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Food Waste Management in Rajshahi City Corporation, Bangladesh: Challenges and Opportunities

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***Abstract*—** *Bangladesh is facing the problem of food waste management like other countries in the world. In Bangladesh, around 70% of municipal waste is food waste. Rajshahi City Corporation (RCC) area was selected as a study area to represent the situation of Bangladesh. The study was aimed to identify key challenges and opportunities to food waste management focused on Rajshahi City Corporation. An online-based survey was conducted through 300 respondents to collect the primary data and analysis. To investigate the association among gender with knowledge chi-square was conducted and found a significant association. From the analysis, we found that lack of knowledge about food waste, absence of source separation, below collection capacity, low budget for waste management may hinder systematic food waste management. For instance, the first opportunity is electricity production through the anaerobic digestion (AD) process that fulfills the increasing electricity demand. Second is digestate will be produced as a byproduct in that process, which is one type of bio fertilizer, use for safe food production. The third is employment opportunities which will be generated in the AD plant, where many unemployed people can get a job. Fourth is the reduction of greenhouse gas emissions from food waste which helps to clean the environment. From the findings, it can be concluded that the present research would be helpful for food waste management in RCC as well as their possible use in different fields.*

***Keywords*—** *Food waste, Waste management, Challenges and opportunities, RCC.*

I. INTRODUCTION

Food waste management (FWM) is a threat full issue all over the world. In most cases, the end result of food waste (FW) is in a landfill which enhances global warming by generating greenhouse gas emissions (GHGE), especially methane (Adhikari et al., 2006; Kumar et al., 2004; Bhide, 1994). Globally the anthropogenic GHGE from FW was estimated at 8% from landfills (Adhikari *et al.,* 2009) and 19–29% from the total food system (Vermeulen *et al.,* 2012). Methane, which is 34 times stronger than CO_2 (Islam, 2016), harms the environment very badly and acts as a powerful influencer for climate change. If it is not managed wisely, it will destroy the ecological balance and create pollution which affects human health (Ma et al., 2017; Islam *et al.,* 2011). Some disease vectors like insects, parasites, vermin, and pathogens are attracted by FW (Louis, 2004; Yedla and Parikh, 2001). However, proper management of FW can improve our environment and decrease health risks (Adhikari *et al.,* 2009). It is a very common scenario and only way of waste management system for low and middle-income countries, like Bangladesh (Scarlat et al., 2015), because of its significant influence on air, water, and soil resources (Adhikari *et al.,* 2009). Besides, it has some common drawbacks, like decreasing land availability for food production, enhancing polluted leachate which contaminated soil and groundwater with toxic organic compounds and heavy metals (Louis, 2004; El-Fadel et al., 2003).

Most of the Bangladeshi people are not used to separating their FW from others (Habib *et al.,* 2021), which is a very initial step to managing the FW smartly to turn it into wealth. FW comes with other municipal solid waste (MSW) or solid waste (SW) in Bangladesh (Alam et al., 2019) and ends up in a landfill. Bangladesh has just started its journey as a developing country (Byron and Mirdha, 2021). In the future, it has to face lots of challenges including FWM which may hinder its future development. But if the FW manages properly, it will turn into a great resource by producing electricity through AD and environment-friendly biofertilizer and also helps to reduce environmental pollution by decreasing GHGE. In addition, it helps to decrease the demand for natural wealth by saving fertile land that is used for landfills, producing energy and creating new job facilities like other countries (Ahsan *et al.,* 2005; Suthar *et al.,* 2016).

In 2015, the total solid waste generation rate (SWGR) was about 58963.15 tons/day in which MSW was 19,361.73 tons/day (Rahman *et al.,* 2013; Sujauddin *et al.,* 2008). By 2025, the municipal solid waste generation rate (MSWGR) will reach 47, 064 tons/day in which food waste generation rate (FWGR) will be 31,768.2 tons/day, and the waste generation rate (WGR) is projected to move 0.6 (Kg/cap/day) from 0.4 (Kg/cap/day) (Alamgir and Ahsan, 2007; Yousuf and Rahman, 2007).

Bangladesh is one of the most populous countries in the World meter. The life of the citizens struggles with different challenges including waste management, especially in urban areas. Now it is high time to improve its waste management system as it is usually in very bad condition. To produce energy by using FW may be one of the best approaches to save the

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environment and natural resources, reduce the volume of waste, health risk, and GHGE.

Though Bangladesh has 67 to 75 % FW, there is not enough data or research based on FW management. So, the present study was designed to identify some key obstacles on FW collection, transportation, re-use, disposal and opportunities of FWM.

II. Materials and Methods

Research area: Rajshahi City Corporation is one of the largest city corporation in Bangladesh which is situated beside the bay of the Padma River. According to the RCC authority, in 2018 the total population of RCC was around 0.85 million (Islam et al., 2020; Habib et al., 2021) with a land area of 96.69 km^2. Figure 1 represented a map of RCC (Halder et al., 2014) along with whole Bangladesh. According to the RCC authority, there is only one dumping site which is 15.98 acres with 3.5 feet deep (Alam and Qiao, 2020). Every day around 300 tons of MSW was generated in RCC (Rahman et al., 2019). Inappropriate landfilling causes odors and environmental pollution because the waste spread around the landfill (Rahman and Jakia, 2015). At present, FWM is becoming a serious issue for Rajshahi city like other big cities in the world.

