



# A COMPREHENSIVE STUDY ON THE EFFECT OF WASTED FOOD ON GREENHOUSE GAS EMISSIONS

Food waste is a significant problem in the United States and across the world, as produced food is never completely eaten or finished. As a result, the food is wasted while the resources are not well used. Research has estimated that the amount of lost or wasted food during all stages of the food supply chain has ranged from 73 to 152 million metric tons per year or 223 to 468 kg per person per year, which equates to about 35 percent provision of food in the US. Fruits and vegetables, as well as dairy and eggs, are the most commonly wasted goods throughout the consumption stage (households and food service). On the other hand, the food wasted in the US can feed more than 150 million people each year, and some countries do not have enough food to serve all populations. The overproduction of uneaten food creates landfills of wastes and impacts the environment in the US. In order to meet the Paris Agreement and to decrease the global temperature, the food system needs to be addressed. Even if fossil fuel emissions were to be controlled, present food system tendencies would preclude this goal from being met.

## Introduction

Food loss and waste account for 8 percent of anthropogenic greenhouse gas emissions globally, giving an incentive for substantial cuts. Waste minimization can contribute to more sustainable feeding of the world's rising population. Food waste prevention can limit the demand for new agricultural production, deforestation reduction, habitat destruction, greenhouse gas emissions, water contamination, and water shortages. Overall, the US wastes more food than almost any other country. Furthermore, each unit of wastage in the US has a bigger carbon footprint than in most other nations, as the US wastes more food supplies and more animal products than the world average. As the world's population and earnings increase and the ecosystem confronts greater food production needs, reducing agriculture's per-person environmental impact will be critical to the world's long-term viability. Food waste not only affects the environment but also impacts social and economic. For instance, it influences public health and wastes money on food production. The goals of this paper are to raise awareness about the environmental cost of food loss and waste (FLW) in the US and the environmental advantages that can be realized by lowering US FLW. FLW is referred to as food that is produced for human consumption but is not eaten by people [9]. Food waste is classified as edible food that is not eaten for any purpose (for example, cosmetic flaws, spoilage, or cooking failure). Non-edible food wastage refers to food components that are not meant for human consumption but are manufactured alongside edible elements (that is, peach pits and watermelon rinds) [4].

## US Food Supply Chain

The chain of distribution of food begins with primary agricultural production and continues through distribution, processing, and

retail ends with the consumption (or waste) of food at home or away from home. FLW can be found at each point of the supply chain. Crops are abandoned on the farm and seafood is released during production because they do not satisfy particular requirements. Losses are due to handling and storage as a result of insects and diseases. Also, losses occur during processing and packaging from spilled and broken products. Food is discarded during distribution because it is unsightly or is not sold out before the 'best by date.' Food is wasted during consumption as customers do not intake the entire amount of purchased goods [4]. Primary production consumes the majority of land, fertilizer, and pesticides, and even the preponderance of blue water usage and greenhouse gas (GHG) emissions. With this in mind, animal foods use more resources and release more GHG. In addition, fruits and vegetables and milk and eggs are classified as food wasted the most in the retail and consumer stage. Furthermore, the consumption stage burns the most energy. Besides, the management of FLW is a part of the food system [9].

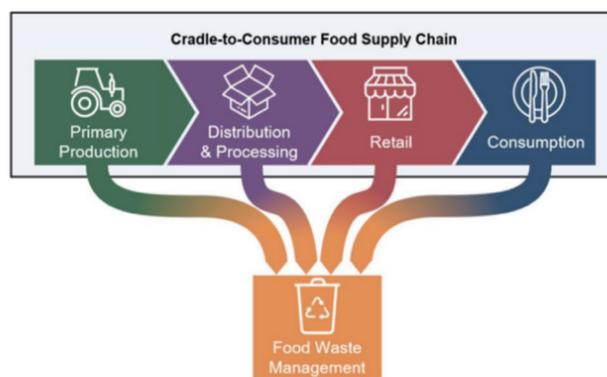


Fig. 1. Stages of the US food supply chain [9]

## Environmental Impacts

A large number of materials, such as land, fertilizer, pesticides, water, and energy, are used to make food. To illustrate, see Figure 2 below. In order to produce food, an extensive variety of environmental inputs have to take an important role in the food supply chain. Land use, as well as pesticide and fertilizer delivery, operate mostly during primary production, whereas water and energy use, along with GHG, occurs throughout the food supply chain. FLW produces an environmental footprint that is calculated based on US domestic food production [9]. Therefore, reducing FLW contributes greatly to a more sustainable food system. Also, it enhances resource efficiency for land and water and even lowers the amount of GHG emitted per unit of meals consumed. However, lowering losses at or near the farmlands can raise the overall quantity of GHG emissions, hence focusing on decreasing consumer waste is more successful in reducing carbon output [5].

