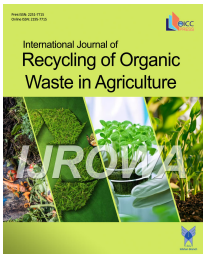

Volume 13, Issue 4, 132448 (1-9)

International Journal of Recycling Organic Waste in Agriculture (IJROWA)

https://dx.doi.org/10.57647/ijrowa-j00z-1n69

Quantitative analysis of feeding kitchen food waste to domestic animals in rural and semi-urban areas from Sammanthurai Divisional Secretariat Division in Sri Lanka

Mohamed Gazzaly Mohamed Thariq[1,*], Mohamed Ismail Mufassara[1], Mohamed Mujithaba Mohamed Najim[2]

[1]*Department of Biosystems Technology, South Eastern University of Sri Lanka, Sri Lanka.*
[2]*Faculty of Agriculture, Sultan Sharif Ali Islamic University, Sinaut Campus, Kampong Sinaut, Tutong, Brunei Darussalam.*

[*]**Corresponding author:** mgmthariq@seu.ac.lk

Original Research

Received:
30 August 2023
Revised:
10 November 2023
Accepted:
29 February 2024
Published online:
19 June 2024

Abstract:

Purpose: Some literature on feeding kitchen food waste (KFW) to domestic animals is available. However, the quantifi-cation of such consumption by those animals is limited. This study attempts to investigate how various domes-tic animals contribute to disposing of the KFW by feeding in rural and semi-urban areas of the eastern province of Sri Lanka.

Method: Simple random sampling was used to select 75 households from the Sammanthurai DS division. The KFW was collected, segregated, and weighed from each of the households. The weight of KFW fed to domestic and stray animals was recorded before feeding. A semi-structured questionnaire was also used to collect the necessary data from the households selected.

Results: The study found that the KFW accounted for 49 %. 25 % of the households disposed of their KFW by feeding to the domestic animals and another 3 % was consumed by stray animals. The village chickens consumed the highest KFW (59.5 %) per day. Each village chicken, cow, other birds, dog, and cat consumed 47.8 g, 695 g, 43.3 g, 128 g, and 91.7 g of KFW per day, respectively, on average. By feeding the KFW to domestic animals, the reduction in greenhouse gas emission was estimated to be 871 kg of carbon dioxide equivalent (CO_2-e) per day.

Conclusion: A quarter of the households fed their KFW to domestic animals they grow. The village chickens were the highest contributor to the disposal of KFW by consuming them. Feeding KFW to domestic animals reduces greenhouse gas emissions and contributes to rural food security through bioconversion.

Keywords: Bioconversion; Village chicken; Stray animals; Greenhouse gas reduction; Rural economy

1. Introduction

Generating waste is a natural and unavoidable part of the existence of human beings (Guerrero et al., 2013). According to the Food and Agriculture Organization (FAO, 2011), one-third of food produced in the globe for human consumption is misplaced or wasted. Food waste contributed nearly 50 % of municipal waste (Gustavsson et al., 2011). Food loss and waste harm the surroundings. Thus, minimizing food waste is expected to improve sustainability and reduce environmental impact (Castrica et al., 2018). Many developing nations struggle with environmental and hygienic issues due to insufficient and disorganized handling and management of food waste. According to Sustainable Development

Goals (SDG 12), the per-capita food waste should be reduced to half by 2030 at the consumer level (Schanes et al., 2018).

The generation of municipal garbage in Sri Lankan towns has grown due to population expansion during the last numerous years, rapid infrastructure development, urbanization, commercial boom, changing lifestyle, rising living standards, and improvement of monetary conditions of a section of the society. Most of Sri Lanka's urban regions had severe problems with waste collection and disposal (Kumara and Pallegedara, 2020). Recent estimates showed that around 7,000 tonnes of solid waste are generated daily in Sri Lanka, comprising around 4,000 tons of food waste (Arachchige et al., 2019; Jayathilake et al., 2022). As stated by FAO (2011), approximately one-third of food produced globally for human consumption, estimated to be about 1.3 billion tons per year, was wasted. It was reported that per capita food waste of consumers from North America and Europe was 95–115 kg/year (FAO, 2011), whereas it is 6–11 kg/year in sub-Saharan Africa and South/Southeast Asia. According to Vidanaarachchi et al. (2006), it was expected that municipal solid waste would reach 1.0 kg/day/head by 2025 in Sri Lanka. However, Basnayake et al. (2019) reported that the municipal solid waste generated in Sri Lanka is 0.48 kg/day/head.

Of the total municipal solid waste collected by Sri Lanka's Local Authorities, food waste comprised an average of 57 % (Jayathilake et al., 2023). In Sri Lanka, the management of solid waste within the locality is the responsibility of the local authorities according to Pradeshya Saba Act No. 15 of 1987, Urban Council Ordinance No. 61 of 1939, and Municipal Council Ordinance No. 16 of 1947 (Saja et al., 2021). According to Hikkaduwa et al. (2015), waste collection is carried out by local authorities such as Pradeshya Saba - 33 %, urban councils - 17 % and municipal councils 50 %. The solid waste management techniques in Sri Lanka include open dumping, compost making, biogas generation, and landfill (Arachchige et al., 2019). However, Sri Lanka's solid waste management system needs to be more effectively established with more research and development inputs.