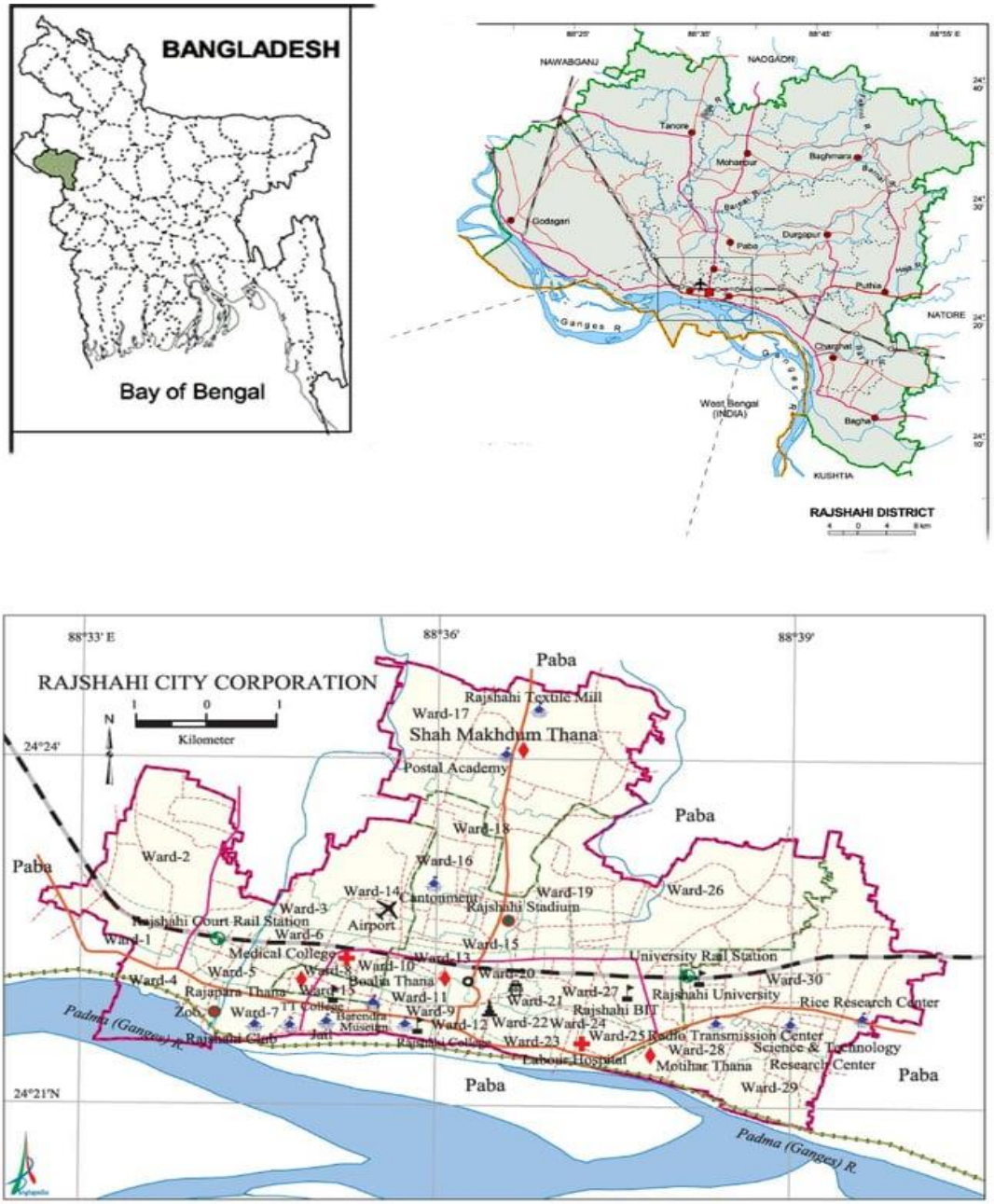

Fig. 1. Layout of Bangladesh, Rajshahi District and Rajshahi City Corporation area.

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Proportion of food waste from Municipal Solid Waste in RCC: FW is mainly happening at the food production stage, processing stage, retailing stage, and consuming level. From previous literature (Alamgir et al., 2007), it was observed that most of the proportion of MSW (77.18%) came from household waste (Figure 2). For that reason, in this research, the survey data collection, analysis and results were based on household-generated FW. The average physical composition of the MSW of six major municipalities (Dhaka, Chittagong, Khulna, Rajshahi, Barisal, and Sylhet) in Bangladesh (Alamgir et al., 2005; Abedin and Jahiruddin, 2015; Paul et al., 2014; Shams et al., 2017).

Fig. 2. Scenario of waste management in Rajshahi City Corporation.

Surveys and questionnaires: According to Rahman and Ahmeduzzaman (2013), Rajshahi city was called a 'Dustbin free city' consider its previous environmental situation; but now it is not like that. RCC only can collect 40%–50% of daily produced MSW efficiently while another big part is left. Only 10%–15% of the budget is practiced for MSWM. Hence, to achieve its present status as the cleanest city in Bangladesh, a systematic waste management process should be started. To start the process, it is important to identify some key challenges and possibilities. For this, an online written questionnaires were used to survey in RCC. Questionnaires were send to a total of 300 respondents by Email, Facebook, Messenger and others online media. The fill up questionnaires were collected from the participants. On the basis of questionnaires, data were collection and analyzed.

