

# Systematic Approach to Sustainability of Novel Internet-Based System for Food Logistics

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**Abstract—** The aim of this paper is to evaluate the sustainability of a novel internet-based system for food logistics and to create a framework for more detailed future sustainability assessments. Digitalization enables food shopping via the internet and food delivery from producers to consumers using only a single terminal. The sustainability of different food logistic options was evaluated through a literature review and life cycle assessment. Given the frame of reference, there is a gap in the knowledge on the sustainability of food logistics. In addition, the current literature does not recognize a novel internet-based system for food logistics, as the literature has focused on evaluating the internet-based food logistics of traditional actors. The life cycle assessment results show that new food logistic options could reduce GHG emissions, but various factors affect the magnitude of the reductions. We also present a systematic approach to which factors should be included in future research. This paper creates a base for more detailed future food logistic sustainability assessments.

**Key words—** Sustainability, Food, Logistics, LCA, Internet Grocery

## I. INTRODUCTION

Food production plays a significant role in the intensification of climate change due to the use of fossil energy sources and changes in carbon stocks. Approximately 14 % of global greenhouse gas (GHG) emissions are directly related to agricultural processes [1]. In addition, food systems lead to GHG emissions also via energy use, land use change and transportation. Due to the growth of the global population, GHG emissions from food systems risk increasing in the future [2].

Much attention has been paid to improving food production sustainability in agriculture and food processing, but consumer logistics have received less attention. Digitalization, web services and new food delivery concepts may help to improve food distribution logistics, thus also reducing GHG emissions from storage, retail and transportation. Digitalization is a key enabler for new concepts and improved logistical systems.

In the past twenty years, internet-based grocery shopping has been researched from several points of view. Typical objects of interest have been value creation for customers and the adoption process of customers. For example, Anckar et al. [3] have argued that customer value in online grocery shopping is created by a large specialized selection, superior comfort, superior customer service, and price competition. In other words, by similar means as in a traditional super market. The diffusion of innovation and customer adoption has been widely studied also in recent years, and the early adopters have been stated to play a key role in the diffusion of mobile grocery shopping [4].

However, interfaces between sustainability and internet-based grocery shopping have been more absent from current literature. Whereas internet-based grocery shopping is tightly associated with logistics, in recent years some emerging studies have responded to calls to consider the role of logistics in sustainability. For example, Björklund et al. [5] have recognized that logistics has a major role in pursuing sustainability. In addition, the effect of the retail industry on sustainability has also been a target of special interest. The magnitude of retailers' environmental impact might not be large, but retailers play an important role in ensuring sustainable behavior in their supply chains [6, 7]. In addition, the current literature of internet-based grocery shopping tends to focus on business models that are an additional operation for traditional grocery retailers, such as Tesco or Walmart [8, 9].

In this paper, we turn the focus on a novel internet-based system for food logistics (NISFL) where customers shop for groceries on the internet, and the food is delivered by producers or by logistic companies to consumers using only a single terminal. We then attempt to determine the

sustainability effects of the novel internet-based system for food logistics. In our paper, the business model differs from that of traditional actors so that in our case, the retailer is highly focused on the internet markets and actually has no tangible retailing store. The aim of this paper is to compare the sustainability aspects of web-based food distribution system to traditional retail operations. Is there potential for GHG emission reductions and which factors along the life cycle are important? What are the strengths and weaknesses of this process? We present our case actor, a local food logistics operator, and calculate the potential emission reductions by utilizing life cycle assessment (LCA) methodology. In addition to the case actor, we present a literature review considering the current state of internet-based grocery shopping. To conclude, we present the results of our LCA calculation and ponder the possible sustainability benefits of the NISFL. We also create a model to present which factors should be taken into account in future sustainability assessments of food logistics. To our knowledge, this paper contributes to the current literature on internet-based grocery shopping by offering a more sustainability oriented view and suggests more innovative ways to deal with the challenge of food system sustainability.

## II. METHODS AND DATA ASSUMPTIONS

In this research, various methods have been utilized to evaluate new NISFL. First, the fundamental difference between new distribution methods and traditional methods is described based on literature and interviews. Then, a frame of reference is presented to see where the current literature of internet-based grocery stands on. In addition, we explore the relation of sustainability and retail in past research. The third phase is to carry out an LCA comparison of GHG emissions from different food logistics systems.

### A. *Food logistic concepts*

Typical food logistics from producers to retail through various terminals and storages is a well-known concept especially in developed countries. In addition, new, innovative concepts are emerging and challenging this traditional food logistics system. Information related to food logistic systems and the NISFL was attained by visiting and interviewing a food logistics operator thrice during 2016. Figure 1 illustrates this information and literature data of traditional retail and logistic processes. Traditional processes are based on large central terminals and storages. From there, food is delivered to local storages before delivery to retail. Consumers typically do their shopping in retail stores. Some retail operators have, however, started to deliver food for customers. A customer typically orders food via the internet with an application. The food is then delivered from retail stores to customers. In these cases, food is collected from retail store shelves. The new innovative approach in the NISFL is to have only one logistic terminal. Food is collected directly from producers based on online orders. The orders are then delivered to customers within two days directly from the terminal. In this case, no multiple terminals or retail phase is needed.

