




## Article

# Food Waste in Da Nang City of Vietnam: Trends, Challenges, and Perspectives toward Sustainable Resource Use

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**Abstract:** Food waste has become a critical issue in modern society, especially in the urbanized and fast-growing cities of Asia. The increase in food waste has serious negative impacts on environmental sustainability, water and land resources, and food security, as well as climate and greenhouse gas emissions. Through a specific case study in Da Nang City, Vietnam, this paper examines the extent of food waste generation at the consumption stages, the eating habits of consumers, food waste from households and service establishments, as well as prospects for the reuse of food waste as pig feed. The results of this study indicate that per capita food waste generation in Da Nang has increased from 0.39 to 0.41 kg in 2016, 0.46 in 2017, and reached 0.52 kg in 2018. According to the results of our consumer survey, 20% of respondents stated that they often generate food waste, 67% stated they sometimes do, and 13% stated they rarely do. Furthermore, 66% of surveyed households stated that their food waste is collected and transported by pig farmers to be used as feed for pigs. The use of food waste as feed for pigs is a typical feature in Da Nang. The study also found that there is a high level of consumer awareness and willingness to participate in the 3Rs (reduce, reuse, recycle) program, which was being initiated by the city government. In service facilities such as resorts and hotels, daily food waste reached 100–200 kg in large facilities and 20–120 kg in small facilities. This waste was also collected for use in pig farming. However, there has been a fall in demand for pig feed in line with a decrease in the number of pig farms due to the African swine fever epidemic that occurred during the implementation of this study. This paper suggests that there is a strong need to take both consumer-oriented waste prevention and waste management measures, such as waste segregation at source and introduction of effective food waste recycling techniques, to ensure that food waste can be safely and sustainably used as a “valuable resource” rather than “wasted.”

**Keywords:** 3Rs program; landscape sustainability; municipal solid waste; pig farming; resource circulation; resource use efficiency; urban–rural nexus; zero-waste lifestyle



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## 1. Introduction

On a global scale, it is estimated that about a third of the food produced for human consumption, or 1.3 billion tons, is lost at different stages of the food supply chain annually [1]. The environmental, social, and economic losses from food waste cost the global economy USD 2.6 trillion [2]. Environmental impacts occur from both food production and food waste management perspectives. The production stage requires 250 km<sup>3</sup> of water and 1.4 billion hectares of land, with about 30% of the agricultural land used to produce uneaten food [3]. Food loss and waste also emit 4.4 Gt CO<sub>2eq</sub> of greenhouse gases (GHG), accounting for 8% of the total anthropogenic GHG emissions annually [4]. Looking at global food waste management, 58% of food waste from the distribution and marketing

stages and 84% from the consumption stage is landfilled [5]. Like most developing countries in Asia, Vietnam still relies on open dumping as the main waste disposal method for waste management [6,7]. Landfill of food waste causes several health and environmental concerns, such as transmission of diseases [8] and GHG emissions [9].

Most studies on food waste are currently examining food waste in the context of developed economies. The per capita food waste in developed economies, such as in Europe and North America, is particularly high compared with other regions [10]. Moreover, the prevention of food waste generation is considered to be the most attractive option, as most waste can be prevented with proper measures [10]. Households in the United Kingdom discard about one third of the food they purchase, and 61% of this amount could have been consumed if the produce had been managed better [11]. Similarly, two thirds of the food waste from households in Germany could have been partly or completely avoided [12]. It has been shown that the average amount of per capita food waste generated in developed and developing countries is 107 kg/year and 56 kg/year, respectively [13]. Buchner et al. [14] also showed that there is a strong correlation between per capita food waste generation and income levels. For example, the amount of per capita food waste (kg/cap.day) in developed countries such as Australia, Germany, Singapore, the UK, and the United States comes to 0.25, 0.34, 0.40, 0.37, and 0.52, respectively [13]. On the other hand, the per capita food waste in countries such as Malaysia, China, Thailand, and Vietnam amounts to only 0.18, 0.14, 0.14, and 0.06, respectively. Nevertheless, in the context of urbanized cities in developing countries, food waste at the consumption stage in developing economies could be even higher than in developed countries [15,16], which indicates that addressing food waste in urbanized cities is an urgent issue in Asia.