According to Muth et al. (2019), lowering food waste will prevent the loss of water, land, energy, and other resources. Therefore, it is necessary to enhance the sustainability of food production and consumption systems and create a situation suitable for food security, the environment, and the economy. The "food waste hierarchy" encouraged by FAO aims to back food waste prevention by facilitating its use as animal feed, whereas landfills are the least favored option (FAO, 2009). Further, food waste is presently a problem for the environment since municipal solid waste is not adequately separated from it, which has led to a rise in landfill greenhouse gas emissions (Thi et al., 2015). According to Jones et al. (2021), food waste is one of the important contributors to carbon footprint (CFP), which leads to increased global temperature. It is thus necessary to reduce food waste and thereby reduce CFP. To this effect, Jones et al. (2021) suggested the treatment of food waste using sustainable methods to influence the CFP and the environment positively.

Apart from the policies by the government in Sri Lanka and the subsequent actions taken by the local authorities so far, the issues related to solid waste management are of serious concern. Recently, researchers in Sri Lanka showed interest in using food waste to feed animals. Feeding kitchen food waste to domestic animals is a usual practice around the world, which was investigated previously by many researchers (Westendorf, 2000; García et al., 2005; Angulo et al., 2012; Salemdeeb et al., 2017). According to Jayathilake et al. (2022), feeding food waste to animals has been a practice in domestic-level animal husbandry. This feeding practice has also been observed in commercial livestock animal farming. For example, in China's pig farms, it was found that around 80 % of the kitchen waste collection was used as feed directly (Li et al., 2016). A study of piggeries in Colombo, Sri Lanka found that food waste was a major feed source, contributing 82 % of total feed on average. Further, about 40 % of the pig farms collect food waste chiefly from restaurants, institutional canteens, and hotels (Jayathilake et al., 2022). It was reported that urban food waste from commercial and domestic sources is used to feed animals, i.e. backyard cows and urban livestock (Narayanan, 2019). According to Kumar et al. (2019), edible waste dumped on roadsides provides food for urban livestock, mostly cows and other animals in urban areas. According to Shurson (2020), opportunities exist to circulate energy and nutrients from different food waste into poultry and swine by feeding them because non-ruminants are unable to utilize roughages efficiently and require feed that is dense in energy and nutrients compared to ruminants. According to Chen et al. (2015), the feeding action of food waste should be changed with the different qualities of the products, such as restrictions on feeding to ruminants and recycling as formula feeds. Despite the potential of kitchen food waste to be used as animal feed, its recycling as animal feed was banned in Europe (European Parliament and the Council of the European Union, 2002).

The literature cited above indicated the potential and use of KFW for feeding animals in raw form as they are. Our preliminary observations in the rural and semi-urban areas of the eastern province in Sri Lanka too showed that domestic and stray animals consume kitchen food waste (KFW) in the environment, which is considered as a contribution of animals in the ecosystems to dispose of KFW materials. The literature on the contribution of different types of animals in the ecosystems in the disposal of the KFW and its expected climate benefits is limited. Hence, this study was an attempt to find out and quantify how various animals in the ecosystems contributed to disposing of the KFW in village and semi-urban areas in the eastern province, hence minimizing the environmental concerns; further, the present study proposed a quantitative model having the KFW consumption by domestic animals and expected economic and climate benefits.

2. Materials and Method

Study area

This study was conducted in the Sammanthurai Divisional Secretariat area in the Ampara district of the Eastern province of Sri Lanka. It has fifty-one (51) Grama Niladhari Divisions (the lowest administration unit under a state officer) divided into ten zones. The Divisional Secretariat Division (DSD) Sammanthurai covers an area of 52 km^2. The total population of Sammanthrai DSD is 77,284, as per statistical data in 2021. The Sammanthurai DSD has around 17,800 household units. Sammanthurai Pradeshya Saba is the local government authority responsible for managing solid wastes generated within this area according to the Pradeshya Saba Act No. 15 of 1987. This DSD consists of village and semi-urban areas. Sammanthrai Pradeshya Saba collects solid wastes, including the KFW, from each household; however, the collection coverage may vary depending on many factors.

Data Collection

Ethical review

The study was reviewed by the Ethics Review Committee (ERC) of the Faculty of Technology of the South Eastern University of Sri Lanka and was approved (ERC/FT/2022/15).

Sampling method and sample size

A simple random sampling method was used to select 75 households covering all ten zones. The households were then divided into workable clusters considering proximity so that the households could be accessed within a few minutes to collect data. The researcher(s) visited the households from each cluster on the same day.