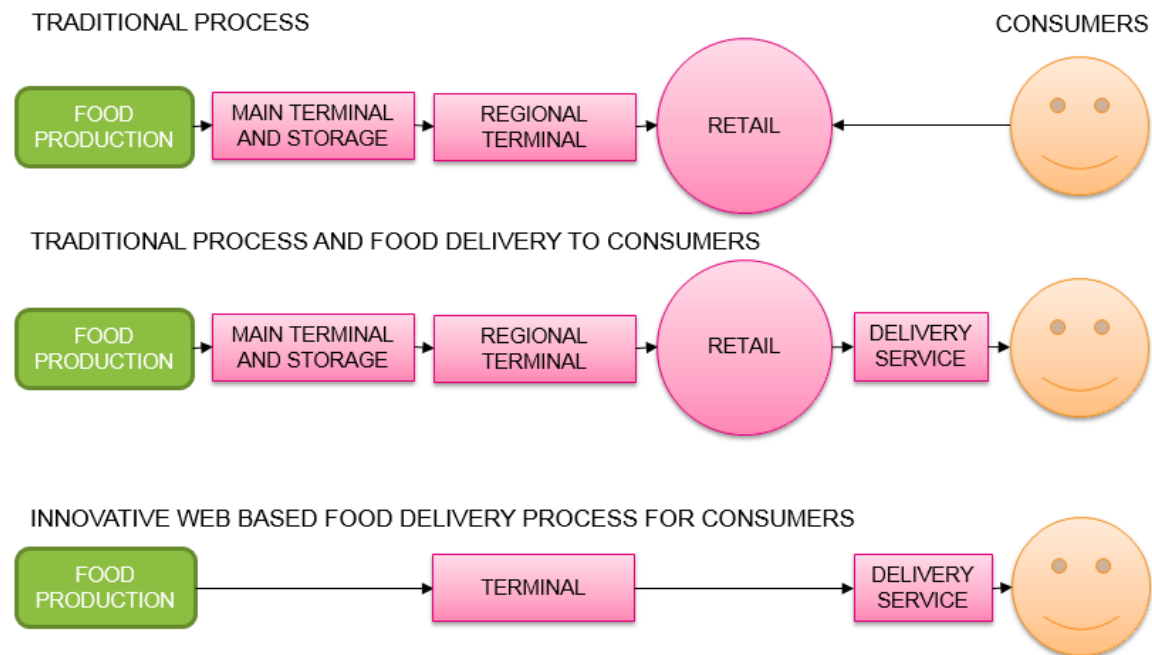


Figure. 1 Differences between various food delivery systems

#### B. Framing the past research

The literature on consumer value, consumer behavior, and the adaption process of consumers has dominated the recent debate concerning the internet-based system for food logistics. In addition, the current literature has mainly focused on finding differences between traditional and online grocery markets [10]. The prevailing impression is that consumers have not transitioned from traditional grocery shopping to the internet yet. Other than grocery stores have already obtained remarkable markets in the internet, and hence, the development of internet-based groceries and the demand from them is likely to increase significantly as well [11].

Recently, the number of people who use mobile devices for purchasing is rapidly increasing, for example, in Spain [4]. The customers of internet-based system for food logistics re-late values such as higher compatibility, higher usefulness, fewer difficulties in the purchase process, or more positive social norms to their purchasing behavior compared to customers who do not operate online or even to those who use the internet for purchasing but not grocery shopping [12]. As in traditional grocery retail systems, also in our project case; the novel internet-based system for food logistics (NISFL), the customer value is created by price competition, a wide and specialized selection, superior purchasing com-fort, and superior customer service [3]. In addition, the previous scholars have stated that the circumstances and life situations of customers, such as having a child or health issues, might trigger the move from traditional groceries to shopping groceries via internet [13, 14]. We believe that it is likely for NIFLS also to gain customers through life situational changes. Furthermore, the actual online platform is crucial for positive purchasing behavior; customers visiting a virtual grocery store tend to prefer a hierarchical/tree structure on the web pages [8]. Quite recently, re-search has also suggested that customers' purchase behavior is dependent on transaction costs [10]. Customers achieve savings in transportation costs and in time when shopping online instead of in traditional grocery stores [15].

For the NISFL to expand beyond its present niche, retailers need to understand both what drives consumers to change their purchase behavior, and also the extent to which their online shopping experience reinforces the adoption process [13]. The role of early adopters is crucial in the diffusion process of the NISFL, and the early adopters are able to create positive word of mouth to other diffusion groups [4]. The problem has been that, for the time being, most of the internet-based groceries have not been able to compete enough with prices [3]. A typical bottleneck for price

competition is the rise in distribution costs when internet-based grocery sales need to respond on the increased demand [16, 17].

