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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Vegetable Losses and Waste Along the Supply Chain and Farmers' Willingness to Pay for Recycling: Towards to Green Supply Chain*

Tedarik Zinciri Boyunca Sebze Kayıpları ve Atıkları, Geri Dönüşüm için Çiftçinin Ödeme İstekliliği: Yeşil Tedarik Zincirine Doğru

Selime CANAN[1*], Ebru Nur ULUIŞIK[2]

Abstract

The aims of the study were (i) to determine amount of the vegetable losses and waste generated along the supply chain by production system such as under greenhouse and conventional system in open area, (ii) to explore the amount of willingness to pay for recycling vegetable losses and waste by composting and its determinants, (iii) to reveal the economic feasibility of composting vegetable losses and waste at district level and (iv) to calculate the individual and social cost of vegetable losses and waste along the supply chain by production system in Turkey. The farm level research data were collected from 81 conventional farms and 45 greenhouse farms in the Samsun province of Turkey by using questionnaires. In addition, 50 traders and 17 greengrocers, 13 supermarkets and 9 local marketers were interviewed. When quantifying vegetable losses and waste in mass, vegetable supply chain was examined in five different stages such as production, postharvest handling and storage, processing and packaging, distribution and retail. Contingent valuation method was used to asses willingness to pay of farmers, traders/merchants in wholesale market hall, greengrocer and super markets for composting of vegetable losses and waste. The economic feasibility of recycling of waste was revealed by using the net present value, cost-benefit analysis and internal rate of return. According to the research findings, the loss rates of vegetables produced per hectare in the greenhouse at the farm, wholesaler and retailer levels were respectively 2.2%; 1% and 20.3%. The loss rates of vegetables produced per hectare in the conventional farm at the farm, wholesaler and retailer levels were 3%, respectively; 0.9% and 16.8%. The individual loss of producers in the examined area was 0.67 thousand US $/year. The rates of individual loss of farms to annual agricultural income were 1.7% and 2.4% in greenhouse and conventional farms, respectively. Other individual losses in wholesales, retailer and consumers were 0.25, 4.89 and 1.02 thousand US $, respectively. The total social loss in the examined area was 6.83 thousand US $. When an assessment was made at the national level, the social loss was about 4% of the annual agricultural income. According to the research results, it has been concluded that depending on the amount of losses, the compost production facility to be established in the district can economically recycle vegetable losses and wastes.

Keywords: Vegetable losses and waste, Vegetable production system, Vegetable Supply chain, Willingness to pay, feasibility of waste recycling

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ÖZ

Çalışmanın amaçları (i) örtü altı ve konvansiyonel sistem gibi açık alanda üretim sistemi ile tedarik zinciri boyunca oluşan bitkisel kayıpların ve atıkların miktarını belirlemek, (ii) bitkisel kayıplar ve atıkların geri dönüşümü için çiftçinin ödeme istekliliği miktarını araştırmak, (iii) sebze kayıplarını ve atıklarını kompostlaştırmanın bölge düzeyinde ekonomik fizibilitesini ortaya koymak ve (iv) Türkiye'de tedarik zinciri boyunca sebze kayıpları ve atıklarının bireysel ve sosyal maliyetini üretim sistemine göre hesaplamaktır. İşletme düzeyindeki araştırma verileri, Samsun ilindeki 81 konvansiyonel işletmeden ve 45 sera işletmesinden anketler kullanılarak toplanmıştır. Ayrıca 50 tüccar ve 17 manav, 13 süpermarket ve 9 yerel pazarlamacı ile görüşme yapılmıştır. Sebze kayıplarını ve atıklarını kütlesel olarak ölçerken sebze tedarik zinciri; üretim, hasat sonrası işleme ve depolama, paketleme, dağıtım ve perakende satış olmak üzere beş farklı aşamada incelenmiştir. Çiftçilerin, tüccarların/tüccarların hallerde, manavlarda ve süper marketlerde sebze kayıpları ve atıklarının kompostlanması için ödeme yapma istekliliğini değerlendirmek için koşullu değerleme yöntemi kullanılmıştır. Atıkların geri dönüştürülmesinin ekonomik fizibilitesi net bugünkü değer, maliyet-fayda analizi ve iç karlılık oranı kullanılarak ortaya koyulmuştur. Araştırma bulgularına göre serada üretilen sebzelerin hektar başına işletme, toptancı ve perakendeci düzeyindeki kayıp oranları sırasıyla %2,2; %1 ve %20,3'dür. Konvansiyonel işletmelerde hektar başına üretilen sebzelerin işletme, toptancı ve perakendeci düzeyindeki kayıp oranları sırasıyla %3; %0,9 ve %16,8'dir. Araştırma alanındaki üreticilerin bireysel kaybı ise 0,67 bin ABD Doları/yıl olarak gerçekleşmiştir. İşletmelerin bireysel kaybının yıllık tarımsal gelire oranı seralarda %1,7, konvansiyonel çiftliklerde ise %2,4'dür. Diğer bireysel kayıplar toptancı, perakendeci ve tüketicide sırasıyla 0,25, 4,89 ve 1,02 bin ABD Dolarıdır. Araştırma alanındaki toplam sosyal kayıp ise 6,83 bin ABD Dolarıdır. Ulusal düzeyde bir değerlendirme yapıldığında sosyal kaybın yıllık tarımsal gelirin yüzde 4'ü civarında olduğu görülmektedir. Araştırma sonuçlarına göre ilçede kurulacak kompost üretim tesisinin kayıp miktarına bağlı olarak bitkisel kayıp ve atıkların ekonomik olarak geri dönüştürülebileceği sonucuna varılmıştır.

Anahtar Kelimeler: Sebze kayıpları ve atıkları, Sebze üretim sistemi, Sebze tedarik zinciri, Ödeme istekliliği, Atık geri dönüşüm fizibilitesi

