The Potential Effects of Developing Different Marketing Channels on Waste Reduction in the Leafy Vegetable Supply Chain in Kermanshah Province

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Abstract

Every year, approximately one-third of the total food produced for human consumption is lost or wasted due to various reasons. This level of wastage has substantial adverse impacts on the environment, economy, and society. Numerous studies have proposed various policies to address the issue of food waste, such as incorporating technology into existing supply chains. However, concerns about their effectiveness and unintended consequences have led researchers to emphasize market-based approaches for waste reduction. The present study was carried out to estimate waste and investigate the potential for developing different marketing channels as market-based approaches to reduce waste in the leafy vegetable supply chain in Kermanshah province. To achieve this purpose, a system dynamics modelling of the waste system in the leafy vegetable supply chain was developed by using the literature review and interviews with experts and stakeholders. The tool for collecting research data was a questionnaire. The statistical population of this study is two groups including 22 experts and 728 actors in the leafy vegetable supply chain. Based on the findings, around 31,000 tonnes (39%) of leafy vegetables are wasted annually across the supply chain. The research scenarios indicate that the establishment of processing industries will effectively decrease the overall waste of leafy vegetables from around 31,000 tons to approximately 20,000 tons annually. Therefore, government initiatives and policies in the field of leafy vegetable exchange in the study area must focus on supporting businesses associated with leafy vegetable processing industries and establishing infrastructure prerequisites for these industries.

Keywords: Food chain, Food waste, Leafy vegetables, Marketing channels, System dynamics modeling

Introduction

A considerable quantity of fresh agricultural products, specifically fruits and vegetables, is annually lost or wasted across different operational channels and levels of the supply chain (Anand & Barua, 2022). This wastage has major economic, environmental, and societal consequences resulting from the inefficient utilization of resources, e.g. land, water, energy, and labor (Ganesh et al., 2022; Parsafar et al., 2023). For instance, the inefficient utilization and wastage of agricultural products at the farm level result in increased expenses and decreased revenue for farmers (Lipinski et al., 2013). Similarly, at the household level, the disposal of food leads to higher expenditures for consumers per unit of food purchased (Latka et al., 2022). Moreover, food waste is one of the most important contributors to greenhouse gas emissions (Amicarelli et al., 2021). Despite ongoing endeavors to accurately measure and implement efficient strategies to mitigate food waste, a comprehensive assessment of the current literature in this area reveals persistent gaps and limitations. The lack of comprehensive global data on food waste, along with restricted geographical coverage, poses challenges in establishing a baseline for tracking progress towards the Sustainable Development Goals. Therefore, there is a pressing requirement for additional studies into the magnitude of food waste and the implementation of effective mitigation strategies, particularly in developing countries.

In Iran, a substantial portion of agricultural products goes to waste each year for various reasons across the supply chain (Nakouzi, 2017). According to the Food and Agriculture Organization of the United Nations (FAO), approximately 35 million tons of agricultural products are discarded annually in Iran, accounting for 2.7% of global food waste (FinancialTribune, 2017). Vegetables are identified as a significant contributor to food waste in Iran, alongside bread, fruit, and rice (FinancialTribune, 2017). Among these vegetables, leafy vegetables have been found to

have particularly high waste rates (Moradi et al., 2023). The primary obstacle in the supply chains of these products is ensuring their freshness from the time they are harvested until they reach the end customer (Kumar & Agrawal, 2023; Mohan et al., 2023). The supply chain can be defined as a complex network of activities, individuals, organizations, information, and resources that work together to ensure the efficient delivery of goods from the initial production stages to the end customer (Van der Vorst et al., 2007). As a result, any challenges or inefficiencies within the supply chain cause a substantial portion of these products to be withdrawn from the consumption chain (Parsafar et al., 2023). Studies indicate that in Kermanshah province, a considerable amount of leafy vegetable production is wasted each year across the supply chain (Moradi et al., 2023). This wastage can be attributed to various factors such as the perishable nature of these products, production challenges, inadequate marketing infrastructure, and improper consumer food consumption management (Abadi et al., 2021; Moradi et al., 2023). In recent years, extensive literature has focused on various strategies to address food waste in the supply chain. These strategies include the implementation of technical solutions at different stages of the supply chain (Gardas et al., 2017; Kör et al., 2022; Magalhães et al., 2022). However, concerns about the effectiveness and potential unintended consequences of these approaches have prompted researchers to highlight the importance of market-based approaches to tackle food waste (Adebola, 2020; Aramyan et al., 2016). The marketing channels that are used have a considerable impact on the waste generated within the agricultural product supply chain. Hence, recognizing the potential of these channels as a form of market-based approach can be effective in guiding the decisions of policymakers and relevant planners to implement appropriate policies and measures to reduce waste. Given the significance of the topic, this study employed system dynamics modelling to quantify waste

and assess the potential of different marketing channels in minimizing waste within the leafy vegetable supply chain in Kermanshah province. System dynamics is a powerful methodology for accurately representing real-world events, which enables the evaluation of different policies on the overall performance of the system over time (Forrester, 1992). The utilization of system dynamics modelling by assessing the interdependencies among various variables within the leafy vegetable waste system provides a comprehensive overview of the efficacy of the suggested waste reduction initiatives. This study seeks to answer questions on what is the exact structure and process of the leafy vegetable supply chain in Kermanshah province, how much waste is annually generated within the leafy vegetable supply chain in Kermanshah province, what will be the projected trend of waste in the leafy vegetable supply chain in the upcoming years, and what impact will the development of different marketing channels have on the overall waste amount in the leafy vegetable supply chain?

Materials and Methods

The geographical area under investigation is Kermanshah province in the west of Iran (Fig. 1). This study specifically concentrated on leafy vegetables within the category of fruits and vegetables. Leafy vegetables hold significant dietary value for Iranians as staple food items, commonly consumed in cooked dishes and desserts. Leafy vegetables encompass various green edible plants, including celery, spinach, leek, watercress, mint, parsley, coriander, etc. In this research, the inclusion of lettuce and cabbage was omitted due to the distinct marketing and sales characteristics of these products compared to other leafy vegetables, as well as the difficulty in monitoring their waste. This study does not differentiate between the terms "food waste" and "food loss" and examines waste within the leafy vegetable supply chain from farm to table. Consequently, the term "leafy vegetable waste" is used broadly in this study to encompass those portions of the products intended for human consumption but are discarded from the supply chain for various

reasons (FAO, 2014; Parfitt *et al.*, 2010).

Sampling method

The statistical population consisted of two categories. The first category comprised national and regional subject matter experts, such as university faculty members, researchers from the Horticulture Research Center, and agricultural experts and managers in Kermanshah province. Additionally, a group of individuals with relevant executive experience were included. This group played a role in ensuring the quality of the questionnaire, identifying the structure and process of the leafy vegetable supply chain, and validating the model and its results. The total number of studied samples in this section was 22 participants who were selected purposefully. The second category focused on stakeholders involved in various sectors of the supply chain, such as farmers, wholesalers and retailers, processing units, and final consumers in Kermanshah province. The data collected from this group was utilized to simulate the research model. In the farmers and households sections, samples were selected in a stratified sampling with proportional assignment, following Cochran's formula to determine the sample size. For the other groups, a full count was conducted. A total of 728 samples were chosen and analyzed, consisting of 172 farmers, 83 wholesalers and retailers, 16 processing units, 384 households, and 73 food services. Furthermore, population data and future trends were calculated based on United Nations (UN) forecasts for Iran's population in the upcoming years (UN, 2018).