Waste sample collection, segregation, and weighing

During the initial stage of the data collection, all 75 households were visited to complete the questionnaire to collect data related to the households. Further, the households feeding domestic animals were also identified during the initial stage. After the questionnaire survey was completed, the next stage of the data collection was done where KFWs were collected from each selected household (within the workable clusters) and segregated according to the waste composition/type. Then, the weight of each segregated waste sample was measured using a weighing scale. The waste collection, segregation, and weighing of wastes from each sampled household within each workable cluster were performed daily for a week by visiting each household (each household was visited seven times). Having daily data for seven days from each household weekly averages were calculated for all the households. The data collection was carried out from April to June 2022 in the dry season.

Measuring the weight of KFW given to animals

As the process of weighing and recording data on KFW feeding is difficult, obtaining that data directly from the households is not possible. Therefore, the researcher(s) negotiated with the households to identify convenient dates for both parties to collect KFW feeding data. On the dates of mutual understanding, the researcher(s) visited the household that fed KFW to animals, to collect data. The day of visiting the household was determined based on many factors, and those dates were not consecutive days. Each household was, however, visited seven days within the three months of the data collection period. The households feeding KFWs to animals were requested to keep the waste without feeding animals until the researcher(s) visited the household on the data collection day. When the researcher(s) visited the households, the KFW were segregated and weighed. After weighing, the KFW was fed to respective animals. The researcher(s) ensured that the animals consumed all the KFWs. As this process required considerable time and was tedious, only a few houses could be covered within a day. Likewise, the same process was continued with one household for seven days (not consecutive days). The total time spent to collect data from all the households was three months. The number of animals feeding on these food wastes was also recorded. Data on the kitchen food waste given to animals and feeding-related data were also collected for seven days, and averages were calculated.

Questionnaire survey

A semi-structured and pre-tested questionnaire was used to collect the data from the prominent household member responsible for handling the kitchen food waste. It consisted of questions about the type of waste generated at the household level, the present household kitchen waste disposal practices, types of domestic animals and stray animals fed on food wastes, weights of KFW used for feeding domestic and stray animals, etc. The questionnaire was filled out during the study by face-to-face field interview.

Estimation of greenhouse gas emission

Fugitive emissions of greenhouse gas emissions proposed by the IPCC 2006 Tier I method and 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Eggleston et al., 2006) were used in the estimation of the reduction of greenhouse gas emissions due to feeding kitchen food wastes to domestic animals.

Data analysis

Data were entered into Microsoft Excel worksheets and transferred to Statistical Package SPSS (version 26) for statistical analysis. Descriptive analysis of the data was done using Microsoft Excel 2013.

3. Results and discussion

Household demographics details

Table 1 provides the characteristics of the respondents in the study. Household's socio-financial demographic characteristics are vital in waste control as they affect the type and quantity of waste generation (Etengeneng, 2012).

According to Table 1, the results reveal that kitchen waste is solely handled by females (100 %) in the study, indicating females' greater involvement in the cleanliness and sanitation of houses and their premises. Most of the females (72 %) involved in handling the kitchen waste were 30–49 years old. It was found that the mean household size was 4.

Table 1. Characteristics of respondents.

Variables	Category	Response
Gender	Female	100 %
Age	20–29	16 %
	30–39	44 %
	40–49	28 %
	50–59	11 %
	60–69	1 %
Household size	Mean	4 (SD = 1)
Educational level	Primary	75 %
	Secondary	16 %
	Diploma	6 %
	Degree	3 %
Employment status	Unemployed	43 %
	Government	35 %
	Private Sector	15 %
	Own business	7 %

Most respondents (75 %) received primary education, and a significant portion (43 %) were unemployed. Since the females perform the waste handling, the awareness among them about the kitchen waste and its management will play a vital role in the disposal of kitchen food waste. According to Kumara and Pallegedara (2020), methods used for waste disposal by households vary corresponding to their socioeconomic characteristics such as age, family size, education level, economic status, and living locality in Sri Lanka. For example, household heads with primary education tend to burn household waste rather than give them for collection by waste collectors. On the other hand, household heads with tertiary education levels (Diploma/Degree) tend to choose collection by collectors rather than burning within their premises. Taye et al. (2024) found that the employment status of households is an important factor influencing waste disposal methods at the urban household level. The existing literature (Kumara and Pallegedara, 2020; Taye et al., 2024) may indicate that waste disposal methods at the household level vary from country to country, region to region within a country in addition to the socio-economic characteristics of the households. Since the objective of this study is different, it did not put much focus on the influence of the socio-economic characteristics of the households on waste disposal methods.

