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Assessing Community-Based Strategies for Sustainable Kitchen Food Waste Management in Samdrup Jongkhar District, Bhutan

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Abstract

Kitchen food waste is one of the critical environmental concerns facing the rapidly urbanizing areas of Bhutan. This study examined the effectiveness of community-based kitchen food waste management in Samdrup Jongkhar District by assessing waste composition, management practices, awareness, and community participation. A mixed-method research design was employed, and data were collected from 370 households selected through stratified random sampling across rural and peri-urban areas. The results showed that leftovers of cooked food constituted 100% kitchen food waste, while vegetable peels accounted for the largest proportion (71.1%) of the waste composition. The most common disposal method was kitchen garden disposal (30.3%), followed by burning (27.8%) and mixing with general waste (19.7%). Although respondents were generally aware of the barriers to composting, no statistically significant relationship was found between awareness and composting practices ($\chi^2 = 2.375$, $p = 0.498$). Furthermore, more than 50% of respondents across all regions expressed a positive perception of community composting initiatives. These findings indicate considerable potential for promoting community-based composting as a sustainable waste management strategy that supports Gross National Happiness (GNH) and environmental sustainability.

Keywords— Kitchen food waste, community-based waste management, composting practices and sustainable development

1 Introduction

1.1 Background

The issue of food waste has been identified as an emerging concern, which has a substantial impact on environmental, social, and economic factors. It has been reported that an estimated one-third of total food produced for human consumption, or one billion tons of food waste every year [1]. According to a report by UNEP Food Waste Index Report 2021, it has been identified that "Households are the biggest contributor to food waste, representing 61% of total food waste, followed by food service providers, 26%, and then retail, 13% [2].

The [3] discovered that food waste is one of the major sources of greenhouse gas emissions. When organic waste undergoes anaerobic decomposition in landfills or dumpsites, methane gas is produced, which has a higher global warming potential than carbon dioxide [4], [5]. Estimates indicate that food loss and waste contribute about 8-10% of global greenhouse gas emissions. Moreover, wasted food represents a huge resource, such as land, water, energy, and labor, hence aggravating resource depletion and environmental degradation [2], [6]. Although food waste is a universal problem, its causes and patterns are significantly different in developed and developing countries. In developing countries, food loss mainly happens in the early stages of the supply chain in the production, harvesting, storage, and transportation phases because of a lack of infrastructure, absence of cold chain facilities, and a lack of technical knowledge, which sometimes exceeds 40% in the post-harvest stage [7], [8]. But due to rapid urbanization and changes in consumer behavior, food waste in developing countries is increasingly happening at the household level in urban and peri-urban areas. Research studies in South Asia reveal that organic waste, especially kitchen food waste, contributes between 50% and 70% to the total municipal solid waste streams. Kitchen food waste generally consists of cooked meals left over, vegetable peels, spoiled food, and plate waste, most of which is biodegradable and recyclable [9].

In Bhutan, waste characterization studies showed that organic waste dominated MSW, especially in urban areas [10]. Though Bhutan has robust environmental regulations and a strong commitment to sustainable development, there is limited effective management of kitchen food waste at both household and community levels. Past studies in Bhutan have concentrated on overall waste management practices, policy guidelines, and community awareness, but little emphasis has been placed on food waste generation and recovery practices like composting, especially at household levels [2], [11].

Samdrup Jongkhar District is a district in southern Bhutan, sharing a border with India. This district is experiencing rapid socio-economic change, driven by rapid urbanization, international trade, and changing consumption patterns. Studies on other Bhutanese cities, especially those experiencing rapid change, showed that rapid socio-economic change is linked to increased food consumption, resulting in a rise in household food waste [12]. With a rise in municipal waste, unmanaged kitchen food waste can cause negative impacts on public health, environmental quality, and municipal services [13].

Community-based food waste management approaches have been recognized as effective and appropriate approaches in managing food waste, particularly in developing countries. Studies conducted in Nepal, India, and Sri Lanka have shown that food waste management approaches such as community-based composting, decentralized waste segregation, and community-based awareness programs are effective approaches towards managing organic waste disposal [14], [15].

Bhutan's cultural values of community cooperation and environmental protection are good prerequisites for implementing community-based food waste management approaches for kitchen food waste. However, it is noted that there is a significant lack of empirical study on how these approaches operate at specific local levels, such as Samdrup Jongkhar. Such an approach is important in ensuring that food waste management approaches are aligned with national food waste management goals while promoting Gross National Happiness.

