LOCAL FOOD SYSTEMS: GENERAL CHARACTERISTICS AND THE ROLE OF LOGISTICS

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Abstract

There is an increase in initiatives towards more localised food systems, consisting of less complex and shorter supply chains. The expectations are that such food systems reduce carbon emissions and food losses and waste, as well as contribute to healthier diets. It is however not clear to what extent these expectations can be met. This paper aims to outline the main characteristics and claimed benefits of local food systems as described in the scientific literature, as well as to analyse and evaluate the role of logistics on the economic and environmental performance of local food systems by developing simple local food supply chain scenarios in the setting of the Dutch province of Flevoland. The results, supported by findings from literature, suggest that the use of cooperation and coordination in the supply chain is necessary to achieve more efficient and sustainable local supply chains.

1. Introduction

In today's globalized society, the food we consume is produced all over the world and often transported over long distances: from production locations, via processing locations, warehouses, retail stores, and foodservice outlets to the final consumer. This development has in many cases led to economically efficient, but complex, food production and distribution systems that are able to offer a variety of food products all year around. The complexity of these food supply chains has however led to societal concerns about their sustainability. It is argued that they contribute to climate change, food losses and waste, environmental degradation, as well as an increase in non-communicable diseases.

As a response, we see an increase in initiatives towards more localised food systems, stimulating the development of less complex and shorter supply chains. These local-for-local food supply chains aim to connect producers and consumers in the same region, often centred around urban environments. The expectations are that more localised food systems contribute to a reduction in carbon emissions and food losses and waste, as well as an increase in the uptake of healthy whole foods in urban diets. For such an urban food system, it is necessary to combine distribution of food products from an inevitably global origin with products from a local or regional origin. The possible assortment of local products depends on the regional soil and climate conditions, combined with the entrepreneurship of local growers. The supply of products from any origin must match the demand for various products of consumers in the region.

The Amsterdam metropolitan area, and particularly Almere as the hinge between the rural production area of Flevoland and the Amsterdam metropolitan area, is a case in point in this more local or regional orientation. The city of Almere has also expressed ambitions to move towards a more local food system, linking production in the province of Flevoland to consumption in the city of Almere. However, insight is lacking as to the consequences of this ambition, in terms of economic benefits, environmental footprint, land use, health, etc. Also, there is little understanding of what this shift would require in the

(organisation of) local food systems in Flevoland and the Amsterdam metropolitan area, from agricultural production to distribution and consumption.

Currently, the last stages of food supply chains are often dominated by larger retail corporations, with centralised distribution systems, supplying both products of global and local origin. As a result, local products sometimes first travel to processing locations or warehouses outside a region, to end up being sold in a local supermarket. In contrast, local-to-local initiatives such as farmer's markets aim to shorten supply chains with the goal of achieving the benefits mentioned earlier. However, to what extent and in what ways urban food systems can become more localized, provide safe and adequately diversified healthy food products, and contribute to the sustainability expectations is not clear. Therefore, the objectives of this paper are (1) to outline the main characteristics of local food systems as described in the scientific literature, as well as the claimed benefits; and (2) to analyse and evaluate the role of logistics on the economic and environmental performance of local food systems by developing simple local food supply chain scenarios.

In Section 2, we provide a brief overview of relevant literature on local food systems. In Section 3, we subsequently discuss a small example of local food distribution in the Flevoland setting, providing a concrete context for the local food discussion, followed by the conclusion in Section 4.

2. Related literature on local food systems

Local food systems have seen significant attention in the scientific literature. We outline the main characteristics of local food systems as described in the literature, as well as the claimed benefits.

2.1. Characteristics

A local food system (LFS) is a system in which foods are produced, processed, and distributed within a certain geographical area. 'Local' is often understood in relation to larger spatial scales like national or global, but there is no clear boundary between local and non-local (Kneafsey et al., 2013). Since 'local' is thus a relative concept, the movement towards 'more local than before' becomes more important than its absolute size (Deller et al., 2017). Eriksen (2013) examined various definitions of local food and proposes a taxonomy based on three types of proximity: (1) geographic proximity, (2) relational proximity (direct relations between local actors), and (3) values of proximity (such as place of origin, authentic, freshness and quality). McFadden (2015) also discusses the value perspective, with a broader range of characteristics such as sustainable production practices, smaller businesses size, more producer-oriented governance, and fewer intermediaries.

