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Sustainability of Food Systems: An Analysis of Household Food Waste on the Economy, Society, and Environment in Maryland, USA

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Abstract: Sustainability involves actions that consider environmental, social, and economic aspects. Food waste is a major issue, accounting for nearly one-third of the global food supply and resulting in significant environmental, economic, and social consequences. Preventing food waste, especially at the household level, is crucial due to the high levels of wastage. This study investigates the environmental, economic, and social impacts of food waste on the sustainability of family food systems in Prince George's and Montgomery counties, Maryland, USA. Primary data was collected through an online survey and personal interviews, utilizing the IBM SPSS statistical data tool. The methodology evaluation employed a 5-point Likert-type frequency scale, with scores ranging from 'strongly agree' (5) to 'strongly disagree' (1). The study's findings reveal several critical points. Firstly, consumers frequently dispose of leftover food, which adds to the accumulation of waste in landfills. Secondly, the energy and water expended in preparing food that is ultimately discarded pose significant environmental costs for households. Lastly, the issue of food waste not only exacerbates hunger but also contributes to global food insecurity, emphasizing the need for more sustainable food practices and waste management strategies.

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1. Introduction

Food waste is a primary global concern with significant environmental, economic, and social consequences (Cederberg & Sonesson, 2011; Reynolds et al., 2019). Approximately one-third of the food produced for human consumption, amounting to an estimated 1.3 billion tons, is lost or wasted annually globally (Davenport et al., 2019), according to the Food and Agriculture Organization (FAO). As the global population is estimated to reach 8 billion by 2030 (United Nations, 2014), addressing food waste across the supply chains is crucial for ensuring global environmental sustainability and food security (Wang et al., 2018).

Private houses are the greatest contributors to food waste within the food supply chain, according to research on food waste volumes and related emissions (Maynard et al., 2020). Given the significant quantity of food waste that occurs at homes, it is critical to address waste avoidance in the last stages of the supply chain to reduce future climate change consequences (Thyberg & Tonjes, 2016). When food is rejected at the end of the supply chain, all the energy (including fossil fuels) and greenhouse gas emissions consumed throughout its production, processing, shipping, refrigeration, and preparation are squandered.

Sustainability rests on three pillars: environmental, social, and economic (Teuber et al., 2016). To disrupt the existing development trend, attaining sustainable development would entail seeking quality of life as well as ecological balance (Maynard et al., 2020; Vu et al., 2017). Our literature search used the terms "household food waste," "consumer waste," and "food sustainability" in the title, abstract, and keywords. We also searched the databases Science Direct, Business Source Complete, and Web of Sustainability and Environmental Management for relevant literature. Several studies have been conducted on food waste, the impact of the environment on food consumption, and sustainable economic development.

Several situational factors have been linked in the past to the quantity of food thrown away by households.

One commonly held view is that minimizing food loss and waste can play a crucial role in environmental and social sustainability (Vu et al., 2017), reducing production expenses, boosting the effectiveness of the food supply chain, and enhancing food security. In Montgomery County, individuals and businesses waste approximately 124,000 tons of food scraps every year, and about 77,000 tons of waste are processed annually. This may not seem like a huge amount to throw away unnecessary or leftover food, but it adds up (County, 2018).

Consumers perceive food waste as a food-related behavior more than as an environmental or social behavior (Thyberg & Tonjes, 2016; Quested et al., 2011). Food waste can be viewed as the final decision-making step in the domestic food provisioning process and as being closely linked to other regular food-related activities, like cooking, stockpiling, and shopping (Porpino et al., 2015). Therefore, these food-related behaviors might play a significant role in explaining home food waste.

Routines related to planning and shopping account for the majority of the variation in food waste, with the latter having a greater impact, according to findings (Stefan et al., 2013). Food waste increases because consumers frequently rely on food shopping routines and acknowledge that they frequently buy more food than is necessary (Porpino et al., 2015; Maubach et al., 2009).

