The Economic Impacts of Food Waste Carbon Footprint on climate change:The Case of Egypt

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Abstract

Food waste become one of the most important global issues because of its economic, environmental, and social ramifications. Besides, food waste has a close relationship with climate change as food produced from agriculture and ends up as waste whereas energy is consumed during its life cycle stages. The goal of this article is the estimation of Greenhouse Gases GHG emissions associated with food waste generation in EGYPT. The scope of the research includes only the emissions associated with the management of food waste. To evaluate the food waste generation from Egyptians, the study depend on the FAO food balance sheet of Egypt, and relevant GHG emissions data found in literature sources and international databases, an estimation of the GHG emissions associated with food waste in EGYPT has been conducted. The results indicate that approximately 73 kg of food waste per person are generated annually. Moreover, the calculations of the present research reveal that emissions of 18676.03 Gg of CO2 eq. are associated with food waste in EGYPT.

Keywords: Food waste; Greenhouse Gases; CO2 emissions; Climate Change

1 Introduction

Food waste is considered major threating factor for sustainable development as it causes severe economic, environmental, and ethical problem. Every year, over one-third of the food produced for human use in the globe - around 1.3 billion tonnes - is lost or wasted (UN environment programme, 2021). Food waste is estimated to be worth almost 1 trillion USD per annum (FAO, 2021). According to the report of the United Nations Food and Agriculture Organization (FAO, 2021), 6-8 percent of all global greenhouse gases come from food waste. Moreover, combating food waste and loss is a specified aim under the globally agreed-upon Sustainable Development Goals (SDGs, 2015) and a critical component of the Zero Hunger Challenge. In this

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regard, reducing the food waste not only mitigates the global warming but also supports to achieve sustainable development targets.

Due to the growing population worldwide, it is important to feed more people through wasting less of food and keep growing it. According to 2021 Food Waste Index, two countries with the largest populations generate the highest food waste totals. China came first with an estimated 91.6 million tonnes of discarded food annually, followed by India's 68.8 million tonnes (Food waste index, 2021). Moreover, huge percentage of global food-waste occurs in the developing countries – mainly because of poor infrastructure and the dysfunctionality of the distribution networks. Food losses in industrialized developed countries are as high in the developing countries, however in developing countries more than 40% of food losses occur at the processing stages and post-harvest, whereas in industrialized countries, more than 40% of the food losses occur at the retail stage and consumer levels (World counts, 2020).

Indeed, number of scholars, policymakers and industry professionals are becoming more interested in this topic and proposed number of arguments on the negative effect of wood waste on environmental problem (Ahmad M. et al., 2023). Scholars defined two main kinds of wasted food: food waste and food loss. Food loss is defined as a reduction in the bulk or nutritional content of food that was originally intended for human consumption. This includes crops that are left in the field, food which spoils in transportation, besides all other food that doesn't make it to a store. Some amount of food is lost at nearly each stage of food production (Thyberg et al., 2020). Food waste is defined as the thrown food that is fit for human consumption, whether it has been held over its expiration date or has been allowed to expire. According to USDA Economic Research Service it is described as "food discarded by retailers because of color or appearance and plate wasted by consumers".

To achieve sustainable clean environment, it is necessary to reduce the food waste carbon footprint. In the past few years, numerous studies have explored the relationship between food waste and climate change in case of different countries and services. The research based on developing countries, namely Egypt there is not enough scientific findings and arguments. To this aim, the current article reports mainly economic impacts of food waste and its influence on climate change in case of Egypt. The guiding research questions for this study were:

1. How are the economic impacts of food waste in Egypt?
2. How food waste could be reduced in all sectors in Egypt to minimum level?
3. How is food waste affecting climate change in Egypt?

The remainder of the study is organized as follows: Section 2 provides an overview of the related literature; Section 3 discusses data and the empirical strategy. Section 4 offers the main results and robustness checks, and Section 5 concludes the study.