A significant part of the literature discusses consumer perspectives, focusing on how consumers understand local food. Findings suggest a wide variety of interpretations, ranging from transport efficiency, supporting local economy, food security, to animal welfare, environment preservation, and

fostering relationship (Granvik et al., 2017). A study on the retailer perspective also found that 42% of the studied retailers define local food not only on location, but also on produce practice, farm size, and local ownership and operations (Dunne et al., 2011).

Based on the literature, we were able to identify four commonly mentioned and supply-chain-related characteristics to distinguish local food systems from global ones: geographic proximity, fewer intermediaries, smaller business size, and different production practices.

2.1.1 Geographic proximity

Geographic proximity is an important aspect in most of the literature on local food. It relates to food being produced, sold, and consumed in a specific area (Bosona & Gebresenbet, 2011). This area is often defined by a certain distance radius or by an administrative area (Dunne et al., 2011; Trivette, 2015). Nevertheless, due to lack of standardization, most research bases its definitions on consumer perceptions (Feldmann & Hamm, 2015). The upper bound of 'local' distance varies between studies, ranging from 10 to 30 miles up to 50 miles (Feldmann & Hamm, 2015; McFadden, 2015). A study in the USA on consumer perceptions of local food, found that 70% respondents considered a 50-mile radius as local, while a 300-mile radius is considered regional (Ozonaka et al., 2010). This 300-mile radius is also often used by retailers as a boundary for local to make procurement decisions.

In terms of administrative borders, other forms of spatial proximity can be provinces, states, or counties (in the US). Similarly, there is also a disparity of consumer perception in terms of administrative borders (Onozaka et al., 2010), possibly because the consumer perception of 'local' tends to be affected by context (Feldmann & Hamm, 2015). The boundary of local would vary between a small nation and a large state. Apart from consumers, stakeholders involved in local food movements also have a wide range of definitions for local food. For instance, a survey by McCaffrey & Kurland (2014) saw responses ranging from political boundaries, concentric distances, ecological based definitions (such as watersheds), relationship-based definitions, to statements on morality and justness. These different interpretations of 'local' indicate a wide variety of motivations behind local food movements, and certainly show that local food is a multidimensional construction rather than a mere discussion on geographic proximity.

2.1.2 Fewer intermediaries

Some studies stressed how personal relationships and interactions influence consumers' perception of localness (Dunne et al., 2011). According to Marsden et al. (2000), a common characteristic of a short supply chain is the emphasis of the relationship between the producer and the consumer in these supply chains, and the role of this relationship in constructing value and meaning, rather than solely the type of product itself. Trivette (2015) states that the conceptualization of relationships assumes that farmers are selling directly to consumers. Also, Deller et al. (2017) indicate that local foods means fewer

intermediaries. Kneafsey et al. (2013) point out that in a local food system, the number of intermediaries between farmer and consumer should be minimal or even zero.

Local food thus becomes a social construct, with social connection as an important benefit. Having fewer intermediaries not only enables increased retention of money within the local economy (Deller et al., 2017), but it also connects producers and consumers more directly (Schmitt et al., 2018). The presence of intermediaries can then also be used to categorize food sales channels into direct-to-consumers sales and intermediate sales.

Direct-to-consumer sales is a marketing strategy where a producer sells products directly to consumers without intermediaries. Mechanisms of this strategy include farmers' markets, farm stands, pick-your-own, community-supported agriculture, and direct internet sales. Limited by distribution capacity, initiatives following this strategy are often small scale.

Within the development of local food industries, intermediate entities such as food processors, food hubs, and stores have also played a role, allowing for more coordination and efficiency as well as a wider range of products (Barham et al., 2012; Cleveland et al., 2014; Hara, 2017; Matson et al., 2013). Consumers obtain these food products indirectly through foodservice providers (such as restaurants, hospitals, and schools) or traditional retailers. These intermediaries play an important role and facilitate efficiency in distribution. Also, they enable associated farms and distribution systems to operate in a larger scale and thus also blur the boundaries with conventional food distribution systems.