Analytical process and method

Identifying research variables and the structure of their interactions

Initially, studying the literature and the opinions of experts and actors using the focus group discussion technique, the structure, and procedure of the leafy vegetable supply chain were compiled.
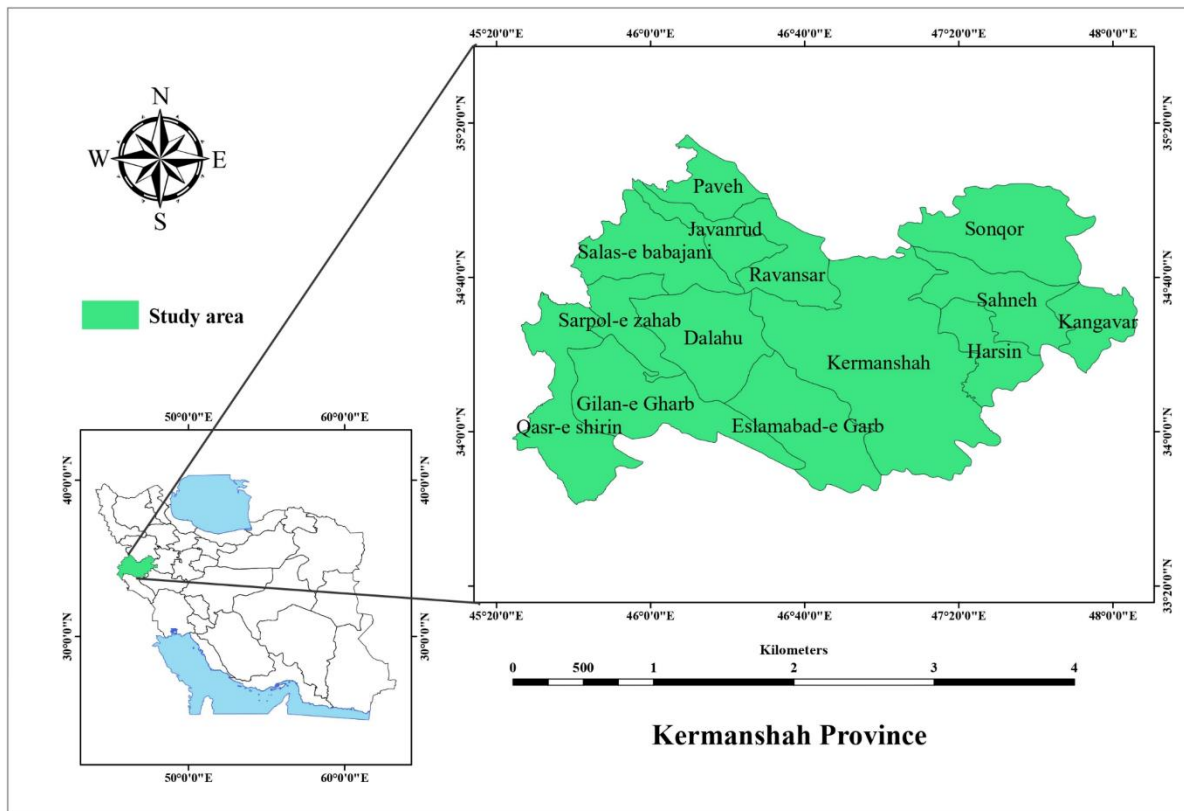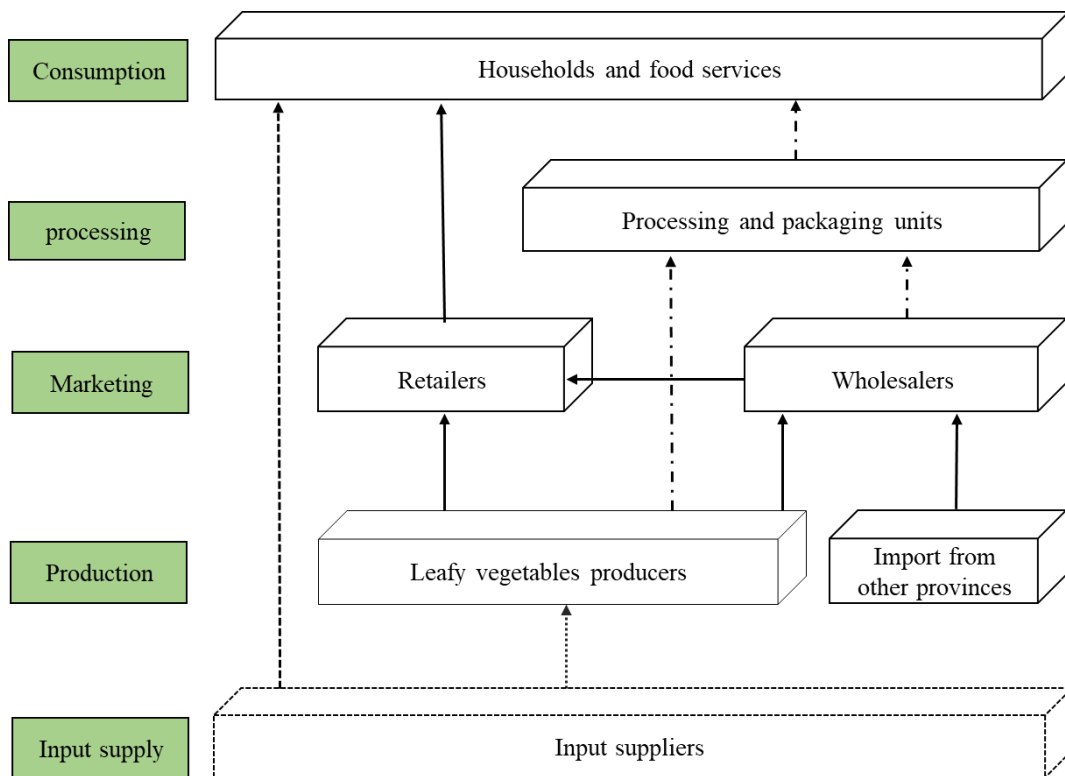
Figure 1– A map of the study area

Figure 2- Leafy vegetable supply chain in Kermanshah province

Leafy vegetable supply chain

In the case of Kermanshah province, the leafy vegetable supply chain can be categorized into five main groups: suppliers, producers (farmers), marketing and distribution (retailers and wholesalers), processing industries, and consumers (food services and households) (Fig. 2).

Marketing channels

Marketing channels refer to the methods through which farmers supply their products to consumers. In Kermanshah province, leafy vegetable farmers utilize a variety of marketing strategies to successfully reach their target customers. One common method is direct marketing, wherein farmers sell their produce directly to customers through stalls and stores

located within the fields or along roadsides. The second approach involves the traditional system of distributing agricultural products to consumers. In this marketing strategy, fresh leafy vegetables are provided to consumers through various markets, including wholesale and retail stores. The third approach entails processing and preparing leafy vegetables in specialized facilities and subsequently distributing them to customers. In this marketing strategy, a portion of the leafy vegetables is transformed into frozen products, while the rest is packaged and delivered fresh to consumers. It is important to note that during the winter season when severe weather conditions restrict local production, a portion of the leafy vegetables required in the study area are supplied from other provinces and subsequently distributed in the market (Fig. 3).
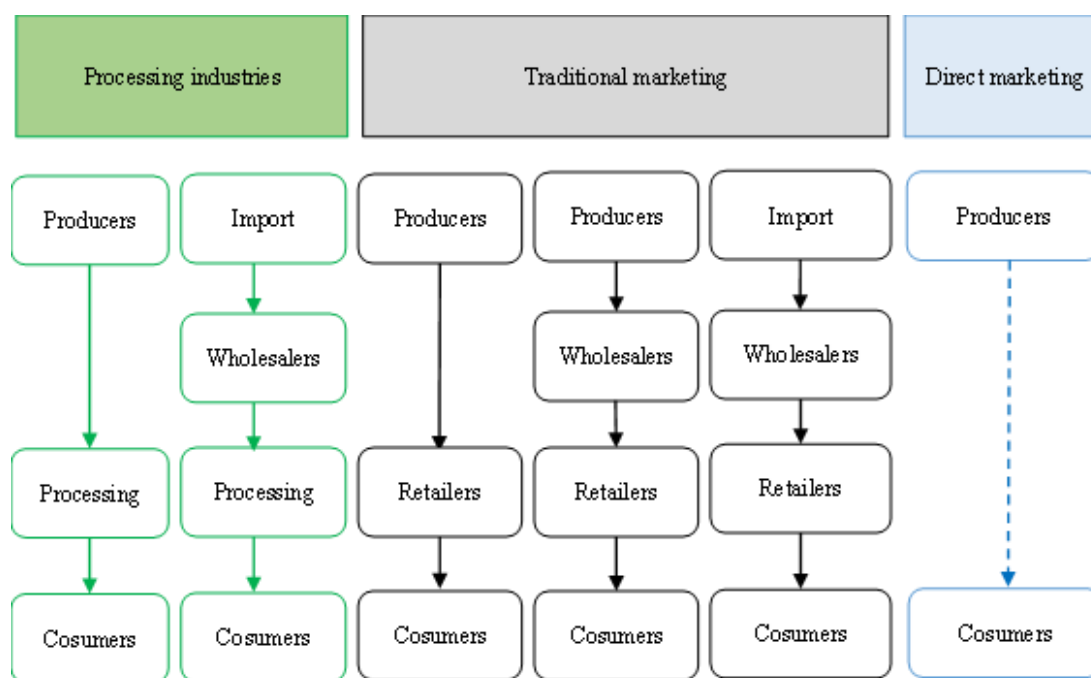