The variables and statistical analysis: Data was collected through email and social media in a google form. The questionaries' were sent to 150 male and 150 female respondents. The questionaries' were made to know about respondents' general profile, current domestic (household-level) arrangements for managing general waste and FW, people's knowledge about FW, and their opinion about FWM. From previous literature, it is known that females are more directly involved with FWM at the household level, so to investigate the association chi-square test was conducted with a significance level of 0.05 (5%). To do so three test was conducted-

- Gender and knowledge about FW after collection
- Gender and knowledge about the negative effect of FW on the environment
- Gender and knowledge about renewable energy production from FW.

III. Results and Discussions

Personal information of respondents: Approximately 29% and 71% of the respondents were female and male, respectively; whereas 97% of people are higher educated. A similar proportion was found by Afroz *et al.* (2010). They researched to identify the factors that influence waste generation in Dhaka city and conduct a face-to-face interview where they found 33% female and 67% male respondents of which 61% completed their higher education. This suggests that female respondents were less interested to participate in any survey on the issue of FW or waste. We found more responses from higher educated people compare to Afroz *et al.* (2010); which may be due to the survey was conducting through email and social media. Total 42% people responded to the survey (Figure 3) belong to the age group 25 to 34 years old. It is noticeable that 37% of people, who responded to the survey, were involved in agriculture-related professions which indicate, these people were more concerned about FW, possibly because they are directly or indirectly involved with food production for the enormous population of Bangladesh. It was observed that 60 % of the respondents have 4 to 6 members in their family (Figure 4).

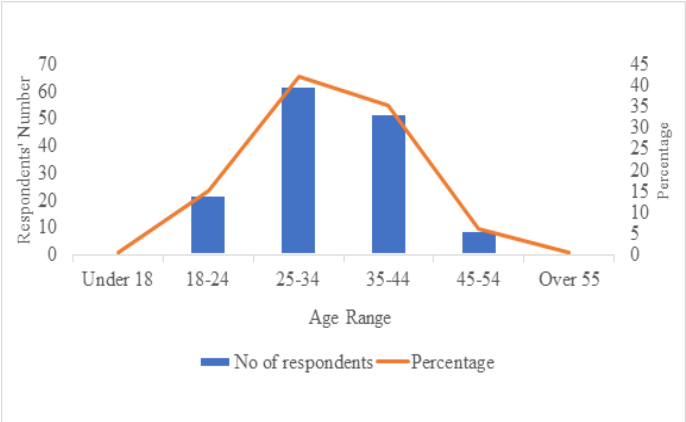

Fig. 3. Distribution of age groups of respondents.

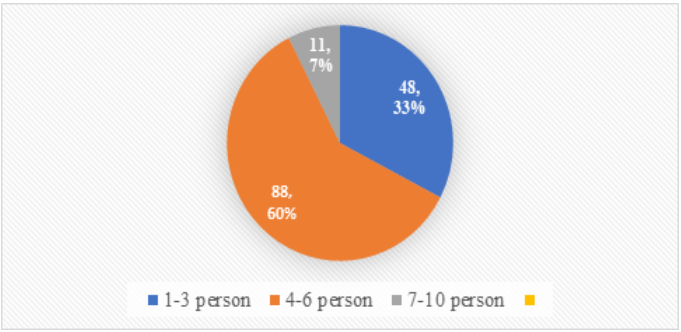

Fig. 4. Number of members in the family of the respondents.

The way people usually manage their general household waste: The highest proportion of 46% females were involved with waste management at the household level. The second-highest percentage was 33%, which was for the maid. In Bangladesh, females are usually doing the job of a maid in the household.

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Afroz *et al.* (2010) found that 64% of household waste was discharged by a maid and 23% was wife or mother. From the personal information of the respondents, it was observed that females were less interested in food waste. Another vital issue is, maids are not so well educated to know about the adverse effect of FW in Bangladesh. According to Afroz *et al.* (2010), most of the cases mother or wife left their education to take care of their families in Bangladesh.

The most important limitation of the study is the fact that it was conducted only by higher educated people, whereby more than 97% of respondents completed their graduation, and more than 83 % were had a very sophisticated profession. However, among them, 20% of people never separated their FW, 24% of people do it rarely, and 27% of people separated their FW often. Though, Habib *et al.* (2021) got a different result from their survey. They conducted research in RCC considering fifty families for measuring daily generated municipal solid waste and calculating electric potential from that. While doing their survey, they found that FW was not separated by any family.

From the survey, it was found that only 24% of people collected their FW to make compost (Table 1). However, 69 % of people mixed it with other waste which has a very adverse effect on the environment and human health, because that large portion usually goes to landfills without doing any pre-treatment or separation and increase methane emission and leachate (Ahsan et al., 2012; Enayetullah and Hashmi, 2006; Moqsud et al., 2011). About 7% of people threw FW on the roadside or into the drainage system which made the situation unhealthy. Because the waste blocks the normal flow of drainage water. As a result, dirty drain water overflows into the streets. In the rainy season, it becomes worse (Alam et al., 2019). It is noticeable that most of the respondents are higher educated. Among them, 7% of people do that. It was noticed that most the people (97%) were used to with cooked food and most of the time, they waste vegetables (52%) and cereals (42%)(Table 1). This information gives the idea, which type of food usually waste in RCC.