2.1.3 Smaller business size

Business size might be a less intuitive characteristic related to 'local', but Brunori et al. (2016) indicate that the size of operations is strongly associated with localness. A locally oriented business is likely to be of smaller size. Larger farms produce more food for which local demand might be too small and thus they tend to sell at a longer distance (Trivette, 2015). Jarosz (2008) illustrates that farm size is one the defining features of alternative food networks and her interviews with farm owners showed that large-scale farmers tend to rely on national or international markets due to their production volume.

Mount (2012) identified the sources of added value that are difficult to access at larger scales. He states that it is a challenge for large-scale farms to access the advantages of local food supply chains which smaller producers can easily take, such as geographical proximity, direct sales to consumers, and minimal processing requirements (Mount, 2012). Lamine (2005) argues that the change of scale is decisive in that uncertainties generated by global food crises are answered through guarantees and promises provided in the frame of local systems. Milestad et al. (2010) state that the motivations of local producers are to be independent from large-scale structures: to stay flexible and creative, and to avoid exploitation from large retailers.

2.1.4 Production practice

Another defining feature of local food system is production practice (Deller et al., 2017; Hinrichs, 2000; Jarosz, 2008; Kneafsey et al., 2013; McFadden, 2015). Farmers who rely on local food networks tend to more often practice alternative cultivation techniques. Kloppenburg et al. (2000) state that these alternative practices stress holistic and environmentally friendly production methods, and typically avoid the use of pesticides, synthetic fertilizer, or genetically modified seed. Even though alternative practices are often used, the resulting products might not always be formally recognized or certified as such (Jarosz, 2008), nor are they necessarily better for the environment (e.g., Smith et al., 2019).

Milestad et al. (2010) emphasize that local food producers leverage their smaller business size and direct sales channels to be more flexible and creative than their competition. Producers are able to create their own niches in the market by focusing e.g. on rare or old product varieties or artisan production methods. Another competitive advantage is achieved through the producers' social network. In terms of the small-scale business, especially family business, producers know much about farming methods of people in their network (their neighbours for instance), thus they tend to observe each other and to carry on mutual quality control going beyond standardized practices (Milestad et al., 2010).

2.2. Motivations and perceived benefits of local food systems

The producers' initial motivation for local foods are often to counter industrial production and to engage personal interaction with consumers. Premium consumers tend to believe that local food will help local farmers and is of high quality, and thus deserves a higher price (Maples et al., 2013; Thilmany et al., 2008). Gumirakiza et al. (2014) found that high spenders at farmers' market tend to be married females at higher income levels, people with health concerns, and people that value the support of local farms. Similar results are found in a study on a farmers' market in New Zealand: consumers' willingness to pay for local produce is positively related to age and income (Berg & Preston, 2017). Interestingly, a study on consumers of restaurants shows different results: people who are willing to pay more for meals made from local foods are mainly young people with high levels of conservation and self-enhancement (Contini et al., 2017). These motivations result from different perceived benefits of a transition to more local food systems, ranging from social and economic to environmental. We discuss these further below.

2.2.1 Social benefits

One reported benefit is consumers' increased knowledge and positive behavioural change as a result from participating in LFSs. For the USA, Berning (2012) found that access to local food is negatively related to an individual's weight and has a significant association with greater weight loss. Another study found that the concentration of farmers' markets within a community is positively associated with public health (using metrics such as adult obesity percentage, adult diabetic percentage, and premature mortality) (Deller et al., 2017b). A study in Italy has shown similar results, the density of farmers'

markets is associated with a lower Body Mass Index (BMI) of Italian adults (Bimbo et al., 2015), and the impact of access to local food on health outcomes is more marked for people facing limited incidence of local foods (Bimbo et al., 2015). A key limitation of the above-mentioned research is that a causal relationship between LFS participation and a healthier lifestyle cannot be claimed. It is also possible that people who are concerned about health and have more dietary knowledge are more likely to engage in local food schemes. Consumer health concerns might positively influence their local food purchasing decision. For instance, research has shown that people who have health issues (cancer, diabetes, obesity, and back/joint pain) are more likely to buy local foods, suggesting disease incidence might have a significant effect on local food purchasing (Thapaliya et al., 2017).