1. Introduction

For several decades, rapid increase in the world population has caused to intensive use of resources due to pressure of food demand. Nations have exhibited tremendous effort to ensure food security and food safety. Despite all remedies that put into practice for balancing food supply and demand, response of food production to the increasing food demand has become more complex issue. Most nations have focused on alternative ways to reduce the pressure of food demand on resources to provide more sustainable food production. Therefore, food losses have come into the agenda worldwide. The issue of reducing the food losses along the food supply chain have increased their importance more and more in agriculture and food industry. Especially, the product losses along the fresh vegetable supply chain (VSC) had priority due to they are perishable. However, stakeholders of fresh VSC have ignored the product loss. Unfortunately, product wastes have been disposed by randomly landfilling and it hindered the switching to green supply chain. Lipinski et al. (2013) suggested that food losses at the levels of production, retail and consumer in developed country were 10%, 5% and 28%, respectively, while that of developing countries were 14%, 7% and 7%, respectively. Although product losses may vary depending on plant type, varieties and production system, the amount of food loss in Turkey was 26 million tons/year (Salihoğlu et al., 2018). Reducing the food losses along the supply chain was complex issue having multiple level and actors and it was very difficult to reduce food losses with current management practices. There has been in need of changing production and marketing structure and habits of actors take place along the supply chain such as producer, traders, merchants, consumer etc. This situation forces the actors take place along the supply chain and policy makers to reduce food losses. In Turkey, vegetables have produced both in open area and under greenhouse and high level of food loss and waste along the VSC. However, quality data about food losses along the supply chain associated with farm type in vegetable production were required by farmers, other actors in VSC and policy makers to develop action plan for reducing vegetable losses and waste (VLW). The issue of reducing food losses has been required urgent solutions and good quality of data related to amounts of food losses along the supply chain, and opportunity cost of recycling it. Up to now, lots of studies have been conducted on food losses and reduction of food losses. While studies on food losses were quite high in developed countries, there has been very limited study on food losses in developing countries, as well as Turkey. Some previous studies examined the amount of food loss and reasons behind the food losses focusing on specific product, or product groups (Hazarika, 2006; Gangwar et al., 2007; Hazarika, 2008; Khan et al., 2008; Murthy et al., 2009; Sharma and Singh, 2011; Bahattarai et al., 2013; Abass et al., 2014; John, 2014; Kalidas and Akila, 2014; Arah et al., 2015a; Rehman et al., 2015; Jha et al., 2016; Kirigia et al. al., 2017; Bantayehu et al., 2018; Chegere, 2018; Verma et al., 2019). On the other dimension, some researchers focused on the issues of reducing and recycling of food waste (Jeger and Plumbley, 1988; Basavaraja, 2007; Gajanana et al., 2011; Begum et al., 2012; Ku et al., 2013; Kannan et al., 2013; Adepoju, 2014; Kiaya, 2014; Arah et al., 2015b; Kumari and Pankaj, 2015; Kumar and Kalita, 2017; Rahiel et al., 2018; Tadesse et al., 2018; Krijger et al., 2020). Some studies compared the reasons of product losses in developed countries with those of developing countries (Hodge et al., 2011; Prusky, 2011). However, there has been a limited number of studies related to exploring the relationships between pesticide use and food losses (Harris and Lindblad, 1978; Cappellini and Ceponis, 1984; World Resources, 1998). There have been also a few studies focusing on food losses and recycling of food wastes in Turkey and these studies examined the food losses in terms of technical aspects and oulined the general situation by using macro level data (Sessiz and Özdemir, 2007; Baran et al., 2012; Demirbaş et al., 2017; Tatlıdil et al., 2013; Demirbaş and Gölge, 2018; Salihoğlu et al., 2018; Demirbaş, 2018; PHP, 2019; Çiftçi and Demirbaş, 2020; Alabouıd and Bayhan, 2022). When glancing at the economic aspect of the food losses, it has been clear that the study focusing on VLW along the supply chain and economic feasibility of recycling VLW by production system such as under greenhouse and conventional methods in open area was scarce worldwide. Also, there has been less or no study related to VLW along the supply chain and the feasibility of recycling product losses in Turkey. Despite the previous study conducted by Erden et al. (2017), Elik et al. (2019) and Bayramoğlu et al. (2020) examined the food losses along the supply chain and designing the strategy for reducing food waste in Turkey, they ignored the differences arising by production system. This research gap has motivated the research. Therefore, the study intended to fill information gap existing in literature due to there has been no information about the amount of VLW along the supply chain by production system such as under greenhouses and conventional system in open area. The study tested the prior hypothesis of whether the amount of VLW has changed associated with production system, or not at first. Following the study focused on the hypothesis of whether VLW was more in retail level comparing to the harvest and post-harvest losses. The study also tested the hypothesis of whether switching to green supply chain by composting the VLW at district level was economically feasible, or not. The objectives of the study were (i) to determine amount of the VLW generated along the supply chain by production system such as under greenhouse and conventional system in open area, (ii) to explore the amount of willingness to pay for recycling VLW by composting and its determinants, (iii) to reveal the economic feasibility of composting VLW at district level and (iv) to calculate the individual and social cost of VLW along the supply chain by production system in Turkey.

2. Materials and Methods

2.1. Research coverage and data

Research focused on the VLW along the VSC, reasons behind the losses and feasibility of composting food waste. VSC was examined in five different stages, which were production, postharvest handling and storage, processing and packaging, distribution and retail. The research covered the active stakeholders along the VSC such as vegetable farmers, wholesale level traders and merchants, retail level actors such as greengrocers, supermarkets and seller at local bazaar. Since it was an appropriate environment that allows comparison due to the summer and winter vegetable have been produced both under greenhouses and in open area together, Çarşamba district of the Samsun Province of Turkey was selected as a case and identified as a research area. Carşamba District, which forms one of the fertile delta plains of the Yeşilırmak river, has an area of 69129 ha (Anonymus, 2021a). The average altitude above sea level was 128 meters. 72% of the villages of the district were settled on the plain. The district has a humid and temperate climate. The annual average precipitation was 936,9 mm and the annual average temperature was 15,1 °C. (Anonymus, 2021). There was a total of 57 thousand hectares of agricultural land in the district, 4.68% of it was vegetables. There was also 911 hectares of meadow pasture and 6 thousand hectares of forest in the research area (Anonymous, 2021a; Anonymus, 2021b). The most common vegetables are beans, tomatoes, peppers, eggplants, cucumber, lettuce, cabbage, parsley. Lettuce, cucumber, tomato, pepper and eggplant were the main vegetables under greenhouse production (TUIK, 2020). The average farm size was 2,73 hectares. Map of the research area was depicted in *Figure 1*.

Farm level research data were collected from randomly selected 27 greenhouse farms and 81 conventional farms produced vegetable in open area in Çarşamba district of Samsun province, Turkey. Questionnaires were administered to the operators of sample farmers in 2020 considering the production year of 2019-2020. Regarding the wholesale actors of supply chain, wholesale research data were gathered from 50 traders/merchants, which was all active traders/merchants in Çarşamba wholesale market hall by using semi structured interviews. For the retail level data, well designed questionnaires were administered to randomly selected 17 greengrocers, 9 sellers from district bazaar and managers of 13 supermarkets.

Figure 1. Map of the research area

2.2. Determining amount of the VLW and its cause along the supply chain

VLW was explored along the VSC with the case of Çarşamba district of Samsun province in Turkey. VSC included the farm level such as greenhouses and conventional production in open area, wholesale level such as traders and merchants, and retailer level actors such as greengrocers, super markets and sellers in local bazaar. After removing non-human use of vegetable and reducing losses such as harvest losses, packaging and transportation, edible vegetable produced for human consumption started to travel from both greenhouse and conventional farms to traders/merchants that took place in wholesale market hall. Post-harvest losses such as handling, storage etc. was occurred in this stage. Then edible vegetables reached to greengrocers, sellers in local bazaar, or supermarkets. Finally, edible vegetables were eaten by consumers (*Figure 2*).

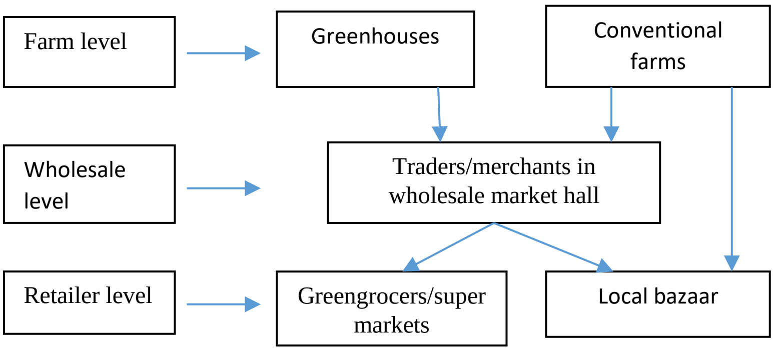

Figure 2. Vegetable supply chain

In the study, VLW was defined as decrease in the amount of edible vegetable in mass produced for consumers along the VSC from harvest to consumption. VLW were quantified by using the framework suggested by HLPE (2014) due to being easy to apply and easy to relate to specific data. Based on the FAO (1981), Stuart (2009), Parfitt et al. (2010), FAO (2011), Gunders (2012), Gustavsson et al. (2011) and HLPE (2014), FW occurred at consumer level and FL occurred any stage before the consumer level, regardless of the real underlying explanatory cause, and regardless of its behavioural character or not, or of its voluntary character or not. Non-avoidable waste was not considered as a VLW in the study. When quantifying VLW in mass, VSC was examined in five different stages such as production, postharvest handling and storage, processing and packaging, distribution and retail. Monetary losses in mass (ML) were also calculated in the study. HLPE (2014) suggested that loss of value added linked to the degradation of the food quality or to food loss or waste could take place at every step of the food chains. Time could be an important determinant of ML. When calculating the ML, prices of good quality vegetable, prices of lower quality vegetable, discounts applied in greengrocers and super markets and transaction costs of supply chain agents such as merchants, retailers and market operators etc. Since the vegetable was composite variable including many species, weighted average value of prices was considered by using the share of species in total vegetable mass. Same approach was also adopted for calculating transaction costs.

The causes of VLW along the supply chain were explored at micro, meso and macro level. The definitions of micro, meso and macro level causes at the behind of food loss and waste suggested by HLPE (2014) were used in the study. Micro-level cause was defined as the causes of food loss and waste at each particular stage of the food chain from production to consumption. Meso-level cause dealt with organization of different actors, relationships along the food chain and state of infrastructures etc. and it could be found at another stage of the supply chain. Macro-level cause was related the factors explained by more systemic issues such as a malfunctioning food system, the lack of institutional or policy conditions to facilitate the coordination of actors (including securing contractual relations), to enable investments and the adoption of good practices (HLPE, 2014).