Vietnam has made a remarkable journey from low to middle income in the past three decades. This rapid growth, along with industrialization and urbanization, has led to significant shifts in production and consumption patterns, as well as bringing about lifestyle changes, in line with increased consumerism and modified habits related to eating out [17]. As a result, there has been a significant increase in the amount of urban waste and food waste generated per capita, especially in large and rapidly developing cities like Da Nang City. This is having a detrimental impact on the environment and natural assets. It has been reported that food waste accounts for approximately 50–60% (or more in some cities) of the solid waste generated in urban areas, with this waste being eventually disposed of in landfills [18]. Existing research on food waste issues in Vietnam is dominated by waste management [9,19–22]. There are several waste management options identified, such as animal feeding, anaerobic digestion, composting, incineration, and landfilling [13]. Utilizing food waste for livestock feed is considered one major way to manage food waste in Vietnam. In Ho Chi Minh City, as much as 70% of the total food waste is used for livestock feeding [22,23]. Nevertheless, within the existing literature on food waste in Vietnam, little attention has been paid to the factors contributing to food waste generation at the different stages of the food supply chain, notably in the consumption stage, and so this paper aims to fill this research gap.

Through a specific case study conducted in Da Nang City, this paper aims to answer key questions on (i) the extent of food waste at the consumption stage of food supply chains in fast-urbanizing cities like Da Nang; (ii) habits of purchasing, preparing, and disposal of food waste by households and service establishments (e.g., resorts, hotels, and restaurants), as well as demand for food waste by pig farms on the outskirts of Da Nang; and (iii) the roles that reuse and recycling play in the reduction of food waste. The paper also initiates discussion on methodological issues of food waste relevant to the consumption stage of the food supply chains. In this study, food waste is defined as “any food, and inedible parts of food, removed from the goods supply chain to be recovered or disposed,” as proposed by FUSIONS [24]. It does not include packaging waste, or food used for redistribution.

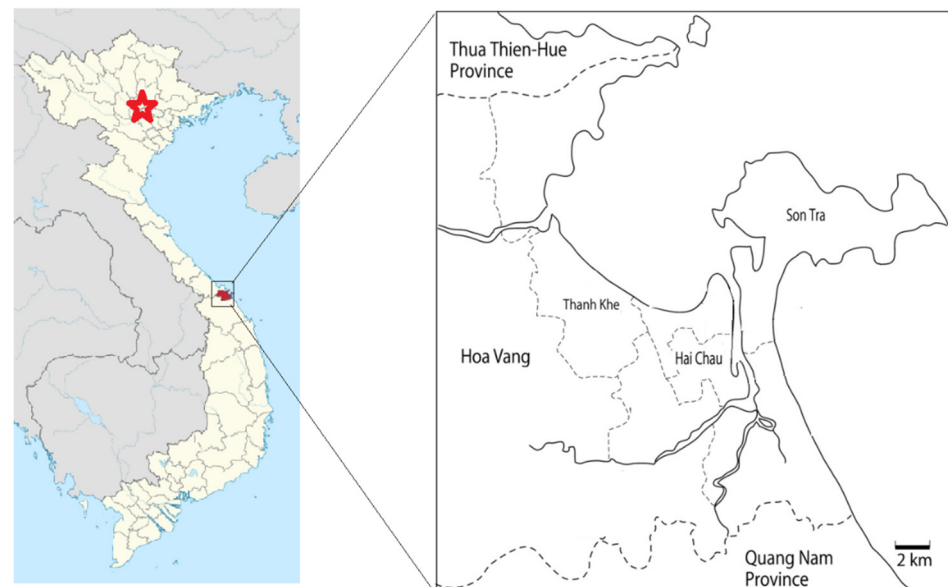
## 2. Materials and Methods

### 2.1. Description of the Study Site

Da Nang City is a port city located in central Vietnam. Da Nang is the fifth most populous city in the country, with a population of 1,080,700 as of 2018 and an area of 1285.4 km<sup>2</sup> [25]. Da Nang is subdivided into eight districts: six urban districts (Cam Le, Hai Chau, Thanh Khe, Lien Chieu, Nguyen Chieu, Ngu Hanh Son, and Son Tra) and two rural districts (Hoa Vang and Hoang Sa). It is further subdivided into one commune-level town, 14 communes, and 45 wards [26,27].

Municipal solid waste in Da Nang is generated from homes, hotels, restaurants, markets, shops, offices, schools, institutions, hospitals, airports, parks, and other commercial facilities. Municipal solid waste in the city is managed by the Da Nang Urban Environment Company [28]. The volume of municipal solid waste in Da Nang is projected to reach 1800 metric tons per day by 2025, 2400 metric tons per day by 2030, and 3000 metric tons per day by 2040. Currently, all municipal solid waste generated is treated at the Khanh Son landfill. The disadvantage of municipal solid waste disposal and treatment at this landfill is that it has become a hotspot for environmental pollution in Da Nang, and is an adverse, unfavorable use of land. Over time, costs for municipal solid waste collection and costs for treatment in this landfill have also increased, particularly to deal with odor, GHG emissions, and leachate that emerge from the landfill [29].

To collect data for this study, questionnaire surveys and key stakeholder interviews were conducted in three districts in Da Nang, namely, Hai Chau (urban district), Thanh Khe (urban district), and Hoa Vang (rural district), targeting local residents, owners of service facilities, and pig farmers, based on the characteristics of each district (Figure 1).



