frozen pig meat (excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	11 326 988	11 079 439	-
Pig meat salted, in brine, dried or smoked (including bacon, 3/4 sides/middles, fore-ends, loins and cuts thereof; excluding hams, shoulders and cuts thereof with bone in, bellies and cuts thereof)	2 666 029	114 394	-
Fresh or chilled carcases and half-carcases, of pig meat (including fresh meat packed with salt as temporary preservative)	145 082	5 247	-
Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat (including fresh meat packed with salt as a temporary preservative)	368 753	150 421	6 747 300
Frozen carcases and half-carcases, of pig meat	31 132	13	-
	188 584 543	66 140 528	337 381 307
			44,1 kg per person per year, Eurostat doesn't have all the values for production giving this low result

Appendix 3, different imported meats in percentage for the respective years of 2019-2021.
Table X3.1 Imported swine meat to Sweden for respective year and from where.

Imported swine meat to Sweden	**2019** Total import: 64 492 800 kg	**2020** Total import: 50 511 900 kg	**2021** Total import: 49 933 800 kg
Germany	48 %	43.3 %	49.2 %
Denmark	19.3 %	25.7 %	26.3 %
Poland	14.6 %	17.2 %	16.5 %
Finland	9.2 %	8 %	2.2 %

Table X3.2 Imported poultry meat to Sweden for respective year and from where.

Imported poultry meat to Sweden	**2019** Total import: 57 629 500 kg	**2020** Total import: 53 098 500 kg	**2021** Total import: 57 425 300 kg
Denmark	63.6 %	61.9 %	59.6 %
Netherland	13.3 %	14.1 %	16.9 %
Germany	8.4%	8.7 %	7.1 %
Poland	4.9 %	-	5.7 %

Table X3.3 Imported bovine meat to Sweden for respective year and from where.

Imported bovine meat to Sweden	**2019** Total import: 76 209 100 kg	**2020** Total import: 66 451 800 kg	**2021** Total import: 70 908 600 kg
Ireland	24.5 %	27.7 %	28.8 %
Netherland	19.4 %	17.1 %	15.7 %
Poland	15 %	15.9 %	13.5 %
Denmark	11 %	8.2 %	9.7 %
Germany	10 %	10.6 %	14.9 %

Table X3.4 Imported sheep and goat meat to Sweden for respective year and from where.

Imported sheep and goat meat to Sweden	**2019** Total import: 9 887 800 kg	**2020** Total import: 9 699 700 kg	**2021** Total import:8 632 000 kg
Ireland	47 %	46.5 %	50.6 %

Netherland	18.9 %	22.1 %	19 %
New Zealand	14.3 %	17.2 %	16.9 %
Germany	6.5 %	4.3 %	5 %

Table X3.5 Imported horse meat to Sweden for respective year and from where.

Imported horse meat to Sweden	**2019** Total import: 202 900 kg	**2020** Total import: 214 800 kg	**2021** Total import: 230 107
Italy	21.7 %	56 %	-
Finland	35.7 %	27.1 %	-
Belgium	30 %	9.3 %	-

Table X3.6 Imported unroasted coffee, not decaffeinated to Sweden for respective year and from where.

Imported coffee to Sweden	**2019** Total import: 110 918 500 kg	**2020** Total import: 109 766 800 kg	**2021** Total import: 96 715 100
Brazil	37.6 %	38.4 %	41 %
Peru	13.1 %	10 %	9.7 %
Honduras	10 %	10 %	9.4 %
Kenya	3.9 %	4 %	4.1 %

Appendix 4, the different countries TRFR and EFR and the calculated TFW caused by Sweden due to importing coffee and meats for the year of 2019.

Table X5.3.1 Data collected to calculate water stress by our imported products for the consecutive years, 2019.

Countries	TRFR (m^3/year)	EFR (m^3)	TFW (m^3)
Brazil	17 939 10^9	6 478 149 10^6	662,991 10^6
Peru	4063 10^9	950 886 10^6	230,989 10^6
Honduras	214 10^9	77 475 10^6	176,627 10^6
Germany	353 10^9	118 312 10^6	402,1 10^6
Ireland	114 10^9	20 193 10^6	329,107 10^6
Netherland	186,5 10^9	9 603 10^6	278,457 10^6

Poland	133 10^9	57 256 10^6	244,37 10^6
Denmark	14 10^9	9 538 10^6	361,079 10^6
Italy	414 10^9	112 771 10^6	2,289 10^6
Finland	222 10^9	18 219 10^6	39,234 10^6
Belgium	37,5 10^9	15 574 10^6	3,159 10^6
New Zealand	327 10^9	270 181 10^6	12,356 10^6

Appendix 5, the different countries TRFR and EFR and the calculated TFW caused by Sweden due to importing coffee and meats for the year of 2020.

Table X5.3.2 Data collected to calculate water stress by our imported products for the consecutive years, 2020.

Countries	TRFR (m^3/year)	EFR (m^3)	TFW (m^3)
Brazil	17 939 10^9	6 478 149 10^6	670,066 10^6
Peru	4063 10^9	950 886 10^6	174,496 10^6
Honduras	214 10^9	77 475 10^6	174,496 10^6
Germany	353 10^9	118 312 10^6	339,336 10^6
Ireland	114 10^9	20 193 10^6	323,747 10^6
Netherland	186,5 10^9	9 603 10^6	226,349 10^6
Poland	133 10^9	57 256 10^6	214,997 10^6
Denmark	14 10^9	9 538 10^6	304,263 10^6
Italy	414 10^9	112 771 10^6	6,229 10^6
Finland	222 10^9	18 219 10^6	25,359 10^6
Belgium	37,5 10^9	15 574 10^6	3,019 10^6
New Zealand	327 10^9	270 181 10^6	14,617 10^6

Appendix 6, the different countries TRFR and EFR and the calculated TFW caused by Sweden due to importing coffee and meats for the year of 2021.

Table X5.3.3 Data collected to calculate water stress by our imported products for the consecutive years, 2021.

Countries	TRFR (m^3/year)	EFR (m^3)	TFW (m^3)
Brazil	17 939 10^9	6 478 149 10^6	630,367 10^6

Peru	$4063\ 10^{9}$	$950\ 886\ 10^{6}$	$149{,}136\ 10^{6}$
Honduras	$214\ 10^{9}$	$77\ 475\ 10^{6}$	$144{,}523\ 10^{6}$
Germany	$353\ 10^{9}$	$118\ 312\ 10^{6}$	$430{,}826\ 10^{6}$
Ireland	$114\ 10^{9}$	$20\ 193\ 10^{6}$	$352{,}886\ 10^{6}$
Netherland	$186{,}5\ 10^{9}$	$9\ 603\ 10^{6}$	$227{,}983\ 10^{6}$
Poland	$133\ 10^{9}$	$57\ 256\ 10^{6}$	$211{,}38\ 10^{6}$
Denmark	$14\ 10^{9}$	$9\ 538\ 10^{6}$	$332{,}862\ 10^{6}$
Italy	$414\ 10^{9}$	$112\ 771\ 10^{6}$	-
Finland	$222\ 10^{9}$	$18\ 219\ 10^{6}$	$6{,}480\ 10^{6}$
Belgium	$37{,}5\ 10^{9}$	$15\ 574\ 10^{6}$	-
New Zealand	$327\ 10^{9}$	$270\ 181\ 10^{6}$	$12{,}776\ 10^{6}$