1.2 Rationale

Kitchen food waste constitutes a significant portion of household solid waste and poses serious environmental, social, and economic challenges, particularly in rapidly urbanizing areas such as Samdrup Jongkhar. Changing lifestyles, increased consumption of packaged foods, and limited awareness of waste reduction practices have contributed to the growing generation of food waste. Improper disposal results in environmental degradation, greenhouse gas emissions, health risks, and increased pressure on waste management services.

Although Bhutan has established national policies for sustainable waste management, effective implementation at the community level remains limited. Community-based approaches, including waste segregation, composting, and awareness campaigns, are considered practical and sustainable solutions, especially in the Bhutanese context where community participation is highly valued. However, limited research has focused specifically on household food waste management in Samdrup Jongkhar.

This study aims to evaluate the effectiveness of current household food waste management practices, identify key challenges faced by the community, and recommend practical strategies to improve sustainable waste management. The findings will support informed policy decisions and contribute to achieving Bhutan's Gross National Happiness and environmental sustainability goals.

1.3 Objectives

- To evaluate the composition and quantity of food waste produced from the kitchens of households in Samdrup Jongkhar.
- Investigate the existing practices of food waste management from the kitchens.
- Evaluate the awareness and perceptions of the residents regarding the composting and waste management programs.
- Identify the requirements and barriers associated with the promotion of sustainable food waste management from the kitchens.

2 Materials and Methods

2.1 Sampling Method and Sample Size Determination

This research employed a stratified random sampling technique to arrive at the sample size of households to investigate the food waste management in kitchens of households in Samdrup Jongkhar District. Stratified random sampling helped in achieving a fair representation of households from different geographical areas, which in turn helped in achieving accurate results. The total population of the research area was found to be 5,004 households in total. An overall sample size of 370 households was derived using descriptive statistical methods such as Mean, Mean Deviation (MD), Standard Deviation (SD) with the margin of error 0.05 at 95% confidence level, as shown in equation 1, 2 3, to ensure proper representation of the households in the research area.

2.1.1 Means ($\bar{x}$)

The mean represents the average population size across the selected regions and provides a central reference point for further analysis.

$$\bar{x} = \frac{\sum x}{n} \tag{1}$$

Where:

- $\bar{x}$ = Mean value of the population
- $\sum x$ = Sum of all observed values
- n = Total number of observations

2.1.2 Mean Deviation (MD)

Mean Deviation measures the average dispersion of population values from the mean and indicates the degree of variation among regions

$$MD = \frac{\sum |x - \bar{x}|}{n} \tag{2}$$

Where:

- x = Individual observation
- $|x - \bar{x}|$ = Absolute deviation of each observation from the mean
- n = Total number of observations

2.1.3 Sample size

Once the total sample size was fixed, samples were allocated proportionally to each region based on their population size using proportional allocation:

$$n_i = \frac{N_i}{N} \times n \tag{3}$$

Where:

- n_i = sample size for region
- N_i = population of region
- N = total population
- n = total sample size

Table 1: Sample size of the study

Sl. No.	Region	Population (N)	Sample Size (n)
1	Phuntshothang	725	40
2	Lauri	545	46
3	Martshala	621	21
4	Langchenphu	284	33
5	Pemathang	450	54
6	SJ Thromde	2379	176
	Total	**5004**	**370**

2.2 Study Area

The study was carried out at Orong, Phuntshothang, Pemathang, Dewathang, Martshala Gewog, and Samdrup Jongkhar Thromde, which are rural, semi-urban, and peri-urban areas of Bhutan, respectively. Selection of study sites was influenced mainly by population density, agriculture activities.

2.3 Research Design and Data Analysis

A mixed-methods research design was implemented that integrated quantitative waste audits with qualitative participatory approaches. Quantitative data were analyzed using descriptive statistics through SPSS and Excel, while qualitative data from focus group discussions and interviews were thematically analyzed.

3 Results and Discussion

3.1 Demographic Information

A total of 370 respondents were sampled from the population six region, with females outnumbering males in all the selected regions. From Phuntshothang, Lauri, Martshala, Langchenphu, Pemathang, and SJ Thromde, the proportion of the population sampled was 14%, 11%, 12%, 6%, 9%, and 48%, respectively. The proportion sampled from SJ Thromde was larger due to its high population density. The female-dominated population surveyed is significant, given that it is more likely for females to be responsible for food handling practices.