Overall, from this section, it is observed that most of the families, females did the responsibility of waste management. So, it is very important to make them know why FW is harmful, how it will be separated and managed systematically. To handle the FW, it is important to know about people's food habits along with the information of the food category, because to make energy through the AD process, the high moisture content is very suitable (Habib *et al.*, 2021). The most important and surprising information from the section is people's thinking about FW segregation, because FW separation is a prerequisite to convert energy from it. At present, mixing FW with other MSW is a common practice all over the country, which hampered the recycling potential of other MSW. Moreover, when FW is mixed with other SW or MSW, it increased the volume of total waste along with the disposal expense (Gustavsson *et al.*, 2011; Baqui, 2005; Huda et al., 2014). As a result, more valuable fertile land, which is now used for food production, will be required for landfills (Alam and Qiao, 2020). It is a very strong barrier to start the systematic way of FWM, which was also identified from this section.

TABLE 1: Issues and reply rates (%) relating to Rajshahi City Corporation residents' current domestic (household-level) arrangements for managing general waste and food waste.

Sl No.	Questions	Option	Number of respondents	Percentage (%)
1.	In your family, who is responsible for collecting and managing the household general waste?	Father/ Husband	28	19
		Mother/ Wife	68	46.3
		Child	3	2
		Maid	48	32.7
	Total		147	100
2.	Do you separate your food waste from other waste?	Regularly	43	29.3
		Often	39	26.5
		Rarely	35	23.8
		Never	30	20.4
	Total		147	100
3.	How do you manage your food waste?	Separately collect it and make organic waste; e.g., compost	35	23.8
		Collect it with other waste and manage through RCC	102	69.4
		Throw it on the road side or into drainage system	10	6.8
	Total		147	100
4.	What kind of food do you eat most in your home?	Uncooked food	3	2
		Cooked food	143	97.3
		Fast food/ Food bought from outside	1	0.7
		Wrapped food	0	0
	Total		147	100
5.	What is the main type of food waste in your family?	Cereal food like Rice, Wheat, Maize	62	42.2
		Vegetables	77	52.4
		Pulse	5	3.4
		Fruits	3	2
	Total		147	100

People's knowledge about food waste: Among the higher educated people, 45% of them did not know what happens to the FW after collection, 29% of people did not know anything about the negative effect of food on the environment, 33% of people never heard about methane emission from FW (Table 2). Even 29% of respondents had no idea about energy production from FW, and 17 % of people never thought about biofertilizer production from it. Though 97% of people agree, if the FW is managed systematically, it will help to save valuable fertile land which may use to produce food production or can fulfill other demands of the growing population like housing. To verify human awareness about waste, they were asked about the information of permanent waste dumpsites or landfills. Shockingly, only 44% of people answered the city has a landfill site (Table 2). Overall, it was observed that the higher educated respondents of RCC did not have too much concern about FW and its future possibility because they did not have enough knowledge about FW, its negative effect on the environment, and human health. Lack of knowledge about the issue is another important factor to convert it to wealth. However, most of them

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agreed about saving the land which will be used as a landfill. Because the increasing amount of waste needs more land to be managed which is a very big challenge (Sharholy et al., 2007).

TABLE 2: Issues and reply rates (%) about people's general knowledge of food waste in RCC.

Sl No.	Questions	Option	Number of respondents	Percentage (%)
1.	Do you know what happens to the food waste after collection?	Yes	81	55.1
		No	66	44.9
	Total		147	100
2.	Do you know anything about the negative effect of food on the environment?	Yes	105	71.4
		No	42	28.6
	Total		147	100
3.	Do you know anything about Methane emission from food waste?	Yes	98	66.7
		No	49	33.3
	Total		147	100
4.	Do you know anything about renewable energy production from food waste?	Yes	105	71.4
		No	42	28.6
	Total		147	100
5.	Do you know anything about biofertilizer production from food waste?	Yes	122	83
		No	25	17
	Total		147	100
6.	If the food waste is managed in a different way, do you think the land will be saved?	Yes	140	95.2
		No	7	4.8
	Total		147	100
7.	In your city do you have any permanent waste dumpsites or landfills?	Yes	66	44.9
		No	40	27.2
		Don't know	41	27.9
	Total		147	100

People's opinion about food waste management: Approximately 44% of people said that RCC does not the capacity to collect all types of waste (Table 3). Similar opinions were found from previous research. For instance, according to Bangladesh Municipal Development Fund (BMDF-2012), and Waste Concern (2009), MSW collection efficiency was 40%–72% by RCC Rahman and Ahmeduzzaman (2013).

Around 40% of people think RCC can not manage the waste properly due to the enormous amount of waste and insufficient manpower. About 42% of people thought the absence of a proper place to drop the waste was the main issue with the present general waste management system. 51% of respondents said when they passed through a dustbin, they felt odor and tried to go very quickly. This opinion describes the worse situation surrounding any dustbin. About 79% of people thought this affects not only the environment but also human health. However, 21% of people from these highly educated respondents did not sure about the adverse effect of food waste. Though 79% of people were not happy with the present waste management system. Mostly. 95% of the respondents thought that if it is possible to produce electricity and safe fertilizer (digestate) from FW, it will be helpful to save the natural resources. According to Islam et al. (2017), major cities can only manage around 35% of daily generated waste. As a result, a vital portion of the MSW was left uncollected (Sujauddin et al., 2008). Below collection capacity of the responsible authority is another vital threat to start systematic FWM.

TABLE 3: Issues and reply rates (%) about people's opinion about food waste management.