2.3. Exploring the amount of willingness to pay for composting VLW and its determinants

Contingent valuation method (CVM) was used to asses willingness to pay (WTP) of farmers, traders/merchants in wholesale market hall, greengrocer and super markets for composting of VLW. The specific question used in the analysis was a hypothetical scenario-based question that asked respondents about their willingness to pay for the composting of VLW. The exact wording of the question typically presented a situation where the respondents are asked how much they would be willing to pay for a certain environmental service, in this case, the composting of VLW. This hypothetical scenario question is chosen because it allows researchers to gauge the monetary value individuals place on the given service, even though it might not currently have a market price.

According to the question type feature, the maximum amount of expressed willingness to pay was determined. The reason for choosing this method and question type lies in the nature of the service being assessed – composting of VLW. Since this service might not have an established market value, it is necessary to elicit individuals' preferences and their monetary valuations through a structured question. The hypothetical scenario question helps simulate a market-like situation where respondents express their stated willingness to pay, which can then be analysed to understand the potential economic value of the composting service to different stakeholders. CVM has been commonly used method, when an individual was asked to important to understand what is the individual's WTP to composting of VLW in mass generated along the VSC (Hanemann, 1984, Johansson et al., 1985, Mitchell and Carson, 1989, Akgüngör, et al., 1999; Winpenny, 1991). For farmers, bazaar sellers, traders/merchants in wholesale market hall, greengrocer and super markets, to explore information on WTP in a detail, we need a statistical model that relates individuals' responses to monetary amounts. Multiple regression model was used to explain variations in their willingness to pay for composting vegetable waste. While analysing the model, business data was divided into three groups as farmers, wholesalers and retailers. Generally, the WTP was a function of socio-economic variables (Hanemann, 1984; Johansson et al., 1985; Danso et al., 2002; Abdullahi et al., 2023; Yelboğa et al., 2023). The general form of multiple regression model constructed for determining the determinants of WTP is depicted below.

$$WTP = \alpha + \beta X + e \qquad \text{(Eq.1)}$$

where α is constant, X is the explanatory variables, β is an unknown parameter, and e is the disturbance term, which is normally distributed.

The explanatory variables of the WTP model were income (1000 US $/year), age (year), gender, education, experience of operators (year), labour (MLU) and operating capital (1000 US $/year) Gender was a dummy variable and 1 was assigned for male and 0 was assigned for female in the model. The variable of education was proxy variable. Primary school was included into the model by using 1, while that of secondary school, high school and university were 2,3 and 4, respectively. VSC actors were included into the model as dummy. When the respondent was producer (conventional or greenhouse), in first dummy (D1) variable producers equalled, 1 while the rest were 0. In second dummy (D2), wholesalers equalled 1, while that of other VSC actors were 0. In third dummy variable (D3), all retailers were assigned 1, while that of others were 0 (*Table 1*).

Table 1. Description of explanatory for linear regression model

Variable name	Description of variable	Greenhouse[1]	Conventional farm[1]	Retailer[1]	Wholesale[1]
		Mean	Mean	Mean	Mean
WTP	US $/year	750.00 (137.78)	1722.22 (512.16)	14222.31 (5501.30)	18144.10 (929.80)
Gender of operators	male = 1. female = 0	0.93 (0.01)	0.91(0.03)	0.95 (0.02)	0.90 (0.03)
Age of operators	year	51.48 (2.30)	52.61 (2.49)	49.44 (13.20)	54.00 (12.34)
Education level of operators	primary school = 1. secondary school = 2. high school = 3 and university = 4	2.48 (0.20)	2.36 (0.24)	2.64 (0.82)	2.60 (0.77)
Experience	year	31.35 (3.76)	30.18 (8.37)	18.13(5.26)	24.74 (2.83)
Labour	MLU	8.58 (0.28)	6,73 (0.26)	1.62 (0.63)	6.04 (2.02)
Operating capital	1000 US $/year	1048.31 (866.78)	1361.14 (735.99)	6203.13 (2743.17)	8816.59 (1398.01)
Income	1000 US $/year	116.91 (1.24)	106.07 (0.98)	4346.79 (1433.10)	7902.37 (994.11)
Dummy	D1: farmers=1, others=0, D2: wholesalers=1, others=0, D3: retailers=1, others=0	0,04 (0,20)	0,59 (0,49)	0,14(0,35)	0,23(0,42)

1The numbers in parentheses indicate the standard error.

In order to determine the most appropriate regression model, the linear model with the highest coefficient of determination and the smallest standard error among the tried models was preferred. While applying the linear regression models, care was taken to provide the necessary assumptions such as the conformity of the data to the normal distribution, the constant variance of the error terms, and the absence of autocorrelation problem between the error terms.

2.4. Examining the economic feasibility of composting VLW at district level

When economically analysing the alternative of switching to composting, the wet weight of the VLW generated in Çarşamba district was considered 34378 tons, on average. Dry weight of VLW was 20% of its wet weight. The amount of produced compost was equal to 50% of dry VLW. The average dry weight of VLW in Çarşamba was 6876 tons, resulting in 3438 tons of compost in a year. The price of compost per ton was 409.36 US $. If VLW generated along the VSC in Çarşamba were composted, it would be annually gained extra revenue by approximately 1.46 million US $. Based on the quantity of VLW along the VSC in Çarşamba, for constructing district level compost plant with 5 tons of capacity per day, 3500 m^2 of land and investment by 541.435.44 US $ were required to compost generated VLW along the VSC. It was assumed that district level compost plant was actively worked along with the 10 months in a year for producing compost. Economic life of the district level compost plant was 10 years. Required investment per ton for composting was 15.79 US $. The cost of raw material was also included by 66.128.69 US $ in order to consider the opportunity cost in the feasibility analysis. The cost of cleaning raw materials from inorganic materials in compost plant was 19.838.60 US $. And the cost of raw material purchasing/collecting was 66.128.69 US $.

A technician, 3 workers and an office staff work at the compost plant. In addition, 2 workers who will collect the VLW from the lost collection centres and deliver them to the facility work with a mini garbage truck. Farms sell their VLW to this facility for 2.92 US $/per tonne, both recycling the VLW and covering the transportation costs. Others in the VSC leave the VLW to the VLW bins, where the compost plant collect the VLW and transport it to the plant. on the other hand, the compost plant has the opportunity to earn economic profit by selling the compost it produces directly to farmers or fertilizer distributor. Thus, VLW will be offered to farms again as compost (*Figure 3*).

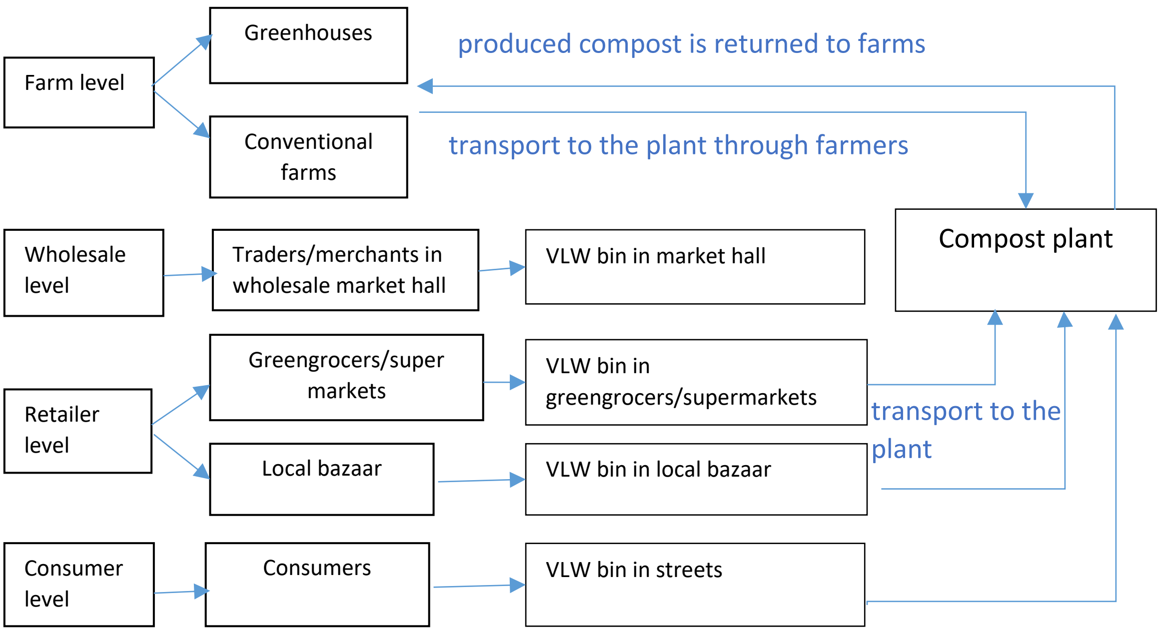

Figure 3. Compost production process

The analyses used to test the economic feasibility of recycling VLW in the compost plant in the district are given below:

(Net Present Value): $NPV = \sum_{t=0}^{n} CFt \div (1+r)^t$ (Eq.2)

where:

CFt=net cash flow during a single period t r=discount rate(0,12)

t=time period cash flow

n=number of periods (10 year)

(Cost Benefit Analysis): $NPV = \sum_t^n \frac{Bt-Ct}{(1+r)^t} = \sum_t^n \frac{Nt}{(1+r)^t}$ (Eq.3)

where:

B=benefits

C=costs

N=net results

(Internal Rate of Return): $IRR = r_a + \frac{NPVa}{NPVa-NPVb}(r_b - r_a)$ (Eq.4)

where:

ra=lower discount rate chosen (0,05)

rb=higher discount rate chosen (0,20)

Na=NPV at ra

Nb=NPV at rb

2.5. Calculating the individual and social cost of VLW along the supply chain

The social cost calculation aimed to provide a comprehensive understanding of the economic implications of VLW on a larger scale, beyond the individual or farm level (Buzby et al., 2014; ReFED, 2016; Stenmark et al., 2016). By quantifying the total economic losses associated with wasted vegetables, the study was highlighting the significance of reducing waste and improving waste management practices within the vegetable production and distribution system (Buzby et al., 2014; ReFED, 2016; Stenmark et al., 2016; Campoy-Muñoz et al., 2017). The results of the social cost calculation were used in various ways to guide policy and decision-making processes in conclusions.

Individual costs were calculated for each level of VSC. While calculating individual costs, the loss amount of each vegetable variety was multiplied by its price. Çarşamba district and national losses were calculated by area rate based on the areas of the sample farms. The social cost of VLW was calculated by adding up the individual losses at the national level.

2.5. Statistical analysis

Parametric methods (t-test and analysis of variance) for continuous and normally distributed variables in the comparison of waste types and amounts in tomato production, alternative recycling methods, and loss amounts caused by using inappropriate waste recycling method by management types, greenhouse types and provinces. Non-parametric methods (Chi-square, Friedman, Kruskall Wallis, Mann Whitney U, Wilcoxon, Duncan multiple comparison test etc.) were used when the measurement levels of data were nominal and ordinal level.

3. Results and Discussion

3.1. Farm attributes

In the research area, greenhouses and conventional farms produce vegetables on 0.614 and 1.687 ha, respectively. Pepper (35%), tomato (26%), eggplant (17%), cucumber (17%), bean (4%), lettuce and parsley (0.1%) were produced in greenhouse lands. Bean (53%), pepper (22%), tomato (13%), eggplant (9%), zucchini (2%), cucumber (1%), lettuce, spinach, onion and pea (0,1%) production were found in the supply of conventional farms.

Operators of greenhouses were younger. The family labour force and the number of households in operators of conventional farms was higher. The operating capital, total capital, farm income per labour force, farm income, gross income, net return on total capital, rate of return on total capital and rate of return on operator’s capital of greenhouses were higher than conventional farms. According to the results of comparative socio-economic analysis, there was a statistical difference between the farm size, farm income, gross income of conventional farms and greenhouses (*Table 2*).

Table 2. Socio-economic characteristics of vegetable farms

Variables	Greenhouses[1]	Conventional farms[1]
Age of the farm operator (year)	51.48 (2.30)	52.61(2.49)
Labour (MLU)	1.33 (0.24)	1.40 (0.23)
Family size (person)	4.00 (0.28)	4.00 (0.26)
Farm size (ha)*	0.614 (0.68)	1.687 (5.79)
Operating capital (1000 US $/ha)	249.61(186.36)	117.96 (185.88)
Total capital (1000 US $/ha)	2330.81(33.34)	1860.26(46.43)
Farm income (1000 US $/ha)**	278.37 (9.08)	91.93(1.73)
Farm income (1000 US $/MLU)	128.51(38.39)	110.77(47.27)
Gross income (1000 US $/ha)**	217.61(19.30)	109.34 (15.98)
Net return on total capital (1000 US $/ha)	13.67 (0.78)	3,41 (1.84)
Rate of return on total capital	5.45(2.48)	4.80 (1.46)
Rate of return on operator's capital	11.49(2.64)	9.48(2.79)

1The numbers in parentheses indicate the standard error.
* The difference between farms protected the environment and conventional is statistically significant at 1% probability level.
**The difference between farms protected the environment and conventional is statistically significant at 10% probability level.

3.2. Losses along the VSC by production system

824 kg of vegetables produced in one-hectare greenhouse and 502 kg of conventionally produced vegetables were lost during the production. Disease and pest control in the examined farms was carried out entirely by chemical means. During this application, the farms generally stated that they paid attention to the recommended dose. However, they added that when they could not reach a solution, they could use more pest than necessary or turn to a different pest. 6.66% of greenhouses lose vegetables due to wrong spraying. Conventional farms, there was no farm that lost product due to wrong spraying. While 57% of greenhouses bore diseases, 73% of conventional farms bore diseases. In addition, 9% of greenhouses bore pest, while 8% of conventional farms bore pest. The difference in disease and pest bearing rates between the two farm types reveals that conventional farms were more at risk for vegetable loss.

Vegetable farming requires intensive workforce. Seedling planting, hoeing and harvesting require a lot of labour. Therefore, the ability and knowledge of temporary and permanent workers was very important in terms of reducing VLW. In the research area, labour deficiencies that will result in VLW during the production process were not encountered. However, 3.70% of conventional farms experience VLW due to labour during the hoeing. Farm was not found in the greenhouses that experienced VLW due to hoeing.

In the research area, disasters such as floods, hail, and frost were not observed during the 2019-2020 production period. However, in the past years, most of the vegetables have been lost due to such disasters. Compared to greenhouses in conventional farms, more product loss occurs due to climate. Despite this, the rate of vegetable farms that have insurance against VLW caused by hail, storm, tornado, fire, landslide, earthquake, flood and flood risks was 4.4% in greenhouses and 2.5% in conventional farms.

The most critical process in terms of VLW was harvest. The losses that occur during the harvest phase directly cause a decrease in the income of the farms. The rates of losses at the harvesting of vegetables produced in a hectare greenhouse and conventional farm were 1.3% and 2.3%, respectively. While the rates of greenhouses experiencing losses during the harvesting due to temporary workers and other reasons (weight loss, rash appearance, shrinkage, etc.) were respectively,27.93% and 91.11%, the rates of conventional farms were 25.92% and 93.82%, respectively (*Figure 4*). The vegetable that temporary workers cause the most loss was tomato in greenhouses and conventional farms. Due to the soft and delicate structure of tomatoes, there was a possibility of more crushing and damage. For this reason, it was the product that needs more care during harvest. Adepoju, in his study in Osun State of Nigeria in 2014, found that Ogbomosho farmers lost 95.5% of their tomato income after harvest. Arah et al. (2015a) emphasized that postharvest losses in tomatoes were partially affected by preharvest practices (fertilization, pruning, variety selection, irrigation, etc.). Vegetables, most of which are harvested by hand, must be plucked from the branch without damage by the harvesting workers. Freshness was one of the most important features sought in the products to be taken to the trader. For this reason, harvests were divided into time and made at frequent intervals. In this process, the availability, experience and skills of temporary and permanent workers were very important. In order to reduce losses, the rates of managers of greenhouse and conventional farms who are willing to attend the farms upon the proposal to participate in the harvest-related course were 44.4% and 54.2%, respectively.

