

# Sufficiency in Agriculture

An evaluation of the Practices of a Community Supported Agriculture in Wanderup, Germany and the Environmental Impact of Different Ways of Marketing Vegetables

By Luca Sprick

## Abstract

This case-study evaluates sufficiency-considering practices of the community supported agriculture (CSA) in Wanderup, Germany. Their practices not using any packaging for their produces from production until arrival to the place of distribution and not generating any food wastes within the supply chain can be declared as sufficiency-considering. Their practice of not using any chemical fertilizer is restricted in the guidelines of demeter, therefore can not be considered as sufficiency-considering compared to other demeter produces. The life-cycle-assessment (LCA) of the different ways of marketing vegetables show, that the way of transport of the consumer in most cases has the bigger effect on the environmental impact than the way of transport of the vegetables to the place of distribution. The comparison of a consumer using a bike instead of using a car shows the biggest differences. In the **cases a to d** the environmental impact of climate change is less than 7 %, for land occupation its less than 13 %, for water scarcity its less than 21 % and for particulate matter formation its less than 17 %, when the consumer uses the bike. This shows how important it is to use the bike to reduce the negative environmental impact while buying food. Nevertheless, **case e** shows when a vegetable is transported a long distance via plane, the negative environmental impact is barely affected, when a consumer takes a bike or a car, because of the strong environmental impact of a plane as a transport vehicle.

## 1 Introduction

In recent years many studies have analyzed the environmental impact of different diets (Lacour et al. 2018), (Clark Chai et al. 2019) or (Rosi et al. 2017). Most of them are showing that a vegetarian or vegan diet has less negative environmental impact than a diet containing meat. In the meantime, the way of transport of the produces was not in the scientific focus, even though its effect on the environment is not neglectable (Mengyu Li et al. 2022). This is the reason why one focus of this paper is on the transport of different ways of marketing vegetables in Germany. The second focus lies on the sufficiency-considering vegetable production practices of the CSA in Wanderup, Germany. Sufficiency is next to efficiency and consistency one of the three pillars of sustainability. While mainly efficiency and consistency measures are discussed to achieve a climate neutral economy. Sufficiency measures have been mentioned the first time in the latest report of the IPCC ever since (IPCC 2022). This shows a lack of research on the topic of sufficiency measures against which this paper wants to counteract.

The basis for this research is a side visit of the CSA in Wanderup. CSA is a concept where not the individual vegetable will be sold by kilogram, but the costs of production will be divided by all members of a CSA.

In the first step of this paper, sufficiency-considering practices on this farm must be identified by comparing the practices of the farm with average values of farms with the same organic standard or general data if the previous data is not available. In the

second step, the way of marketing of the CSA in Wanderup with the focus of the transport of the produces is compared to the most common ways of marketing of vegetables in Germany. Here are the environmental impacts on climate change, land occupation, water scarcity and particulate matter formation compared with an LCA.

An LCA is a standard tool in science and industry to evaluate the anthropogenic effects on the environment of good or a product (Rosenbaum et al. 2018).

## 2 Methodology

The following chapters define how and under which restrictions the practices of the CSA in Wanderup are analyzed. After defining what sufficiency-considering practices are, the observed practices to be analyzed will be described. In the second part five different ways of marketing vegetables will be defined, to make the basis of the LCA.

### 2.1 Declaration of Sufficiency-Considering Practices

The CSA in Wanderup is producing its vegetables within the restrictions of the organic demeter standards (Hendrik Henk). In this paper, all the observed possible sufficiency-considering practices are compared with the demeter standards. If the detected practices are not considered in the demeter standards, they are compared to average values of organic vegetable production practices. If no data for organic vegetable production is available, general data is used. A comparison with the standards of the demeter standards or with average values make it possible to declare a practice as sufficiency-considering. The

term sufficiency does not have one definition. In (Böcker et al. 2020) sufficiency is described as a strategy to reduce the resource and nature consumption by a behavioral and lifestyle change. To understand how to change the behavior or lifestyle the question of “what is enough” must be asked. Oriented to this definition of sufficiency, the practices that have a higher standard than average or than the standards of the demeter practices are considered as sufficiency-considering, because this means a decreased consumption of resources than allowed.