**Figure 1.** Location of survey area in Da Nang City, Vietnam.

### 2.2. Surveys—Questionnaire and Key Stakeholder Interviews

From 12 December 2018, to 1 January 2019, a survey on food habits and food waste segregation was conducted through interviews and questionnaires among 360 households in Hai Chau and Thanh Khe urban districts. This sample size was calculated using a formula developed by Yamane [30], setting a confidence level at 95%, and accounting for missing data. In order to understand food waste generation and demand, the research team interviewed owners of selected service establishments (resorts, hotels, and restaurants) and pig farmers (small-scale farms—less than 20 pigs, and medium-scale farms—less than 200 pigs) in Hoa Vang rural district from November to December 2019.

The survey was conducted through stakeholder interviews and questionnaires, which ensured a high recovery rate and minimized divergence due to respondent apathy. The questions asked in the household survey were based on the following points: (i) basic information about the respondents and their households; (ii) lifestyle habits (location of food purchases, daily meal preparation, and dietary habits); (iii) sorting and disposal habits of municipal and food waste; and (iv) knowledge of and willingness to participate in and implement the 3Rs (reduce, reuse, and recycle) program.

On the other hand, for swine producers, the survey focused on the demand for food waste, including (i) basic information on pig farms; (ii) food waste demand and collection methods; (iii) food processing methods for feeding pigs from food waste; and (iv) demand for pig feed from food waste in the near future.

### 3. Results and Discussion

#### 3.1. Increase in Food Waste Fraction in Cities in Vietnam

Food waste-related studies have shown that the organic fraction of the waste tends to be higher in low-income countries and lower in high-income countries. Total organic waste tends to increase steadily with increasing affluence, at a more modest rate than the non-organic waste fraction. The organic rate in low-income countries is 64%, compared to 28% in high-income countries [31]. In many large cities in Vietnam, food residues account for a large proportion of the discarded municipal solid waste [32–37]. It has been reported that food waste in Ho Chi Minh City accounted for about 64.3–98.3% (average value of 81.6) by wet weight after three months of monitoring at Binh Thanh landfill in 2011 [36]. The composition of food waste at Ge Cat and Phuoc Hiep landfills in Ho Chi Minh City was reported to be 70.84% [35] and 61.3–68.9% [32] in 2011, and the proportion of food waste in the city's municipal waste increased to 83–88.8% in 2015 [13]. This suggests that the food waste component in municipal solid waste in Ho Chi Minh City has increased by several tens of percent. This is similar to the case in Da Nang. Kajima Corporation randomly sampled waste from garbage trucks arriving at the Khanh Son landfill in Da Nang and reported that food residues accounted for 43.7% of the wet weight of municipal solid waste [38]. Meanwhile, this data was reported by Da Nang DONRE [26,39] to be 56.85% in 2009. According to the Da Nang Department of Natural Resources, the percentage of biodegradable organics in municipal solid waste at the Khanh Son landfill was 66.71–74.65% [29,40], of which 80–90% was food waste for the period 2010–2014 [18]. This percentage of organic matter in solid waste in the city is similar to that published by Da Nang URENCO between 2007 and 2011, which was 68.47% [28]. This figure suggests that the organic and food waste components in Da Nang's municipal solid waste have been steadily increasing over the past decade.

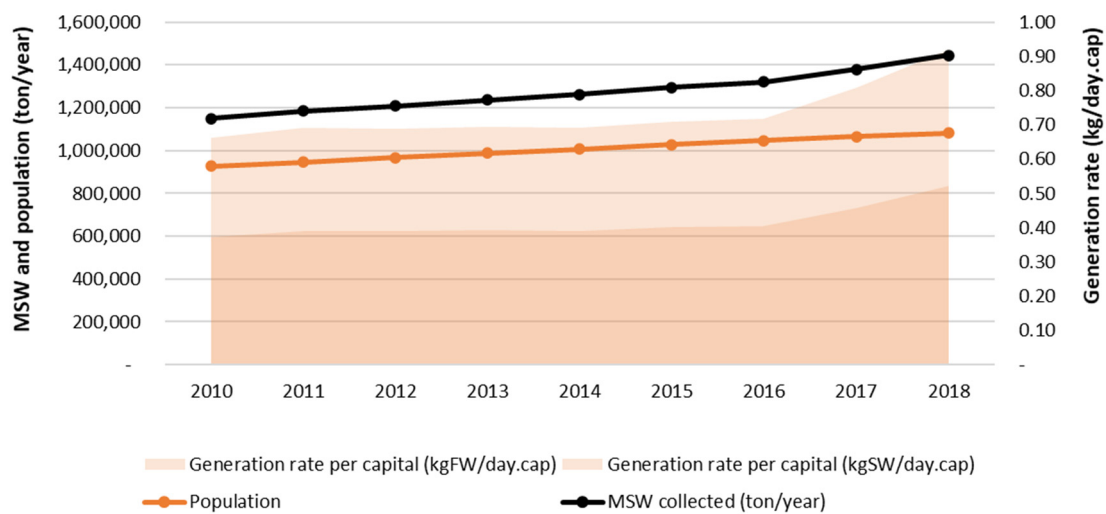
#### 3.2. Trends of Food Waste Generation in Da Nang City