Another stream of research consists of emerging studies that respond to calls to consider the roles of logistics and retail in sustainability. For example, Björklund et al. [5] have recognized that logistics plays a major role in pursuing sustainability. It has also been stated that sustainability could be implemented throughout the logistics operations of a company [18]. Special attention has been paid to the transport phase of logistics system, since transport has the greatest environmental impact in the logistic system [19]. Especially retailers are crucial in supply chains, as they are intermediaries between consumers and producers and therefore in a key position in implanting sustainability along supply chains [20, 21]. Retailers alone may not have a large environmental impact, but since they act as intermediaries, they are able to secure sustainable behavior in their supply chains [7, 5]. For example, retailers can use their position to open or restrict market access for suppliers, but also to influence consumer behavior, and consequently, the retailer's role is important in the process of achieving sustainable consumption and understanding what it means to consume sustainably [22, 23]. In addition to motivating customers to behave more sustainably, retailers can implement sustainability by offering more sustainable products and even addressing more sustainable business processes [7]. Even though the impact of retail on sustainability has lately been acknowledged, the interaction between sustainability and supply chains will require attention increasingly in the coming years [18].

The prevailing research on internet-based grocery shopping emphasizes traditional actors that have added an online platform to their traditional grocery store. For example, research has recognized Tesco's, Walmart's, Sainsbury's and Waitrose's online retailing facilities [9, 8]. To our knowledge, this paper is among the first ones to study the food logistics model where the internet-based system for food logistics is the main function for the retailer as in our project case. Hence, our conclusion is that current literature does not recognize alternative internet-based systems for food logistics. In addition, comprehensive knowledge on how sustainability relates to internet-based food logistics is still lacking. Some studies have stated that internet-based shopping causes less CO<sub>2</sub> emissions compared to the traditional system [24]. Online purchasing could be considered more sustainable since most of the emissions of traditional stores are caused by travelling to and from the stores [7]. To contribute to the current knowledge, this paper explores the possible environmental benefits of the NIFSL, where the online market is not only an additional operation for a business but actually the dominating business model.

### *C. Life cycle assessment, assumptions and data collection*

One of the goals in this paper is to calculate effects of the food distribution systems presented in the Figure 1 on GHG emissions. In other words, we aim to compare GHG emissions of our project case to traditional actors that are already represented in current literature. Therefore, a calculation model was created based on life cycle assessment (LCA) methodology. LCA can be used to compare different production systems from the perspective of the entire life cycle (cradle to grave). The LCA method is based on the international standards ISO 14040 and 14044. The goal of this LCA study is to compare GHG emissions from different food logistics options. To estimate the role of retail and distribution options, four different typical consumer products were compared: honey marinated chicken, bred rainbow trout, whole grain barley and toilet paper. Inventory data has been collected from literature. The study has been carried out in Finland, using the city of Lahti as an example of an average-sized Finnish city with approximately 100 000 inhabitants.

GHG emissions along the life cycles of the chosen example products are taken from literature, and the calculation model created in this paper concentrates only on distribution, retail and consumer delivery. More detailed descriptions of actual product production processes, logistics and retail related GHG emissions have been provided by Katajajuuri et al. [25] for honey marinated chicken, Silvenius [26] for bred rainbow trout, Finer [27] for whole grain barley, and Hohenthal and Behm [28] for toilet paper. One of the main methodological challenge from the LCA perspective is to estimate GHG emissions only for the chosen products because in retail and distribution processes emissions are related to a variety of products. Therefore, an allocation procedure has been applied

to divide the emissions of shopping between different products in consumer logistics. The allocation has been carried out based on the economic values of the products [29, 30].

An average Finnish family uses € 4 300 for food annually [31]. Traditionally, they make 3.2 weekly shopping trips to retail stores. However, there is an indication that when consumers use a web-based food delivery system, they order only two times a week. This may result from more carefully planned shopping. Nevertheless, it is also possible that in addition to these two orders, consumers also use the services of traditional retail stores. Based on the web pages of local super markets, the prices of the selected example products are 10 € kg<sup>-1</sup> for honey marinated chicken, 16 € kg<sup>-1</sup> for bred rainbow trout, 4 € kg<sup>-1</sup> for whole grain barley, and 5 € kg<sup>-1</sup> for toilet paper. In the calculation model, emissions are calculated using a 400 g consumer pack-age for the products, and this is also the functional unit of the model.

For the consumer distribution comparison, we selected 20 addresses randomly from the studied region. This is approximately the number of households to which food can be distributed with one car. The selected households are mainly located in neighborhoods where the use of passenger cars is the most intensive. Traditionally, there are two important concentrations of retail stores (A and B) in the region where consumers do their weekly shopping, and the consumers mainly drive to the store in private passenger cars. Table 2 also presents the current shopping distance for the selected households. A food logistics terminal is assumed to be located in A.

Table 1. Distances from selected households to supermarkets A and B.