Figure 3- Leafy vegetable marketing channels in Kermanshah province

System dynamics modeling of waste within the leafy vegetable supply chain

After identifying the research variables and their relationship structure, the waste system within the leafy vegetable supply chain was modelled using the system dynamics

modelling. To develop the waste system in the leafy vegetable supply chain in Kermanshah province, the following steps were followed:

Problem Statement

The first stage in system dynamics

modelling involves defining the structure and extent of the research problem (Sterman, 2000). In socioeconomic research, the boundaries of a system are defined by two key factors: 1) the research purpose, and 2) the importance and effect of various factors on the elements within the boundaries of the system.

Designing a conceptual model

After formulating the research problem and defining the boundaries of the system, the next step is to create a conceptual model. Fig. 4 provides a structured overview of the variables and their key component interactions for testing the research hypotheses.
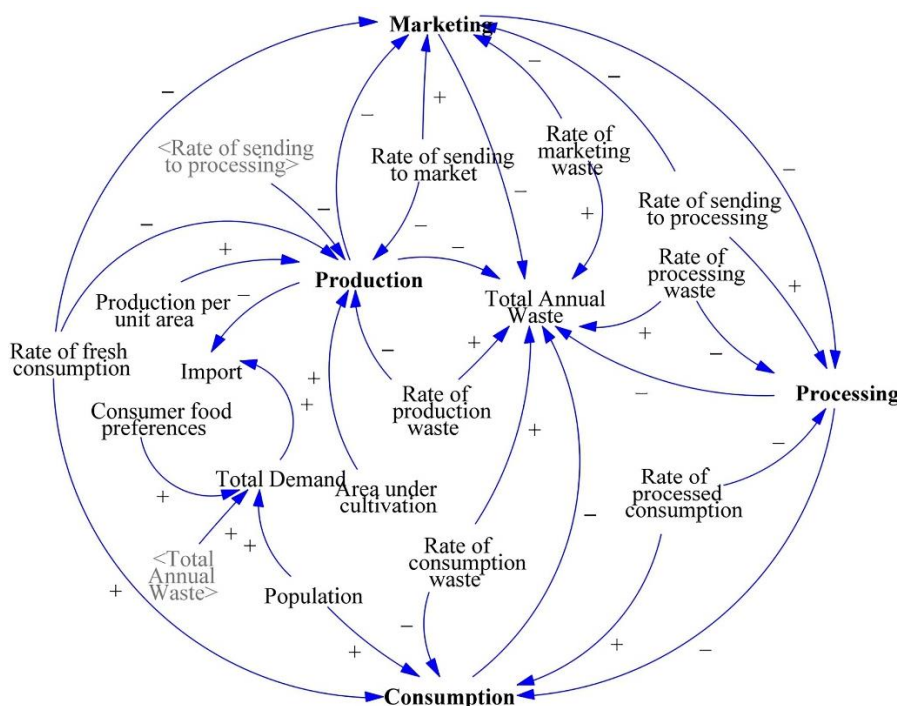

Figure 4- Causal loops diagram of a waste system within the leafy vegetable supply chain

Formulation of the simulation model

To simulate the results of the model, the causal loop diagram is required to be converted into a stock and flow diagram. This part encompasses specifications of the system structure, parameter estimations, model interactions, and initial values (Fig. 5 and Table 1).

The ultimate model created comprises multiple sub-models, which are detailed as follows:

1) Estimating the total demand for leafy vegetables

The total demand for leafy vegetables in this study was estimated by considering the population of the province, the per capita consumption of leafy vegetables, and the total annual waste across the supply chain. This

model acknowledges that a portion of the demand for leafy vegetables in Kermanshah province is met through local production, while during the colder seasons of the year, another portion is sourced through imports from other provinces (Equation 1).

$$Total\ demand = (Po \times PLVC) + TAW \qquad (1)$$

Where; Po is the population of the province, PLVC is the per capita consumption of leafy vegetables, and TAW is the amount of total annual waste.

2) Production subsystem modelling

Cumulative production indicates the overall volume of leafy vegetables during the production stage over a year (Equation 2).
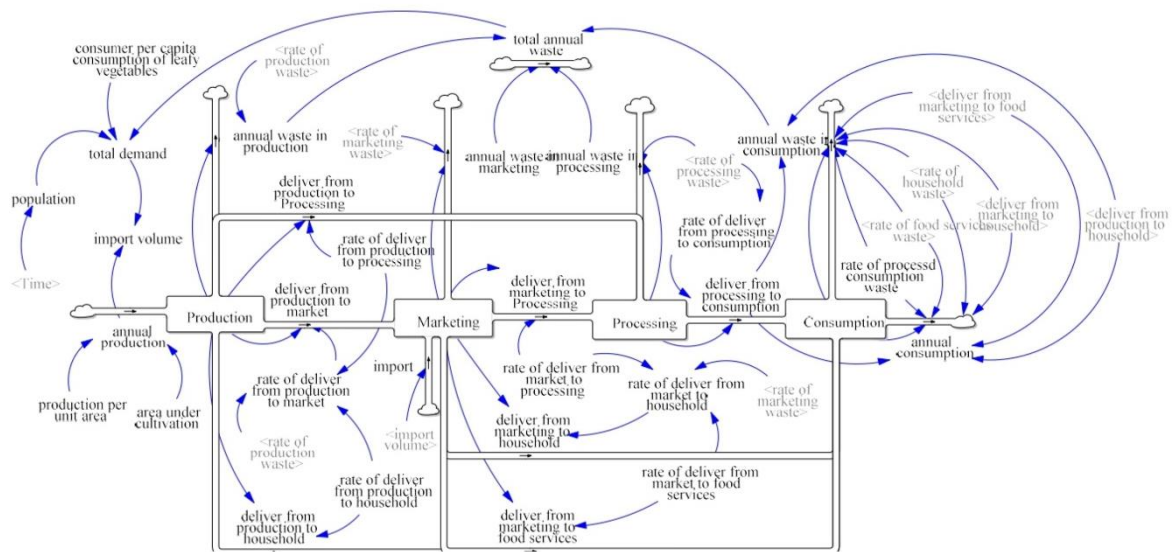
Figure 5– Stock and flow diagram of waste system in Leafy vegetable supply chain

Table 1- Initial values of research variables

Subsystems	Flows	Variables			Symbol	Value	Units
Demand subsystem	–	Population			Po	2.070	Person
	–	Per capita leafy vegetable consumption			PLVC	24	kg
Production subsystem	Input flows	Annual production of leafy vegetables			AP	52000000	kg/year
	Output flows	Deliver from production to household			DPH	25	%
		Deliver from production to processing			DPPro	4	%
		Deliver from production to market			DPM	47	%
		Annual waste in production			AWP	24	%
Marketing subsystem	Input flows	Import			I	28492000	kg/year
		Deliver from production to market			DPM	47	%
	Output flows	Deliver from market to household			DMH	84.5	%
		Deliver from market to processing			DMPro	1.5	%
		Deliver from market to food services			DMFS	3	%
		Annual waste in marketing			AWM	11	%
Processing subsystem	Input flows	Deliver from production to processing			DPPro	4	%
		Deliver from market to processing			DMPro	1.5	%
	Output flows	Deliver from processing to consumption			DProC	93.5	%
		Annual waste in processing			AWPro	6.5	%
Consumption subsystem	Input flows	Deliver from production to consumption			DPC	25	%
		Deliver from market to consumption			DMC	84.5	%
		Deliver from market to food services			DMFS	3	%
		Deliver from processing to consumption			DProC	93.5	%
	Output flows	Annual consumption			AC	48740000	kg/year
		Annual waste in consumption (AWC)	Annual waste in household		AHW	21	%
			Annual waste in food services		AWFS	18	%
			Annual waste of processed leafy vegetable		AWPC	5	%

Source: Research findings

$$Cumulative\ production =$$
$$\int_{t_0}^{t} AP - (AWP + DPH + DPPro + \quad (2)$$
$$DPM)$$

Where; AP is the annual production of leafy vegetables, AWP is the annual waste in production, DPH is delivered from production to household, DPPro is delivered from production to processing, and DPM is delivered from production to market.