Post-harvest spoiling causes significant economic losses. The reasons such as lack of knowledge about post-harvest physiology, lack of post-harvest storage or unsuitable storage conditions cause increased losses. Post-harvest losses in agricultural products may continue during packaging, transportation and storage of products. The loss rates of vegetables produced in a hectare greenhouse during packaging and selling to the trader were 0.05% and 0.6%, respectively. The loss rates of vegetables produced on a hectare conventional farm during packaging and selling to the trader were 0.1% and 0.59%, respectively. Jeger and Plumbley (1988) stated that spoilage in tropical fruits and vegetables can be managed with an integrated approach that includes biological and environmental control before and after harvest. In the farms examined, vegetables were not stored after harvest and the waiting period of the vegetables that will go to sale after harvest was at most 1 day. Farms sold vegetables immediately after harvesting piecemeal, so that farm-level harvested vegetables did not spoil. During sale of the product to the trader; the packed vegetables were loaded into the farm manager's vehicle and transported to the trader. VLW after the transport belonged to the trader.

Farmers sold vegetables to the fresh vegetable and fruit wholesale hall or directly to the local market (*Figure 3*). All of the greenhouses sold their products to the wholesale hall. Conventional farms sold their vegetables to wholesale hall (89%) and local market (11%). Some of the conventional farms sold their vegetables in the local market by packaging. Vegetables brought to the local market could become unusable due to spills on the ground during sales, as well as losses due to the inability to reach the seller of all the vegetables offered in the local market. Unsold vegetables could spoil prematurely during hot periods when they were put on hold.

The vegetable transferred from the greenhouses was lost to the traders, during the unloading of the product from the operator's vehicle (0.4%), packaging (0.03%), storage (0.5%) and transportation to the retailer (0.1%). The vegetable transferred from the conventional farms was lost to the traders, during the unloading of the product from the operator's vehicle (0.4%), packaging (0.1%), storage (0.3%) and transportation to the retailer (0.9%).

The average amount of vegetables traded by a trader in the fresh vegetable and fruit wholesale hall was 27918.16 kg/year. Traders were buying and selling more than one type of vegetable at the same time. All of the vegetables were loaded into vehicles not as a single type, but as multiple vegetable types. Stabbing the stems of vegetables onto other vegetables during transportation was an important factor affecting the losses. The most used vehicle for transporting products was a pickup truck. This vehicle was widely used because it was fast and convenient for product transportation. The average transportation distance of the traders interviewed was found to be 500 km. The traders were trying to stack them in accordance with the characteristics of the vegetables. Stacking types were crate, sack, bagging, tie method and stacking directly into the frame of the vehicle to be transported. Critical and soft vegetables such as tomatoes were placed in crates. The rate of traders who store different type of vegetables in the same place was 51%. The average storage period was 15 days. The storage capacity at the traders was on average 25 tons. The rate of traders with cold storage was 90%. The ambient temperature of vegetables was 8.41 degrees on average.

Part of the vegetables that reach the wholesale hall from the producer were shipped to the provinces of Ordu, Giresun, Trabzon and Rize provinces to be delivered to the consumer. The other part of the vegetables in the wholesale hall were bought by the greengrocers and supermarkets in the district. Buying periods of vegetables for greengrocers and supermarkets vary. Since there was no storage or cooling process in the examined greengrocers, the loss rates experienced in hot summer periods were high. In supermarkets, the careless choice of consumers when buying vegetables caused crushing of vegetables. Since a different consumer would not want to buy the damaged vegetable, the sale of vegetables became difficult and they were subject to decay over time. The loss rates at retailer level of vegetables produced in a hectare greenhouse and conventional farms were 20.3% and 16.8%.

As a result, the ratio of vegetables reaching the consumer from one-hectare greenhouse and conventional farms was 72.8% and 75.3%, respectively (*Table 3*). There was a statistical difference between the amount of VLW during the pre and post-harvest in greenhouses and conventional farms (t= 6.41, p=0.002).

Doğan (2014) stated that VLW was approximately 8 times higher in developing countries than in developed countries. Kirigia et al. (2017) examined the losses in the VSC from the farm to the consumer in Africa and determined the loss rate as 50%. Rahiel et al. (2018) determined that VLW rate of potatoes and other vegetables pre and post-harvest was between 30% and 50% in the Tigray province of Ethiopia.

Table 3. WLW along the fresh VSC by farm type

	Greenhouse farms			Conventional farms		
	kg	**%**	**%**	**kg**	**%**	**%**
Production losses (a)	824,3			501,7		
Raw production (total harvest)	87564,5			32719,7		
Non-human uses	5253,9			1963,2		
Farm level edible vegetable weight (kg/ha) b	82310,6	100,0		30756,5	100,0	
Losses from farm to traders/merchants (kg) (c)=d+e+f	1772,0	2,2	7,9	929,8	3,0	12,2
Harvest losses (d)	1087,1	1,3	4,9	693,7	2,3	9,1
Farm level packaging (e)	42,8	0,0	0,1	41,7	0,1	1,5
Transportation from farm to trader/merchant (f)	642,1	0,9	2,9	194 ,4	0,6	2,6
Wholesale level weight (kg)	80538,6	97,8		29826,7	97,0	
Post-harvest losses (kg) (g)=h+i+j+k	794,0	1,0	3,5	288,8	0,9	3,8
Handling (h)	301,4	0,4	1,3	131,5	0,4	1,7
Packaging (i)	28,4	0,0	0,1	10,5	0,1	0,1
Storage (j)	355,2	0,5	1,6	104,1	0,3	1,4
Transportation from trader/merchant to retailer (k)	109,0	0,1	0,5	42,7	0,1	0,6
Retail weight (kg)	79744,6	96,8		29537,9	96,1	
Losses in retailer (l)	16691,9	20,3	74,5	5158,5	16,8	67,9
Consumer weight (m)=b-c-g	63052,7	76,5		24379,4	79,3	
Consumer waste(kg)	3152,6	3,8	14,1	1218,9	4,0	16,1
Consumed vegetable (eaten) kg	59900,1	72,8		23160,5	75,3	
Total losses along the supply chain (kg) (n)=c+g+l	22410,5	27,2	100,0	7596,0	24,7	100,0
Total losses along the supply chain including production losses (kg) (o)=a+c+g+l	23234,8			7380,5		

*Consumer waste was considered 5% of the consumer weight based on the results of the studies conducted by Bayramoğlu et al. (2020) and Elik et al., (2019).

The rates of farms that do not recycle VLW in greenhouses and conventional farms was 26% and 57%, respectively. The ratio of farms that used the remaining domes in the greenhouses as tomato paste and offered them for sale was 28.3%. Additionally, the rate of farms that used peppers as paste was 45.7%. While the rate of farms that fed the eggplants remaining in the farms without being sold to the animals was 7%, the rate of the farms that fed the cucumbers to the animals was 4.5%. The ratio of farms that used the remaining domes in the conventional farms as tomato paste and offered them for sale was 27.8%. Additionally, the rate of farms that used peppers as paste was 35.8%. The remaining VLW were not recycled and were thrown away or left in the field.

The traders and retailers did not attempt to recycle VLW. The rate of traders and retailers who throw away their vegetable losses was 77%. The rate of those who sold their vegetable losses at very low prices was 22.45%.

3.3. Willingness to pay for composting of VLW and factors affected the amount of willingness to pay

While the rate of greenhouses that want to recycle VLW was 75%, the rate of conventional farms was 63%. The amounts of WTP were 109.65 US $ for greenhouses and 25.17 US $ for conventional farms. While the rate of retailers that want to recycle VLW was 80%, the rate of wholesalers was 85%. The amounts of WTP were 2079.29 US $ for retailers and 2652.65 US $ for wholesalers.

The rate at which VSC managers explained the total change in the "amount of WTP" was 98% of the variables "gender, age, education, experience, labour, income, and operating capital". The variables of education, income and operating capital of VSC had an impact on the amount of WTP for the expense incurred in recycle of VLW. However, in VSC, the variables of gender, age and experience did not have an effect on the amount of WTP. The increase in the education of VSV, income, and operating capital positively affected the amount of WTP. When the education of the managers increased by 1 level, the amount of WTP increased by 12.30 US $. When income increased by 1 US $, the amount of WTP increased by 0,002 US $. When operating capital increased by 1 US $, the amount of WTP increased by 0,001 US $. There is a positive relationship among WTP and all types of VSC (*Table 4*).