Sl No.	Question	Option	Number of respondents	Percentage (%)
1.	Do you think the City Corporation has the ability to collect all types of waste?	Yes	83	56.5
		No	64	43.5
	Total		147	100
2.	In your opinion what is the main problem faced by the city corporation to collect the waste?	Man power	17	11.6
		Lack of vehicle	2	1.4
		Budget	17	11.6
		Large amount of waste	18	12.2
		Option 1 and 4	58	39.4
		Option 2 and 4	13	8.8
		Option 3 and 4	22	15.0
	Total		147	100
3.	What could be done to improve the capability of the city corporation to collect waste?	Bigger budget	12	8.2
		More manpower	6	4.1
		Introduction of new technology	28	19.0
		All of the above	101	68.7
	Total		147	100
4.	What is your main complaint against general waste management in the city?	Bad odor	20	13.6
		Irregular collection system	44	29.9
		Absence of proper place to drop the waste	62	42.2
		Lack of garbage pots and plastics	13	8.9
		Lack of sufficient place into household	8	5.4
	Total		147	100
5.	When you pass through any dustbin or pile of waste, how you feel?	I feel bad odor and try to pass it quickly	75	51.0
		I try to change my route, as it is very dirty and massy place	6	4.1
		I must cover my nose with a napkin and feeling worried about my health	23	15.6
		I feel very irritating and try to stop taking my breath for that moment.	43	29.3
		I feel nothing, it is as clear and clean as other places.	0	0
	Total		147	100

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6.	In your opinion which of the following is affected most by waste?	Human health	11	7.5
		Environment	19	12.9
		Both	116	78.9
		None of the above	1	0.7
	Total		147	100
7.	If it is possible to produce electricity and safe fertilizer (digestate) from food waste, it will be helpful to save our natural resources. Do you agree with the statement?	Yes	141	95.9
		No	2	1.4
		Don't know	4	2.7
	Total		147	100
8.	Are you happy with the present waste management system?	Yes	24	16.3
		No	117	79.6
		Don't know	6	4.1
	Total		147	100

Gender and knowledge about food waste after collection: The chi-square test was statistically significant, χ^2 (1) =5.95, p = 0.02, with Phi (Φ) coefficient of 0.20, indicating small to medium relationship. As can be seen in figure 5, females were more likely to have the knowledge gap than males and from table, it is observed that only 21% of females have the knowledge whereas 79% of males have the same.

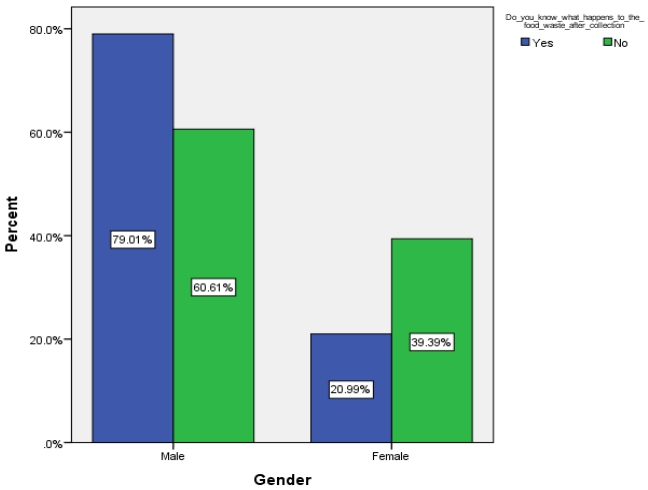

Fig. 5. Percentage of response about knowledge of food waste after collection with respect to gender.

TABLE 4: Chi-square test to determine whether or not there is a statistically significant relationship between Gender and Knowledge about Food Waste after collection.

			Gender		Total
			Male	Female	
Do you know what happens to the food waste after collection?	Yes	Count	64	17	81
		% within Do you know what happens to the food waste after collection?	79.0%	21.0%	100.0%
	No	Count	40	26	66
		% within Do you know what happens to the food waste after collection?	60.6%	39.4%	100.0%
Total		Count	104	43	147
		% within Do you know what happens to the food waste after collection?	70.7%	29.3%	100.0%

Gender and knowledge about negative effect of food waste on the environment: The chi-square test was statistically significant, χ^2 (1) = 7.26, p =0.01, with Phi (Φ) coefficient of 0.22, indicating small to medium relationship. As can be seen in figure 6, females were more likely to have the knowledge gap than males and from table 5, it is observed that 77 % of males have the knowledge whether only 23% of females have the same.

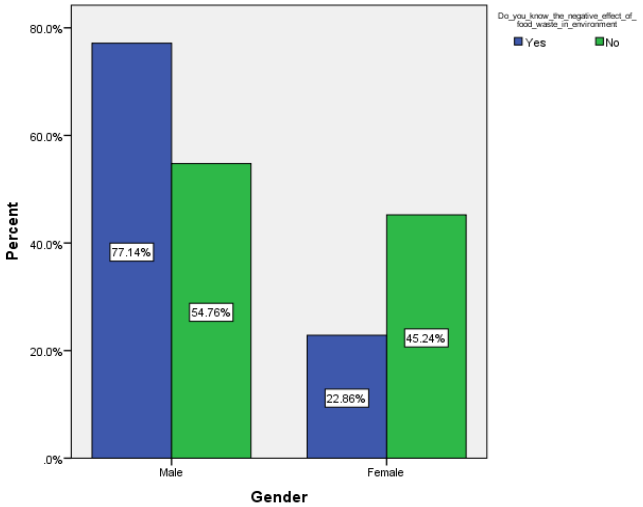

Fig. 6. Percentage of response about knowledge of negative effect of food waste on the environment with respect to gender.