3) Marketing subsystem modelling

Cumulative marketing quantifies the overall amount of leafy vegetables in the marketing stage over a year.

$$Cumulative\ marketing$$
$$= \int_{t_0}^{t} (I + DPM)$$
$$- (DMH + DMPro \quad (3)$$
$$+ AWM)$$

Where; I is the import, DPM is delivered from production to market, DMH is delivered from market to household, DMPro is delivered from market to processing, and AWM is the annual waste in marketing.

4) Processing subsystem modelling

Cumulative processing integrates the input and output flow of leafy vegetables in the processing stage over one year (Equation 4).

$$Cumulative\ processing$$
$$= \int_{t_0}^{t} (DPPro$$
$$+ DMPro) - (DProC \quad (4)$$
$$+ AWPro)$$

Where; DPPro is delivered from production to processing, DMPro is delivered from market to processing, DProC is delivered from processing to consumption, and AWPro is the annual waste in processing.

5) Consumption subsystem modelling

Cumulative consumption indicates the total amount of leafy vegetable consumption over one year, including household and food services (Equation 5).

$$Cumulative\ consumption$$
$$= \int_{t_0}^{t} (DPC + DMC$$
$$+ DMFS + DProC) \quad (5)$$
$$- (AC + AWC)$$

Where; DPC is delivered from production to consumption, DMC is delivered from market to consumption, DMFS is delivered from market to food services, DProC is delivered from processing to consumption, AC is the annual consumption, and AWC is the annual waste in consumption.

6) Waste estimation modelling in the supply chain

The total waste of leafy vegetables was estimated by considering the cumulative waste generated at various stages of the supply chain, including production, market, processing, and consumption (Equation 6).

$$TAW = AWP + AWM + AWPro$$
$$+ AWC \quad (6)$$

Where; TAW is the amount of total annual waste, AWP is the annual waste in production, AWM is the annual waste in marketing, AWPro is the annual waste in processing, and AWC is the annual waste in consumption.

After developing and formulating the model simulation, the parameters were estimated using Vensim (Version 9.0) software.

Scenario Development

We defined four scenarios to address which marketing channel development can play a more impactful role in minimizing waste within the leafy vegetable supply chain. These scenarios are maintaining the current condition, development of processing industries, development of direct marketing, and development of traditional marketing. At this stage, by directing the flow of distribution of leafy vegetables in each of the marketing channels, their potential to reduce the amount of waste in the supply chain of leafy vegetables was documented. Policy scenarios were

simulated based on the conditions in Table 2.

Table 2– Model variable values in four different scenarios

Variables	Baseline	Development of direct marketing	Development of traditional marketing	Development of processing industries
Deliver from production to household	25	76	0	0
Deliver from production to processing	4	0	0	76
Deliver from production to market	47	0	76	0
Deliver from market to household	84.5	84.5	86	0
Deliver from market to processing	1.5	1.5	0	89
Deliver from market to food services	3	3	3	0

Source: Research findings

Assessment of model validity

The validation of a system dynamics model is a crucial step in ensuring its accuracy and reliability. Thus, initially, the results of evaluating the validity and accuracy of the model are presented. Fig. 6 presents the results of sensitivity analysis for the four main variables of the study based on four different ranges of changes (50%, 75%, 95%, and 100%). Based on these findings, it can be concluded that the outputs of the model are sensitive to the changes in its inputs, which indicates the reliability of the model.
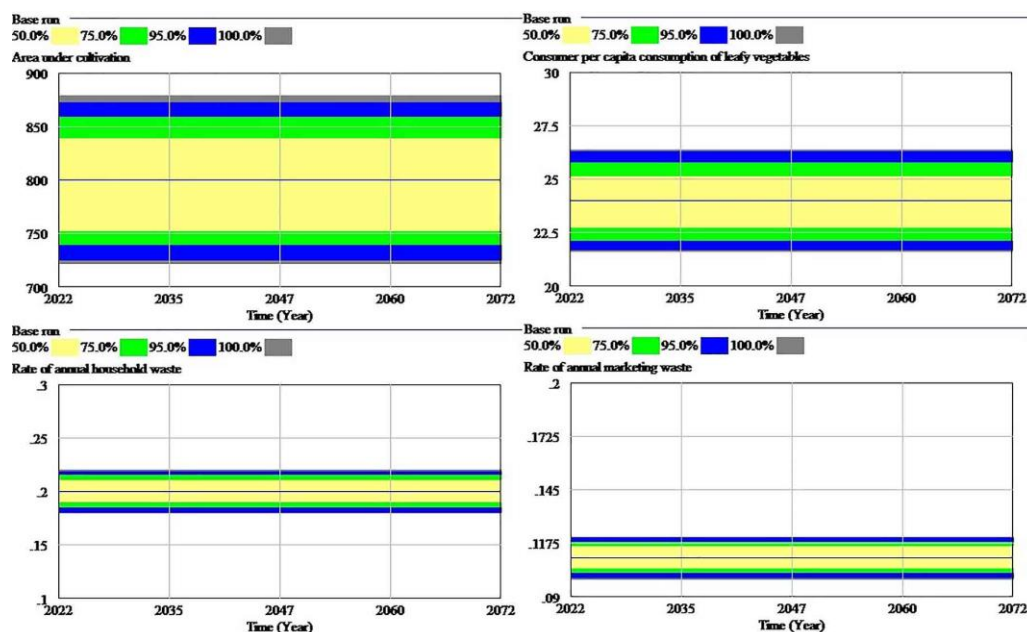

Figure 6– Confidence limits for four of the most important model variables

Results and Discussion

Scenario 1) Continuation of the current condition

Model estimates show that of the total annual demand of 80,000 tons for leafy vegetables, approximately 31,000 tons (around 39%) are wasted across the supply chain. The highest amount of waste occurs during