A guided tour on the CSA in Wanderup with the focus on sufficiency aspects is the fundament of the observations made. During the side visit the following possible sufficiency-considering practices were detected that are analyzed in this paper:

- The vegetables are not packaged during the production, transport, and distribution
- Within the supply chain no food-waste is generated
- On the farm in Wanderup no chemical fertilizers are used

Because of the limited time to hand in this term paper the following possible sufficiency-considering practices are observed but not analyzed:

- The greenhouses of the CSA in Wanderup are not heated
- parts of the farm are only processed by hand
- the vegetables do not need a transport back to the farm because of the way of marketing this CSA is pursuing
- the farm has an absolute size limit which limits its growth potential
- one part of the community work of the CSA in Wanderup is to work on the field together with the farmer. This could increase the appreciation of the vegetables, which could decrease the amount of food-waste of the consumers.

In the second part of this paper the following observed possible sufficiency-considering practices are analyzed within the life-cycle-analysis:

- The transport distance of the vegetables of the CSA in Wanderup is 14 km
- the transport distance is taken by electric driven cargo bicycle
- within the supply chain no cooling is used for fresh produces.

## 2.2 Life Cycle Assessment

In this paper, five ways of marketing vegetables are compared with an LCA. The program openLCA (version 1.10) was used to implement the LCA. The open-source software by GreenDelta, developed in 2006, is primarily used for carbon footprint calculations, en-

vironmental label verification, product policy consulting, and LCA development. The tool openLCA considers all up-stream environmental impacts (Ciroth et al. 2019). The ecoinvent 3.7 database is used for the LCA, as it is free to use for students at the Hochschule Flensburg.

The focus of the LCAs is the transport distance from production to consumption of the product, the transport vehicle, the amount of packaging and cooling that is necessary during the transport of the good. A second comparison differentiates between the way of transport of the consumer. Using a bicycle is compared to using a medium sized car for distances the consumers must travel to buy the good.

Neglected in the analysis is the effect on the environment of the production of the good itself. Adding to this, it is not evaluated what is being transported. In the analysis it is brought down to a transported weight of 1 kilogram of a good to make it comparable.

### 2.2.1 Methodological Procedure and Technical Framework Conditions

The approach used for LCA implementation is based on the ISO 14040 and ISO 14044 standards (Rosenbaum et al. 2018).

The IMPACT World+ at Midpoint was chosen as the assessment method for the derived data. The reason for this is that the IMPACT World+ is one of the most up-to-date and internationally recognized methods used in LCAs. In addition, the impact level 'at midpoint' was chosen instead of 'at endpoint', which allows for better transparency and verifiability in data tracking of results (Moreno Ruiz et al. 2020). Of the impact categories available in this method, climate change long-term, water scarcity, particulate matter formation and land-occupation are used (Bulle et al. 2019).

**Climate change long-term** considers the caused CO<sub>2eq.</sub> emissions in kg of the process of manufacturing and use that remain in the atmosphere after 100 years and up to 500 years (Bulle et al. 2019).

**Water scarcity** is based on the water supply per area that remains after subtracting human and environmental demand. The impact category describes the potential to deprive other users of this resource per unit of water consumed, relative to the global average. The identified water scarcity is expressed in m<sup>3</sup> world eq (Bulle et al. 2019; Boulay et al. 2018).

The impact category **land occupation** determines the annual land requirement of a product unit on land that could otherwise be farmed. The value is expressed in m<sup>2</sup> arable land eq. yr. (Bulle et al. 2019).

**Particulate matter formation** describes the amount of particulate matter in kg PM<sub>2.5</sub> eq. that is caused within the life cycle. PM<sub>2.5</sub> describes the aerodynamic diameter of a particulate matter formation smaller than 2.5 μm (Bulle et al. 2019).