Address	Distance to A	Distance to B
1	9.6 km	
2	11.5 km	
3	4.1 km	
4	1.8 km	
5	4.0 km	
6		8.6 km
7		2.4 km
8		4.7 km
9		4.3 km
10		6.7 km
11	8.5 km	
12	10.3 km	
13	11.0 km	
14	3.2 km	
15	6.6 km	
16		8.8 km
17		4.4 km
18		2.9 km
19		5.5 km
20		5.2 km

For the consumer distribution calculations, people are assumed to use a passenger car with average GHG emissions of 145 g km<sup>-1</sup>. Food delivery is assumed to be carried out with a larger car with consumption of 170 g km<sup>-1</sup>. However, goods could also be transported with a large van with a much higher consumption of 255 g km<sup>-1</sup>. [32]

A typical distribution model for consumer products is to use central and regional storages before retail stores. In our innovative web-based food logistics, only one terminal is required. Therefore, emissions from the retail part are avoided. In addition, distribution may be more direct and storage periods shorter. The storage period is important for products that require cold storage. In the calculation model, it is assumed that distribution from producers to terminals or to retail is carried out with similar vehicles in all studied cases. A rough estimation is that direct distribution from producers to regional storage cuts emissions in half compared to a situation where various storages and terminals are used in addition to retail stores. However, for whole grain barley these emissions are

assumed to be equal because of its direct logistics from packaging to retail. The life cycle model and system boundaries are presented in Figure 2.

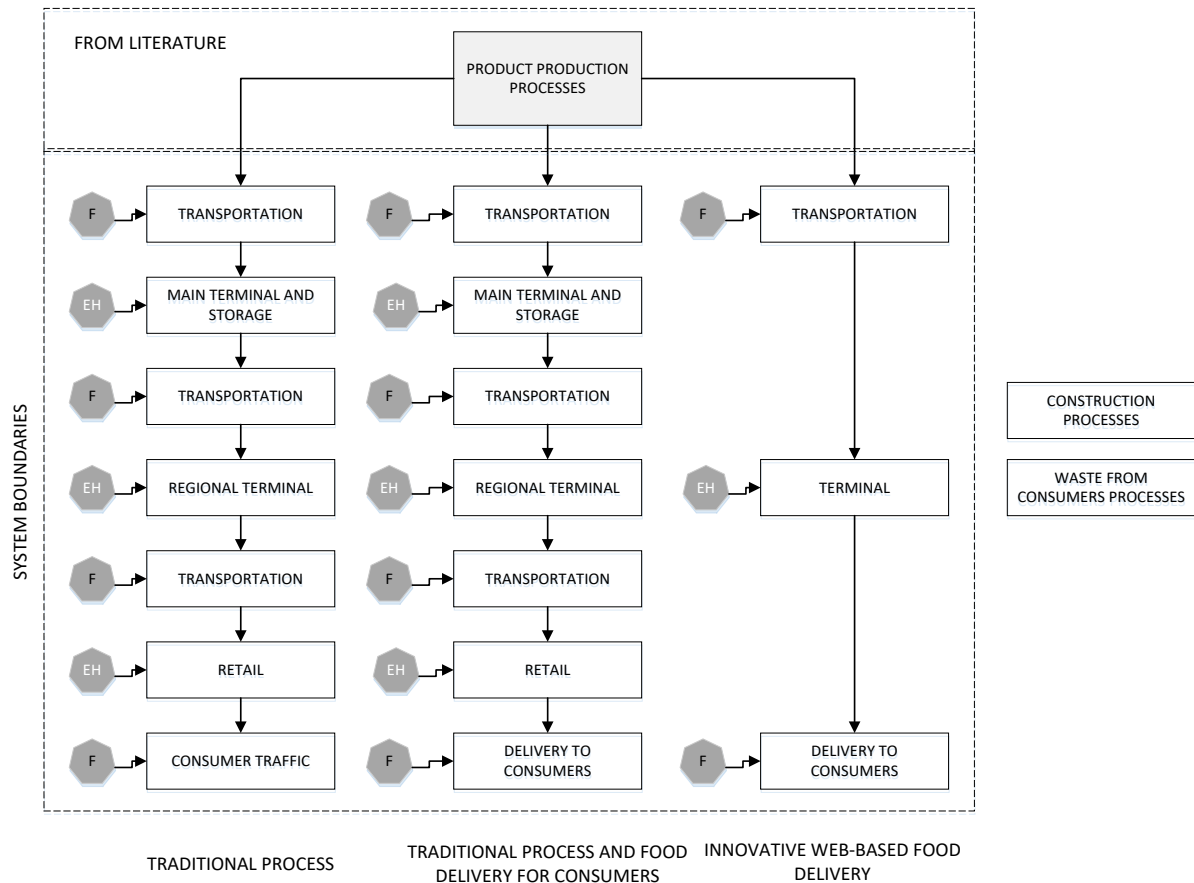


Figure 2. Process steps of different food logistics systems included in this study. F is fuel production, EH is electricity and heat production.