Household waste generation rate

Fig. 1 shows the relationship between the quantity of waste generated and the number of family members. A strong correlation between household waste generation rate and family size is observed ($p < 0.05$, $r = 0.793$). With the increase in family size, the quantity of waste generated significantly increased. With the increase of family size, the consumption increases paving the way for higher waste generation. The present findings are in agreement with the

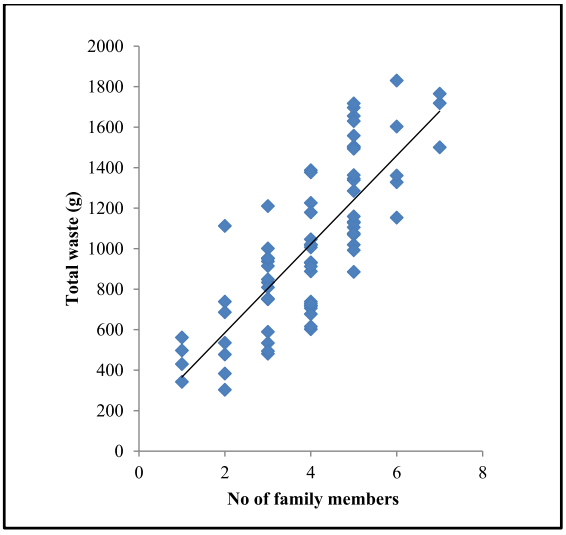

Figure 1. Relationship between family size and waste generated.

previous study by Sujauddin et al. (2008) where it was found that families generate exceptional quantities and types of waste based on their earnings, eating habits, family size, lifestyle, and academic and occupational repute.

Kitchen waste composition analysis

Fig. 2 shows the waste types generated by all 75 households per day on average. The KFW accounted for 37 kg (49 %), the highest composition of the total wastes, and the least was hazardous waste, which accounted for 1 kg.

In the household waste generation, food waste is the biggest component. The present findings are confirmed by the previous studies. For example, a study by Jayathilake et al. (2023) found that food waste in daily municipal waste accounted for 56.5 % in Sri Lanka. According to Thirumarpan et al. (2015), food waste accounted for 79 % of the total waste generated by households daily in the Eravur urban council area in Sri Lanka. If the food waste is collected separately from other waste materials at the household level, it is possible to use them as feed to poultry, fish, and ruminants provided that they are in fresh form (Salemdeeb et al., 2017). Truong et al. (2019) proposed that food waste generated from various sectors in the supply chain can be used as an alternative feed ingredient in the poultry industry replacing corn and soy. Thus, food waste can be one of the important resources that can be utilized as animals directly or in a processed form at domestic and industrial levels.

Food waste disposal method

Table 2 summarizes the KFW disposal methods adopted by the respondents in the study area.

The results in Table 2 show that the majority of the households' KFW i.e., (items 1 and 3 both together amount to 52 %) were collected and disposed of by the Pradeshya Saba. In addition, when the KFW was not suitable to feed domestic animals, households gave those to the Pradeshya Saba for disposal which was practiced by 5 % of the households. These results may indicate that Pradeshya Saba is the main entity involved in the disposal of KFW. The study found

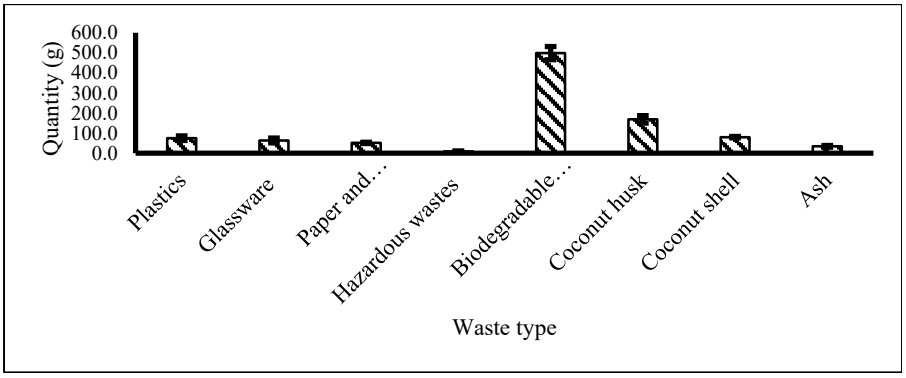

Figure 2. Waste types generated by 75 households per day on average.

that 25 % of the households disposed of their food waste by feeding it to the domestic animals they raised. The present study found that another 3 % of the households disposed of the KFW by feeding those stray animals.

Another important finding of this study was that 43 % of the households (i.e., feeding domestic animals – 25 % + open dumping in the garden – 11 % + burying in the garden – 4 % + feeding stray animals – 3 %) in the study sample did not dispose their KFW to the Pradeshya Saba which is the authorized government body to collect and dispose of the household and municipal solid waste. Another 36 % of the households dumped the KFW at the roadside, and then the Pradeshya Saba vehicle collected the waste. When we discussed with the households about the Pradeshya Saba collection, we found that the waste collection by the Pradeshya Sab was not performed daily. Therefore, households dump their waste on the roadsides, and when the Pradeshya Saba vehicle comes for waste collection, the wastes dumped on the roadsides are collected. The findings indicate that waste collection by the authorized body is not efficiently done. We observed the stray animals feeding on waste dumped on the roadsides. The KFW dumped openly in gardens is also consumed by domestic and stray animals. However, we were not in a position to quantify those.