A commonly reported benefit related to LFSs is increased interaction, both between producers and between producer and consumers, which can better ground actors in communities and support social inclusion (Blay-Palmer et al., 2013). Chiffoleau's (2009) network analysis of farmers' markets and box schemes shows that ties between producers are tightened after their integration into a sale system. Another study also provided evidence that intellectual capital can be passed along the networks created by LFSs (Schmit et al., 2017). The evidence is found in changes in production practices, more varieties of products grown, as well as creation, sharing, and implementation of new ideas for production and marketing techniques. In terms of the interaction between producers and consumers, building relationships of trust is often regarded as a major benefit of LFSs. Nevertheless, in a consumer survey, Murphy (2011) found that interaction with producers is not highly valued by consumers, lower than intrinsic characteristics such as food quality.

2.2.2 Economic benefits

One of the most claimed benefits of LFS is a positive impact on the local economy, both in local wealth retention and in creating jobs. The shorter supply chains increase retention of money within the local economy. Many studies assessing the economic impact are based on IMpact Analysis for PLANning (IMPLAN) (Schmit et al., 2016) and several researchers quantified this impact in terms of multiplier effects. With the help of an input-output model, Otto & Varner (2005) calculated that the multiplier effect of a farmers' market in Iowa was 1.58 in one season. Similarly, a multiplier effect of 1.78 was reported from another study in Oklahoma. Other similar discoveries have been reported in studies of community-supported agriculture and food hubs. Apart from gross sales, this multiplier effect is also estimated in labour markets. Otto & Varner (2005) estimated in their study that each full-time job created at a farmers' market will bring half a job extra in supporting sections.

However, other research questions these assessments. If the input purchases and output sales patterns for small-scale direct agriculture producers are sufficiently different from that of conventional agriculture producers, the estimates based on IMPLAN data may be misleading (Schmit et al., 2016). Using a case study in New York, Schmit et al. (2016) found different results: small-scale direct agriculture producers have lower total employment and output impacts but higher effects on labour income and total value

added. A similar result is found in a case study of craft beer in West Virginia, USA. No significant changes in employment were found after sales channels were legalized, but labour income experienced a significant increase (Malone & Hall, 2017). Other critiques are mainly focused on two aspects: the first is that most studies analysed absolute sales and ignored the suggested increases in returns; the second is that few studies take opportunity costs into account (Hughes et al., 2008). Furthermore, there is also opportunity costs beyond the LFS, such as negative impact on initial suppliers and non-local suppliers (Ballingall & Winchester, 2010).

2.2.3 Environmental benefits

The most-claimed environmental benefits of LFS are reductions in food miles and encouragement of sustainable production methods. The reason for reduction in food miles is the apparent shorter transportation links in a local supply chain, and thus less energy use and GHG emission are generated.

However, if consumer transportation is taken into account, the total environmental impact of local food supply chains can be greater. Coley et al. (2009) compared carbon emissions generated in a large-scale vegetable box system with those from a local farm shop. Results showed that if a consumer drives more than 6.7 km in their round-trip to buy foods in a local farm shop, the carbon emissions tend to be higher than those from the large-scale vegetable box system.

Furthermore, food miles cannot give a true picture of total energy consumption and GHG emission since it ignores the impacts from other parts of the supply chain, such as production and inventory. For example, in order to satisfy local demand throughout the year, inventory might be required prior to consumption, probable resulting in greater energy use and GHG emission. Life Cycle Analysis (LCA), according to Edwards-Jones (2010), can only achieve accurate estimates when the system boundary includes all phases of the food chain.

In terms of production, another claimed environmental benefit is positive impacts on (agro-) biodiversity (Kneafsey et al., 2013). The diversity of species in farm landscapes is important since one-third of the earth is covered by farms (Duram & Oberholtzer, 2010). A study conducted in Ohio, USA, suggests that LFS can encourage cropping diversity. It shows that the production of old product varieties is strongly associated with the sales in local markets, suggesting an important role of local markets in the preservation of heirloom products varieties (Goland & Bauer, 2004).