### 2.2.2 Definition of the Analyzed Ways of Marketing

The average travel distances of a consumer to get to a supermarket and back is 5 km, which will be assumed for all cases except case 1 (BMVI 2017). The World Health Organization (WHO) recommends at least 400g of vegetables, fruits, and legumes per day (WHO Technical Report Series 2003). It is assumed that each consumer buys a week worth of vegetables for two people living in a household in average based on the data of the micro census for 2021 in Germany (Statistische Ämter des Bundes und der Länder 2022). This means, each customer buys 5.6 kg of vegetables, fruits, and legumes. In average fruits and vegetables are packaged with 23 grams of plastics and paper per kg of produce. Around 64 % of the packaging is made from plastics and 31 % is made from paper and 5 % are other packaging materials, which are here neglected (Katharina Istel 2019). Therefore, it is assumed that 14.72 g of plastic and 7.13 g of paper are used to package the produces in the cases which need packaging.

Few information is given by the ecoinvent database. In all cases the consumer uses a medium sized car that uses petroleum and reaches the EURO 5 restrictions. How much the car weighs, its petroleum consumption or other properties are not available. Similarly, it is with the plane and transport truck. The plane is a freight plane with cooling. The truck weighs 7.5-16 tons and reaches the EURO 5 the restrictions.

### 2.2.3 The Cases

#### a. On-Farm-Sale

In this case, the vegetable is produced and sold on the farm. Therefore, the vegetable itself does not have a travel distance, only the consumer must travel to get to the product and back. The product does not have to be packaged nor cooled to get to the consumer. Since there is no available data for the average distance to a farm-sale, it is assumed that the consumer must travel 20 km to the farm and back in total. No cooling is needed since the produce must not travel any distance to the place of distribution.

**Table 2.1 Properties of on-farm-sale-case**

travel distance, producer	0 km
travel distance, consumer	20 km
packaging	0 g
cooling	no

#### b. Week-Market-Sale

In this case, the produces must travel the distance to the week market, the consumer must travel to the week market and back with the vegetables. Based on the yearly productions of a CSA in Italy it is assumed that the producer transports 250 kg of produce by a transporter (Silvio Cristiano 2021). The products do

not have to be packaged nor cooled to get to the consumer on the 10 km travel to the week-market. It is assumed that the producer must travel the 10 km back. Therefore, the total travel distance is 20 km.

**Table 2.2 Properties of week-market-sale-case**

travel distance, producer, transporter	20 km
travel distance, consumer	5 km
packaging	0 g
cooling	no

#### c. CSA Wanderup

The CSA in Wanderup is transporting their produces weekly via electric cargo bike into the city center of Flensburg. The distance between Wanderup and Flensburg is 14 km. The vegetables are picked up by the members at a location close to the city center. The products do not have to be packaged nor cooled to get to the consumer. Here as well, it is assumed that 250 kg of produce is transported, because the CSA Wanderup is not keeping any data on this information.

**Table 2.3 Properties of CSA-Wanderup-case**

travel distance, producer, electric driven bike	28 km
travel distance, consumer	5 km
packaging	0 g
cooling	no

#### d. Locally Produced Vegetables Sold in a Supermarket

The term locally produced does not have a definition of distance and due to lack of research on transport distances of vegetables within the supply chain, the term "locally produced" will be defined as 50 km between production and place of sale. It is assumed that the vegetables need to be transported 25 km to a distribution center with a truck without packaging. The vegetables must be transported another 25 km by truck, now packaged, to the supermarket. It is also assumed that the vegetables are not cooled, due to the short transport distances.