### III. RESULTS AND DISCUSSIONS

#### A. Specialty of the Novel Internet-Based System for Food Logistics

We want to provide some implications based on the previous literature and then applied to our project case, novel internet-based system for food logistics (NIFSL), on how NIFSL could contribute in sustainability compared to traditional actors. The most crucial difference of the NIFSL presented in this paper compared to traditional actors discussed in previous research is having an internet-based distribution system as the dominating operation, whereas the traditional actors see online platforms as an additional operation. Having the online platform as a dominating operation, as in our presented NIFSL case, involves certain benefits that help achieving sustainability throughout the retailing industry and that traditional actors lack.

As stated earlier, one of the main bottlenecks of traditional internet grocery shopping is the inability compete with prices. The novel internet-based system for food logistics overcomes this problem through the significant cost savings embedded in its business model; without large terminal storages and retail stores, the NIFSL is able to keep expenses moderately low. The NIFSL is also able to save in personnel costs since there are no traditional retail stores or need for staff. Hence, the end prices of products are as affordable as in traditional grocery stores. The lack of terminal storages and

retail stores also result in smaller environmental impacts since resources are not tied to buildings, and the transportation routes can be more effective.

Since the NIFLS has simplified the retail process, retailers are able to locate their terminals logistically very efficiently. Consequently, the distribution phase of the NIFLS can be executed to avoid traffic jams in cities and reduce driving distances. The stores of traditional actors are located in cities and their distribution is forced to go regularly in cities even if their regional terminals would be efficiently situated. The NIFLS also saves natural resources by using well-optimized delivery routes as opposed to traditional grocery stores to and from which customers must drive. We add to current knowledge by stating that the novel internet-based system for food logistics provides significant environmental benefits in the distribution phase of the process, whereas traditional actors use the online platform merely as an addition to their operations.

Since the NIFLS does not have any tangible stores, the online platform enables a large specialized selection with products that are not in the selections of traditional actors. This means that favoring green and environmentally friendly products is easy for the system. By offering green products, the NIFLS is able also reach green customers effectively. Hence, we add that the NIFLS is able to fulfil its role as an intermediate of sustainability between suppliers and customers. Without tangible stores, the NIFLS responds directly to customer demand. Consequently, customers receive their purchases fresh and straight from the producers. We imply that this may be important in reducing food waste from households, which is a major cause of food-related emissions. In addition to decreasing household food waste, the NIFLS does not cause any food waste itself, unlike traditional actors, since the NIFLS does not have any storage units where food can spoil. The possibility to avoid food waste has a positive environmental impact on the entire food system – from production to consumption. To conclude, we state that NIFLS can have a significant leverage on food systems sustainability.

Our conclusion is that the innovative business model of the novel internet-based system for food logistics is able to enhance sustainability in the field of retail. However, the NIFLS needs to reach customers sufficiently and expand their business models further from their current niche to achieve a greater sustainability impact.

#### *B. The future sustainability possibilities of the novel internet-based system for food logistics*

We add that the novel internet-based system for food logistics can increase its sustainability benefits in the future if the NIFLS is able to establish and even strengthen its position on the markets. As stated earlier, the pressure to branch out to online grocery shopping is constantly increasing. Based on the three interviews with the operator of the NIFLS during our project, the target customer segment is young, well-educated adults. Young adults are a crucial segment of green consumers, and the responsibility they feel for their environment is reflected in their way of thinking and their behavior [33, 34]. If the NIFLS is able to reach young adults, it will contribute to the ongoing changes in consumer behavior, where ensuring sustainability is in the focal point. If the changes in consumer behavior result in the large-scale expansion of internet-based grocery shopping, people may also become more systematic in their purchasing behavior online since internet-based stores cannot tempt customers as easily into impulse purchases as traditional grocery stores can. Consequently, we state that the increased systematicness in customers' purchasing behavior might again decrease food waste since customers would buy products simply according to their needs, not to their wants.

We also draw a conclusion that, if the NIFLS grows out of its current niche and reaches a solid position on the markets, it would result in many sustainability benefits. In addition, we suggest that with a larger customer base, the NIFLS would be able to improve its logistical performance even further, which in turn would lower the system's transportation emissions. The environmental benefits of the NIFLS could also be increased by incorporating other logistical operations to its business model; for example, merging NIFLS with a courier operator can significantly decrease the total emissions from transportation. In an optimistic scenario, a considerable number of customers could give up on owning a car. Furthermore, a larger customer base would ensure crucial services in areas of dispersed settlement, and hence, with efficient logistics the decrease in transportation emissions would be even greater compared to the emission decrease in suburban areas. In addition, with efficient and cost-effective logistics, the NIFLS might also invest in transportation that uses bio- or

recycled fuels. If the NIFLS stabilizes the position of its business model on the market, it could generate a positive snowball-effect where the NIFSL could favor other green niche innovations in, for example, its product selection. Our conclusion is that the possible growth of the NIFLS to a remarkable actor in the grocery industry and the related benefits would lead to a significant sustainability effect, increasing pressure on the traditional, incumbent, actors to alter also their business models towards greater sustainability. We summarize the existing and possible future benefits of NIFSL in Figure 3.