Based on data collected from Da Nang DONRE [26], Da Nang UPI [29], and GSO [25], the municipal solid waste generation and corresponding food waste generation rates and solid waste generation rates were calculated and shown in Figure 2.

According to Figure 2, the population of Da Nang increased by 16.6%, from 926,000 in 2010 to 1,080,000 in 2018 [25]. On the other hand, the rate of increase in solid waste generation in the city during this period was much higher, calculated at 62.8%: from just 223,000 metric tons of municipal solid waste collected in 2010, this increased to 363,000 metric tons in 2018 [29]. Based on food waste composition data collected from previous reports, the generation rate per capita was calculated as 0.37 kg of food waste per day per capita in 2010, and this figure was maintained at 0.39–0.41 kg until 2016. Then in 2017, the figure rose to 0.46 kg, with a further increase to 0.52 kg in 2018.

Comparing this rate with other large cities (Hanoi, Ho Chi Minh City, Bangkok, and Phnom Penh) in Vietnam and other Southeast Asian developing countries [18,26,28,40,41], it shows that food waste generation in Da Nang is at a high level (Table 1).

As can be seen in the above table, the fraction of food waste in Da Nang's municipal waste was similar to that of Hanoi and Phnom Penh, but much lower than that of Ho Chi Minh City and much higher than that of Bangkok. It should be noted that although Bangkok's population was about nine times larger than that of Da Nang, the food waste generation rate per capita of the two cities was comparable in 2016. Similarly, the population of Ho Chi Minh City was about eight times larger than that of Da Nang, but the food waste generation rate per capital was only about 48% higher than that of Da Nang. This can be attributed to differences in lifestyles, solid waste management (food waste demand and disposal), people's attitudes, and local people's knowledge in Da Nang compared to other cities.



**Figure 2.** Municipal solid waste (MSW) and food waste generation in Da Nang City (2010–2018).

**Table 1.** Volume of municipal solid waste, composition, and ratio of food waste generation per capita in selected cities in Southeast Asia [18,26,28,40,41].

City	Da Nang	Hanoi	Ho Chi Minh City	Bangkok	Phnom Penh
Year	2018	2015	2018	2016	2015
Population (1000 persons)	1080	4371	8100	9166	1446
Food waste fraction (%)	57.3	57.3	65.7	47.6	51.9
Collected/landfilled municipal solid waste (tons/day)	994	4980	9400	10,130	1121
Food waste generation rate (kg/day.cap)	0.52	0.65	0.76	0.53	0.40

Moreover, looking at developed countries, based on the latest official data by the Tokyo Metropolitan Government, the average food waste per person per day was around 0.39 kg in 2012 [16]. Based on a report by the Natural Resources Defense Council, an average of 0.23 kg per person per day was wasted at home in the three US cities of Denver, Nashville, and New York [42]. WRAP reports the average food waste per capita per day was 0.42 kg in the UK in 2015 [43]. In addition, food waste generation per capita per day is 0.25 kg in Australia, 0.32 kg in Denmark, 0.27 kg in Sweden, 0.34 kg in Germany, 0.27 kg in South Korea, and 0.52 kg in the US [13]. Although the data are not directly comparable because of the different definitions of food waste and the scope of estimation, it is clear that food waste generation in Da Nang City is even higher than the average in many developed cities and countries.

### 3.3. Results of the Survey

#### 3.3.1. Characteristics of the Selected Respondents

Table 2 summarizes the characteristics of households that participated in the survey.

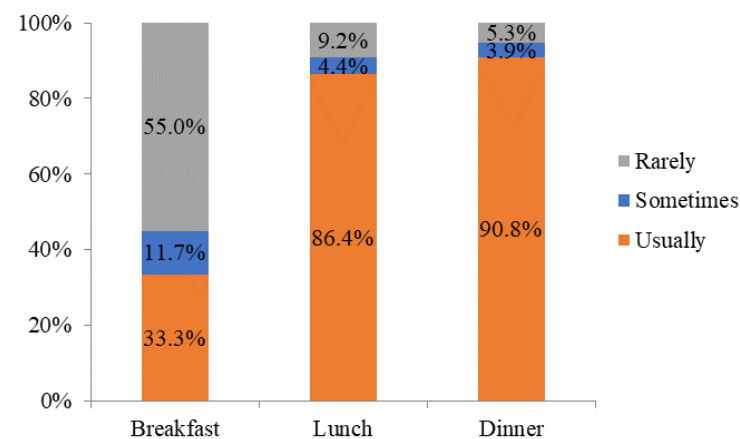
**Table 2.** Characteristics of the respondents.