3. Local food supply chain scenarios

In order to analyse and evaluate the role of logistics in a local food distribution system in Flevoland, we develop simple local food supply chain scenarios to illustrate the analysis that might help provide insights in the economic and environmental performance of local food distribution. More specifically, we choose to develop scenarios for mixed-vegetable packages with cut carrots and unions. These are readily available in Dutch supermarkets, as the key ingredients of the typical Dutch dish 'hutspot'. Carrots and

onions are also two of the most-grown vegetables in the province of Flevoland (Ten Brug et al., 2018), so it should be possible to have locally produced packages in local supermarkets. Hutspot packages are minimally processed products, which does require the processing industry in the supply chain.

3.1. Supply chain scenarios

Three hutspot supply chain scenarios are defined, illustrated in Figure 1. The first, 'farm shop' scenario is a local supply chain, from farmers in Flevoland, via a processor, to a farm shop in Almere. This scenario shows a short supply chain in which the origin of the food products is most close and most clear to consumers, completely within Flevoland.

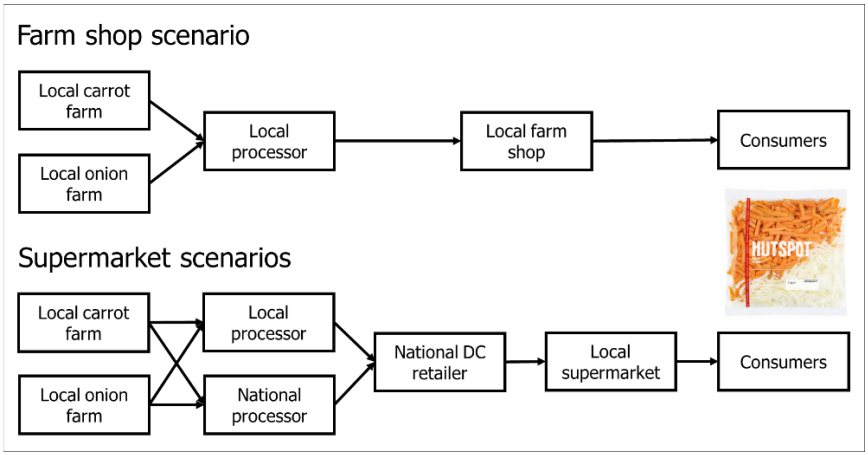

Figure 1. 'Hutspot' scenarios: one farm shop scenario and two supermarket scenarios.

The second and third scenario are 'supermarket' scenarios, which we construct based on the locations of a large Dutch retailer. We assume that the ingredients of the hutspot packages are still produced in Flevoland, but the processing (i.e., washing, cutting, and packaging) of the vegetables is performed either on the same location as in the farm shop scenario in Flevoland, or at the preferred processor of the retailer in the province of Noord-Holland. All packages are replenished via the retailer's distribution centre in Noord-Holland to the supermarkets in Almere.

The farm shop scenario has the characteristics of a local food system as described in the literature, with close geographic proximity and fewer intermediaries in the chain. The business size and production practice are unknown in this example, but for an initial assessment of the logistics activities, this is less relevant. Looking at the distances, the supermarket scenarios could also be considered local but have an extra intermediary.

3.2. Economic and environmental evaluation

The scenarios can be evaluated on many performance indicators. In this exploratory study, we focus only on costs and on environmental impact. To be able to make calculations for these scenarios, we made several assumptions on the locations in the supply chain and on the means of transportation.

Only the transportation in the supply chain from farm to consumers is included in the calculations. Potential economies of scale in processing are not considered. Details and calculations of all scenarios can be found in the appendix.

For the farm shop scenario, we use an existing farm shop in the city of Almere as the retail location. We assume there are 1,000 consumers, living all over Almere, in proportion to the number of inhabitants of the five districts of Almere. The consumers travel by car to the farm shop and buy one package of hutspot of 1 kg. The total distance is calculated by estimating the distance from the middle of the district to the farm shop and back, multiplied by the number of consumers from the district. The washing, cutting, and packaging of the carrots and onions is done by a local processing company in Flevoland. We assume each package contains 600 g carrots and 400 g onions, reflecting existing retail packages. The processing company is supplied by different farms for carrots and for unions. We assume that transportation from farm and processing plant in this supply chain is done by vans with a load capacity of 1.5 ton, in a single trip.