TABLE 5: Chi-square test to determine whether or not there is a statistically significant relationship between Gender and knowledge about negative effect of food waste on the environment.

			Gender		Total
			Male	Female	
Do you know the negative effect of food waste in environment?	Yes	Count	81	24	105
		% within Do you know the negative effect of food waste in environment?	77.1%	22.9%	100.0%
	No	Count	23	19	42
		% within Do you know the negative effect of food waste in environment?	54.8%	45.2%	100.0%
Total		Count	104	43	147
		% within Do you know the negative effect of food waste in environment?	70.7%	29.3%	100.0%

Gender and Knowledge about renewable energy production from food waste: The chi-square test was statistically significant, χ^2 (1) = 9.59, p = 0.002, with Phi (Φ) coefficient of 0.26, indicating medium relationship. As can be seen in figure 7, females were more likely to have the knowledge gap than males and from table 6, it is observed that 78% of males have the knowledge whether only 22% of females have the same.

Opportunities associated with food waste management in RCC: Another big challenge for Bangladesh including RCC is the energy crisis (Halder et al., 2014). Power-cut is a usual phenomenon because national grid electricity can only provide

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under 30% connection to houses (Alam et al., 2003; Islam et al., 2014). While considering the demand, the limited natural resource is reducing. Above mentioned problems will be solved if it will manage the FW properly to make energy. FW has a huge potential to generate biogas due to its elements (Das et al., 2014; Imu and Samuel, 2014). The energy will be fulfilled the partial demand for electricity, and its byproduct, digested, will be used to save food production. This step saves natural resources like land, gas, or coal. To do so, an AD plant should be established, where unemployed people may get a job. When the whole FW will be managed, it helps to reduce GHGE which helps to maintain the environmental balance. People enjoy their surrounding area and lead a healthy life as it is cleaner and creates less odor.

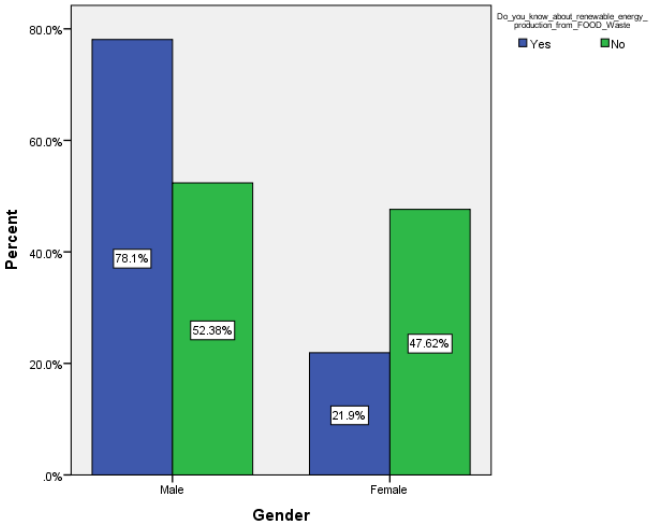

Fig. 7. Percentage of response about knowledge of renewable energy production from food waste with respect to gender.

TABLE 6: Chi-square test to determine whether or not there is a statistically significant relationship between Gender and Knowledge about renewable energy production from food waste.

			Gender		Total
			Male	Female	
Do you know about renewable energy production from FOOD Waste?	Yes	Count	82	23	105
		% within Do you know about renewable energy production from Food Waste?	78.1%	21.9%	100.0%
	No	Count	22	20	42
		% within Do you know about renewable energy production from Food Waste?	52.4%	47.6%	100.0%
Total		Count	104	43	147
		% within Do you know about renewable energy production from Food Waste?	70.7%	29.3%	100.0%

Proposed Recommendations to convert the food waste into wealth: From the findings, it was very clear that even educated people are not aware of the adverse effect of FW. Most of them do not know the possibility of energy and bio fertilizer production from it. So, the first and foremost duty is to make people aware of the negative side of FW and let them know the opportunity to covert it as wealth. Multimedia like television, radio, newspaper, leaflet, personal communication, short films, and social media will be helpful to make people aware of the situation. As females are more involved with managing the FW, the initial step will be convincing them to collect their FW separately from other waste. They have to make understand, as long as it is not possible to manage large-scale food waste processing, they should prepare green manure from food waste by themselves to protect their environment and land. To separate FW from other waste, the government may impose some strict rules. By following the rules, initially, people may receive some rewards. Otherwise, punishment should be imposed. The budget should be increased to manage a large amount of waste. According to Alam and Qiao (2020), RCC can manage only 40%–50% and the rest of the MSW was left and only a little portion (10%–15%) of the whole municipal budget is used for MSWM. To improve their capacity to collect the whole generated used, it is very important to increase the money. People should charge money depending on as much they create waste. This practice will be helped to reduce the volume of waste. As a result, they may reuse their waste, like use the waste to make compost. AD plants will be made to start the energy production system. As it is a new technique for Bangladesh and establishing such a setup may be very expensive, the public-private partnership may be helpful to tackle the situation. Above all, more extensive research will be needed on FWM.