	Parameter	Number of Respondents
Gender	Male	119
	Female	241
Age	≤20	20
	21–30	60
	31–40	61
	41–50	64
	51–60	77
	>60	78
Occupation	Company employee	101
	Daily-base laborer	110
	Full-time housewife, pensioner	122
	Student (university, junior college, etc.)	27
Education	University, master's degree or higher	63
	Upper secondary school	261
	Lower secondary school	32
	Primary school	4
Household income	≤5 million VND/month	56
	5–10 million VND/month	172
	>10 million VND/month	132

As seen in Table 2, two thirds of the interviewees were women. Respondents' ages ranged widely from 18 to over 60 years of age, with more than half (57%) between 18 and 50 years of age. The level of education of the interviewees is also important in this study. About 90% of the respondents had a secondary education or higher. The occupation of the respondents was very diverse, with 28.1% working full time, 33.9% being retired and working at home, 30.6% working part time, and the remaining 7.5% being students. On the other hand, about 84% of the respondents had a medium to moderate income or higher.

#### 3.3.2. Household Lifestyles Related to Food Waste Generation

Figure 3 shows the results of the survey on eating habits. Most respondents stated that they eat three meals a day. None of the respondents stated that they have no breakfast, and very few people answered that they have four meals a day.



**Figure 3.** Frequency of eating meals at home.

These results are indicative of Vietnamese culture and traditions, with people usually eating lunch and dinner at home, four to five times a week. Conversely, more than half of the respondents reported that they rarely eat breakfast at home and prefer to eat out for breakfast. The survey results imply that Da Nang residents prefer to cook lunch and dinner at home rather than eating out. This trend is similar to Hanoi, indicating that most people tend to eat at home more often in both urban and rural areas [16,44]. Responses to the survey also showed that health and food safety is a key factor in decision-making on diet amongst consumers in Da Nang and Hanoi.

The results of the survey on places to buy food or ingredients for cooking food in Da Nang showed that the most common place is the traditional fresh market. Ninety-four people indicated that they choose both supermarkets and traditional fresh markets as the place to buy food or ingredients on a daily basis, whereas 239 people choose traditional fresh markets only. Very few households (19 households) purchase ingredients from either the supermarket or the hawker alone. A total of 242 respondents said that they are in the habit of going to the traditional fresh market every day, whereas the rest of the respondents stated that they go to the market three to six times a week. On the other hand, of the 108 people who choose to go to the supermarket to buy food, 91 of them buy food once or twice a week. This result indicates the traditional practice of Vietnamese people, whereby locals prefer to go to traditional fresh markets to buy ingredients for preparing food, may suggest the potential burden of food waste generated by the markets, e.g., expired foods, un-eaten parts of vegetables, fish, etc.

In the survey results on where people buy food, 360 people chose "fresh food" as their preferred choice. This figure is in line with the number of people who preferred to buy at fresh markets. Neither "prepared food" nor "canned food" were preferred by Da Nang households. This characteristic is also similar to the findings from the surveys in Hanoi [44]. They showed that residents in both rural and urban areas consume ready-made meals relatively infrequently. Buying fresh food and cooking it at home generates a lot of food waste from households. This is different from Bangkok, where local people eat out or consume ready-made meals frequently [16].

When asked how often they generate food waste, 20% stated "often" (four or more times a week), 67% stated "sometimes" (two to four times a week), and 13% stated "rarely" (two or fewer times a week). That means that about 87% of the respondents generate food waste more than twice a week. On the other hand, it was found that 66% of these households use food waste to feed pigs and just 2% use it to fertilize vegetables and for gardening. Food waste is collected and transported by pig breeders. In addition, 32% of households generate it with other waste. Compared to other large cities in Vietnam, a much higher percentage of food waste from households in Da Nang is used to feed pigs. This figure is comparable to other Asian countries, where there is a high demand for animal feed. For example, Japan and South Korea encourage reusing food waste to feed animals, with 33% and 81% of total food waste being used this way, respectively [45,46]. In contrast, the separation and collection of food waste are not practiced in many developing countries, and therefore almost all food waste is mixed with municipal solid waste (MSW), which is not then able to be purified and utilized for animal feed. The use of food waste to feed pigs is typical in Da Nang.