**Table 2.4 Properties of locally-produced-vegetables-case**

travel distance, producer	50 km
travel distance, consumer	5 km
packaging	23 g
cooling	no

#### e. Non-Locally Produced Vegetables Sold in a Supermarket

The last case represents an extreme case, to estimate what impact the transport distance and the transport option can have on the ecological footprint of a product. It is assumed that the vegetables cover

9.200 km by plane, which is the distance between Brasilia in Brazil and Hamburg in Germany, and 100 km by truck to get to the supermarket.

travel distance, truck	100 km
travel distance, consumer	4 km
packaging	23 g
cooling	yes

**Table 2.5 Properties on non-locally-produced-vegetables-case**

travel distance, plane	9.200 km
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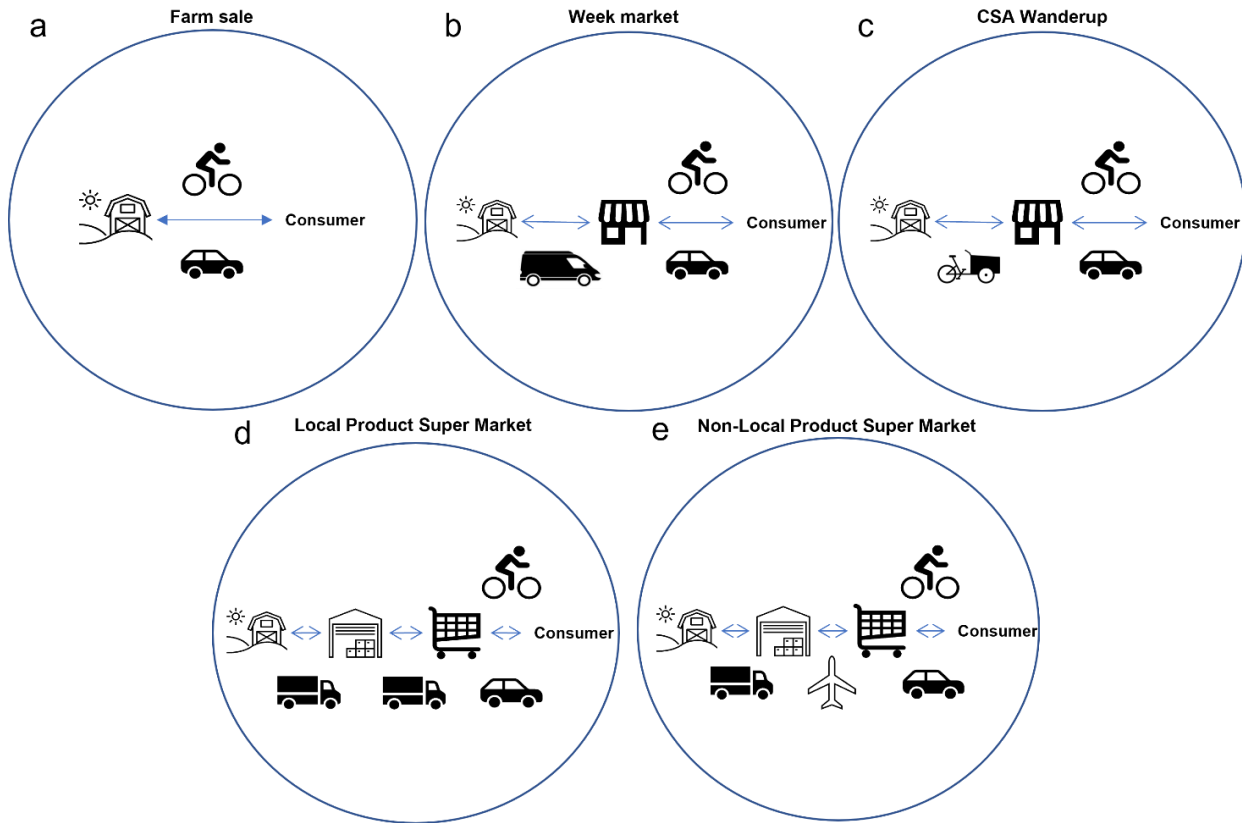


Figure 2.1: Visualization of the defined cases a to e. Source: author

### 3 Results

#### 3.1 Sufficiency-Considering Practices

- **The vegetables are not packaged during the production, transport, and distribution**

In 2019 the average weight of packaging for 1kg of vegetables or fruits was 23 g consisting of plastic and paper in German supermarkets (Katharina Istel 2019). Since the CSA Wanderup is not using any packaging during the production, transport, and distribution, except for reusable containers during the transport, its practices can be declared as sufficiency-considering. The least amount of packaging possible is used during the whole process of production until the consumer gets the produce.