IV. Conclusion

In this work, several key challenges and opportunities associated with FW are identified with the help of the opinion of the people of the RCC and previous literature. There are not enough data or research on FW. So, the dissertation is designed to collect some initial data. Though the report could not involve any respondents from the concerning authority, and people belong to all educational levels, it gives some unique information. Such as, gender is a significant factor for FWM. Because in the household, mainly females do the job of managing FW. So, it is essential to investigate the association of gender with knowledge. When a responsible person for FWM have knowledge about FWM, opportunity, and problems associated with FW, it will be easier to manage. An online survey was conducted among 104 male and 43 female participants to get the result. Chi-square was done to investigate the association.

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Author Contribution Statement

SPL: Conceived and designed the experiments; collected the fund, collected the data; analyzed and interpreted the data, wrote the draft manuscript.
MDS: Assist to interpret the data and draft manuscript writing.
NES: Assist to data analysis, image editing and draft manuscript preparation.
SR: Supervised, reviewed, edited and finalized the manuscript.

Competing Interest Statement

The authors declare no conflict of interest.

REFERENCES

[1]. Abedin M A, Jahiruddin, M. (2015). Waste generation and management in Bangladesh: An overview. Asian Journal of Medical and Biological Research, 1(1), 114–120.
[2]. Adhikari BK, Barrington S, Martinez J. (2006). Predicted growth of world urban food waste and methane production. Waste Manag Res 24, 421–433.
[3]. Adhikari B, Barringtona S, Martinez J. (2009). *Urban food waste generation: challenges and opportunities*. Hal.archives-ouvertes.fr.
[4]. Afroz R, Hanaki K, Tudin, R. (2010). Factors affecting waste generation: a study in a waste management program in Dhaka City, Bangladesh. Environmental Monitoring and Assessment, 179(1-4), 509-519.
[5]. Ahsan A, Alamgir M, El-Sergany MM, Shams S, Rowshon M K, Daud NNN. (2014). Assessment of municipal solid waste management system in a developing country. Chinese Journal of Engineering Article ID 561935, p.11.
[6]. Ahsan A, Alamgir,M, Imteaz M. Daud NNN, Islam R. (2012). Role of NGOs and CBOs in waste management. Iranian J. Public Health, 41(6), 27–38.
[7]. Ahsan A, Alamgir M, Islam R, Chowdhury K H. (2005). Initiatives of non- governmental organizations in solid waste management at Khulna City. In: *Proc. 3rd Annual Paper Meet and Int. Conf. Civil Eng., Mar 9–11, IEB.*
[8]. Alam M, Rahman A, Eusuf M. (2003). Diffusion potential of renewable energy technology for sustainable development: Bangladeshi experience. Energy for Sustainable Development, 7(2), 88–96.
[9]. Alam O, Qiao X. (2020). *An in-depth review on municipal solid waste management, treatment and disposal in Bangladesh*.
[10]. Alam O, He P, Fan L. (2019). Food Waste in Bangladesh - Quantification, Impacts and Management: A Review.
[11]. Alamgir M, Ahsan A. (2007). *Municipal solid waste and recovery potential: Bangladesh perspective*.
[12]. Alamgir M, Bidlingmaier W, Glawe U, Martens J, Sharif L, Visvanathan C, Stepniewski W. (2007). *Safe and sustainable management of municipal solid waste in Khulna city of Bangladesh*.
[13]. Alamgir M, McDonald C, Roehl KE, Ahsan A. (2005). *Integrated management and safe disposal of municipal solid waste in least developed Asian Countries. Final report of 'WasteSafe' a feasibility project under the Asia Pro Eco Programme of the EC* Bangladesh: Department of Civil Engineering, Khulna University of Engineering and Technology.
[14]. Baqui MA. (2005). Post-harvest Processing, Handling, and Preservation of Agricultural Products: Its Present Status and Future Challenges in Bangladesh, FMPHT Division, **Bangladesh** Rice Research Institute (BRRI), Gazipur, p.10.
[15]. Bhide AD. (1994). Methane emission from landfills. Indian Association for Environmental Management, 21,1-7.
[16]. Byron R, Mirdha R. (2021). Becoming A Developing Nation: Bangladesh reaches A Milestone. *The Daily Star*.
[17]. Das D, Ahamed JU, Sahab S, Hossian MS, Akter F. (2014). Study on production of biogas from mixture of cowdung and chicken excreta using silica gel as a catalytic. In: *Proc. Int. Conf. Mech. Eng. Renew. Energy, 1-3 May 2014*.
[18]. El-Fadel M, Bou-Zeid E, Chahine W. (2003). Landfill evolution and treatability assessment of high-strength leachate from msw with high organic and moisture content. International Journal of Environmental Studies, 60(6), 603-615.
[19]. Enayetullah I, Hashmi QSI. (2006). Community Based Solid Waste Management through Public-Private-Community Partnerships: Experience of Waste Concern in Bangladesh. 3R Asia Conference Tokyo, Japan October 30 to November 1.
[20]. Gustavsson J, Cederberg C, Sonesson U, Van Otterdijk R, Meybeck A. (2011). Global food losses and food waste. The Food and Agriculture Organization of the United Nations.
[21]. Habib M, Ahmed M, Aziz M, Beg M, Hoque M. (2021). Municipal Solid Waste Management and Waste-to-Energy Potential from Rajshahi City Corporation in Bangladesh. Applied Sciences, 11(9), 3744.
[22]. Halder PK, Paul N, Beg MRA. (2014). Assessment of biomass energy resources and related technologies practice in Bangladesh. Renewable and Sustainable Energy Reviews, 39, 444–460.
[23]. Huda A, Mekhilef S, Ahsan A. (2014). Biomass energy in Bangladesh: Current status and prospects. Renewable and Sustainable Energy Reviews, 30, 504-517.
[24]. Imu NJ, Samuel DM. (2014). Biogas production potential from municipal organic wastes in Dhaka city, Bangladesh. International Journal of Research in Engineering and Technology, 3(1), 453–460.
[25]. Islam A, Chan ES, Taufiq-Yap YH, Mondal MAH, Moniruzzaman M, Mridha M. (2014). Energy security in Bangladesh perspective–An assessment and implication. Renewable and Sustainable Energy Reviews, 32, 154–171.
[26]. Islam K. 2016. *Municipal Solid Waste to Energy Generation in Bangladesh: Possible Scenarios to Generate Renewable Electricity in Dhaka and Chittagong City*.
[27]. Islam MA, Hossain MS, Islam MA, Islam MT, Iqbal SA. (2017). Municipal solid waste management in Sylhet City, Bangladesh. In: *Proc. 5th Int. Conf. WasteSafe, 25-27 Feb 2017*.
[28]. Islam MR, Alamgir M, Islam MM. (2011). Evaluation of contamination potential of sanitary landfill lysimeter using leachate pollution index. In:*Proc. 13th Int. Waste Manage. Landfill Symp. 3-7 Oct 2011, S. Margherita di Pula*.
[29]. Islam M, Uddin M, Rahman M. (2020). A GIS-based approach to explore the factors contributing towards Urban residential land development and re-development (LDR): a case of Rajshahi City Corporation area. *Geology, Ecology, and Landscapes*, pp.1-12.
[30]. Kumar S, Gawaikar V, Gaikwad S A, Mukherjee S. (2004). Cost-benefit analysis of landfill system witrh gas recovery for municipal solid waste management: A case study Intern. J. Environ. Studies, 61(6), 637-650.
[31]. Louis G. (2004). A Historical Context of Municipal Solid Waste Management in the United States. *Waste Management & Research:* The Journal for a Sustainable Circular Economy, 22(4), 306-322.
[32]. Ma Y, Cai W, Liu Y. (2017). An integrated engineering system for maximizing bioenergy production from food waste. Applied Energy, 206, 83-89.
[33]. Moqsud MA, Bushra SQ, Rahman MH. (2011). *Composting barrel for sustainable organic waste management in Bangladesh - Md Azizul Moqsud, Quazi Sifat Bushra, MH Rahman, 2011*. SAGE Journals.
[34]. Paul N, Halder PK, Hoque ME, Hoque ASM, Parvez MS, Rahman MH. (2014). Municipal solid waste and its management in Rajshahi city, Bangladesh: A source of energy. International Journal of Renewable Energy Research, 4(1), 168–175.
[35]. Rahman A, Nur JN, Islam J N, Hemel S, Rafi S. (2019). *Waste to Energy: An approach to generate electricity by solid waste incineration in Rajshahi City, Bangladesh*.
[36]. Rahman D, Jakia T. (2015). *Solid Waste Management of Rajshahi City in Bangladesh and Its Impacts on Human Health and Environment*.
[37]. Rahman M, Ahmeduzzaman M. (2013). Case Study on the Recent Solid Waste Management Scenario in Rajshahi City, Bangladesh. American Journal of Environmental Protection, 2(2), 58-63.
[38]. Rahman M, Hossain M, Rubaiyat A, Mamun S, Khan M, Sayem M, Hossain M. (2013). Solid waste generation, characteristics and disposal at Chittagong university campus, Chittagong, Bangladesh. *Discovery Science*, Volume 4.
[39]. Rahman SMS. (2005). *A study on solid waste management of Barisal City Corporation.* Master's thesis submitted to the Dhaka: Department of Civil Engineering, Bangladesh University of Engineering and Technology.
[40]. Scarlat N, Motola V, Dallemand J, Monforti-Ferrario F, Mofor L. (2015). Evaluation of energy potential of Municipal Solid Waste from African urban areas. Renewable and Sustainable Energy Reviews, 50, 1269-1286.