production, accounting for 12,500 tons (40.6%), followed by consumption with 12,300 tons (40.1%), and the market with 5,700 tons (18.7%) (Fig. 7 and Fig. 8). This finding is consistent with global trends and highlights the significant levels of waste during both the production and consumption stages in developing nations (UNEP, 2021).
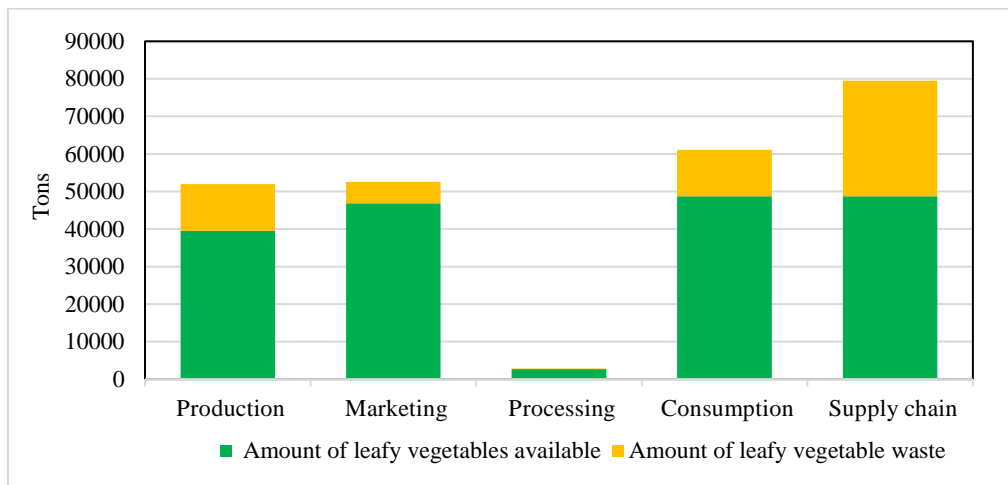
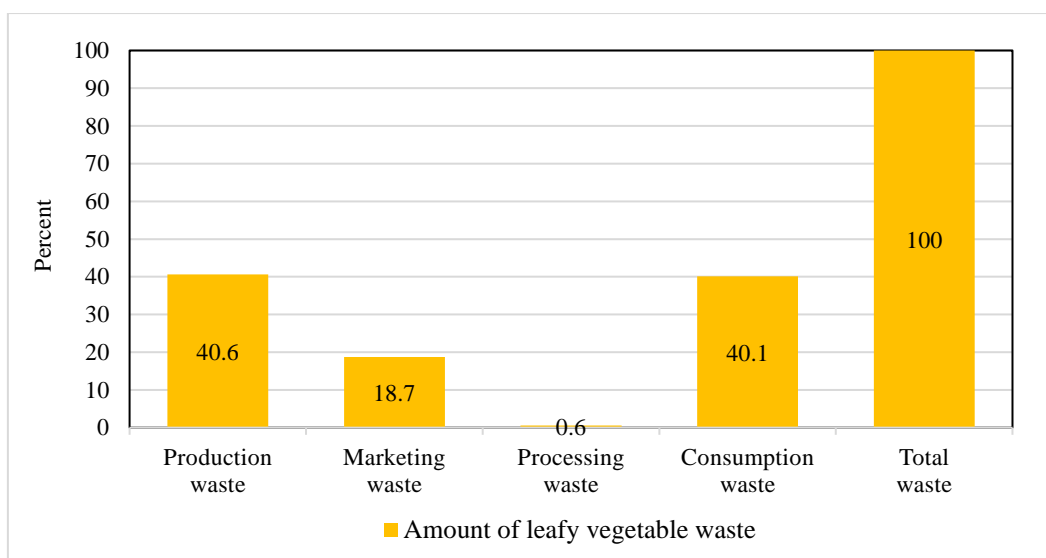**Figure 7- Amount of leafy vegetables available and waste in the leafy vegetable supply chain**

Figure 8- The proportion of waste generated in each stage of the leafy vegetable supply chain from the total waste

The leafy vegetable consumption sector encompasses fresh vegetables consumed by households, fresh vegetables consumed by food services, and processed vegetables consumed by both households and food services (Table 1 and Fig. 5). At the household level, approximately 57,000 tons of leafy vegetables are consumed, with 11,900 tons (21 percent) being wasted. In the food service sector, approximately 1,600 tons of fresh leafy vegetables are consumed each year, with 270 tons (18%) being wasted. Furthermore, approximately 2,700 tons of processed leafy vegetables are eaten in the consumer sector, with 130 tons (5%) ending up as waste (Fig. 9). Although the findings of this study align with the United Nations Environment Office report, which highlights a significant amount of food waste during the consumption stage in developing countries, a closer examination of

the data reveals a distinction between the quantity of leafy vegetable waste supplied to consumers in fresh form and that provided to households in processed form. Upon analyzing the causes of this difference, Moradi *et al.* (2023) have concluded that the primary reason for the disparity in leafy vegetable waste at the household level and food services in the studied area is the deterioration of fresh product quality

across the supply chain. The high waste of fresh leafy vegetables at the household and food service level is primarily attributable to the poor quality of the product, rather than the behavioural patterns of consumers. This issue stems from unfavourable actions and decisions made by other actors in the supply chain (Moradi *et al.*, 2023; Siddiqui, 2018).
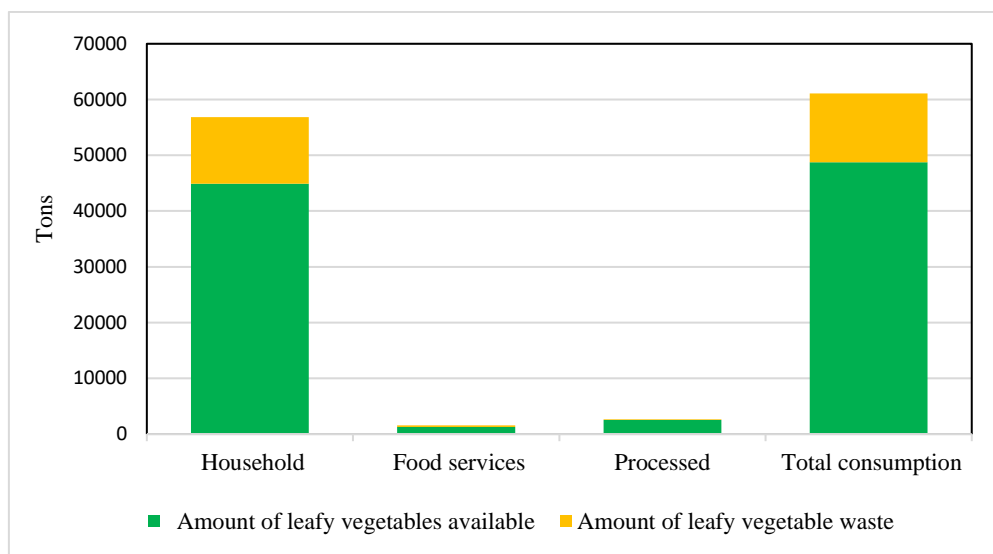

Figure 9- The amount of leafy vegetable waste in the consumption stage
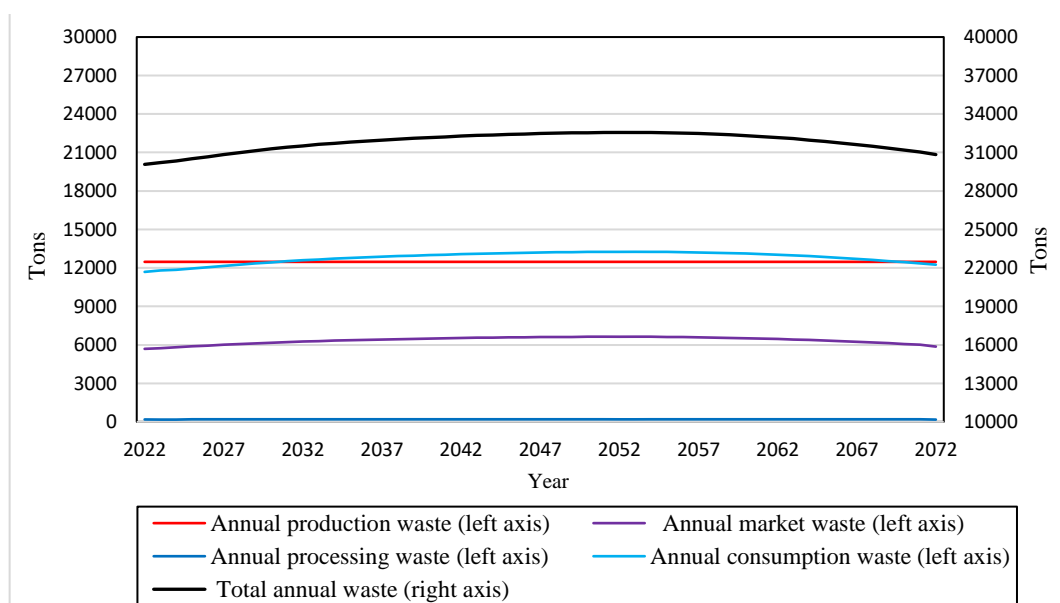

Figure 10- Waste estimation assuming the current trend continues

The simulation of the amounts of waste at different stages of the supply chain of leafy vegetables during the simulation period showed

that the total annual waste of leafy vegetables is projected to increase initially and then decrease with the population growth trend (Fig. 10). This

trend indicates that the continuation of the current trend and lack of intervention to reduce the waste of leafy vegetables will have detrimental economic, social, and environmental consequences for supply chain actors and communities.