- **Within the supply chain no food-waste is generated**

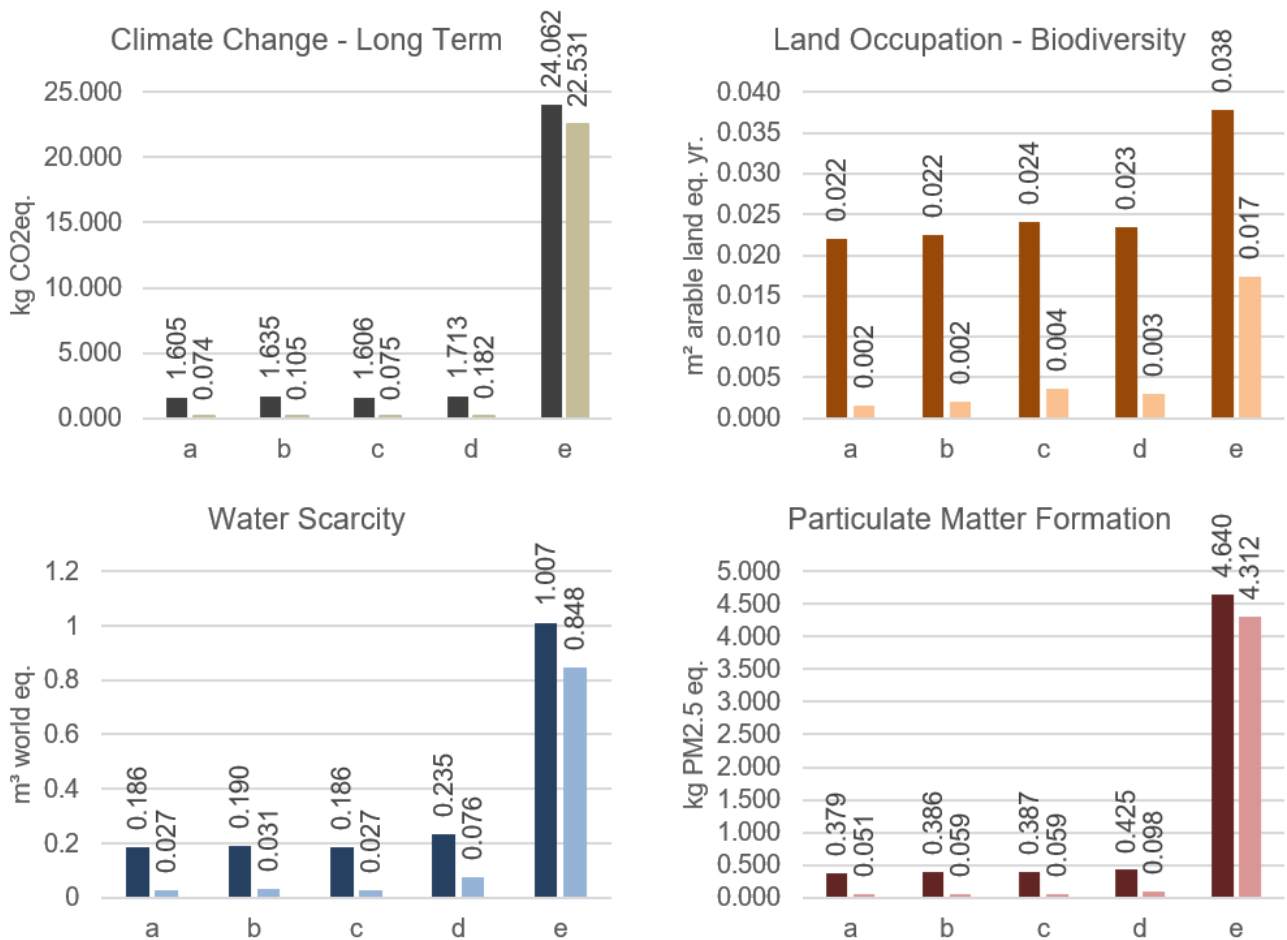
(Åsa et al. 2016) states that in the EU in average 173±27 kg of food waste per person and year is generated. Whereas 19 % is generated during the processing of produces, 11 % is generated within the