The first supermarket scenario 'Flevoland' starts with the same actors as the farm shop scenario, but from the processing plant the products are transported to the warehouse of the retailer. From there the products go to supermarkets in Almere. We assume that consumers live on average 1 km from a supermarket, and 50% of them do their shopping by car. The other 50% walks or uses a bike to go to the supermarket. In the second supermarket scenario 'Standard Retail Practice' the processing takes place at the standard vegetable processor of the retailer in the province of Noord-Holland. The other parts of the supply chain equal the first supermarket scenario.

Table 1 summarizes the results of the calculations on the logistical impact of the scenarios. Based on our assumptions, the results show that the farm shop scenario is less efficient in terms of logistics costs and environmental impact, on the one hand because transportation in the supply chain is not combined with other products, and on the other hand because the customers have to travel to the farm shop, located further away than the supermarket, and consumer travel adds significant costs and impact. The supermarket scenarios assume that most transportation is combined with other products, and because the processing industry is closer to the farms, the Flevoland scenario is most efficient.

Table 1. Summary of results

Scenario	Distance (km)	CO_2 equivalents	Costs
Farm shop scenario	9091.93	2033.72	2213.69
Supermarket scenario 'Flevoland'	1185.00	189.00	175.59
Supermarket scenario 'Standard Retail Practice'	1222.70	200.92	220.98

The simple scenarios studied above consist of a single supply chain, for a single final product, where capacities of the actors are not an issue. This single supply chain can be expanded towards supply chain networks for multiple products and multiple actors, provided that data are available. Also, other performance measures than costs or emissions could be considered, including social measures. It will

however be a challenge (or it might even be impossible) to include all claimed benefits of local food systems in decision support models because the benefits will partly be intangible and hard to quantify.

3.3. Discussion

The findings of our simple local food supply chain scenarios for Flevoland are supported by the literature. We mention a few examples. Cholette (2011) performed a case study of Californian farmer's markets, addressing the greenhouse gas emissions associated with food distribution. In her case study, the transport from local small or larger farms, or conventional import from Mexico to a farmers' market or a supermarket in San Francisco is compared. The scenario with direct sales from local small farms to the farmers' market has the smallest distance travelled, but generates the highest emissions, due to the use of smaller and less efficient vehicles. By modelling and analysing the supply chain network, Cholette (2011) also showed that the use of a consolidation centre could significantly reduce emissions. Bosona and Gebresenbet (2011) studied the coordinated collection and distribution in local food supply chains in Sweden. They focus on building regional clusters of producers and demonstrate the improvements on logistics efficiency, environmental impact, and traceability of food quality. Melkonyan et al. (2020) assessed sustainability of last-mile logistics and distribution strategies for a case of a local food network in Austria. They compare the current situation in which producers transport the products themselves to a warehouse, where customers collect their online pre-ordered products, with an integrated food network with a logistics service provider organising collection from the producers to the warehouse and distribution from the warehouse to the customers. Generally, the latter option is the more sustainable option. Paciarotti and Torregiani (2021) recently reviewed the literature on the logistics of short food supply chains. They recommend from their review to shift from inefficient systems towards coordinated networks with cooperation among the actors of the supply chain.

4. Conclusions

This paper aimed to outline the main characteristics and claimed benefits of local food systems as described in the scientific literature, as well as analyse and evaluate the logistical impact of a local distribution system. According to the literature, local food systems are characterised by geographic proximity, fewer intermediaries, smaller business size, and often more environmentally friendly production practices. If local food supply chains are developed to improve sustainability or to increase the availability of healthy food products, these factors need to be examined in depth. A decrease in distance or a decrease in the number of links in the chain does not necessarily mean that sustainability or health is improved. On the contrary, our exploratory quantitative analysis of local food supply chain scenarios shows that direct shipments from farmers to a market or store where consumers pick up the products is generally the least efficient in terms of logistics costs and environmental impact. This result

suggests that the use of cooperation and coordination in the supply chain, e.g., by means of a logistics service provider, gives more efficient and sustainable local supply chains. Extensions of the quantitative analysis shown in this paper with focus on collaborative approaches towards local food supply chains would provide additional decision support, and could provide a structured basis to discuss the costs and benefits of a transition towards more localized future food systems.