Lowering food losses and waste can have consequences on global food security, commerce, greenhouse gas emissions, and land use, as shown by utilizing the Simplified International Model of Crop Prices, Land Use, and the Environment (SIMPLE) model (Irfanoglu et al., 2014; Baldos & Hertel, 2014). Food waste is calculated as the difference between food purchased and food consumed. The study included food waste by integrating a household production function into the model. However, they do not provide a framework for forecasting the future.

Household size is a characteristic found in many studies: the larger the household, the more food is wasted (Parizeau et al., 2015). Members of larger households, however, were responsible for less waste per capita than members of smaller households (Quested et al., 2013). Specifically, households with more children produced more food waste because parents reported difficulties in predicting how much food children would eat or who would be eating at home (Parizeau et al., 2015).

There is a correlation between food waste and the age of the people preparing the food; the older the individual, the less food is wasted (Quested et al., 2013; Watson & Meah, 2012). Furthermore, it was found that the quantity of food wasted was correlated with the amount of money spent on groceries. Households who spent more on food purchases were bigger food wasters than households with a smaller food budget. Household income, incidentally, did not appear to be connected to the amount of food wasted (Watson & Meah, 2012; Akande & Oghenetega, 2022).

The quantity of food wasted has also been attributed to shopping style and environment. Food waste was shown to be higher in homes with fewer weekly shopping excursions than in households with more frequent grocery store visits, as it is not always known in advance how many people will attend or what they would like to eat (Williams et al., 2012). Moreover, larger shopping visits are typically done as a matter of routine, without assessing the food inventories at home (Wansink & Chandon, 2006). Lastly, it has been proposed that household food disposal practices are connected to large packaging sizes (Quested et al., 2013).

Cuéllar and Webber (2010) estimated that the energy contained in wasted food makes up roughly 2% of the US's yearly energy consumption, using food loss statistics from the US Department of Agriculture for 1995, which revealed that 27% of edible food was wasted. A compilation of the total energy needed for food production (farming, processing, handling, and transportation) at the national level was made using a variety of literature sources. Using relative intensity factors and production mass, the total energy used by agriculture was divided into the energy utilized for ten major food groups. Both of these studies estimated the energy required to produce food that is eventually wasted using top-down techniques, which start with an economy-wide estimate of the energy consumed in agriculture and derive a national average for the farm level or food category level from it. Although Hall et al. (2009) talked about greenhouse gas emissions from food waste decomposition (but not from production or other upstream phases), climate change—possibly the most important environmental issue of our time—was not specifically included in any of these studies.

The environmental consequences of food waste include energy/electricity and water usage for cooking, fuel for transportation, refrigeration, and other safety needs (Asem-Hiablie et al., 2019; Canning et al., n.d.; Pagani et al., 2020; Vittuari et al., 2020). Food waste contributes to greenhouse gas emissions in two ways, according to Garnett (2011): first, through the relatively small amount of decomposition that occurs after food waste is disposed of in landfills; second, through potentially much larger emissions related to the production, processing, transportation, and retailing of food waste. For this second effect, a life-cycle perspective of the discarded food is necessary. It should be highlighted that the life-cycle greenhouse gas emissions associated with food waste provide a more comprehensive assessment of the environmental impact of the trash than do embedded energy or barrels of oil: It comprises not just the emissions from burning fossil fuels but also a sizable amount of emissions from other greenhouse gases, like nitrous oxide and methane, which are unrelated to energy.

The main objective of this study was to analyze the effects of food waste on the environment and society. It examined the social and environmental ramifications of Maryland's household food waste by looking at how it affected resource consumption, environmental sustainability, and community well-being.

2. Materials and methods

The methodology of the research paper involved administering a questionnaire in two counties within Maryland, USA. The questionnaire consisted of 22 items graded on a 5-point Likert scale ranging from strongly disagree to strongly agree. These statements addressed five facets of a consumer's everyday interaction with food: 1) purchase motivations, 2) food waste causes, 3) consuming scenarios, 4) shopping planning, and 5) consumer waste behavior. The survey's statements were based on empirical research evaluating variables influencing consumer-related food waste and actions associated with producing or avoiding food waste (van Boxstael et al., 2014). Comments from comparable food- and sustainability-related research were also integrated into the survey (Chrysochou et al., 2010).