Kumara and Pallegedara (2020) concluded that waste collection methods by local authorities in rural areas were extremely limited. As a result, people dumped their waste on roadsides and carried out open burning, which is in agreement with our findings in the present study. Further, Kumara and Pallegedara (2020) suggested composting as a method used by some households to dispose of their waste, which could be expanded further. However, the present study found that a higher proportion of food waste is utilized as domestic animal feed in the study area, but no one used the waste for composting. Therefore, an area-specific mechanism may be needed for the disposal of different waste in participation with households, Pradeshya Saba, and other relevant stakeholders, which should be socio-economically acceptable. Therefore, it is suggested to carry out more research studies to identify waste disposal methods at local and regional levels to develop participatory and feasible waste disposal methods.

Consumption of KFW by domestic animals and birds

The number of domestic animals of different species in each house where they are reared was counted. The food waste was weighed before being given to the domestic animals in each household. Having the data on waste consumption by different animals in each house, the average waste consumption by different species of animals was calculated and given in Table 3. As we stated already, 25 % of the households fed their food waste to domestic animals, which is 9.25 kg.

Table 3 shows the number of domestic animals consuming food waste at the household level in the study area. Village chickens, cats, dogs, cows, goats, and other birds (i.e., geese,

Table 2. KFW disposal method by households.

S/N	Waste disposal method	Percentage of households
1	Households dumped their KFW on the roadside then Pradeshya Saba collected it	36 %
2	Households fed their KEW to domestic animals	25 %
3	Households gave their KFW directly to Pradeshya Saba	16 %
4	Households open dumped their KFW in garden	11 %
5	Households fed part of KFW to domestic animals (only suitable portions) while the other part which is not Suitable for the consumption of domestic animals was given to Pradeshya Saba.	5 %
6	Households buried their KFW in the garden	4 %
7	Households fed their KFW to stray animals	3 %

Table 3. Mean consumption of KFW with SD by domestic animals.

Animals	Mean consumption/animal/day (g)
Cats	91.7 ± 44.97
Dogs	128 ± 67.06
Village Chickens	47.8 ± 32.79
Cows	695 ± 43.13
Other birds	43.3 ± 22.50

turkey, etc.) are identified as the domestic animals consuming KFW in the study area. The village chicken is identified as the highest contributor to food waste consumption which is 5.5 kg or 59.5 % of the total food waste consumed by the domestic animals. The number of village chickens was 115 from 25 % of the households. Each village chicken consumed 47.8 g of food waste per day as per this study (Fig. 3). Thus, it is expected that a large quantity of food waste can be consumed by village chickens per year. The village chicken, functioning as a bio-converter, can convert food waste into eggs and meat while assisting in disposing of food waste, and the village chicken contributes to the rural economy by producing reliable protein sources (Fig. 3). According to Thariq et al. (2021), a higher consumer preference exists for village chicken eggs; thus, a higher market price than commercial layer eggs is ascertained. Further, Atapattu et al. (2016) found that domestic hens contribute 15 % to national egg production and are at a much lower level to meat production. Hence, the rearing of village chickens can be promoted when sufficient land and other requirements are fulfilled to manage domestic food waste. The local government authorities (Pradeshya Saba) and the Department of Animal Production and Health can work together to promote bioconversion of food waste by village chickens. The kitchen food waste is also fed to cats (5.9 %), dogs (6.9 %), cows (15 %), and other birds (12.7 %). The contribution of cows to the disposal of kitchen food waste was comparatively low (15 %) as the cows were fed limited food waste.

The present study reveals that out of the 37 kg of food waste generated per day in the study area, 9.25 kg is consumed by domestic animals, which is 25 % of the food waste generated per day. From the findings of the study, it is concluded that 25 % of kitchen food waste per day is disposed of by domestic animals by consumption while reducing the negative environmental effects of food waste (Thi et al., 2015). Feeding food waste to animals is considered the best alternative to open dumping and landfilling which is also environmentally friendly and the least cost or non-cost method (Sarker et al., 2022). The utilization of food waste by domestic animals seems promising and encouraging. According to Pinotti et al. (2021), food waste is regarded as an innovative practice concerning the sustainability of animal feed and circular economy; however, ethical, safety and legal concerns still exist. Further, the study was carried out during the dry season in the study area. The food consumption pattern as well as the KFW generation and disposal pattern may be different during the rainy season in the study area. Due to resources and time limitations, it was not affordable for this study to cover both seasons, hence, this is considered a limitation in this study. Therefore, we recommend extending this study with more resources in the future. However, this study becomes globally relevant since it opens up further debates and avenues on the multidisciplinary nature of KFW disposal. This requires the involvement of the global research community to carry out further research on the utilization of KFW as animal feed and its circular nature concerning socio-economic and environmental implications integrating legal concerns.