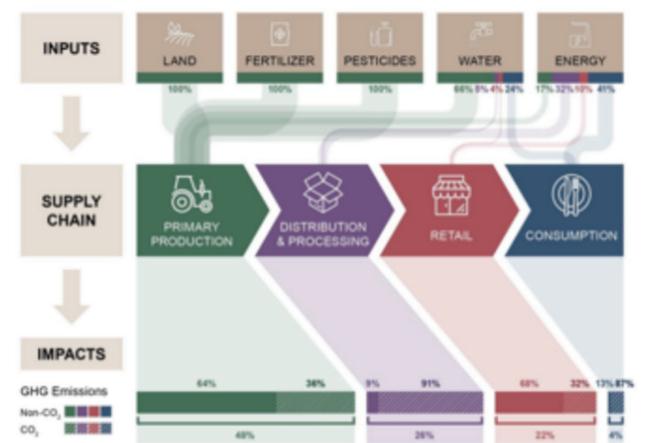


Fig. 2. The environmental footprint of the US [9]

I. Land

Land is the first resource to consider when producing food materials. Agricultural land is required to fulfill the needs of a growing population, shifting dietary habits, and biofuel production [7]. It can also be used to farm, house livestock, produce feed for livestock, and nurture seafood. However, land is limited in the US. Only about 25 percent of US land is used for agriculture. Figure 3 illustrates that the US Department of Agriculture is divided into the categories of six distinct land types - each square on the map represents 250,000 acres of land [11]. It is important to keep land at the minimum and reduce the use of agricultural land because it can result in the loss of biodiversity, affect the ecological cycle and water cycle, increase GHG emissions, and impact local climates [2,7,9].

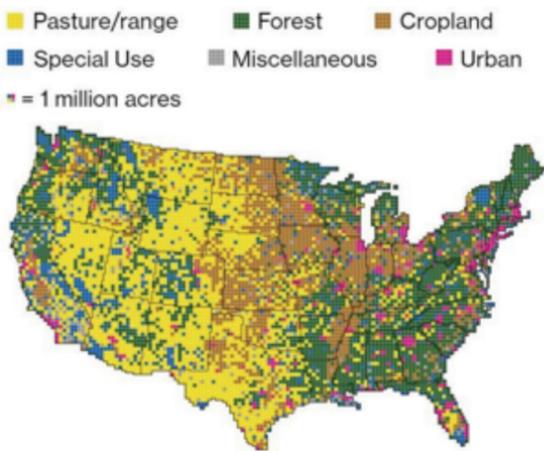


Fig. 3. Six categories of US land use [11]

II. Water

Water plays a critical and essential part in food safety. It is a vital resource for the food industry with numerous applications. Water is used in many ways in food production, including cleaning, sanitation, and manufacturing. Other than those, water can also be used for growing, unloading, fluming, washing, brining, and more. Because of this, water quality is an important factor for food security. It may, directly and indirectly, affect public health. For instance, water can wash off chemical substances and toxins on the surface of the food and lower the allergic spread from each unit of food [3]. Because we are directly ingesting food, the water must be clean to use and drink, necessitating the use of freshwater. Freshwater generally includes rivers, lakes, underground water, glaciers, and part of the total rainfall. They are all categorized as blue water. Nevertheless, freshwater is still in short supply. There is no other available usage of freshwater other than planting, farming animals and seafood, and for human consumption. All stages of the US cradle-to-consumer food supply chain take about 30 percent of blue water outputs. Furthermore, many parts of the US are facing water stress that influences marine life and water-dependent organisms [3,9].