### 3.3.3. Food Waste Management at Service Facilities

Tourism is an important sector in Da Nang's economy, so it is essential to assess the part played by businesses, including resorts, hotels, and restaurants, in the total food waste generation in Da Nang City. This research carried out a survey of food waste in seven service establishments in urban Da Nang City. These included resorts (120 employees, 100–150 per day), hotels (large, 300 employees, 1200 per day) and restaurants (small, 10–35 employees, 50–80 per day). The results showed that the daily amount of food waste ranges from 100–200 kg for large facilities to 20–120 kg for small facilities; the highest daily food waste volumes are generated at the resorts (100–120 kg) and hotels (150–200 kg)

targeted in the survey. Food waste from restaurants ranges from 40–80 kg per day. All of the facilities have a waste collection activity in their kitchens. This way of saving waste can generate income and provide support for pig breeders. Waste is collected from the service facilities in the early morning at 5 or 6 a.m. or late at night at 10 or 11 p.m., depending on the work schedule of the target facility. Since 2019, all types of food waste (including liquid forms) are put into 20–60 liter plastic containers and transported by bike or truck.

#### 3.3.4. Food Waste Demand from Pig Breeders

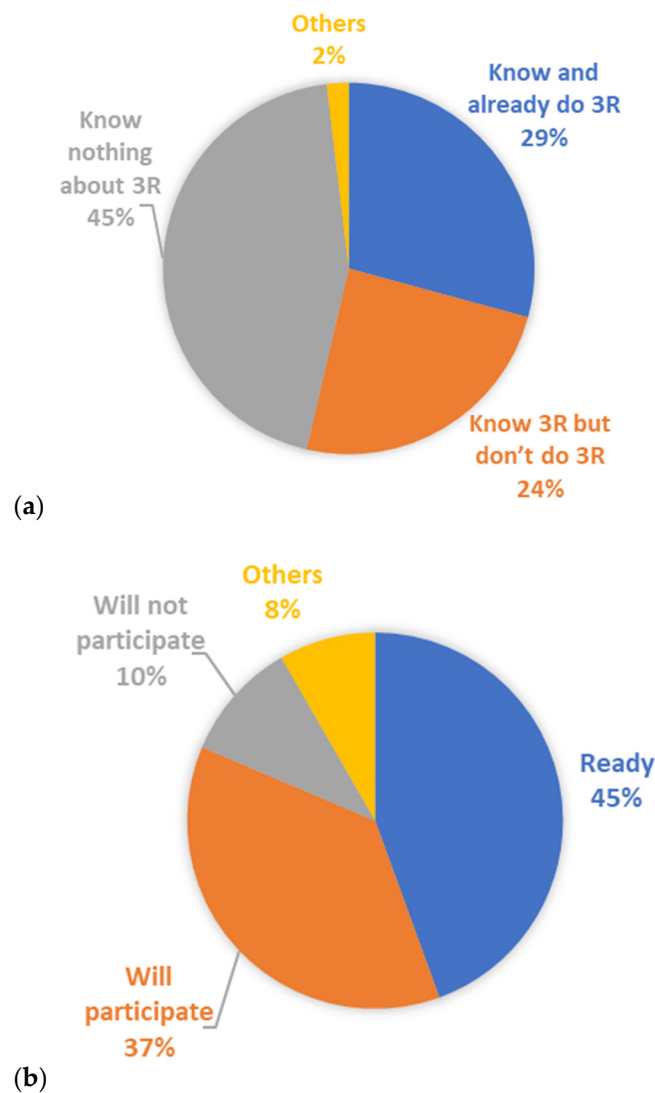
A survey of farmers in the Hoa Khuong commune indicated that due to an outbreak of African swine fever [26], the number of farms and households raising pigs in 2019 decreased by 20–30%. In addition, their capacity also decreased from 80–200 pigs/year to 10–90 pigs/year in the 2018–2019 period. As a result, the demand for food waste decreased and pig breeders only collected it from rural areas. Liquid food waste generated by the service facility is filtered and discharged into the sewer system. Other food waste is mixed with other solid waste and transported to the landfill. Subsequently, the amount of food waste generated in urban areas increased and the amount of municipal solid waste at the Khanh Son landfill increased by 4% per day [26,47].

In fact, food waste could be safely used as pig feed by implementing the following two steps: removing impurities from food waste such as toothpicks, plastic bags, and clam shells, and cooking by adding more fiber and vegetables (which are available on farms) [19]. Existing literature suggests that food waste can be decontaminated for feeding using thermal treatment and preferably by complete sterilization [48]. Pig breeders use bikes to transport 60–240 kg of food waste for their pigs every day. This method could save 50% of the feed costs for pigs. In Vietnam, a farm raising 100–200 pigs can guarantee an annual income for a family with four members. According to Kato et al. [27,49], a large amount of food waste is collected by pig breeders in urban areas of Da Nang, with the amount collected dependent on the number of pigs on the farm and the number of collection trips per day. The study found that farmers collect about 26.3 metric tons of organic waste every day, which is equivalent to 4.1% of the domestic solid waste collected by the local government. Ninety-three percent of the farmers interviewed indicated that they would continue to use food waste for the next five years. Thus, all of the respondents confirmed that they would expand the size of their farms once the African swine fever outbreak is over. They also agreed on the method of collecting food waste at this time.