Consumption of waste by stray animals and birds

The stray animals that came to consume the food waste were identified, and the numbers were counted. However, it was difficult to estimate the food waste consumed by different types of stray animals in the present study since several

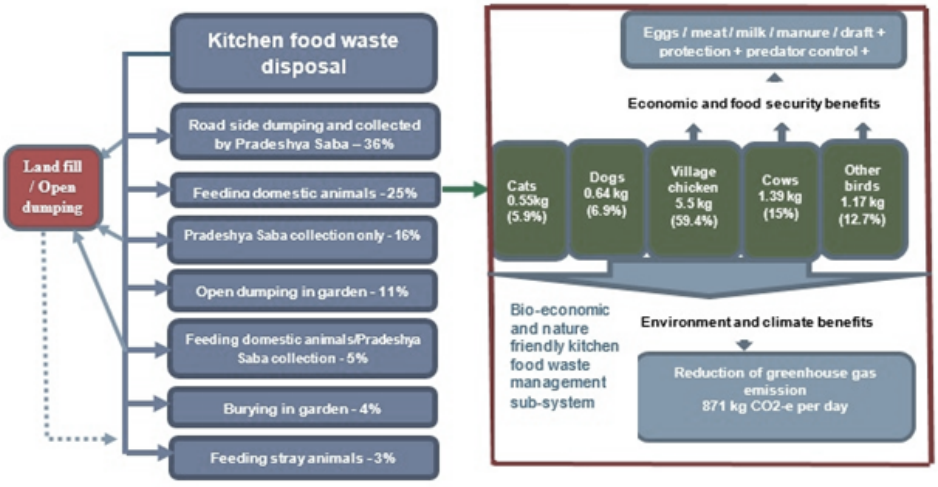

Figure 3. KFW disposal model for rural and semi-urban localities based on existing practices.

stray animals came together to feed on the food waste. It is found that 3 % of food waste is fed to stray animals by households. The stray animals, i.e. house crows, cats, dogs, cows, village chickens, squirrels, and other birds, are identified as consuming food waste of 1.11 kg per day. Previous studies (Chandramohan et al., 2013) found many stray animals, i.e. dogs, cows, pigs, and rats as well as birds such as crows, kites, etc., inside the waste dumping sites. The risk of spreading diseases by stray animals that feed on waste in dumping sites and roadsides was reported by several researchers (Kumar et al., 2019; Dayananda et al., 2021). Therefore, feeding stray animals by households should be avoided and, in this regard, Pradeshya Saba should take necessary actions and also educate the households.

Reduction in greenhouse gas emissions via feeding kitchen food waste to animals

Jaglo et al. (2021) reported that food loss and waste accounted for 8 percent of anthropogenic greenhouse gas emissions equal to 4.4 gigatons of carbon dioxide equivalent (CO_2-e) annually. A meaningful reduction in this amount will contribute to lower resource use and environmental impacts. The emissions from the food waste landfill are 25 times greater than those from composting, even in the lowest net emissions landfill scenario. Poorly managed on-site composts may result in higher methane and nitrous oxide emissions. Average net emissions of kg CO_2-e per tonne of food recovered through aerated pile or vessel and turned windrow composting are 16 and 22.5, respectively (NSWEPA, 2021). Food waste processing into compost reduces emissions by 96 % compared to landfilling (NSWEPA, 2021). Landfilling of food wastes produces 0.6 kg CO_2-e per kg wet weight (600 kg CO_2-e per tonne) (Corona et al., 2020). However, greenhouse gas emissions due to feeding of KFW to animals considerably reduce the greenhouse gas emissions.

The study sample of households of 75 houses produced 37 kg of KFW daily out of which domestic animals consumed 9.25 kg. Prevention of landfilling or open dumping reduces 5.55 kg CO_2-e of greenhouse gases emitted to the atmosphere in a day and 2,025 kg CO_2-e of greenhouse gases within a year by 75 households. Assuming the same trend applies to the Sammanthurai DSD, the total greenhouse gas emission reduction achieved could be 871 kg CO_2-e per day or 318 t CO_2-e per year.

4. Conclusion

The study found that 49 % of total domestic kitchen waste was food materials. The village chickens, cats, dogs, cows, goats, and other birds were identified as the domestic animals in the study area. The crows, cats, dogs, village chickens, squirrels, and other birds were identified as stray animals. The contribution of village chicken in the disposal of KFW was the highest (59.5 %), followed by cows (15 %), other birds (12.7 %), dogs (6.9 %), and cats (5.9 %). The present study found that 9.25 kg (25 %) of the KFW per day, on average, is disposed of by the consumption of domestic animals. On average, each village chicken consumed 47.8 g of KFW per day. The present study found that 3 % (1.11 kg) of KFW was consumed by stray animals per day on average. Concerning the reduction of greenhouse gas emissions, it was estimated that 871 kg CO_2-e per day reduction could be achieved by feeding the KFW to domestic animals. From the findings of the study, it is recommended that the rearing of village chickens be promoted in the areas wherein it is possible to grow them. The local government authorities (Pradeshya Saba) and the Department of Animal Production and Health can work together to promote the bioconversion of KFW into egg and meat by village chickens. Further, Pradeshya Saba should take necessary actions and also educate the households concerning the risk of spreading diseases related to feeding stray animals with KFW. Further research is needed on the nutrient composition, quality, and safety of feeding kitchen food waste to domestic animals.

