华中农业大学

**HUAZHONG AGRICULTURAL UNIVERSITY**

# 博 士 学 位 论 文

# PhD DISSERTATION

## 埃及园艺作物供应链收成后损失的经济评估和分析

## EVALUATION AND ECONOMIC ANALYSIS OF POST-HARVEST LOSSES FOR HORTICULTURAL CROPS SUPPLY CHAIN IN EGYPT


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## Abstract

The world is losing 1.3 billion tons of food, costing approximately $1 trillion, which is emitting 8% of greenhouse gases (GHG) and consumes 25% of all agricultural water. In recent years food losses and waste (FLW) are considered one of the most significant social, economic, environmental and ecological challenges facing humanity. More than 45% of the produced food is lost before consumption in Egypt, which is representing a major obstacle to achieve food security and sustainable agricultural development. Addressing FLW is a better strategy to enhance agribusiness efficiency, ensure food security for the coming years and achieve sustainable use of available natural resources. Horticulture crops have multiple benefits for both consumers and producers alike. They play a significant role to secure and overcoming micronutrient deficiencies for consumers, which could achieve the sustainable food systems transformation. Horticultural crops are the highest in FLW (approximately 50% of production is lost annually), which represents around 38% of total global FLW. Tomatoes and grapes are the mainhorticultural cropsin Egypt and they are perishable products, so the percentage of postharvest losses (PHL) is high compared with other horticultural crops. Then, the current study has focused on these two important crops by analyzing and evaluating the socioeconomic and environmental impacts of PHL.

In the context of PHL, it is crucial to estimate the quantity and value of PHL across the food supply chain (FSC) and evaluate its economic and environmental impacts. At the same time identifying the main causes of PHL and interpreting the interrelationships between these different causes, also analyzes the effects of stakeholders' practices on the share of PHL. A multi-stage sampling strategy is adopted to collect the primary data by investigating 610 tomatoes and grapes stakeholders' including (farmers, intermediates and agro-processors) from different two Egyptian governorates in 2020. The significance and originality of this study are to highlight the priority problems related to food and resource losses by providing empirical evidence about the actual quantity, value and socioeconomic and environmental consequences' of PHL. According to the results of the current study, the policymakers can get whole details supported by field data about the causes, amount, and hotspots of the PHL. This represents

a significant contribution to the literature that is aiming to reduce the PHL and achieve sustainable food systems transformation, particularly after the COVID-19 pandemic. Tackling this issue requires adopting the target-measure-act approach to target the hotspot and measure the PHL, finally acting to address the main and root causes of PHL. The life cycle assessment (LCA) approach, the category method, the microeconomic theory and rational choice theory have been adopted to estimate the percentage of PHL and their socioeconomic and environmental impacts. The marketing efficiency indicators have been used to measure the marketing efficiency, also indexes of (water, energy and land footprint) have been used to estimate the environmental impacts of PHL. For the econometric models, exploratory and confirmatory factor analysis, structural equations modelling (SEM) ،analysis of variance (ANOVA), and Automatic Linear Modeling (ALM) have been used besides the other simple and multiple regression models.

The results revealed the average of PHL for tomatoes was (13.36%, 7.5%, 8.6%, 8.8% and 11.63%) for the stakeholders' including (farmers, processors, village traders', wholesalers and retailers) respectively. Due to most of the produced grapes being a table-grapes in Egypt, then the grapes processors didn't include in this study and the PHL for grapes supply chain actors' were estimated (10.06%, 5.82%, 6.53% and 7.06%) for the (farmers, village traders', wholesalers and retailers) respectively. For the total loss and wasted resources, the total land, water and energy consumed to produce this lost food is estimated at around 80 and 23 thousand hectares, and 306 and 158 million $m^3$ of water and 3.45 and 3.16 billion MJ of fossil energy (96.9 and 105 million litres petrol) for tomatoes and grapes, this besides other production inputs. Which cost the Egyptian economy about 449$ and 203.5$ million annually, this highlights the benefits of lowering these losses for both the individuals and the national economy. For the environmental impacts of PHL, the estimated PHL contribute to increasing the GHG in Egypt by 4.5 million and 145 thousand tons of $CO_2$eq, while its grey water footprint is estimated at around 140 and 42 million $m^3$ of water for tomatoes and grapes respectively. For the impact of the PHL on marketing efficiency, the results revealed marketing efficiency is inversely proportional to PHL.