#### 3.3.5. Assessment of Readiness for Food Waste Reduction, Reuse, and Recycling

This study assessed awareness and willingness to participate in the 3Rs (reduce, reuse, and recycle) for food waste reduction. The results are shown in Figure 4 and indicate a surprising percentage of respondents who had knowledge of the 3Rs and their application. Nearly half of the respondents (160 respondents) indicated that they did not know about the 3R initiative. Eighty-eight of the 360 respondents targeted were aware of the 3Rs but were not interested in applying them. Reasons cited included lack of time to separate waste, odor, and sanitation concerns, and not knowing how to separate waste. Some 105 respondents knew about the 3Rs, but only 85 people were implementing the 3Rs at home. Regarding the willingness of Da Nang residents to participate in the 3R initiative, 293 respondents, or about 82% of the total respondents, indicated that they were ready or willing to participate in the 3Rs (Figure 4b). However, about 18% of respondents either did not participate in the initiative or chose other options. A similar survey was conducted in Hanoi City, showing that the majority of respondents were willing to reduce food waste. Only a few indicated that they had no plans to reduce food waste [48]. The results from this survey suggested the importance of identifying potential ways for consumers to reduce food waste, using easier methods than current practices.





**Figure 4.** Accessing knowledge on the 3Rs (a) and readiness to apply the 3Rs (b) in Da Nang.

#### 4. Way Forward and Policy Implications

The results of the survey carried out in Da Nang confirmed that due to the economic growth and urbanization, food waste in urbanized cities in Vietnam may be even higher than in developed countries, although the quantification methods differ. Thus, Da Nang needs to find a way to simultaneously address food waste generation reduction at the source and deal with food waste management issues.

The survey results show that consumers exhibit high awareness and willingness to apply the 3Rs to reduce food waste. Thus, several measures could be applied to target food waste reduction at the consumption stage. These could include awareness campaigns accompanied by toolkits to help consumers reduce their food waste. This type of guidance could encourage consumers to take practical steps such as improving their skills and knowledge in grocery shopping and planning, ordering smaller portions at restaurants, improving their knowledge about sell-by dates and labels, reusing leftovers and forgotten foods, and improving storage methods, thereby facilitating actions when eating at home and eating out [16].

From a waste management and landscape sustainability perspective, the survey results reveal that reusing food waste for pig farming is a major food waste management measure for food waste generated both in households and in service facilities. If the food waste is not reused, it has to be dumped outside the city, which degrades and devalues land. Therefore, reusing food waste is an economically and environmentally effective solution

for food waste management. Nevertheless, due to the African swine fever outbreak [26], the number of pig farms fell in 2019, resulting in a decreased demand for food waste to use as feed for pigs in 2019. During the implementation of this study, livestock diseases have been brought under control, and households and farmers want to restart their farms to cater to food markets. However, local authorities have not started granting permits for pig re-farming in light of public health concerns. Meanwhile, research findings indicate that proper treatment of food waste using heating and fermentation technologies could effectively avoid contamination of feed for pigs, thereby ensuring stable management of food waste and reducing feed costs [19,50,51]. In accordance with Circular No. 21/2019/TT-BNNPTNT dated 28 November 2019, there have been several updates to the Articles of Law on Animal Husbandry regarding animal feed. Thus, from January 2020, it is now mandatory to carry out quality inspection when using food waste for animal feed. This new legislation is likely to increase the costs associated with feeding livestock, and so small and medium-sized pig farms seeking permission to re-farm are likely to be unable to afford to re-start and will disappear. A decrease in the number of pig farms will be a major problem. It has also been shown that pigs play a vital role in stable food waste management, as they can eat and digest different types of feeds [19,48,49]. Subsequently, if there is a decrease in the amount of food waste used for pig feed, food waste as a part of municipal waste will increase. Liquid food waste, such as fats and oils, flows into the sewer system, where anaerobic digestion causes clogging and produces foul odors. It will become difficult to classify, treat, and manage this increased amount of waste at the Khanh Son landfill [26].

At the policymaking level, national guidance states that the primary solutions for municipal solid waste management are reduction, reuse, and recycling (3Rs). Details and specific goals for municipal solid waste management in 2025 are as follows:

- Collect at least 90% of municipal solid waste and dispose of it at emission standards;
- Increase municipal solid waste reuse and recycling: Treatment process should be combined with energy or organic fertilizer creation;
- Less than 30% of municipal solid waste to be disposed of in landfills.