2 Literature Review

Reviewing the food waste literature, the term "food waste" defined in a variety of ways by different authors. Number of researchers (Okazaki et al., 2008; Parfitt et al., 2010; Aschemann-Witzel et al., 2016; Salihoglu et al., 2017) defined food waste as "any by-product or waste product from the production" or "the wastage or loss of edible food at the harvesting" in their studies. Each research analyzed the cause of food-waste on climate change and the economic development by applying different variables. The recent study by Ahmed et al (2021) explored the tackling of food-waste in the all-inclusive hotels from an employee perspective in case of

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Hurghada, Egypt. During the survey a total of 47 semi-structured interviews were conducted with managers in all-inclusive hotels. The findings indicate that the main driver of food waste were guest behavior, background and unlimited pre-paid service offered by all-inclusive programs. Moreover, these hotels are lack of technology to tackle the food waste practices. The research suggests number of implications in order to reduce the food-waste in 4,5-star hotels.

In another research, Ngoc Bao et al., (2015) studied the governance of food waste in developing countries as these countries always face challenges because of incomplete food waste system. The findings claim that income level, population growth and public participation in food waste management activities are quite important to manage the mentioned problems in developing countries. The study applied integrative management system to proceed the methodology. Taiwan was recognized as the successful country in case of food waste management and can be ideal model for developing countries to follow. Similar research by Viachaslau et al., (2018) reviewed the food waste management in hospitality operations including the challenges in classifying, quantifying and characterizing hospitality food waste. The paper contributes rich theoretical background for hospitality food waste mitigation. In another study (Viachaslau Filimonau et al., 2021) explored the waste food management in transition economy like Uzbekistan. The research obtained primary data by analyzing waste collection records through interviews. The analyses reveal that small restaurant waste 3-7 tonnes of food per year, medium-sized restaurants – 10-23 tonnes and large restaurants – 20-30 tonnes in Uzbekistan. The main reason of food-waste is over demand during the social events as traditions are widely celebrated in Uzbekistan. The study suggests policy implications to reduce food waste in commercial food service sectors in the region.

When it comes to innovations, Carlos Martin-Rios et al., (2018) tested social constructionism to investigate interrelationships of food service provisions in waste management. The article discusses a lot of waste management programs, demonstrating how their implementation in the food-service industry differs based on management's views, goals, knowledge, and actions. The causes of the consumer related food waste and the required actions was studied by Jessica Aschemann-Witzel et al., (2015) through analyzing factors that influence food waste behavior. To reduce the consumer-based food waste, it is quite necessary the education and attitude of customers towards the clear understanding the reason of climate change. The results indicate the consumers' motivation to reduce the food waste is directly connected with their behavior and social attitude. It is highly recommended to take actions in a government level to guide the population in the straight path to achieve sustainable clean environment (Kashif Raza Shah et al., 2023).

Number of scholars explored the role of food consuming and wood waste management to mitigate the climate change. For instance, Lucia A Reisch et al., Identifies the first methodological map that categorizes existing research on behavior-informed interventions that target changes in consumer food consumption and food waste behavior. The systematic map indicates knowledge gaps, where additional primary research is required, and evidence cannot support policy. Moreover, it exposes trends in research methodologies that can indicate best practices and methodology difficulties that can help increase primary evidence creation and reduce research waste. In example of different countries, Konstadinos Abeliotis et al., (2015) analyzed the greenhouse gases emissions on associated with food waste generation in Greece. To procced the research food waste diaries was conducted. According to the findings, around 100 kilograms of food waste per person is created each year, of which approximately 30 kg per person is preventable. Furthermore, the current study's findings show that food waste is responsible for 5672.5 Gg of CO2 eq. emissions in Greece. The environmental impacts in USA were

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examined by Kevin D. Hall et al., (2009) by calculating the nationwide food waste from population. The results revealed that per capita food waste in the United States has gradually increased by about 50% since 1974; Food waste now accounts for more than a quarter of total freshwater consumption and about 300 million barrels of oil annually.