Scenario 2) Development of processing industries

Investigating the effects of the development of leafy vegetable processing industries on waste across the supply chain showed that implementing this scenario leads to an increase in waste during the processing stage while reducing marketing waste (Fig. 11 and Fig. 12). These changes occur as a result of an increased volume of leafy vegetables being processed and the elimination of marketing activities for fresh leafy vegetables in wholesale and retail stores. In addition, the effect of this scenario on waste during the consumption stage was significantly greater compared to the base scenario. According to this scenario, the amount of waste generated in the consumption stage will decrease from 12,300 tons to 3,200 tons (Fig. 13). This reduction can be attributed to several factors. Firstly, the waste generated from processed leafy vegetables is significantly lower compared to that from fresh vegetables. Secondly, the development of processed products leads to a decrease in the consumption of fresh leafy vegetables at the household level. As a result, the amount of low-quality leafy vegetables and discarded parts, such as stems, decreases (Moradi *et al.*, 2023). Thirdly, processing units are generally less affected by the poor quality of purchased leafy vegetables compared to households. Consequently, a significant portion of leafy vegetables that were previously discarded at the household level now remains in the consumption chain. Although this study does endorse the strategy of fostering processing industries to minimize leafy vegetable waste, the limited quantity of processed leafy vegetables in the studied region implies that there are obstacles to establishing a successful leafy vegetable processing sector. These challenges can be analyzed from various perspectives. Firstly, extensive research has

indicated that the majority of regions in Iran lack adequate infrastructure for the development of agricultural product processing industries (Khodayi Steyar *et al.*, 2018; Varmazyari *et al.*, 2016). The presence of an institutional gap and the absence of a clear strategy for the advancement of these industries are among the primary factors contributing to this problem (Varmazyari *et al.*, 2016). Secondly, the implementation of this approach necessitates substantial behavioural modifications from households and other stakeholders within the leafy vegetable supply chain. For instance, from the demand perspective, the establishment of leafy vegetable processing industries calls for a shift in consumer preferences toward purchasing processed and packaged products. In recent years, there has been growing concerns have been raised regarding the use of unconventional water in the cultivation of leafy vegetables and the lack of consumer confidence in compliance with health regulations in processing units. These challenges have significantly impacted the motivation of households to purchase processed leafy vegetables. Therefore, many individuals choose to directly purchase the leafy vegetables they require from local farmers. In addition, the implementation of this strategy necessitates substantial investment in cold chain infrastructure and facilities to support the distribution and marketing of processed products by market actors.

Scenario 3) Development of direct marketing

In scenario 3, it is assumed that all leafy vegetables produced in the studied area will be supplied directly to consumers through stalls and stores located within the fields and alongside the roads. It is important to note that in this scenario, leafy vegetables imported from other regions are still distributed through traditional marketing methods within the supply chain. The simulation results indicate that implementing this marketing approach in the studied area would result in a significant reduction of 3,000 tons of wasted leafy vegetables at the market stage, compared to the baseline scenario (Fig. 11). In line with the

results of this study, Kirci *et al.* (2022), concluded that direct marketing is effective in minimizing product spoilage by eliminating unnecessary intermediaries in the supply chain, especially for perishable products such as leafy vegetables. This approach also minimizes losses incurred from rejected products that fail to meet the standards set by wholesale and retail centers (Johnson *et al.*, 2019). Despite the benefits offered by the direct marketing approach in reducing waste, it is important to acknowledge that it cannot fully replace existing marketing systems due to seasonal limitations and limited access to all consumers (Priefer *et al.*, 2016). Furthermore, in this particular scenario, the decrease in processed vegetable consumption and the rise in fresh vegetable consumption may lead to a slight increase in waste at the consumer stage. Nevertheless, implementing the direct marketing approach could still lead to a significant reduction of approximately 2,500

tons of waste per year compared to the baseline scenario (Fig. 13).

Scenario 4) Development of traditional marketing

In scenario 3 direct marketing and processing industries will cease. Instead, the entire demand for leafy vegetables in the studied area will be met by providing fresh produce to consumers through intermediaries like wholesalers and retailers. The results indicate that implementing this scenario will lead to an increase in the total waste volume of leafy vegetables in the studied area by 2,000 tons per year (Fig. 14). The high volume of food loss and waste in traditional marketing channels is one of the challenges of the agricultural product supply chain in numerous countries, which has been extensively addressed in numerous studies (Anand & Barua, 2022; Kör *et al.*, 2022).
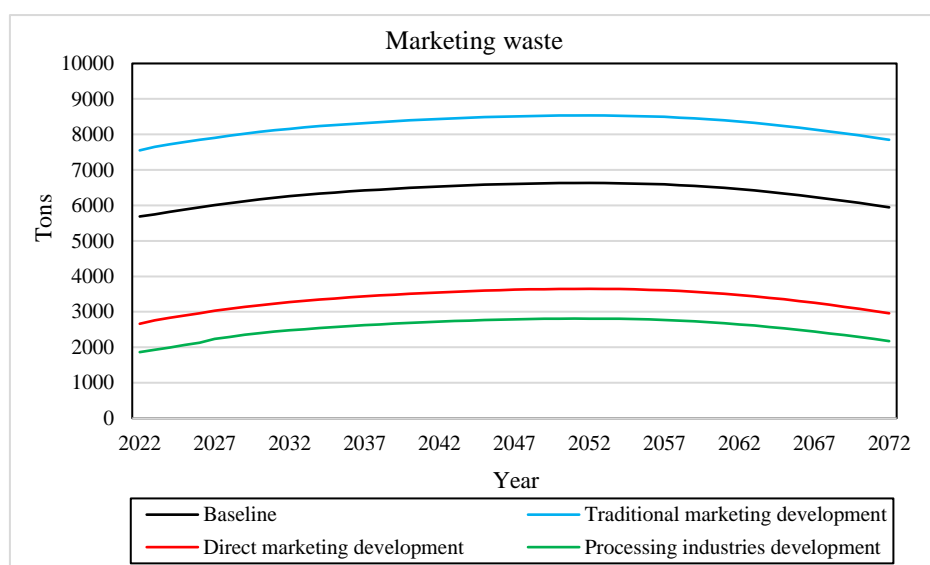

Figure 11- The effects of different scenarios on waste reduction in the market stage

Conclusion

The present study developed a system dynamics model for the waste system across the leafy vegetable supply chain in Kermanshah province to investigate the potential of different marketing channels in minimizing waste. The findings of estimating waste at various stages of the supply chain revealed that approximately

39% of the total volume of leafy vegetables, equivalent to 31,000 tons, in Kermanshah province, ends up as waste. These findings highlight the entry points where intervention and waste reduction strategies can be implemented effectively. This study examined the potential impact of three marketing channels (traditional marketing, direct marketing, and processing industries) on waste

reduction in the study area. The findings indicate that among these approaches, the development of processing industries shows the highest potential for reducing waste in leafy vegetables. By adopting this approach, it is possible to decrease total waste by a significant amount, approximately one-third or 10,000 tons per year. However, it's important to note that a single marketing channel alone may not be sufficient to meet the diverse demands of consumers due to varying interests. Nevertheless, given the effectiveness of processing industries in waste reduction, it is recommended that policy actions and measures in the studied area prioritize the development of leafy vegetable processing industries.
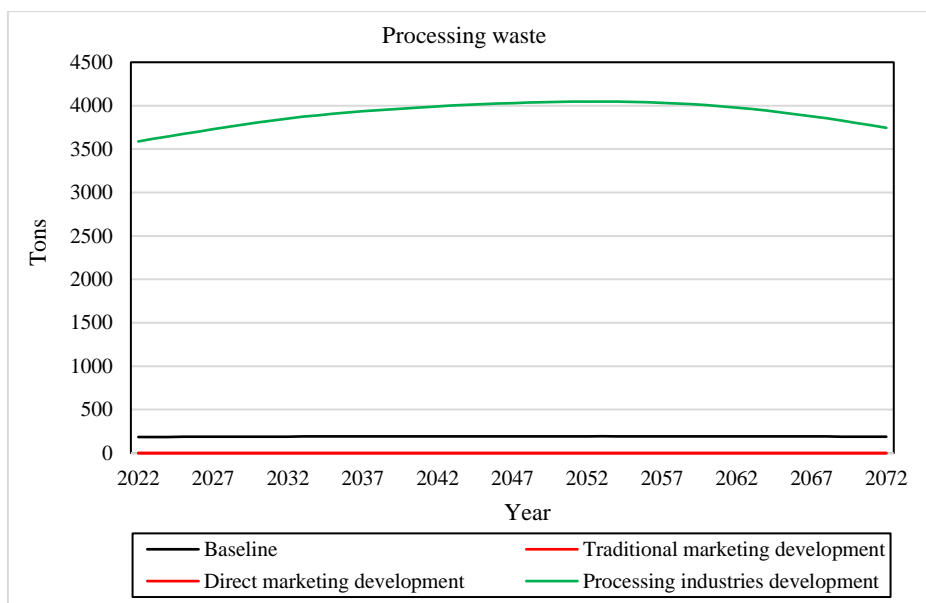