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Appendix: Data sources

Distances retrieved from Google Maps; CO_2 data retrieved from NTMcalc 4.0 (https://www.transportmeasures.org/ntmcalc/v4/basic/index.html#/); Costs per km of vans and trucks retrieved from https://detransporters.nl/tarieven/; Costs per km of cars retrieved from ANWB.

Table A1. Farm shop scenario

Transportation step	Type of vehicle System defaults	Weight (tonnes)	Distance (km)	CO_2 equivalents	Costs
Farm Carrots to PP 600 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	30.2	7.34	19.93
Farm Onions to PP 400 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	27.6	6.71	18.22
PP to farm shop 1000 kg packages	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	50.4	12.25	33.30
Farm shop to consumers	Car CO_2 fuel use 0.073 l/km cold start Cost fuel use 0.077 l/km; € 1.55/l	Retour trip 1 person	8984	2007.42	2142.27
Total			9091.9	2033.72	2213.69

Table A2. Supermarket scenario Flevoland

Transportation step	Type of vehicle System defaults	Weight (tonnes)	Distance (km)	CO_2 equivalents	Costs
Farm Carrots to PP 600 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	30.2	7.34	19.93
Farm Onions to PP 400 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	27.6	6.71	18.22
PP to DC 1000 kg packages	Truck<7.5 tonnes Load capacity 5 t Cargo load factor 40% € 0.83/km	Single trip – combined with other products →load 1 tonne of 5 used (1/5 of costs)	88.2	15.6	14.60
DC to Supermarkets	Truck 14-20 tonnes Load capacity 12 tonnes Cargo load factor 40% € 1.10/km	Single trip – combined with other products →load 1 tonne of 12 used (1/12 of costs)	39.0	5.05	3.58

Supermarkets to consumers	Car CO_2 fuel use 0.073 l/km cold start Cost fuel use 0.077 l/km; € 1.55/l	Retour trip 1 person 1 km distance 50% by car	1000.0	154.30	119.2
Total			1185.0	189.00	175.59

Table A3. Supermarket scenario Standard Retail Practice

Transportation step	Type of vehicle System defaults	Weight (tonnes)	Distance (km)	CO_2 equivalents	Costs
Farm Carrots to PP 600 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	78.7	19.14	51.94
Farm Onions to PP 400 kg raw	Van Load capacity 1.5 tonnes Cargo load factor 20% € 0.66/km	Single trip – single purpose →max load of 0.3 tonnes used	58.3	14.17	38.48
PP to DC 1000 kg packages	Truck<7.5 tonnes Load capacity 5 tonnes Cargo load factor 40% € 0.83/km	Single trip – combined with other products →load 1 tonne of 5 used (1/5 of costs)	46.7	8.27	7.75
DC to Supermarkets	Truck 14-20 tonnes Load capacity 12 tonnes Cargo load factor 40% € 1.10/km	Single trip – combined with other products →load 1 tonne of 12 used (1/12 of costs)	39.0	5.05	3.58
Supermarkets to consumers	Car CO_2 fuel use 0.073 l/km cold start Cost fuel use 0.077 l/km; € 1.55/l	Retour trip 1 person 1 km distance 50% by car	1000.0	154.30	119.2
Total			1222.7	200.92	220.98

Table A4. Calculations from farm shop to consumers

District	Inhabitants 2017*	Consumers per 1000	Central street	km to farm shop
Almere Stad	108605	541	Marga Klompehof	8.4
Almere Haven	22475	112	Rozenwerf	6.7
Almere Buiten	56120	279	Coendersborgstraat	9.9
Almere Hout	2085	10	Koperwieklaan	5.8
Almere Poort	11625	58	Anubisstraat	15.0

* Inhabitants Almere retrieved from Wikipedia pages of the districts.