Also, the results revealed that increasing the percentage of PHL lead to increasing the marketing costs and marketing margins and reduce the marketing efficiency. The total marketing costs were estimated at 1.121 and 1.3 LE/Kg for tomatoes and grapes respectively. Share of producers' estimated 35.7% and 61.6% from the consumer's price,

marketing efficiency estimated to 48.12% and 86.3% for tomatoes and grapes. In some cases, the margin of the intermediaries after considering the quality loss has been found to be negative (loss), similarly to the producers'.

For the causes of PHL, twenty-two determinants of PHL mitigation are identified and categorized into four categories. The interrelationships between these categories are interpreted by the SEM. The results revealed that insufficient infrastructure and shortage of government legalizations are the main determinants for reducing PHL, followed by secondary causes (inadequate marketing systems, improper handling practices and technological and environmental determinants). The direct and indirect interactions are identified and estimated. The respondents reported the causes of rejected products included and are not limited; (1) Neglect postharvest operations; (2) Using inappropriate packing boxes; (3) Late harvesting; (4) Insufficient handling skills; (5) Pests, bacteria and funguses infestation; (6) Lack of infrastructure and logistics; And (7) lack of linkage between the farmers and processing units. Hence, controlling these factors along FSC have a great and immediate impact to reduce the percentage of PHL, which could be a way for enhancing the welfare of small stakeholders (farmers and intermediaries) in developing countries. Regarding the stakeholders' practices and their impacts on the PHL, the results revealed that the irrigation system and farm gate price of tomatoes are the main factors influencing the tomatoes' PHL at the farm level. Furthermore, the most important factors are farm gate price of grapes and covering the products during transportation from the farm to the wholesale or local market. Due to using open trucks and the long distance between the production and wholesale market, most of the farmers didn't cover the products, so the sunshine cause huge damage to the grapes. Meanwhile, the access to finance is related to the type of middlemen which present the role of the ability to use the advanced technologies in handling, storing and transporting fresh products. The percentage of stored products for the next day causes a decrease in the quality of products and an increase in PHL besides the lack of transportation and storage facilities and long distance between the market and farm.

The current results have concluded that co-operative marketing and contract farming could be a more efficient solution in terms of both operations and price. Agro-marketing information is essential to achieve benefits for all actors across the FSC. The Results highlighted the PHL activity and intervention type differ due to the crop nature, handling system, access to financial

services, degree of controlling the surrounding temperature, *etc.* Additionally, diversity of the marketing channels for perishables could contribute to lessening the percentage of PHL by reducing unsold share, meeting the consumers' preferences and providing greater marketing opportunities for small farmers. Therefore, enhancing the transport and storage technology environment should mainly target small stakeholders' (farmers and intermediaries) as a key intervention to reduce the PHL in developing countries. The result of ALM indicates that the small stakeholders could achieve an additional income by adopting good agricultural practices (GAP) that will reduce the percentage of losses across the supply chain. The current study highlights the importance of prevention strategies that are better than recovering ones to mitigate the economic and environmental impacts of PHL. The current study suggests interventions for reducing the FLW including a participatory, holistic, integrated and multidimensional strategy considering the entire supply chain at different stages through adopting a shorter supply chain, cooperative marketing, access to cold shipping and storage services so as to maintain product quality.

Agricultural extension is essential for diffusing the GAP including the postharvest operations to raise stakeholders' knowledge and improve their skills and practices to sustainably use the limited natural resources. Hence, these results could help policymakers, agro-investors, and international funding donors' to design more sustainable intervention strategies for reducing PHL in developing countries. Considering cost-effectiveness and simplicity of generalizing to achieve the environmental preservation, sustainable FSC and the sustainable use of the limited resources at the local and global levels. Evaluating the socio-economic and environmental impacts of various interventions across the FSC over multiple seasons and sites is a crucial need before implementing the strategy of PHL reduction. This requires intensive investment shared among public-private sectors, which could incentive small stakeholders to accelerate food systems transformation and highlights the necessity for adopting innovative technologies and enhancing best handling practices to accelerate the transformation toward sustainability.

**Keywords:** Sustainable resources management**;** Sustainable Food System Transformation**;** Reduce Greenhouse Gas Emissions**;** Agricultural Supply Chain Efficiency**;** Agricultural Investment opportunities; Food Losses and Waste Reduction