Acknowledgment

The assistance of Mr. R.M. Nikzaad is acknowledged.

Authors contributions

The authors confirm the study conception and design: MGMT, MMMN; data collection: MIM; analysis and interpretation of results: MGMT, MMMN, MIM; draft manuscript preparation: MGMT, MMMN. The results were evaluated by all authors, and the final version of the manuscript was approved.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Angulo J, Mahecha L, Yepes SA, et al. (2012) Nutritional evaluation of fruit and vegetable waste as feedstuff for diets of lactating Holstein cows. *J Environ Manage* 95:S210–S214. https://doi.org/10.1016/j.jenvman.2011.06.050

Arachchige USPR, Heshanka S, Peiris HIS, et al. (2019) Proposed model for solid waste management in Sri Lanka. *Int J Sci Technol Res* 8:1544–1550.

Atapattu NSBM, Abeywickrama LM, Gunawardana WWDA (2016) Contribution of backyard chicken egg production to fulfill household nutrient requirement: A study in Southern Sri Lanka. *Int J Livestock Res* 6:7. https://doi.org/10.5455/ijlr.20160619063921

Basnayake BFA, Popuri S, Visvanathan C, et al. (2019) Concerted initiative for planned management of municipal solid waste in target provinces in Sri Lanka. *J Mater Cycles Waste Manag* 21:691–704. https://doi.org/10.1007/s10163-018-0815-5

Castrica M, Tedesco D, Panseri S, et al. (2018) Pet food as the most concrete strategy for using food waste as feedstuff within the european context: A feasibility study. *Sustainability* 10:2035. https://doi.org/10.3390/su10062035

Chandramohan A, Sivasankar V, Chandrahasan R, Rathinagiri S (2013) Microbiological Research in Agroecosystem Management:A probe on the status of microorganisms in the air, soil and solid waste samples of ariyamangalam dumping site at Tiruchirappalli District, South India. Edited by Velu R. *Springer, New Delhi,* 1–9.

Chen T, Jin Y, Shen D (2015) A safety analysis of food waste-derived animal feeds from three typical conversion techniques in China. *Waste Manage* 45:42–50. https://doi.org/10.1016/j.wasman.2015.06.041

Corona A, Ernstoff A, Segato C, Zgola M (2020) Greenhouse gas emissions of food waste: Methodology. *Renens, Switzerland*

Dayananda LGH, Thariq MGM, Rifath MR (2021) Study of stray cattle problems in the Kalmunai regional health division. *10th South Eastern University International Arts Research Symposium, South Eastern University of Sri Lanka, Oluvil, Sri Lanka,* 110.

Eggleston HS, Buendia L, Miwa K, et al. (2006) 2006 IPCC guidelines for national greenhouse gas inventories. *Institute for Global Environmental Strategies,Hayama, Kanagawa, Japan*

Etengeneng D (2012) Municipal solid waste management in Grahamstown, Republic of South Africa. *NOVIA University of Applied Sciences, Raseborg, Finland*

European Parliament and the Council of the European Union (2002) Health rules concerning animal by-products not intended for human consumption. *European Union* 273

FAO (2011) Global food losses and food waste – extent; causes and prevention. *Food and Agriculture Organization, Rome*

——— (2009) The state of food and agriculture 2019. Moving forward on food loss and waste reduction. *Food and Agriculture Organization, Rome*

García AJ, Esteban MB, Márquez MC, Ramos P (2005) Biodegradable municipal solid waste: Characterization and potential use as animal feedstuffs. *Waste Manage* 25:780–787. https://doi.org/10.1016/j.wasman.2005.01.006

Guerrero LA, Maas G, Hogland W (2013) Solid waste management challenges for cities in developing countries. *Waste Manage* 33:220–232. https://doi.org/10.1016/j.wasman.2012.09.008

Gustavsson J, Cederberg C, Sonesson U (2011) Global food losses and food waste: Extent, causes and prevention. *FAO, Rome*

Hikkaduwa HN, Gunawardana KW, Halwatura RU, Youn HH (2015) Sustainable approaches to the municipal solid waste management in Sri Lanka. *Proceedings of the 6th International Conference on Structural Engineering and Construction Management* (Kandy, Sri Lanka), 1–12.

Jaglo K, Kenny S, Stephenson J (2021) From farm to kitchen: The environmental impacts of US food waste. *U.S. Environmental Protection Agency, Office of Research and Development, USA*

Jayathilake N, Aheeyar M, Drechsel P (2022) Food waste to livestock feed: Prospects and challenges for swine farming in Peri-urban Sri Lanka. *Circular Economy and Sustainability* 2:1301–1315. https://doi.org/10.1007/s43615-022-00168-8

Jayathilake N, Aheeyar M, Drechsel P, Bucatariu C (2023) Quantitative analysis of food waste from wholesale to households in Colombo, Sri Lanka.