Existing sustainability benefits of NIFLS	Possible future sustainability benefits of NIFLS
<ul style="list-style-type: none"> <li>• Natural resources are tied less to buildings than to traditional grocery stores, creating environmental benefits.</li> <li>• An effective distribution phase generates environmental benefits.</li> <li>• Products are extremely fresh, which helps to decrease food waste from households.</li> <li>• A green selection attracts green consumers.</li> <li>• NIFLS does not produce any food waste itself.</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in customer behavior lead customers to buy according to their needs, not to their wants, which results in the decreased use of materials (food).</li> <li>• NIFLS could enable customers to give up owning a car.</li> <li>• NIFLS can put pressure on the traditional actors to alter their business models towards greater sustainability.</li> </ul>

Figure 3. Current and future sustainability scenarios of NIFLS.

### C. Results from the life cycle assessment model

The GHG emissions based on our calculations of three food distribution models are compared in Figure 2. As can be seen in Figure 4, a majority of the GHG emissions related to the example products are related to food production processes. Distribution and retail processes have a minor impact on the total GHG emissions, but consumer logistics are more important, causing approximately 12-20% of the total GHG emissions. We add that food delivery instead of private consumer traffic leads to significantly lower GHG emissions. GHG emissions from the retail sections are higher with products that require cold storage. These emissions can be eliminated if no retail phase is required. Our conclusion is that consumer product distribution directly to consumers may reduce GHG emissions of products, but various factors affect the magnitude of these reductions. This research was carried out using mainly secondary data especially related to terminals, storages and the retail phase. In the future, a more detailed primary data based assessment would be highly important. However the results of our paper give an idea what factors have impacts on the total GHG emissions of processes.

Figure 5 presents the sensitivity of the results if some basic assumptions of our calculation are changed. The sensitivity analysis is only carried out for honey marinated chicken, but also other products can be assumed to react similarly. As can be seen, the size of the food distribution vehicle affects GHG emissions in the distribution phase. In addition, if consumers ordered food as frequently (3.2 times per week) as they go to a retail store, the GHG emissions would be much closer to each other. Furthermore, GHG emissions from a traditional retail store model would be lower if consumers rode a bicycle or walked to the store instead of driving. GHG emissions are also presented for a case with delivery to only 10 addresses with one drive instead of 20 addresses (Figure 6). In such a case, the difference between GHG emissions is much smaller.

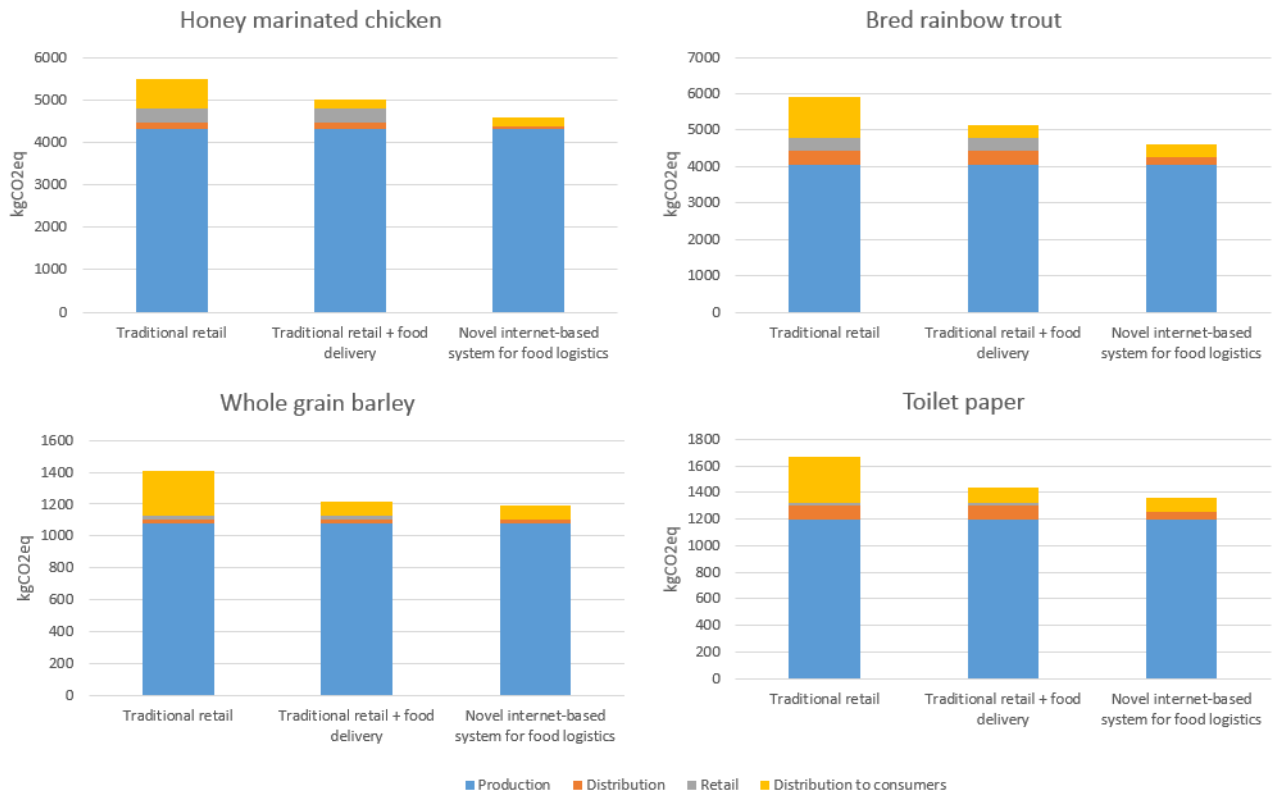


Figure 4. GHG emission comparisons with different food logistics systems for four example products