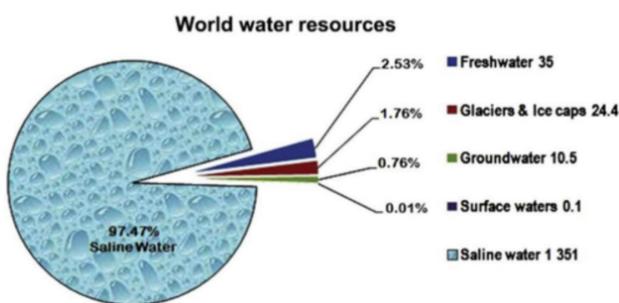


Fig. 4. Distribution of water in the world [3]

III. Pesticide & Fertilizer

Even though both land and freshwater are readily prepared, pests are inevitable. Therefore, to avoid producing loss or damage, farmers spray herbicides and insecticides on their fields and farms. For instance, killing caterpillars that feed on the crop has the advantages of increased production and improving cabbage quality. Also, insecticides keep insects from transmitting dangerous diseases like malaria. Disease not only affects human health but also livestock [1]. Therefore, it is important to control disease spread. However, applying too many pesticides creates disadvantages such as poisoning fruits and vegetables, polluting water, affecting soil composition, wreaking havoc on ecosystems, and risking human health [9]. Importantly, production workers, formulators, sprayers, mixers, loaders, and agricultural farmworkers are among the high-risk populations exposed to

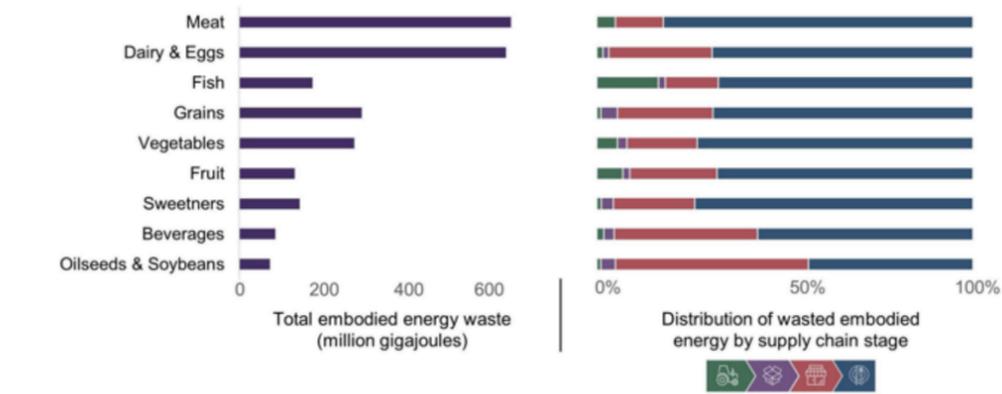


Fig. 5. The embodied energy of US FLW [9]

pesticides. Although insecticides have been the most highly hazardous type of pesticide, herbicides can also harm non-target organisms [1]. In addition, the provision of critical plant nutrients by synthetic and organic fertilizers boosts agricultural production. In the US, the three most common types of artificial fertilizers are nitrogen (N), phosphate (P), and potassium (K). Although the usage of fertilizer can serve more demands, it can also impact the environment. For instance, fertilizer runoff produces adverse effects in potable water, eutrophication of streams, algae growth, and fish mortality. Furthermore, fertilizers emit GHG that causes climate change [9].

IV. Energy

Energy is the most important application in the food supply chain. It needs to be used in all stages from watering with sprinklers to producing food ingredients to powering refrigeration. Energy usage is especially large in distribution and food processing. Big machinery is used to cut crops and break them into ingredients and transport each unit of food all over the US [9]. In order for everyone to have food to eat, a lot of energy needs to be applied. After that, humans need the power to run the refrigerator to keep food fresh and to cook food every day. The usage of big machinery and food factories typically release carbon dioxide into the air. If the food is wasted, energy is also wasted. Figure 5 depicts that more energy is used in downstream processes (retail and consumption) than upstream processes (primary production and distribution and processing) because food needs to be stored for freshness. Moreover, animal products, especially meat, apply the most energy sources.

V. Greenhouse Gas Emissions

Greenhouse gases like carbon dioxide, methane, nitrous oxide, and chemical substances such as chlorofluorocarbon capture some of the Earth's energy release and trap heat in the atmosphere. GHG emissions are mostly produced by human activities and man-made technologies. The increase in GHG emissions would raise the global temperature and affect climate change on ecological systems that exist. This would result in an increase in land, ocean, and air temperature, change in precipitation timing and amounts, permafrost thaw, sea-level rise, and wildfires and hurricanes may all occur. As illustrated in Figure 2, GHGs are released at every process of the cradle-to-consumer food supply chain in the US with the different amounts depending on its stage. Research has shown that primary production produces the highest quantity of

GHG emissions. Figure 2 also shows that almost half of the GHG footprint is carbon dioxide emitting from energy use and land-use change. Additionally, land clearing and forest destruction are also significant contributors to GHG emissions. Furthermore, based on the research in the food category, the production of meat releases the most GHG [9].