Table 4. Factors affecting willingness to pay

	Coefficients	**Standard Error**	**T value**	**P value**
Experience	0,535	1,705	0,314	0,754
Gender	0,032	0,057	0,568	0,571
Age	-0,953	1,433	-0,665	0,507
Education	12,298	21,520	5,715	0,019*
Labour	1,087	2,255	0,482	0,630
Income	0,002	0,001	5,913	0,001*
Operating capital	0,001	0,001	5,891	0,021*
D1	235,323	93,684	2,512	0,033*
D2	774,969	118,647	6,532	0,001*
D3	397,968	177,821	2,238	0,026*
R^2	0.982	1513.77	-	-
F	1094.38	-	-	0,001*

* Significant at 5% probability level.

3.4. Economic feasibility of composting VLW at district level

Several alternatives were considered when determining VLW management strategies for farms in the VSC. There was a tomato paste plant in Bafra where another district of Samsun Province. Tomato and pepper paste were produced in the plant. The vegetable farms in Çarşamba District did not sell their tomatoes and peppers to this plant due to the length of the road and because they did not have any contracts. Selling the tomatoes and peppers directly to the tomato paste plant from the farms secured by the contract would have been one of the best alternatives to reduce the loss of these products. However, the vegetable farms in Çarşamba district were not only producing tomatoes and peppers. The VLW recycling method, which would include other vegetables, would be more inclusive.

When farms bought a forage machine to convert VLW into animal feed or a drying oven to dry, the return on capital did not exceed the opportunity cost. Since Samsun Province had humid weather conditions, it was not possible to dry vegetables by using the sun. In addition, dried vegetables were turned into food and legal permission was required during the packaging or processing stages of the food. There were separate costs for all these. When the farms wanted to take VLW to the biogas plant in Samsun, they would cover the transportation costs themselves and would not earn any income. However, if the farms gave VLW to the compost plant in the district for a certain fee, they would have covered the costs of transportation. If the VLW from other stakeholders of the VSC were also collected from VLW collection centres, the plant could produce more compost and the farmers could benefit from more compost.

The compost production process was planned according to the attitudes and behaviours of all stakeholders in the VSC (*Figure 3*). In the compost production process, farms would carry VLW to the compost plant with trailers for a certain fee. For other stakeholders in the VSC, compost production from VLW would be sustainable if local government distributed VLW bins such as garbage container to collect VLW in fresh fruit and vegetable wholesale hall, local markets, supermarkets/grocers and settlements and if the compost plant collects VLW itself.

Figure 4. Distribution of total product loss along the VSC by farm type (kg/ha)

The initial capital needed for the establishment of the compost plant in the district was 540 thousand US $, which consisted of amount of fixed investment (66.34%) and working capital (33.68%.) The fixed investment amount of the compost production facility was 360 thousand US $, which consisted of machinery (54.84%) and equipment costs, land, construction and VLW collection area costs (41%). The working capital of the facility was 180 thousand US $, which consisted of fixed costs (49%) and variable costs (51%).

Table 5. Feasibility of compost plant

Amount of VLW (tonne/year)	34,378.00
Amount of compost (tonne/year)	3,437.80
Compost price (US $/tonne)	409.36
Compost income (US $/yıl)	1,407,286.55
Machine/equipment cost	196,975.27
Land supply cost	33,260.23
Construction project cost	17,019.59
Construction cost	94,502.92
Fixed investment capital (US $/year)	66,810.80
Fixed costs	88,890.55
Variable costs	93,336.44
Working capital (US $/year)	182,226.99
Initial investment (US $/year)	541,435.44
Net present value (US $/10years)	4,351,498.15
Internal rate of return	0.41
Benefit/cost ratio	2.21
Payback period	less than 1 year

As a result of the 540 thousand US $ investment made in the compost plant today, a net profit of 4.35 million US $ would be obtained with the present value during the 10 years, which is the economic life of the investment. This showed that the project could be done economically. The internal rate of return for the compost plant was calculated as 41%. This value indicated that the investment was profitable, as it was greater than the 12%

opportunity cost of capital. The benefit-cost ratio above 1 means that the present value of the cash inflows to be provided during the useful life of the investment is higher than the present value of the expenses incurred for this investment. In addition, the investment cost of the facility could be paid with cash flow within the first year (*Table 5*).

3.5. Social cost of VLW along the supply chain

The individual cost of farmers in the examined area was 0.67 thousand US $. The individual cost of greenhouses was 1.7% of their annual agricultural income. In conventional farms, this rate was 2.4%. Individual costs of traders were 0.25 thousand US $. The stakeholders of VSC with the highest individual cost were groceries/supermarkets. Individual costs of groceries/supermarkets were 4.89 thousand US $. And individual cost of consumers was 1.02 thousand US $. The total social cost in the examined area was 6.83 thousand US $ (*Table 6*).

When the calculation was made for the whole of Çarşamba district, the individual costs were 796.88 thousand US $ for the farmers. Individual costs of traders were 275.22 thousand US $. Individual costs of groceries/supermarkets were 5201.29 thousand US $. Individual cost of consumers was 1139 thousand US $. And the total social cost was 7412.39 thousand US $ (*Table 6*).

When individual costs were calculated at the national level, they were 216785.58 thousand US $ for farmers. Individual costs of traders were 72067.20 thousand US $. Individual costs of groceries/supermarkets were 133599.64 thousand US $. Individual cost of consumers was 300307.63 thousand US $. And the total social cost was 1925167.95 thousand US $ (Table 6). This value was approximately 4% of the annual agricultural income of 49.27 billion US $.

Buzby et al. (2014) assessed the total value of Food Loss and Waste (FLW) in the United States at $161.6 billion, with meat, poultry, fish, vegetables, and dairy contributing the most. Expanding to the entire food lifecycle, a 2016 report estimated a $218 billion value of FLW in the US, distributed across on-farm, processing, consumer-facing businesses, and households (ReFED, 2016). In the European Union, Stenmark et al., (2016) estimated the value of FLW at approximately 143 billion euros, with households accounting for two-thirds due to higher food value as it moves through the supply chain. Campoy-Muñoz et al., (2017) have directly incorporated FLW into economic models for comprehensive assessment. This study used models based on social accounting matrices to evaluate the impact of reducing avoidable FLW in various sectors across Spain, Germany, and Poland. Findings indicated potential economic output reductions ranging from -1.21% to -2.15%, emphasizing the intricate relationship between FLW and the broader economy.

Table 6. Monetary value of VLW

			Vegetable land (ha)	**Farmers cost (Thousand US $)**	**Trader's cost (Thousand US $)**	**Cost of groceries/supermarkets (Thousand US $)**	**Consumer cost (Thousand US $)**	**Social cost (Thousand US $)**
Individual costs	Greenhouses	Sample farms	0,61	0,30	0,13	2,81	0,53	3,77
		Çarşamba	415,00	201,51	90,29	1898,16	358,51	2548,47
		Türkiye	70897,50	34425,03	15425,21	324277,18	61246,25	435373,67
	Convantional farms	Sample farms	1,69	0,37	0,12	2,08	0,49	3,06
		Çarşamba	2682,90	595,38	184,93	3303,12	780,49	4863,92
		Türkiye	821758,60	182360,55	56641,99	1011730,36	239061,38	1489794,28
	Total	Sample farms	2,30	0,67	0,25	4,89	1,02	6,83
		Çarşamba	3097,90	796,88	275,22	5201,29	1139,00	7412,39
		Türkiye	892656,10	216785,58	72067,20	1336007,54	300307,63	1925167,95

4. Conclusions

The study delved into the examination and recycling of Vegetable Losses and Wastes (VLW) within the Vegetable Supply Chain (VSC) in the Çarşamba District of Samsun Province. The research findings revealed important insights into the stages and factors contributing to VLW, highlighting critical areas for intervention and improvement. Harvest emerged as a pivotal phase causing significant VLW due to manual labor, mishandling, and inadequate training. The research emphasized the necessity of tailored training programs for workers and farm managers to enhance skills, reduce losses, and improve practices during harvesting and packaging. Although VLW-related challenges were shared between greenhouse and conventional farms, the actual quantities of VLW differed, with conventional farms experiencing higher losses. Insurance against VLW was relatively low, especially among conventional farms. Encouraging both farm types, particularly those more vulnerable to natural conditions, to invest in agricultural insurance could play a crucial role in mitigating VLW-associated losses. Recycling of VLW through composting emerged as an economically feasible solution, with a proposed compost plant exhibiting favorable profitability. The research underscored the importance of incentivizing greenhouse and conventional farms to participate in VLW recycling, suggesting the need to focus on enhancing income and working capital for these entities.