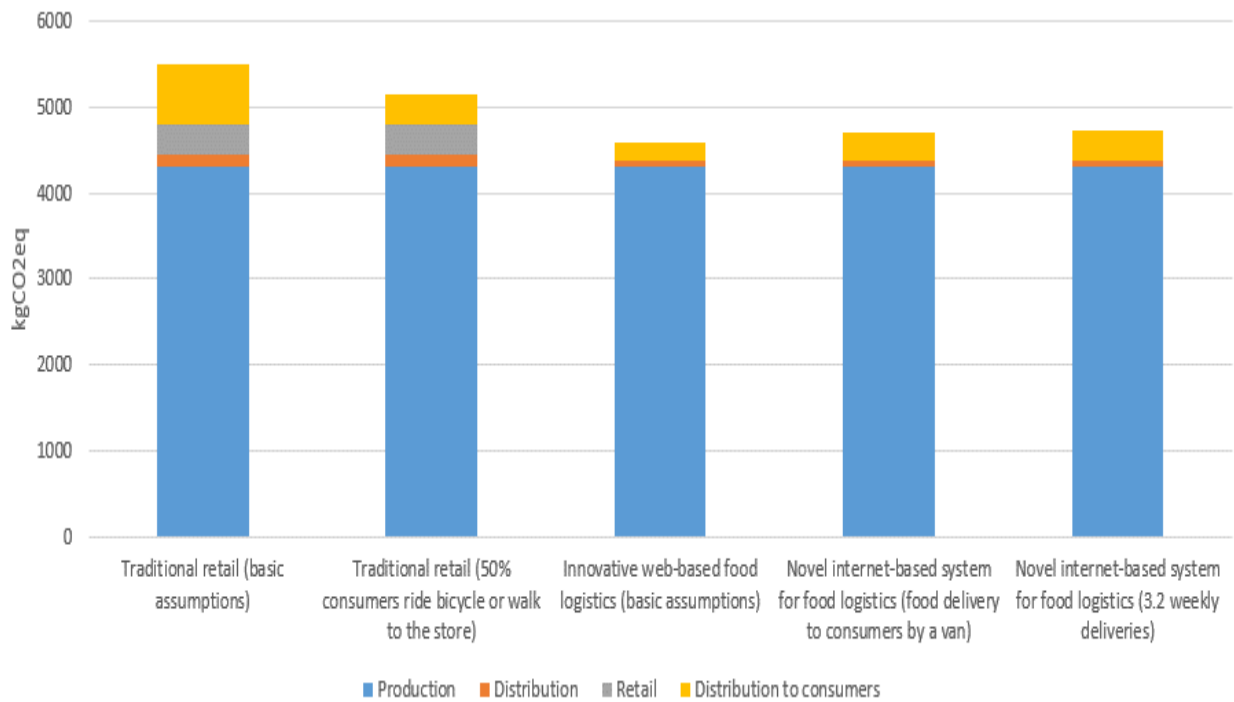


Figure 5. Sensitivity analysis

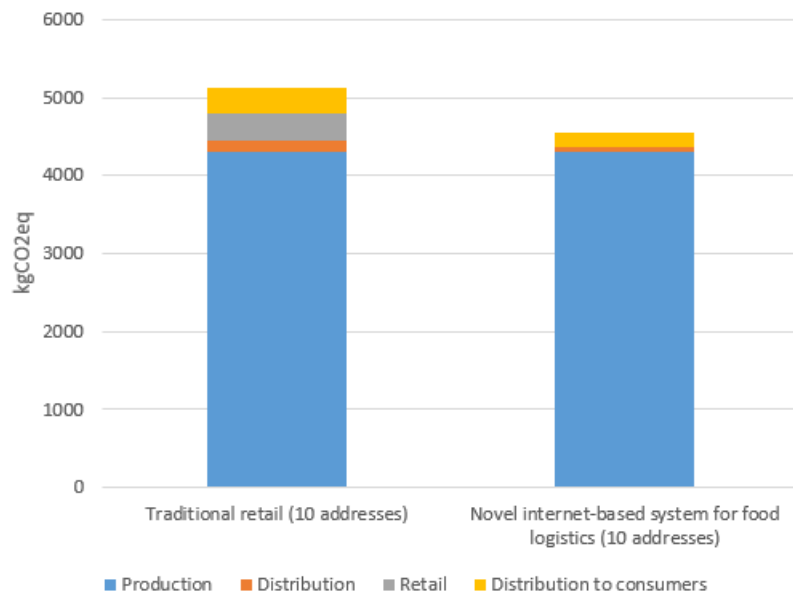


Figure 6. Sensitivity analysis when only 10 addresses are delivered

As our conclusion, this study shows that innovative web-based food logistics may reduce GHG emissions throughout the life cycle of different food products. The magnitude of the effect is, however, affected by various factors. Figure 7 illustrates these factors. This figure can be used when food logistics comparisons are evaluated in future research. The LCA phase of this paper focused only on global warming impacts but also other sustainability perspectives should be included in the future research.