[41]. Shams S, Sahu JN, Rahman SMS, Ahsanf A. (2017). Sustainable waste man-agement policy in Bangladesh for reduction of greenhouse gases. Sustainable Cities and Society, 33, 18–26.
[42]. Sharholy M, Ahmad K, Vaishya R, Gupta R. (2007). Municipal solid waste characteristics and management in Allahabad, India. Waste Management, 27(4), 490-496.
[43]. Sujauddin M, Huda SMS, Hoque ATMR. (2008). Household solid waste characteristics and management in Chittagong, Bangladesh. Waste Management, 28(9), 1688-1695.
[44]. Suthar S, Rayal P, Ahada CPS. (2016). Role of different stakeholders in trading of reusable/recyclable urban solid waste materials: A case study. Sustainable Cities and Society, 22, 104–115.
[45]. Vermeulen SJ, Campbell BM, Ingram JSI. (2012). Climate change and food systems. Annu. Rev. Environ. Resour. 37 (1), 195–222.
[46]. Yedla S, Parikh J. (2001). Economic evaluation of a landfill system with gas recovery for municipal solid waste management: a case study. International Journal of Environment and Pollution, 15(4), 433.
[47]. Yousuf TB, Rahman M. (2007). Monitoring Quantity and Characteristics of Municipal Solid Waste in Dhaka City. Environmental Monitoring and Assessment, 135(1-3), 3-11.

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