food production, and 5 % in wholesale and retail. These statistics consider all food wastes and not only vegetable and fruit food wastes. (Parfitt et al. 2010) agrees with these numbers while having a focus on food waste from vegetables. In the UK approximately 20 % of food waste emerges from food processing, distribution, and retail. Since the CSA in Wanderup has no food wastes within food processing, distribution and sale, its practice can be declared as sufficiency-considering. The amount of food losses during the production phase because of pests are not considered.

- **On the farm in Wanderup no chemical fertilizers are used**

The restrictions to label vegetables or fruits with the demeter label do not consider chemical fertilizers at all. (Demeter e.V. 2021) Therefore, the practice of the CSA in Wanderup is not sufficiency-considering compared to other demeter produces. A comparison with conventional produces is not intended in this research.

### 3.2 Results LCA



**Figure 1: LCA comparison of the cases a – e, including the internal case comparison of a consumer using a bike (right) compared to using a car (left). Examined are the climate change long term effect in kgCO<sub>2</sub>eq., the land occupation in m<sup>2</sup> arable land eq. yr., the water scarcity in m<sup>3</sup> world eq. and the particulate matter formation in kg PM<sub>2.5</sub> eq. per kg of vegetables or fruits. Source: author based on own calculation.**

The results, seen in Figure 1, show a clear picture. In all examined impact categories **case e** has the strongest environmental impact. In all the other cases the environmental impact varies just slightly. Biggest differences are caused by the different way of transport of the consumer. This shows that not the way how a product gets to a place of distribution, but how the consumer gets to the product and back, effects the environmental impact the most. Except for a product that travels a long distance via plane.

#### Climate Change – Long Term

Examining the effect on climate change of the transport way of 1 kg of produces, shows that in **cases a-d** the emissions vary slightly from 1.605 to 1.713 kgCO<sub>2</sub>eq., when the consumer rides a car to the point of distribution. The bigger difference has the change of transport of the consumer to a bike. With the bike the emissions vary from 0.074 to 0.182 kgCO<sub>2</sub>eq., which is in average less than 7 % of the emissions compared to a consumer taking the car, only considering the **cases a-d**. The exception

here is the vegetables transported by plane, **case e**, where the emissions in the internal comparison result in 22.531 kgCO<sub>2</sub>eq. and 24.062 kgCO<sub>2</sub>eq.

#### Land Occupation - Biodiversity

A similar result can be seen, looking at the environmental impact on land occupation per kg of vegetables or fruits. In the **cases a-d** the environmental differs stronger between the way of transport of the consumer. While the values, from a consumer using a car, vary from 0.022 to 0.024 m<sup>2</sup> arable land eq. yr. The values from a consumer using the bike vary from 0.002 to 0.004 m<sup>2</sup> arable land eq. yr., which is in average less than 13 % of the occupied land, compared to the **cases a-d**, where the consumer takes the car. Again, **case e** is an exception, but not as strong as in the other environmental impact categories. In **case e** the values of the occupied land vary from 0.017 m<sup>2</sup> arable land eq. yr., which is less than all the cases where the consumer takes the car, to 0.038 m<sup>2</sup> arable land eq. yr.