The research quantified individual and social losses across various stakeholders within the VSC. These findings further emphasized the economic and environmental significance of reducing VLW throughout the supply chain. It is clear that collaborative efforts involving governments, private sectors, local authorities, NGOs, and educational institutions are essential to effectively monitor and manage VLW, mitigating both individual and societal losses. Future research focusing on geographical variations among greenhouse and conventional farms could enhance the effectiveness of VLW monitoring and recycling initiatives. By systematically addressing the identified challenges and gaps, the vegetable supply chain could become more sustainable, economically resilient, and environmentally conscious, ultimately contributing to the betterment of the entire agricultural sector.

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Ethical Statement

This study was prepared under the permission numbered 2020/758, dated 27.11.2020, from the Ethics Committee of the Social and Human Sciences Ethics Committee of Ondokuz Mayıs University.

Conflicts of Interest

The authors declare no competing interests.

Authorship Contribution Statement

Selime Canan contributed to the project idea, design and execution of the study. Ebru Nur Özmen completed the survey work. Ebru Nur Özmen and Selime Canan analyzed and wrote the manuscript.

References

Abass, A., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N. and Bekunda, M. (2014). Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research*, 57: 49–57.

Abdullahi, A. N., Abubakar, M. I., Ijaekayi, V. and Nahantsi, S. (2023). Households' and Farmers' Willingness to Pay for Improved Municipal Solid Waste Management in Metropolitan Area of Sokoto State, Nigeria.

Adepoju, A. O. (2014). Post-harvest losses and welfare of tomato farmers in Ogbomosho, Osun state, Nigeria. *Journal of Stored Products and Postharvest Research*, 5(2): 8-13.

Akgüngör, S., Miran, B., Abay, C., Olhan, E. anad Nergis, K. N. (1999). Estimation of the potential demand of consumers for environmentally friendly agricultural products in Istanbul, Ankara and Izmir provinces. Agricultural Economics and Policy Development Institute, Project Report 1999-3, Ankara.

Alabouıd, A. and Bayhan, E. (2022). Determination of the loss ratio on some melon varieties from the melon fly, *Myiopardalis pardalina* (Bigot, 1891) (Diptera: Tephritidae). *Journal of Tekirdag Agricultural Faculty*, 19(2): 404-411.

Anonymus, (2021). https://www.tarimorman.gov.tr/Belgeler/Mevzuat/Talimatlar/ToprakAraziSiniflamasiStandartlariTeknikTalimativeIlgiliMevzuat_yeni.pdf (Accessed Date: 06.09.2021).

Anonymus (2021a). https://amasyaobm.ogm.gov.tr/SamsunOIM/Lists/varlik/AllItems.aspx (Accessed Date: 07.09.2021).

Anonymus, (2021b). https://samsun.tarimorman.gov.tr/Belgeler/Yayinlar/Faaliyet_raporlarimiz/2020%20y%C4%B1l%C4%B1%20faaliyet%20 raporu.pdf (Accessed: 07.09.2021).

Arah, I. K., Amaglo, H., Kumah, E. K. and Ofori, H. (2015b). Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: a mini review. *International Journal of Agronomy*, 2015: 478041.

Arah, I. K., Kumah, E. K., Anku, E. K. and Amaglo, H. (2015a). An Overview of post-harvest losses in tomato production in africa: causes and possible prevention strategies. *Journal of Biology, Agriculture and Healthcare*, 5(16): 78-88.

Bantayehu, M., Alemayehu, M., Abera, M. and Bizuayehu, S. (2018). Determinants and extent of pre- and postharvest losses of fruits in northwestern Ethiopia. *International Journal of Sustainable Agricultural Research*, 5(4): 68-75.

Baran, M. F., Ülger, P. and Kayişoğlu, B. (2012). The effect of the table used in canola harvest on harvest losses. *Journal of Tekirdag Agricultural Faculty*, 9(3): 35-44.

Basavaraja, H., Mahajanashetti, S. B. and Udagatti, N. C. (2007). Economic analysis of post-harvest losses in food grains in india: a case study of Karnataka. *Agricultural Economics Research Review*, 20: 117-126.

Bayramoğlu, Z., Karakayacı, Z., Ağıran, K., Ağızan, S. and Bozdemir, M. (2020). *A research on the determination of tomato marketing channels and market margin.* T.R. Ministry of Agriculture and Forestry Research-Development Support Program Project Final Report.

Begum, E. A., Hossain, M. I. and Papanagiotou, E. (2012). Economic analysis of post-harvest losses in food grains for strengthening food security in Northern Regions of Bangladesh. *International Journal of Applied Research in Business Administration & Economics* 1(3): 56– 65.

Bhattarai, R. M., Rijal, R. K. and Mishra, P. (2013). Postharvest Losses in mandarin orange: a case study of Dhankuta District of Nepal. *African Journal of Agricultural Research,* 8: 763-767.

Buzby, J. C., Wells, H. F. and Hyman, J. (2014). The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States. Economic Information Bulletin Number 121, Washington, D. C.

Campoy-Muñoz, P., Cardenete, M. A. and Delgado, M, C. (2017). Economic impact assessment of food waste reduction on European countries through social accounting matrices. *Resource Conserv. Recycle*. 122: 202–9.

Cappellini, R. A. and Ceponis, M. J. (1984). Postharvest losses in fresh fruits and vegetables. In: H.E. Moline (ed.), Postharvest pathology of fruits and vegetables: postharvest losses in perishable crops. *University California Bull*etin 1914: 24-30.

Chegere, M. J. (2018). Post-harvest losses reduction by small-scale maize farmers: The role of handling practices. *Food Policy*, 77(C): 103-115.

Çiftçi, R. and Demirbaş, N. (2020). Factors affecting losses in fruit and vegetable production: The case of İzmir province. *Mediterranean Agricultural Sciences,* 33(1): 85-91.

Danso, G., Fialor, S. C. and Drechsel, P. (2002). Farmers' perception and willingness to pay for urban waste compost in Ghana. *WIT Transactions on Ecology and the Environment*, 56: 231-241.

Demirbaş, N. (2018). Evaluation of Food Waste-Prevention Actions in The World and in Turkey. *VIII. IBANESS Congress Series* – Plovdiv / Bulgaria.

Demirbaş, N. and Shadow, E. (2018). The Utilization of Food Waste in Feed and Fertilizer Production in Turkey: Needs and Challenges. *Proceedings of the IX International Agricultural Symposium*. 04 – 07 October, P.1562-1566. Bosnia and Herzegovina.

Demirbaş, N., Niyaz, Ö. C. and Apaydın, Y. M. (2017). An Evaluation on problems within food supply chain in Turkey in terms of food losses and waste. *International Balkan and Near Eastern Social Sciences Conference Series (IBANESS)*. 5-6 March, P.830-835, Edirne, Turkey.

Dogan, A. (2014). A New storage technology: palistore (palliflex) storagesystem for horticultural crops. *Fruit Science*, 1(2): 1-6.

Elik, A., Yanık, D. K., Istanbullu, Y., Guzelsoy, N. A., Yavuz, A. and Gögüs, F. (2019). Strategies to reduce post-harvest losses for fruits and vegetables. *International Journal of Scientific and Technological Research,* 5(3): 29-39.

Erden, F. F., Dellal, I. and Bayramoğlu, Z. (2017). Food losses and waste in fruits and vegetable agri-food chain in Turkey. *Viii International Agricultural Symposium*. 04 – 08 October, P.2547-2552. Jahorina, Bosnia and Herzegovina.

FAO (1981). Food Loss Prevention in Perishable Crops. FAO Agricultural Services Bulletin 43, Rome, 72.

FAO (2011). SAVE FOOD: Global Initiative on Food Loss and Waste Reduction. URL: SAVE FOOD: Global initiative on food loss and waste reduction | Food and Agriculture Organization of the United Nations (fao.org) (Accessed Date: 07.09.2021)

Gajanana, T. M., Murthy, D. S. and Sudha, M. (2011). Post-harvest losses in fruits and vegetables in South India – A review of concepts and quantification of losses. *Indian Food Packer*, 65(6): 178-187.

Gangwar, L. S., Singh, D. and Singh, D. B. (2007). Estimation of post-harvest losses in Kinnow Mandarin in Punjab using a modified formula. *Agricultural Economics Research Review*, 20: 315-331.