The research involved conducting surveys, interviews, and questionnaires with residents of Prince George's and Montgomery counties in Maryland. This study built upon prior research, including a literature review and expert interviews (Aschemann-Witzel et al., 2015, 2017), as well as investigations involving consumers and households. Measuring food waste at the consumer level is a challenging and time-consuming task, leading to limited studies conducted with a small sample size of 77 households. However, to explore consumer behaviors and identify different consumer segments, a larger dataset is necessary. The questions concerned consumers' economic impact and global food insecurity. A 5-point Likert-type scale of frequency was used, with 5 corresponding to 'strongly agree' and 1 to strongly disagree.

Consumers from two counties (Prince George's and Montgomery) were surveyed. A set of questionnaires in the national English language, which took approximately 10 to 15 minutes to complete, were administered. The questionnaires were in sections, the first focused on self-reported behavior and attitudes toward food waste, while the second path was about the perceived consequences of food waste. Additionally, personal interviews with residents were conducted at various malls and shopping locations around Prince George's and Montgomery Counties. According to the US Census Bureau, the estimated population of Prince George's County is 946,000, with approximately 342,000 households. The gender distribution indicates that males constitute 48%, while females make up 52% of the population. The average annual income is $65,000, with an unemployment rate of 5.75%. Additionally, about 83% of the population has attained education beyond the high school level. In 2022, the estimated population of Montgomery County is around 1.06 million, based on the 2022 census. The gender distribution shows that males account for 49%, while females make up 51% of the population. There are approximately 386,600 households, averaging about 3 people per house. The average annual household income is around $172,000. Moreover, about 77% of the population has received education beyond the high school level, and the unemployment rate is at an average of 3.5%. The survey responses were carefully managed to maintain a reflection of the demographics of the counties in terms of gender, age, income, and education.

		N	%
Gender	female	38	49.40%
	male	39	50.60%
Level of Education	College degree	22	28.60%
	graduate	43	55.80%
	professional	12	15.60%
Race/Ethnicity	Asian	3	3.90%
	Black/African American	35	45.50%
	Hispanic/Latino	14	18.20%
	Native American	6	7.80%
	White/Caucasian	19	24.70%
Age	20-30yrs	8	10.40%
	30-40yrs	16	20.80%
	40-50yrs	18	23.40%
	above 50yrs	19	24.70%
Household monthly Income	below 20yrs	16	20.80%
	$50,000-$75,000	24	31.20%
	$75,000-$100,000	17	22.10%
	above $100,000	1	1.30%
	Below $50,000	35	45.50%

3. Results and discussion

The results from the demographic sample indicate that 15.6% of the participants were employed professionally, and 87.4% were well-educated, with 58.8% having a university education and 28.6% having secondary education. The sample was taken randomly from the demographic distribution of both counties in terms of the level of education, age, and race/ethnicity of the general urban population in the USA. The study uses Spearman's correlation, which works by calculating Pearson's correlation on the ranked values of the data. Ranking is obtained by assigning a rank of 1 to the lowest value: $-1 \leq rs \leq 1$. Spearman′s correlation coefficient is a statistical measure of the strength of a monotonic relationship between paired data (Bonett & Wright, 2000).

Table 1: The statistical correlation between food storage capacity and home technique, and food waste at home.

			Storage capacity and home preservation technique	**Food waste at home**
Spearman's rho	Storage capacity and home preservation technique	Correlation Coefficient	1	0.011
		Sig. (2-tailed)	.	0.922
		N	77	77
	Food Waste at Home	Correlation Coefficient	0.011	1
		Sig. (2-tailed)	0.922	.
		N	77	77

These results indicate no statistically significant positive correlation between food storage capacity and home preservation and food waste r=.011, n=77, p=0.922.