## Water Scarcity

As in all examined environmental impact categories, water scarcity shows a similar result per kg of produces. Again, the values from **cases a-d** are close to each other, while **case e** is an exception. When a consumer takes the car, the values vary from 0.0186 to 0.0235 m<sup>3</sup> world eq. for the **cases a-d**. When a consumer takes the bike, the values are in average less than 21 % compared to a consumer using the car and vary between 0.027 to 0.076 m<sup>3</sup> world eq, only considering the **cases a-d**. Because the **case e** shows again an exception. Here the values differ from 0.0848 to 1.007 m<sup>3</sup> world eq. between a consumer using a bike or a car.

## Particulate Matter Formation

As seen in the previous results, the **case e** is an exception compared to the **cases a-d**. While the values here vary from 0.379 to 0.425 kgPM<sub>2.5eq.</sub>, when a consumer takes the car. They vary from 0.051 to 0.098 kgPM<sub>2.5eq.</sub>, when a consumer takes the bike. In average, this is less than 17 %, when the consumer takes the bike compared to taking the car. In **case e**, the values are significantly higher. Here, they vary between 4.312 kgPM<sub>2.5eq.</sub>, when using the bike, and 4.640 kgPM<sub>2.5eq.</sub>, when taking the car.

## 4 Discussion

The following discussion is separated into the two parts of this paper. First the methodology of the declaration of sufficiency-considering practices is discussed, followed by the methods of the LCA.

### 4.1 Discussion Sufficiency-Considering Practices

The first part of this paper gives an overview of the sufficiency-considering practices of the CSA in Wanderup. The gathered information is based on a side visit, therefore are not replicable for any other CSA or agriculture. Adding to this, only little data of the examined practices is available. More data must be available to compare only ecological farming or only non-ecological farming. To find better results, more farms must be compared to each other than only one farm compared to broad international data. Nevertheless, it gives a first impression of which practices can be declared as sufficiency-considered on a farm. Thus, the first part can only give a first overview about sufficiency-considering practices for farming.

### 4.2 Discussion LCA

The second part of this paper gives an overview of the environmental impact of different ways of marketing vegetables. As well as in the first part, the LCA is examining on a very specific case, here five very specific cases, which gives only an impression of what environmental impact the way of marketing has.

Within the LCA only the transport vehicles and the distances are considered. The energy used for packaging the produces or the movement of the produces within a distribution center is not considered. One major issue that is not examined is, that in **case a** the consumer drives to a farm, where only the goods produced can be bought. In the other cases, the consumer drives to a place where most probably all goods needed for everyday life can be bought. This would worsen the results of case a compared to the other cases. Also, a case that considers a transport via cargo ship is not compared. This can be an evaluation for a future comparison.

## 5 Conclusion

The examination of the CSA in Wanderup shows that compared to the available data the practices of the farm are sufficiency-considering. The least amount of packaging possible for the produces is used from production until consumption, the least amount of food waste is generated from production until consumption, without considering the food losses due to pests, and the least amount of chemical fertilizer is used during the production of the vegetables. Though, this is not declared as sufficiency-considering because following the restrictions of the demeter standards, no chemical fertilizers are allowed anyways. Compared to conventional farming this could be declared as sufficiency-considering but was not part of the evaluation of this paper.

The results of the LCA show, that the bigger environmental impact is evoked by the way of transport of the consumer. In all cases the environmental impact is lower when the consumer takes the bike instead of the car to the place of distribution of the vegetables. The reason for this is, that during the transport of the vegetables the cargo-vehicle is using its maximum capacity, while the consumer transports only the amounts needed. The **cases a to d** do not vary strongly in the environmental impacts. In the **cases a to d** the environmental impact of climate change is less than 7 %, for land occupation its less than 13 %, for water scarcity its less than 21 % and for particulate matter formation its less than 17 %. This shows how important it is to use the bike to reduce the negative environmental impact while buying food. Though, in all compared cases the environmental impact of **case e** has the most negative impact on climate change, land occupation, water scarcity and particulate matter formation. Therefore, it is also important to check, whether the produce has travelled via a plane or not. A comparison with the transportation via ship must be done in a further study

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