Gunders, D. (2012). Wasted: how America is losing up to 40 percent of its food from farm to fork to landfill. Retrieved April 16, 2019, from NRDC. https://www.nrdc.org/resources/wasted-how-america-losing-40-percent-its-food-farm-fork-landfill (Accessed: 10.01.2022)

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. V. and Meybeck, A. (2011). Global Food Losses and Food Waste: Extend, Causes and Prevention, FAO, Rome.

Hanemann, W. M. (1984). Welfare evaluations in contingent valuation experiments with discrete responses. *American Journal of Agricultural Economics* 66: 332-341.

Harris, K. L. and Lindblad, C. J. (1978). Post-Harvest Grain Loss Assessment Methods. Minnesota, America Association of Cereal Chemist, P 193.

Hazarika, C. (2006). Post-harvest loss and food security — A study on fruits and vegetables in Assam. *Indian Journal of Agricultural Economics,* 61(3): 418-419.

Hazarika, C. (2008). Extent of post-harvest losses of ginger in Assam – A micro level analysis. *Indian Journal of Agricultural Economics,* 63(3): 370-371

HLPE (The High-Level Panel of Experts) (2014). Food Losses and Waste in The Context of Sustainable Food Systems; A Report by The High-Level Panel of Experts on Food Security and Nutrition of The Committee on World Food Security, Rome.

Hodge, R. J., Buzby, J. C. and Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *The Journal of Agricultural Science*, 149: 37-45.

Jeger, M. J. and Plumbley, R. A. (1988). Post-harvest losses caused by anthracnose (colletotrichum gloeosporioides) of tropical fruits and vegetables. *Biodeterioration*, 7: 642–646.

Jha, S. N., Vishwakarma, R. K., Ahmad, T., Rai, A. and Dixit, A. K. (2016). *Assessment of quantitative harvest and post-harvest losses of major crops/commodities in India*. ICAR-All India Coordinated Research Project on Post-Harvest Technology ICAR-CIPHET, PO: PAU, Ludhiana-141004, India.

Johansson, J. K., Douglas, S. P. and Nonaka, I. (1985). Assessing the impact of country of origin on product evaluations: a new methodological perspective. *Journal of Marketing Research*, 22: 388-96.

John, A. (2014). Rodent outbreaks and rice pre-harvest losses in Southeast Asia. *Food Security*. 6 :249–260.

Kalidas, K. and Akila, K. (2014). Micro level investigation of marketing and post-harvest losses of tomato in Coimbartore District of Tamilnadu. *Journal of Stored Products and Postharvest Research*, 5: 1-7.

Kannan, E., Kumar, P., Vıshnu, K. and Abraham, H. (2013). *Assessment of pre- and post-harvest losses of rice and red gram in Karnataka. Agricultural Development and Rural Transformation Centre Institute for Social and Economic Change Bangalore- 560 072*. Research Report: IX/ADRTC/153.

Khan, M., Rahım, T., Naeem, M., Shah, M. K., Bakhtıar, Y. and Tahır, M. (2008). Post-Harvest economic losses in peach production in District Swat. *Sarhad Jorunal of Agriculture*, 24(4): 705-712.

Kiaya, V. (2014). Post-Harvest Losses and Strategies to Reduce Them. Technical Paper on Post-Harvest Losses. Technical paper Scientific & Technical Department, Action Contre la Faim.

Kirigia, D., Kasili, R. and Mibus, H. (2017). African leafy vegetables pre-harvest and post-harvest constrains and technologies for losses reduction along the field to consumer chain. *African Journal of Horticultural Science,* 12: 51-60.

Krijger, I. M., Gerrit, G., Steven, R. B., Peter, W. G., Groot, K., Rokeya, B. S. and Bastiaan, G. M. (2020). Efficacy of management and monitoring methods to prevent post-harvest losses caused by Rodents. *Animals*, 10(9): 2-19.

Ku, K. M., Choi, J. H., Kushad, M. M., Jeffery, E. H. and Juvik, J. A. (2013). Pre-harvest methyl jasmonate treatment enhances cauliflower chemoprotective attributes without a loss in postharvest quality. *Plant Foods for Human Nutrition*, 68(2): 113–117.

Kumar, D. and Kalita, P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. Foods, 6: 7.

Kumari, A. and Pankaj, P. P. (2015). Post-Harvest Losses of Agricultural Products: Management and Future Challenges in India. Recent Trends in Postharvest Technology and Management (pp.141-153). Edition: First. Chapter: Chapter 12. Publisher: Manglam Publishers, New Delhi, India.

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R. and Searchinger, T. (2013). Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute.

Mitchell, R. C. and Carson, R. T. (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for The Future, Washington D. C.

Murthy, D., Gajanana, T. M., Sudha, M. and Dakshinamoorthy, V. (2009). Marketing and post-harvest losses in fruits: its implications on availability and economy. *Indian Journal of Agricultural Economics*, 64(2): 34-43.

Parfitt, J., Mark, B. and Sarah, M. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554): 3065-3081.

PHP (2019). Economic Analysis Report of Post-Harvest Losses for Some Fruits. Innovative Approaches to Reduce Post-Harvest Losses in The Food Chain. http://postharvestproject.com/uploads/outputs/d3270dfd-9d15-4b65-a2b9-9d13567be7e9.PDF (Accessed Date: 21.09.2021)

Prusky, D. (2011). Reduction of the incidence of postharvest quality losses, and future prospects. *Food Security*, 3: 463-474.

Rahiel, H. A., Zenebe, A. K., Leake, G. and Gebremedhin, B. W. (2018). Assessment of production potential and post-harvest losses of fruits and vegetables in northern region of Ethiopia. *Agriculture & Food Security*, 7: 1-13.

Rehman, A., Malik, A. U., Ali, H., Alam M. W. and Sarfraz, B. (2015). Preharvest factors influencing the postharvest disease development and mango fruit quality. *Journal of Environmental & Agricultural Sciences*, 3: 42-47.

ReFED (2016). A Roadmap to Reduce U.S. Food Waste by 20 Percent. Rep. 1-96, Berkeley, C. A.

Salihoğlu, G., Salihoğlu, N. K., Uçaroğlu, S. and Banar, M. (2018). Food loss and waste management in Turkey. *Bioresource Technology*, 248: 88-99.

Sessi, A. and Özdemir, G. (2007). Post-harvest product losses in horticultural products and their causes, *Agricultural Mechanization 24th National Congress*,5-6 September, P. 205-211. Kahramanmaraş, Turkey.

Sharmaa, G. and Singh, S. P. (2011). Economic analysis of post-harvest losses in marketing of vegetables in Uttarakhand. *Agricultural Economics Research Review*, 24: 309-315.

Stenmark, Å., Jensen, C., Quested, T. and Moates, G. (2016). Estimates of European Food Waste Levels. EU FUSIONS, IVL-Rep. C 186, 80, Stockholm, Sweden.

Stuart, T. (2009). Waste – Uncovering the Global Food Scandal. Penguin Books, London.

Tadesse, B., Bakala, F. and Mariam, L. W. (2018). Assessment of postharvest loss along potato value chain: the case of Sheka Zone, Southwest Ethiopia. *Agriculture and Food Security*, 7: 2-14.

Tatlıdil, F. F., Dellal, İ. and Bayramoğlu, Z. (2013). Food Losses and Waste in Turkey, FAO.

TUIK (2020). Vegetable Production Statistics. https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Accessed Date: 20.03.2021).

Verma, M., Plaisier, C., van Wagenberg, C. P. A. and Achterbosch, T. A. (2019). Systems approach to food loss and solutions: understanding practices, causes, and indicators. *Sustainability*, 11(3): 579.

Winpenny, J. (1991). Values for the Environment: A Guide to Economic Appraisal. London: HMSO for the Overseas Development Institute.

World Resources (1998). Environmental Change and Human Health. URL: World Resources 1998-99 | World Resources Institute (wri.org) (Accessed Date: 30.01.2022).

Yamane, T. (1967). Statistics: an introductory analysis, 2nd edition, New York: Harper and Row.

Yelboğa, M. N. M., Sayın, C. and Metin, F. D. (2023). The current issues about waste prevention and willingness to pay: A case study of greenhouse production in Turkey. *Polish Journal of Environmental Studies*, 32(1):.419-426.