Another study by Nikravech Mariam et al., (2020) systematically reviewed the role of food waste reduction as the potential tool to mitigate the climate change. The paper shortly discusses the contribution of psychology-related approaches and social practice theory to manage the food waste activities. The research indicates food waste to be a complex and multi-faceted issue that cannot be traced to a single variable; this also necessitates a greater integration of multiple discipline viewpoints. Mapping the drivers of waste creation improves awareness of home habits and aids in the development of food waste prevention methods. In very good research, Thyberg, K. L., and Tonjes, D. J. (2016) explored the drivers of food waste and their implications for sustainable policy development applying different variables. The study indicate that main drivers of food waste are cultural, personal, political and economic; also, the urbanization, globalization and economic growth highly effect on wastage. It was highlighted that food wastage is different from individual to individual. It is recommended to strengthen food waste prevention policies with the purpose of controlling the behavior and attitude of consumers towards the clean sustainable environment.

Furthermore, the list of these scholars (Mohamed ElFetyany et al., 2021; Kunwar Paritosh et al., 2017; Karin Schanes et al., 2017) also contributed with their different research in this field. From above mentioned literature, it is confirmed the economic impact of food waste management on climate change has not defined yet enough by researchers in case of Egypt, and the paper is going to cover this research gap.

3 Food Waste Impact In Global Warming

In recent years, food waste has received increasing attention from national policy makers, international organizations, NGOs as well as academics from various specialized fields (David Evans, 2012). Growing concerns about food security and environmental impacts, such as resource depletion and greenhouse gases emissions attributable to food waste, have intensified interest in this topic (Fahy, F and Davies, A. 2007). While food waste occurs at all stages of the food supply chain, private households have been identified as major actors in the generation of food waste, (Lanfranchi, Maurizio, et al., 2016). However, the evidence for why food waste occurs is still scattered.

Food consumption contributes to a significant proportion of the total per capita GHG impact (Clune, S. et al., 2017), with agricultural production accounting for 19-29% of anthropogenic GHG emissions (Vermeulen et al., 2012). Consumers also show a “moderately high level of concern” about sustainability with regard to food production (Grunert et al., 2014).

Additionally, food processing, transportation, and packaging increases overall emissions levels from the sector. Since the potential for reducing emissions from food production is limited, the importance of the food transition to reaching climate change goals has been highlighted in several studies. (e.g. by Bajželj et al., 2014, Hedenus et al., 2013, Röös et al., 2017). Since changing eating patterns is a challenge, it is likely that information-based policy choices will be complemented by economic incentive choices (Garnett et al., 2015).

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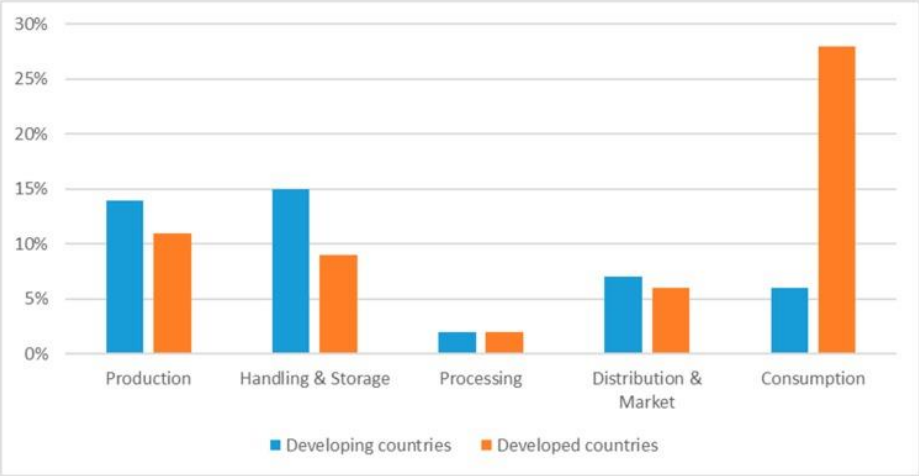

Figure 1: Portion of FLW in the stages of the food supply chain (FSC). Source: (Lipinski et al. 2018).