Meanwhile, Da Nang City has recently implemented waste segregation at source in the two central districts of Hai Chau and Thanh Khe as pilot models [29]. The rate of recycling, reuse, and energy and organic fertilizer production is expected to reach 85% by 2030. Looking at municipal solid waste management between 2015 and 2019 in the city area of Da Nang EPA [47], a municipal solid waste plan up to 2025 will be formulated to classify waste at source in the urban area of Da Nang. Households will be made aware of the importance of waste segregation at source and will be encouraged to participate. In addition, there are some challenges associated with municipal waste management in Da Nang City, including lack of collection and treatment facilities, making it impossible to segregate biodegradable organics. The city relies on farms in the suburbs for food waste collection. Therefore, the following key strategies are recommended to address the existing issues of municipal solid waste in general, and food waste management in particular: (i) supporting tools, equipment, and instructions on waste segregation at the source, particularly for food waste (biodegradable organics); (ii) investment in and upgrading of a secondary collection system and transfer stations for segregated municipal solid waste; (iii) support for research into pilots and models for recycling food waste into feed and organic fertilizer; (iv) additional provisions on classification and reuse; (v) supplementing the “unclassified—no collection” rule for food waste used as feed, municipal solid waste with observations, and penalties for violations; and (vi) strengthening of the urban–rural nexus since most pig farms in Da Nang are located in the rural district of Hoa Vang. This will facilitate more effective and sustainable food waste management, and ultimately prevent land degradation and contamination of the natural environment due to waste dumping in the urban vicinity. The strategies above will also enhance resource circulation and efficiency, and enable more sustainable resource use.

## 5. Conclusions

This case study on food waste in Da Nang City, Vietnam, has once again confirmed that food waste is being generated more and more at the consumption stage in urbanized cities in developing economies, even more so than in developed countries. Consequently, there is a strong need for Da Nang to formulate specific policies and regulations aimed at preventing and reducing food waste at source and in the consumption stage, while at the same time minimizing its negative impacts on the environment (including the reduction of greenhouse gas emissions and ameliorating climate change impacts). This requires appropriate collection, treatment, and recycling and disposal systems. This will facilitate the city in achieving Sustainable Development Goal (SDG) target 12.3, which aims to “halve per capita food waste at the retail and consumer levels, and reduce food losses along production and supply chains by 2030.” Proper strategies will also help to reduce the burden on the existing Khanh Son landfill. Food waste is a cross-cutting issue, with strong interlinkages with other relevant issues such as food security, economic development, and environmental impacts. Therefore, it is also essential for Da Nang to consider establishing a food waste action plan, setting out a clear set of concrete actions aligned with other relevant policies (e.g., municipal solid waste management, food safety and hygiene, use of food waste for animal feed, agricultural development, consumer behavior, etc.). The plan could form part of the city’s overall strategy to promote a circular economy approach through effective resource circulation and resource use efficiency.

It has been reported that households with less food waste tend to regularly practice the following five actions: (i) planning food purchase and use; (ii) less impulse buying; (iii) keeping track of food in stock; (iv) determining accurate portion sizes when cooking; and (v) using leftovers. Policy interventions can trigger changes in consumer behavior and enhance consumers’ awareness and food management skills. Policy should target not only households, but also hotels and resort areas, as they are likely to have a significant impact on food waste reduction in the city.

This paper also suggests that Da Nang could address food waste issues from two perspectives—waste prevention and management, and landscape sustainability. In addition, the urban–rural nexus needs to be further strengthened, which will help to prevent land degradation and protect the natural environment while also enhancing resource circulation efficiency and sustainable resource use within the city. For waste prevention, the city could target consumers using awareness-raising campaigns and specific tips for food waste reduction for different occasions when eating at home or eating out. In terms of food waste management, the city could make it easier for consumers to carry out waste separation and introduce separate collection systems. In the meantime, a safeguard measure to ensure proper treatment of food waste for use as pig feed should be implemented. This will have cost-saving benefits for pig farmers and ensure proper assessment of waste management measurements.

This research is the first step to understanding food waste generation and management in Da Nang City. The data presented in this study may have various uncertainties due to the limited number of samples as well as limitations in self-reporting measures. Future research should aim to validate these self-reporting measures with more objective techniques for data collection. Studies could establish the links between food waste generation and food and waste systems to gain a more holistic view of food waste management. Additionally, more focus could be put on people’s perspectives regarding food waste and their actual behavior, as well as their attitudes to current regulations. This type of study could be very useful in identifying potential and practical methods for consumers to apply the 3Rs more easily. These will consequently assist in achieving landscape sustainability and resource efficiency.

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