Table 2: Determine the correlation between customers' level of education and household meal planning and portion control

			Level of education	**Meal planning and portion control**
Spearman's rho	Level of education	Correlation Coefficient	1.000	-0.017
		Sig. (2-tailed)		0.882
		N	77	77
	Meal planning and portion control	Correlation Coefficient	-0.017	1.000
		Sig. (2-tailed)	0.882	
		N	77	77

The result of table 2 ; indicates r = -0.017, n= 77, and p=0.882 which means food literacy is not a guarantee of household food waste, because there is a negative correlation between the level of education and meal planning in the household(van der Werf et al., 2019a; Visschers et al., 2016a)

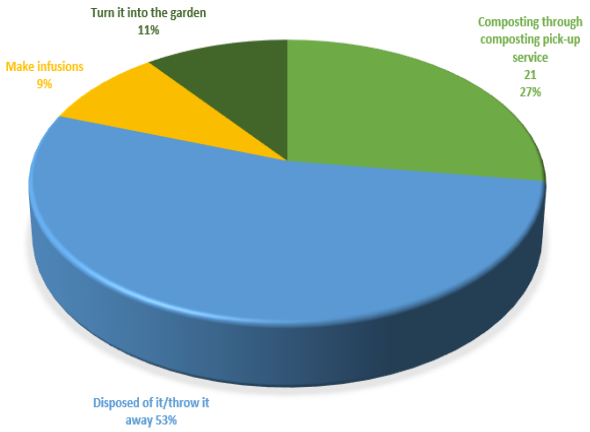


Figure 1: Results for the question 'How do you treat leftover food at home?

Figure 1 results show responses to the question: How do residents treat leftover food? A total of 53% agreed to dispose of it or throw it away, while a significant portion, 27%, composted their leftover food through the composting pick-up service (Bravi et al., 2019). Prince George's organic composting facility allows residents to compost once a week, while 7% make an infusion and 11% use food waste in gardens.

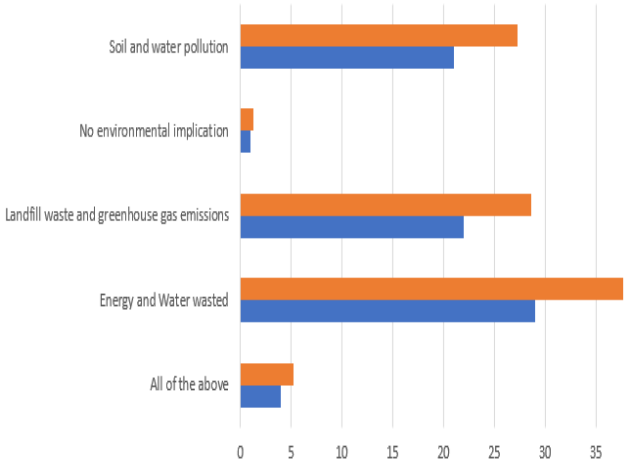
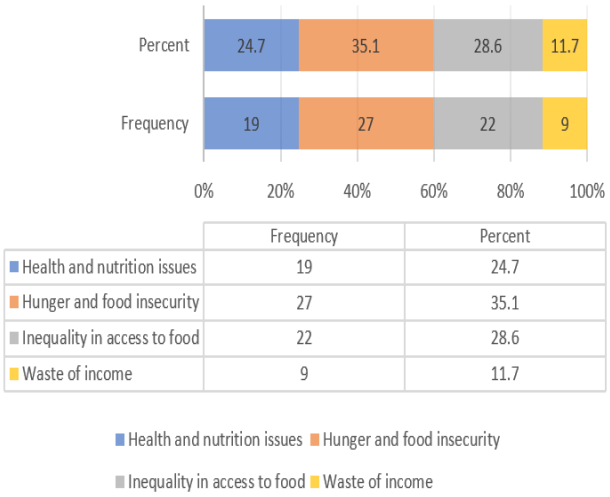


Figure 2: Results for the question: In your opinion, what are the environmental impacts of food waste?