It is estimated that about a third of the food destined for human consumption is lost and wasted (Abiad M.G, et al., 2018). When food is disposed of, all inputs used in the production, processing, transportation, preparation and storage of discarded food are also wasted (Parry M, et al., 2007). Food loss and waste is also exacerbating the climate change crisis with the effect of Greenhouse Gases (GHGs). Food production, handling, and transportation, generates significant emissions of carbon dioxide (CO2) and when food ends up in landfills, it generates methane, a much more efficient greenhouse gases (Ishangulyyev, R. 2019).

Food production accounts for about a quarter - 26% - of global greenhouse gas emissions. Joseph Poore and Thomas Nemecek (2018), in their large meta-analysis of global food systems, published in Science, estimated the amount of greenhouse gas emissions from wasted food. The study by Poore and Nemecek (2018) found that nearly a quarter - 24% - of food emissions come from food lost in supply chains or wasted by consumers. Nearly two-thirds of this (15% of food emissions) comes from losses in the supply chain that result from poor storage and handling techniques; Lack of refrigeration and spoilage in transportation and processing. The remaining 9% comes from foods that are discarded by retailers and consumers.

In this article we rely on the estimations found by Joseph Poore and Thomas Nemecek (2018) to find the food waste carbon footprint of Egypt and its impact on the GHG emissions and climate change; besides, its economic impact on food security, productivity and economic efficiency, and climate change-related shocks in the supply chain.

4 Methodology

Food waste contributes to the generation of greenhouse gases in two ways. First of all, besides food waste, all greenhouse gases emissions generated during the production, processing, distribution, cooling and cooking of food are also wasted. Second, there are emissions that result directly from the management of food waste, (Oldfield and Holden, 2014).

In this article, we assume that food waste entering the waste management system already has an environmental burden, measured in CO2-equivalent emissions, from the life cycle of various foodstuffs.

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Therefore, in order to estimate the greenhouse gases emissions associated with food waste in Egypt, the following methodological procedures were followed:

- Data related to food waste from Egyptian households was extracted from the balance sheet of the Food and Agriculture Organization.
- Greenhouse gases emission factors for foodstuffs were extracted from international databases.
- Greenhouse gases emissions associated with food waste were calculated by multiplying food waste by the emission factor of each food item.
- With regard to food waste management, the main management options in Egypt have been identified and the greenhouse gases emission factors for these options have been extracted from the published literature.
- Finally, food waste generated from all life cycle phases (i.e., before and from households) was multiplied with the greenhouse gases waste emission factors.

It is very difficult to find homogeneous country-specific data on CO2 equivalent. Factors for food products because there are many products, production practices, and system boundaries throughout the life cycle of each food item within different geographic and temporal boundaries, (Renz et al., 2014)
With regard to the current study, the carbon dioxide equivalent. Emission factors for most foodstuffs were extracted from the Barilla database (Barilla, 2016), which makes much food data readily available at no charge. As shown, most of the GHG data in this database originate from the Ecoinvent database, the Danish LCA food database and the Environmental Product Declaration System (Barilla, 2016).
Finally, Egypt's population for the year 2020 was extracted from the World Bank as 102,334,403 people. This figure has been used to estimate per capita greenhouse gases emissions (The World Bank, 2020).
Whereas, there is no specific information yet on the impact of food waste in Egypt on greenhouse gases emissions. This study seeks to measure the impact of food waste - according to the available information in this regard - on the level of emissions of carbon dioxide, methane and other greenhouse gases in Egypt, in relation to the global ratio of the impact of food waste on greenhouse gases emissions.

5 The Estimation Of Egypt's Food Waste Footprint

There is no simple way to calculate the impact of food waste on greenhouse gases emissions, nor is there a direct way to estimate the carbon footprint of food in general. Different foodstuffs have different carbon density for different reasons (FAO, 2015):

- Food is produced through different processes and lifecycles
- Food travels in different ways
- Food is produced in different locations and circumstances
- Food contains different ingredients and resources
- Food has direct (transportation, production etc) and indirect (land use) emissions

In the end, we decided to follow the research conducted by the Food & Agriculture Organization of the United Nations (FAO) from 2013. It estimates that if food waste were a country, then it would be the third highest emitter of GHG emissions. Each year, we waste 1.3 gigatons of edible food and this releases 3.3 gigatons of CO2 equivalent. This means that 1kg of food waste equals to 2.5 kg of CO2 equivalent (or 2.53846 kg to be more exact) (FAO, 2013).