Jones SL, Gibson KE, Ricke SC (2021) Critical factors and emerging opportunities in food waste utilization and treatment technologies. *Front Sustain Food Syst* 5:781537. https://doi.org/10.3389/fsufs.2021.781537

Kumar N, Singh A, Harriss-White B (2019) Urban waste and the human-animal interface in Delhi. *Econ Polit Wkly* 54:1–14.

Kumara AS, Pallegedara A (2020) Household waste disposal mechanisms in Sri Lanka: Nation-wide survey evidence for their trends and determinants. *Waste Manage* 114:62–71. https://doi.org/10.1016/j.wasman.2020.06.028

Li Y, Jin Y, Li J, et al. (2016) Current situation and development of kitchen waste treatment in china. *Procedia Environ Sci* 31:40–49. https://doi.org/10.1016/j.proenv.2016.02.006

Muth MK, Birney C, Cuéllar A, et al. (2019) A systems approach to assessing environmental and economic effects of food loss and waste interventions in the United States. *Sci Total Environ* 685:1240–1254. https://doi.org/10.1016/j.scitotenv.2019.06.230

Narayanan Y (2019) *Jugaad* and informality as drivers of India's cow slaughter economy. *Environment and Planning A: Economy and Space* 51:1516–1535. https://doi.org/10.1177/0308518X19852640

NSWEPA (2021) Emissions impacts of composting food waste, Fact Sheet. *Australia*

Pinotti L, Luciano A, Ottoboni M, et al. (2021) Recycling food leftovers in feed as opportunity to increase the sustainability of livestock production. *J Clean Prod* 294:126290. https://doi.org/10.1016/j.jclepro.2021.126290

Saja AMA, Zimar AMZ, Junaideen SM (2021) Municipal solid waste management practices and challenges in the Southeastern Coastal Cities of Sri Lanka. *Sustainability* 13:4556. https://doi.org/10.3390/su13084556

Salemdeeb R, Zu Ermgassen EKHJ, Kim MH, et al. (2017) Environmental and health impacts of using food waste as animal feed: A comparative analysis of food waste management options. *J Clean Prod* 140:871–880. https://doi.org/10.1016/j.jclepro.2016.05.049

Sarker A, Ghosh MK, Islam T, et al. (2022) Sustainable food waste recycling for the circular economy in developing countries, with special reference to Bangladesh. *Sustainability* 14:12035. https://doi.org/10.3390/su141912035

Schanes K, Dobernig K, Gözet B (2018) Food waste matters - A systematic review of household food waste practices and their policy implications. *J Clean Prod* 182:978–991. https://doi.org/10.1016/j.jclepro.2018.02.030

Shurson GC (2020) What a waste - Can we improve sustainability of food animal production systems by recycling food waste streams into animal feed in an era of health, climate, and economic crises?. *Sustainability* 12:7071. https://doi.org/10.3390/su12177071

Sujauddin M, Huda SMS, Hoque ATMR (2008) Household solid waste characteristics and management in Chittagong, Bangladesh. *Waste Manage* 28:1688–1695. https://doi.org/10.1016/j.wasman.2007.06.013

Taye A, Assefa E, Simane B (2024) Analysis of practices and factors of solid waste management among urban households of Addis Ababa city, Ethiopia. *Environmental Challenges* 14:100811. https://doi.org/10.1016/j.envc.2023.100811

Thariq MGM, Silva PMR, Rikasa AM (2021) Comparative study of physical egg quality characteristics of Naked neck and Bovans chicken in diverse ages in coastal areas of Ampara district. *Sri Lanka J Technol* 3:15–22.

Thi NBD, Kumar G, Lin CY (2015) An overview of food waste management in developing countries: Current status and future perspective. *J Environ Manage* 157:220–229. https://doi.org/10.1016/j.jenvman.2015.04.022

Thirumarpan K, Thiruchelvam T, Dilsath MSA, Minhajkhan MSM (2015) Household knowledge, attitudes and practices in solid waste segregation and management: A study in Eravur urban council area, Batticaloa district. *5th International Symposium – Int Sym 2015, South Eastern University of Sri Lanka, Oluvil, Sri Lanka*

Truong L, Morash D, Liu Y, King A (2019) Food waste in animal feed with a focus on use for broilers. *Int J Recycl Waste Org Agricul* 8:417–429. https://doi.org/10.1007/s40093-019-0276-4

Vidanaarachchi CK, Yuen STS, Pilapitiya S (2006) Municipal solid waste management in the Southern Province of Sri Lanka: Problems, issues and challenges. *Waste Manage* 26:920–930. https://doi.org/10.1016/j.wasman.2005.09.013

Westendorf ML (2000) Food waste as swine feed. Edited by Westendorf M. *Iowa State University Press,* 69–89.