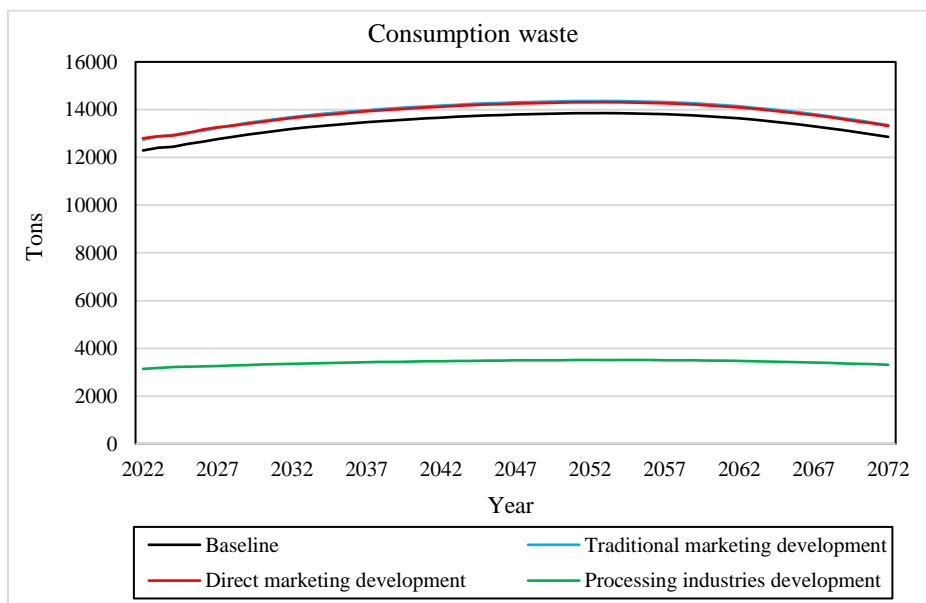**Figure 12- The effects of different scenarios on waste reduction in the processing stage**

Figure 13- The effects of different scenarios on waste reduction in the Consumption stage
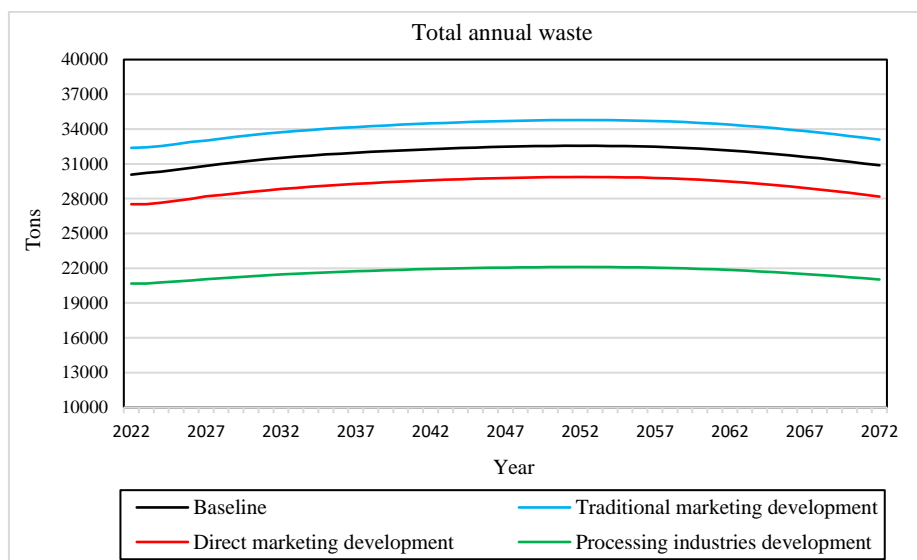
Figure 14- The effects of different scenarios on total waste

The following suggestions are proposed to develop leafy vegetable processing industries in the studied area:

- It is recommended that the governance structure, with the help of effective policy mechanisms and tools, establishes the framework for collaborative investments between private entities and the government to develop essential infrastructure for leafy vegetable processing industries. This infrastructure may include processing facilities, cold storage units, and specialized transportation networks. In addition, offering affordable facilities, subsidies, tax incentives, and facilitating the licensing process are key measures that can encourage entrepreneurs to invest in leafy vegetable processing facilities and infrastructure.

- One commonly used approach for the development of processing industries is contract farming. To successfully implement this production approach, it is recommended that the governance structure through the development of appropriate laws and regulations to manage relations between farmers and processing units provides the basis for farmers' participation in these projects. It is important to note that the establishment of processing units in rural areas and the ownership of farmers on these units while creating a connection between farmers and processing units, can maximize the benefits of the local community from the added value of leafy vegetable cultivation in the study area.

- To implement this approach, it is necessary to invest in and provide market actors with cold chain infrastructure and facilities. One possible strategy is to utilize the existing capacity of supermarkets or equip the existing retail sector with storage facilities specifically tailored for processed and frozen leafy vegetables.

- To facilitate the development of leafy vegetable processing industries, it is essential to implement market development strategies that encourage consumer consumption of processed products. Given that 70% of leafy vegetables are consumed in cooked form, there is a significant opportunity to promote the use of processed vegetables. Educating consumers about the advantages and value of processed products through consumer awareness campaigns, media outlets, and social networks can effectively stimulate their interest in purchasing such products.

- Given the increasing concerns among

consumers regarding health issues associated with processed products, it is imperative to establish robust regulatory frameworks that guarantee the quality and safety of these products across the supply chain. This entails implementing mechanisms to closely monitor the usage of water and other resources during the production process. Additionally, conducting routine health inspections in processing units is vital for upholding the safety standards of processed products.

Acknowledgment

References

1. Abadi, B., Mahdavian, S., & Fattahi, F. (2021). The waste management of fruit and vegetable in wholesale markets: Intention and behavior analysis using path analysis. *Journal of Cleaner Production*, *279*, 123802. https://doi.org/10.1016/j.jclepro.2020.123802

2. Adebola, O.T. (2020). *Market-based approaches for postharvest loss reduction.* Ph.D. Thesis. Georgia Institute of Technology.

3. Amicarelli, V., Lagioia, G., & Bux, C. (2021). Global warming potential of food waste through the life cycle assessment: An analytical review. *Environmental Impact Assessment Review*, *91*, 106677. https://doi.org/10.1016/j.eiar.2021.106677

4. Anand, S., & Barua, M.K. (2022). Modeling the key factors leading to post-harvest loss and waste of fruits and vegetables in the agri-fresh produce supply chain. *Computers and Electronics in Agriculture*, *198*, 106936. https://doi.org/10.1016/j.compag.2022.106936

5. Aramyan, L., Valeeva, N., Vittuari, M., Gaiani, S., Politano, A., Gheoldus, M., Mahon, P., Scherhaufer, S., Paschali, D., & Cseh, B. (2016). *Market-based instruments and other socio-economic incentives enhancing food waste prevention and reduction*. Fusions.

6. FAO. (2014). Food Losses and Waste in the Latin America and the Caribbean.

7. FinancialTribune. (2017). *Iran's Annual Food Waste at 25m Tons.* Available at: https://financialtribune.com/articles/economy-domestic-economy/70344/iran-s-annual-food-waste-at-25mtons. (In Persian)

8. Forrester, J.W. (1992). Policies, decisions, and information sources for modeling. *European Journal of Operational Research*, *59*(1), 42-63. https://doi.org/10.1016/0377-2217(92)90006-U

9. Ganesh, K.S., Sridhar, A., & Vishali, S. (2022). Utilization of fruit and vegetable waste to produce value-added products: Conventional utilization and emerging opportunities-A review. *Chemosphere*, *287*(Pt 3), 132221. https://doi.org/10.1016/j.chemosphere.2021.132221.