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Egypt climbs the top of the highest contributing countries to food waste percentages with 73 kilograms total annual amount of global food waste per person.

According to a study conducted by the Barilla Center for Food and Nutrition (BCFN), Egypt comes in the sixteenth place after Saudi Arabia, United Arab Emirates and Palestine among others (Barilla, 2016).

Finally, the population of Egypt for 2020 was extracted from the World Bank as 102,334,403 people. This number was utilized for the estimation of the per capita GHG emissions (World Bank, 2020).

Table 1: Egypt and Global CO2 eq. emissions and food waste indicators

Global Indicators		Egyptian Indicators	
Global food waste	1.3 Gt.	Egyptian gross food waste	7,4 Million Kg.
Global CO2 eq. emissions from food waste	3.3 Gt.	Egyptian food waste per capita	73 Kg.
Global CO2 eq. emissions per 1 kg of food waste	2.5 Kg.	Egypt population	102.3 million

We developed a model to the find the Carbon footprint of the Egyptian food wastage using the data extracted from the abovementioned sources, and the following variables, including Egypt contribution per person (73 kg) x Egypt population (102,3 million) x Carbon footprint of food wastage (2.5 kg)

$$Y(x_1, x_2) = 2{,}5\, x_1 \times x_2$$

Where

Y- Carbon footprint of the Egyptian food wastage

x_1 - Egypt contribution per person

x_2 - Egypt population

According to the data collected about the CO2 eq. emissions and food waste in the world and in Egypt as well. And according to the analysis conducted through this model, we found that Carbon footprint of the Egyptian food wastage equals Egypt contribution per person (73 Kg) x Egypt population (102.3 million) x Carbon footprint of food wastage (2.5 Kg) which results in 0.018676028547 Gt which is about 18676.03 Gg of CO2 eq.

6 Conclusion And Policy Implications

Food wastage is an endless flow with multiple social, economic and environmental impacts generated during food life cycle stages. Among those stages, in developing countries, such as Egypt, the role of families in the generation of food waste is very significant. Therefore, in order to substantiate the effects of greenhouse gases emissions, it is required to quantify household food waste, so that the main sources of its generation are identified. Thus, for the first time in Egypt, an estimate of food waste generated by households was carried out based on the subjective weight of food waste by the participating households. The results indicate that approximately 75 kg of food waste is generated per person annually

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Based on the above-mentioned measurement, the 2015 FAO Balance Sheet in Egypt, and relevant GHG emissions data found in literature sources and international databases, an estimation of GHG emissions associated with food waste in Egypt was also made. The results indicate that emissions of 18,676.03 gigagrams of carbon dioxide equivalent. Linked to the generation of food waste in Egypt. In order to reduce the global warming burden from food waste, focus should be placed on preventing food waste generated throughout the life cycle of nutrients.

Recommendations and policy implications to eliminate food waste and reduce its impact on climate change can be summarized, but not limited to: Understanding critical points along the supply chain where waste occurs most frequently and implementing integrated solutions; Changing our buying behavior while making conscious decisions to buy only what we need and then eat what we bought; Retailers, wholesalers and policy makers are advised to reconsider the pattern of food labels as it contributes to the reasons why consumers in particular throw out packaged foods; Hotels and restaurants should share the remaining amounts rather than throw them away; The remaining foods must also be composted to farms; Farmers, consumers and businesses need to be aware of the impacts of food waste and solutions. Many other actions can be taken to achieve food waste reduction and our individual actions collectively will turn out to be a huge result.

Reducing and preventing food waste can increase food security, enhance productivity and economic efficiency, enhance resource and energy conservation, and address climate change, which in turn can also reduce climate change-related shocks in the supply chain.

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