VI. Global Trade

The use of land to produce foods and then import those goods internationally threatens the existing species [6,7]. Trading requires mass production, which means more land use, taking away species' habitats and oftentimes making them endangered or even extinct, which would subsequently affect the overall ecosystem and food chain. Based on studies, 30 percent of the global species are threatened because of the global trading system, and the US causes the most harm. Furthermore, the foods need to be imported and exported using different methods. Different transportation produces various amounts of carbon dioxide. In comparison, a boat traveling emits less GHG than a truck [9].

Changing Dietary Behavior

Dietary behavior is often called "foodprint". A foodprint is a resource and environmental influence of a person's daily diet and options. Having healthier diets can result in decreasing FLW, which then can help the environment affected by the food system and improve food security. The results of the American diet and FLW are determined utilizing established sources of energy intake, water use, GHG emissions, land use, and fertilizer regulations. Dietary habits have an impact on humans' health, and nutrition is the principal cause of eating. However, due to overconsumption, the majority of all adults in the US are found overweight or obese. This is because they have taken in too many calories due to excessive intake from surplus food and an unhealthy diet. Poor diets not only result in obesity but also any diet-related disorders. Unhealthy food includes carbohydrates, which have high calories and low nutrition and protein [4]. Figure 6 shown below represents the increase of average body weight among US adults over the past 30 years, but with no change in physical activity. The US obesity outbreak is influenced by the increase in food waste. Overproduction supplies more food in the market at a lower price. As a result, Americans ignore their daily nutrition and intake a great amount of food that they buy at a cheap cost [8].



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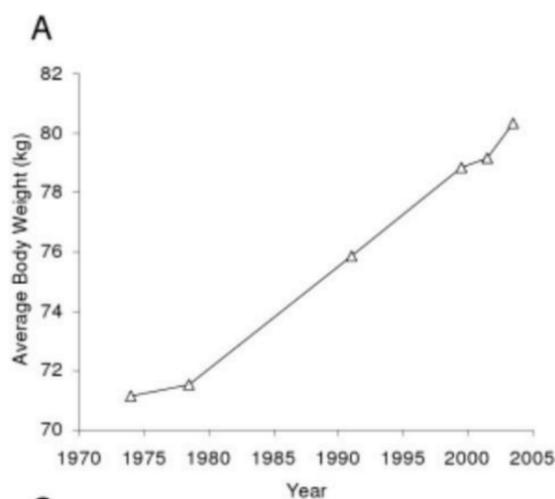


Fig. 6. Measured average adult body weight [8]

## Reducing FLW

Food waste recovery for livestock feed is a feasible choice that has the ability to improve waste disposal (landfilling), food security, and natural resources and environmental issues all at the same time. Nowadays, livestock is fed with grains like maize and soybeans, which increase food production. To change this, the animal feed can be produced from human consumption, which feeds can be an essential component of the food chain and therefore would not be classified as food loss. So, no additional food needs to be produced just for animals and lowers the FLW. When food intended for human use is transferred to animal consumption, it is converted or recycled rather than lost [10].

## Conclusion

Even though Americans have wasted an abundance of food, food production is never reduced. For instance, even if every American

received sufficient nutrients, there is still a large quantity of food leftover with unclaimed. This is also because the food needs to be exported globally to meet other countries' demands. Also, because a lot of food needs to be produced, safety cannot be guaranteed. Studies have shown that the consumption stage yields the greatest amount of US FLW [9]. It represents approximately half of the total FLW in the US. Food is wasted during consumption when customers do not consume the entire amount of purchased goods [4]. As a result of mass production, resources are wasted, and GHG is still emitting at a similar rate. The primary environmental impacts include global warming, a decrease in species, and the quality and availability of water [9]. Even a small change can influence the world's nature. To lessen the environmental effect of the food supply while also improving food security and public health, the US should minimize FLW and promote a change to better nutrition [4].

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