10. Gardas, B.B., Raut, R.D., & Narkhede, B. (2017). Modeling causal factors of post-harvesting losses in vegetable and fruit supply chain: An Indian perspective. *Renewable and Sustainable Energy Reviews*, *80*, 1355-1371. https://doi.org/10.1016/j.rser.2017.05.259

11. Johnson, L.K., Bloom, J.D., Dunning, R.D., Gunter, C.C., Boyette, M.D., & Creamer, N.G. (2019). Farmer harvest decisions and vegetable loss in primary production. *Agricultural systems*, *176*, 102672.

12. Khodayi Steyar, H., Raheli, H., Kohestani, H., & Shojai Mazdi, H. (2018). The analysis of obstacles and problems of processing and complementary agricultural industry units in villages Sari County. *Journal of Rural Development Strategies*, *5*(4), 455-467. https://doi.org/10.22048/RDSJ.2019.121688.1719

13. Kirci, M., Isaksson, O., & Seifert, R. (2022). Managing perishability in the fruit and vegetable supply chains. *Sustainability*, *14*(9).

14. Kör, B., Krawczyk, A., & Wakkee, I. (2022). Addressing food loss and waste prevention. *British Food Journal*, *124*(8), 2434-2460. https://doi.org/10.1108/BFJ-05-2021-0571

15. Kumar, A., & Agrawal, S. (2023). Challenges and opportunities for agri-fresh food supply chain

management in India. *Computers and Electronics in Agriculture*, *212*, 108161. https://doi.org/10.1016/j.compag.2023.108161

16. Latka, C., Parodi, A., van Hal, O., Heckelei, T., Leip, A., Witzke, H.-P., & van Zanten, H.H.E. (2022). Competing for food waste – Policies' market feedbacks imply sustainability tradeoffs. *Resources, Conservation and Recycling*, *186*, 106545. https://doi.org/10.1016/j.resconrec.2022.106545

17. Lipinski, B., Hanson, C., Waite, R., Searchinger, T., & Lomax, J. (2013). *Reducing food loss and waste. Working Paper, Installment 2 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute.* Available at: http://www.worldresourcesreport.org. (In Persian)

18. Magalhães, V.S.M., Ferreira, L.M.D.F., & Silva, C. (2022). Prioritizing food loss and waste mitigation strategies in the fruit and vegetable supply chain: A multi-criteria approach. *Sustainable Production and Consumption*, *31*, 569-581. https://doi.org/10.1016/j.spc.2022.03.022

19. Mohan, A., Krishnan, R., Arshinder, K., Vandore, J., & Ramanathan, U. (2023). Management of postharvest losses and wastages in the Indian tomato supply chain— A Temperature-Controlled Storage Perspective. *Sustainability*, *15*(2).

20. Moradi, M., Shabanali Fami, H., Barati, A., & Salehi Mohammadi, R. (2023). Causes of waste in the leafy vegetable supply chain in Kermanshah province. *Village and Development*. (In Persian). https://doi.org/10.30490/rvt.2023.361267.1510

21. Nakouzi, S.R. (2017). *Is Food Loss an Issue for Iran?* (In Persian). Available at: https://un.org.ir/all-stories/item/3937-8-february-2017-is-food-loss-an-issue-for-iran

22. Parfitt, J., Barthel, M., & Macnaughton, S. (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. https://doi.org/10.1098/rstb.2010.0126

23. Parsafar, B., Ahmadi, M., Jahed Khaniki, G.R., Shariatifar, N., & Rahimi Foroushani, A. (2023). The impact of fruit and vegetable waste on economic loss estimation. *Global Journal of Environmental Science and Management*, *9*(4), 871-884. https://doi.org/10.22034/gjesm.2023.04.14

24. Priefer, C., Jörissen, J., & Bräutigam, K.-R. (2016). Food waste prevention in Europe–A cause-driven approach to identify the most relevant leverage points for action. *Resources, Conservation and Recycling*, *109*, 155-165. https://doi.org/10.1016/j.resconrec.2016.03.004

25. Siddiqui, M.W. (2018). *Preharvest modulation of postharvest fruit and vegetable quality*. Academic Press.

26. Sterman, J. (2000). *Business dynamics*. McGraw-Hill, Inc.

27. UN. (2018). Department of Economic and Social Affairs, Population Division. World Urbanization Prospects: The 2018 Revision.

28. UNEP. (2021). Food Waste Index Report 2021. Nairobi.

29. Van der Vorst, J.G.A.J., Da Silva, C., & Trienekens, J.H. (2007). *Agro-industrial supply chain management: concepts and applications*. FAO.

30. Varmazyari, H., Rostami, F., Samadi, M., & Baniasadi, M. (2016). Analysis of Obstacles and Solutions of Pro-Poor Development of Agricultural Industries in Iran. (In Persian). https://doi.org/10.22059/IJAEDR.2016.59723

اثرات بالقوه توسعه کانال‌های مختلف بازاریابی بر کاهش ضایعات در زنجیره تأمین سبزیجات برگی در استان کرمانشاه

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تاریخ دریافت: ۱۴۰۲/۰۶/۰۸
تاریخ پذیرش: ۱۴۰۲/۰۹/۱۲

چکیده

سالانه تقریباً یک‌سوم کل مواد غذایی تولید شده برای مصرف انسان به دلایل مختلف به ضایعات تبدیل می‌شود. این میزان اتلاف پیامدهای منفی قابل‌توجهی بر محیط‌زیست، اقتصاد و جامعه دارد. مطالعات متعددی سیاست‌های مختلفی از جمله استفاده از راهکارهای فنی برای کاهش ضایعات مواد غذایی پیشـنهاد کرده‌اند. با این حال، تردید در اثربخشـی و پیامدهای ناخواسـته اجرای این راهکارها موجب تأکید محققان بر رویکردها و مداخلات مبتنی بر بازار برای کاهش ضایعات شـده است. بر این اسـاس، مطالعه حاضر با هدف برآورد ضایعات و بررسـی پتانسیل‌های بالقوه توسعه کانال‌های مختلف بازاریابی به‌عنوان اشکالی از رویکردهای مبتنی بر بازار بر کاهش ضایعات در سراسر زنجیره تأمین سبزیجات برگی در استان کرمانشاه انجام شد. بدین منظور با اسـتفاده از مرور ادبیات و مصاحبه با متخصصان و کنشگران کلیدی زنجیره تأمین یک مدل پویایی سیستم ضایعات در زنجیره تأمین سبزیجات برگی در استان کرمانشاه توسعه داده شد. ابزار جمع‌آوری داده‌های تحقیق پرسشنامه بود. جامعه آماری این مطالعه شامل دو گروه از متخصصان موضوعی و کنشگران زنجیره تأمین زنجیره تأمین سبزیجات برگی بود. در مجموع، ۲۲ متخصص و ۷۲۸ کنشگر از مراحل مختلف زنجیره تأمین مورد مطالعه قرار گرفتند. بر اساس نتایج، سالانه تقریباً ۳۱.۰۰۰ تن (۳۹ درصد) از تولیدات سبزیجات برگی در سراسر زنجیره تأمین به ضایعات تبدیل می‌شود. پیش‌بینی روند آینده ضایعات نیز نشان می‌دهد که در صورت تداوم وضعیت فعلی، میزان ضایعات در دهه‌های آینده همچنان افزایش خواهد یافت. نتایج شبیه‌سازی سـناریوهای تحقیق نشان داد که توسعه صـنایع فرآوری، ضایعات کل در زنجیره تأمین سبزیجات برگی را از تقریباً ۳۱.۰۰۰ تن به حدود ۲۰.۰۰۰ تن در سـال کاهش می‌دهد. بنابراین، لازم اسـت که سـیاسـت‌ها و برنامه‌های دولت در زمینه مبادله سـبزیجات برگی در منطقه مورد مطالعه بر حمایت از کسب‌وکارهای مرتبط با صنایع فرآوری سبزیجات برگی و ایجاد زیرساخت‌های اولیه مورد نیاز این صنایع متمرکز شود.

واژه‌های کلیدی: زنجیره غذا، سبزیجات برگی، ضایعات غذا، کانال‌های بازاریابی، مدل‌سازی پویایی سیستم

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