When asked about the environmental effects of food waste, 37.7% of respondents said that food waste had a greater impact on energy and water waste, which is in line with previous research. Reducing food waste reduces the depletion of land, water, energy, and other embedded resources in food production, which is essential for enhancing the sustainability of food systems (Muth et al., 2019). Additionally, 28.6% of respondents felt that

community greenhouse gas emissions and landfill trash are caused by food waste (Principato et al., 2021).



	Frequency	Percent
Health and nutrition issues	19	24.7
Hunger and food insecurity	27	35.1
Inequality in access to food	22	28.6
Waste of income	9	11.7

Figure 3: What do you consider the social impact of food waste?

Food waste can have social impacts on consumers and households. While one might expect that socio-demographics would influence the predictive power concerning food waste, the empirical evidence is far from clear (Lombardi & Costantino, 2021). It is challenging to find socio-demographic determinants or explanatory variables for food waste creation. Nonetheless, some research suggests that the quantity of food wasted in homes could be impacted by a mix of socio-demographic characteristics (Akande & Oghenetega, 2022) (Chrysochou et al., 2010; van der Werf et al., 2019b). Figure 3 results indicate that 35.1% agree with the social issue of hunger and food insecurity and their major impact, while 28.6% considered inequality in access to food, 24.7% health and nutrition, and 11.7% the waste of income. Despite efforts to minimize food waste consumer home food waste generated by consumers remains a significant problem with negative societal consequences (Schanes et al, 2018; Visschers et al., 2016b).

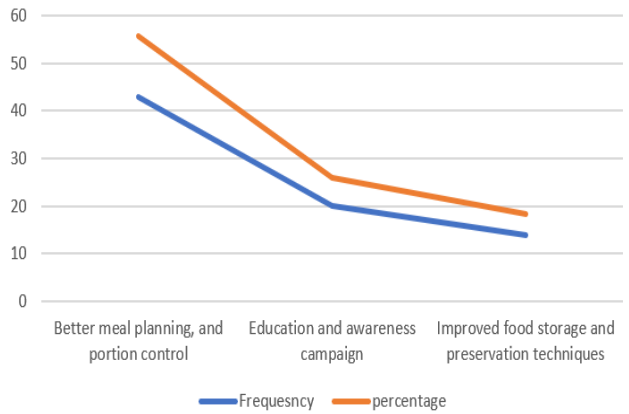


Figure 4: What do you think could be done to reduce food waste in society?

The results from Figure 4 suggest that careful food shopping planning is an efficient measure for food waste prevention at the household level (Romani et al., 2018). A total of 55.8% of the respondents agreed that better meal planning and portion control would support food waste reduction (Graham-Rowe et al., 2014). The consumer level of awareness was 26%, and 18% supported storage and preservation techniques, as indicated in the literature. Studies have found a relationship between food waste and the social value of food (Mallinson et al., 2016) and poor household food planning (Stancu et al., 2016; Stefan et al., 2013), as well as consumer dilemmas over labeling on the package (Abeliotis et al., 2014; WRAP, 2011).

4. Conclusion

This study revealed that household food waste can lead to social issues of hunger and food insecurity in our society. It was found that consumers often overlook the importance of food storage and preservation, leading to food waste and increased landfill, with subsequent environmental consequences. Additionally, only few people recognize the environmental implications of household food waste. It appears that people generally lack concern for food-related aspects such as shopping, preservation, waste cost-benefit analysis, and utilizing leftovers. Consumer intentions to reduce food waste were found to be the most influential factor in determining the amount of wasted food. Furthermore, providing training in skills and control experiences can enhance consumers' perceived control over food waste. Prevention at the household level has the most significant impact on climate change, household income, and global food security.

It is essential to encourage consumers to believe that wasting food is unnecessary, by increasing awareness of the associated costs, such as energy and household income. A comprehensive government food waste prevention policy, such as providing composting services in local communities, promoting the circularization of food items through reduction, reuse, and recycling, and investing in public food storage facilities to support households lacking sufficient storage capacity, is necessary. To ensure the sustainability of household food systems, interventions should prioritize enhancing education on purchasing planning and food preservation techniques, and empowering consumers to take control of their behavior regarding food waste.

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