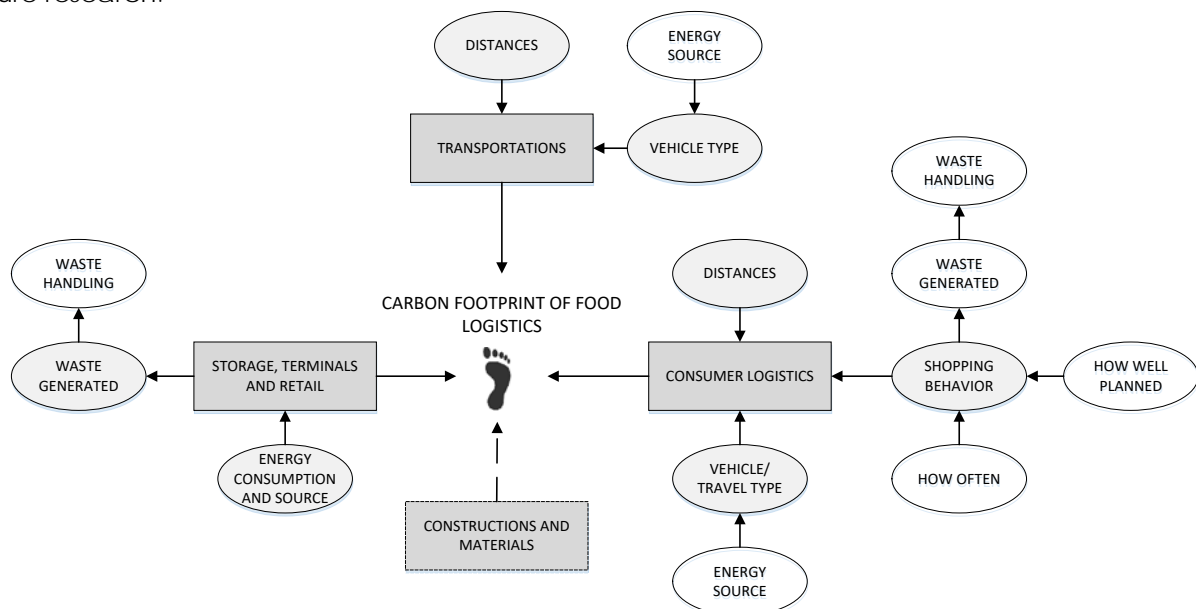


Figure 7. Factors affecting the carbon footprint of food logistics.

#### IV. CONCLUSIONS

We analyzed the sustainability of the internet-based system for food logistics using life cycle assessment (LCA) and literature review based on past research. In this paper we introduced a novel

internet-based system for food logistics (NIFSL) that differed from traditional actors in the internet grocery markets in a crucial way; Traditional actors have food delivery service as an additional operation whereas NIFSL has food delivery service through internet platform as their main business operation. For this reason NIFSL does not have any retail phase and some intermediate storages are avoided compared to traditional actors. We carried out a life cycle assessment by using life cycle assessment methodologies to compare the GHG emissions of NIFSL to traditional actors. The results from our LCA calculation indicate that avoiding the retail phase and certain intermediate storages may have an impact on the reduction of greenhouse gas emissions as well as on other sustainability perspectives. In addition, direct food delivery to consumers may help to avoid consumer traffic to retail stores. However, various factors affect the scale of greenhouse gas emission reductions, such as previous consumer behavior. We compared the novel internet-based system for food logistics to the current literature on internet-based shopping, sustainability and retail, which is typically dominated by the aspects of consumer behavior and innovation adaptation processes. In contrast, sustainability aspects of internet-based shopping are at the moment just emerging. Moreover, we add that, the debate over retail and sustainability is also in its infancy. We conclude that this implies how current literature does not acknowledge novel distributing systems for internet grocery shopping. After examining the previous literature, we evaluated the specialty of the NIFSL and its possible sustainability benefits. The purpose of our paper was to contribute more sustainability-focused knowledge to the current literature on retail by presenting a case actor in internet-based food logistics that has several environmental benefits compared to traditional actors and furthermore bears the potential for even stronger sustainability competence in the future markets of food logistics. This paper creates a base for more detailed future research related to sustainability of food logistics.

#### ACKNOWLEDGMENT

This paper is a part of REISKA project funded by EU regional funding.

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Manuscript received by 1 May 2013. [Manuscript submitted after revision 5. May 2017.]

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