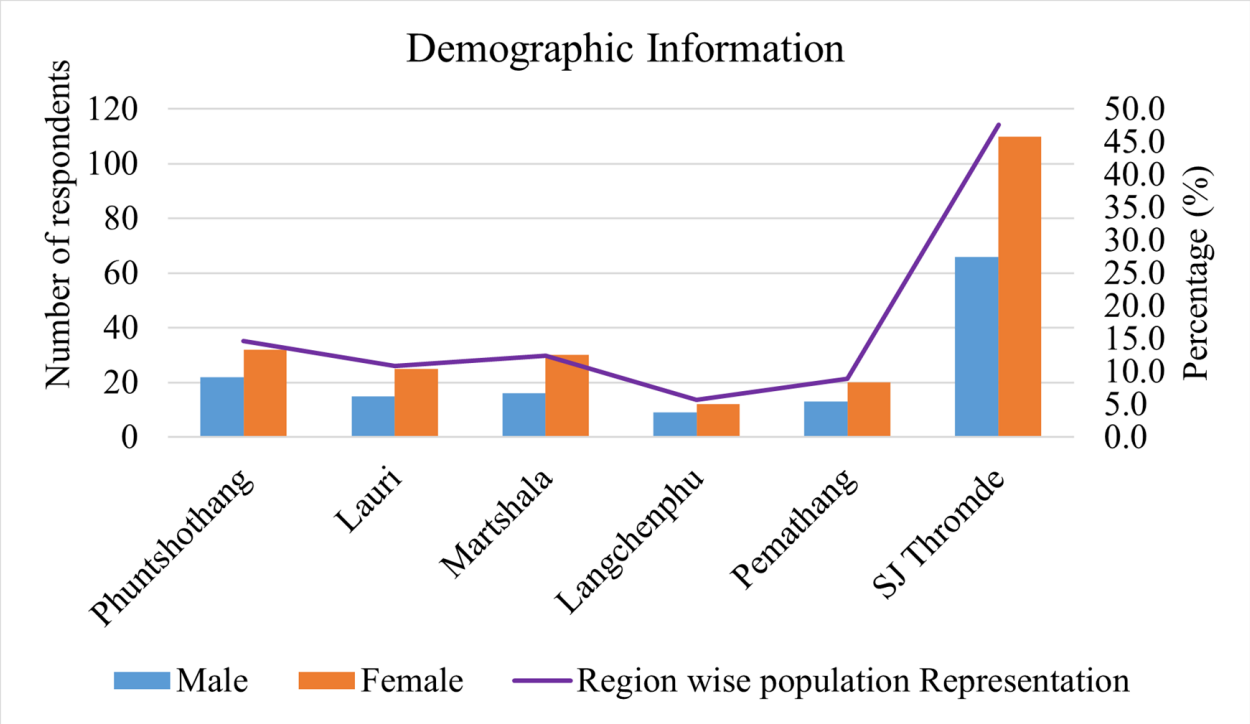


Figure 1: Demographic information

3.2 Composition and Generation of Kitchen Food Waste

Food waste composition analysis reveals that the cooked food leftovers generated by households were universal; 100% of the respondents reported their generation, indicating that leftover prepared food is the most consistent component of kitchen waste. The second most generated fraction was vegetable peels, which were reported by 71.1% of the households, reflecting routine preparation of food in the households. In contrast, spoiled vegetables reported by 43.5% and fruit waste reported by 37.3% of the households relatively point to better utilization of food or lower frequency of purchase. This implies that meat and fish wastes were generated by 47.6% of the households, showing a moderate inclusion of animal-based foods in diets. Other categories of wastes were reported by 34.4% of the respondents. The findings confirm that biodegradable organic wastes are dominant in household food waste streams, pointing to the potential for composting-based management approaches while emphasizing the need for reduction of avoidable food losses.

The findings of this study closely reflects household food waste patterns reported in China, Southeast Asia, and other international studies, confirming the broader applicability of the results. Cooked food leftovers were universally generated in this study (100%), aligning with evidence from China (90.7%) and Southeast Asia, where cereals and rice contribute 52–57% of waste, highlighting over-preparation and plate leftovers as dominant drivers. Vegetable peels and preparation waste were also highly prevalent (71.1%), comparable to China's high incidence (87.7%) and Southeast Asia's range of 37–63%. Fruit waste and spoiled vegetables occurred at moderate levels, reflecting perishability and improved household utilization practices. Meat and fish waste remained relatively low, consistent with regional studies, indicating careful use of higher-value foods and reinforcing the potential for composting-based waste reduction strategies [16], [17].

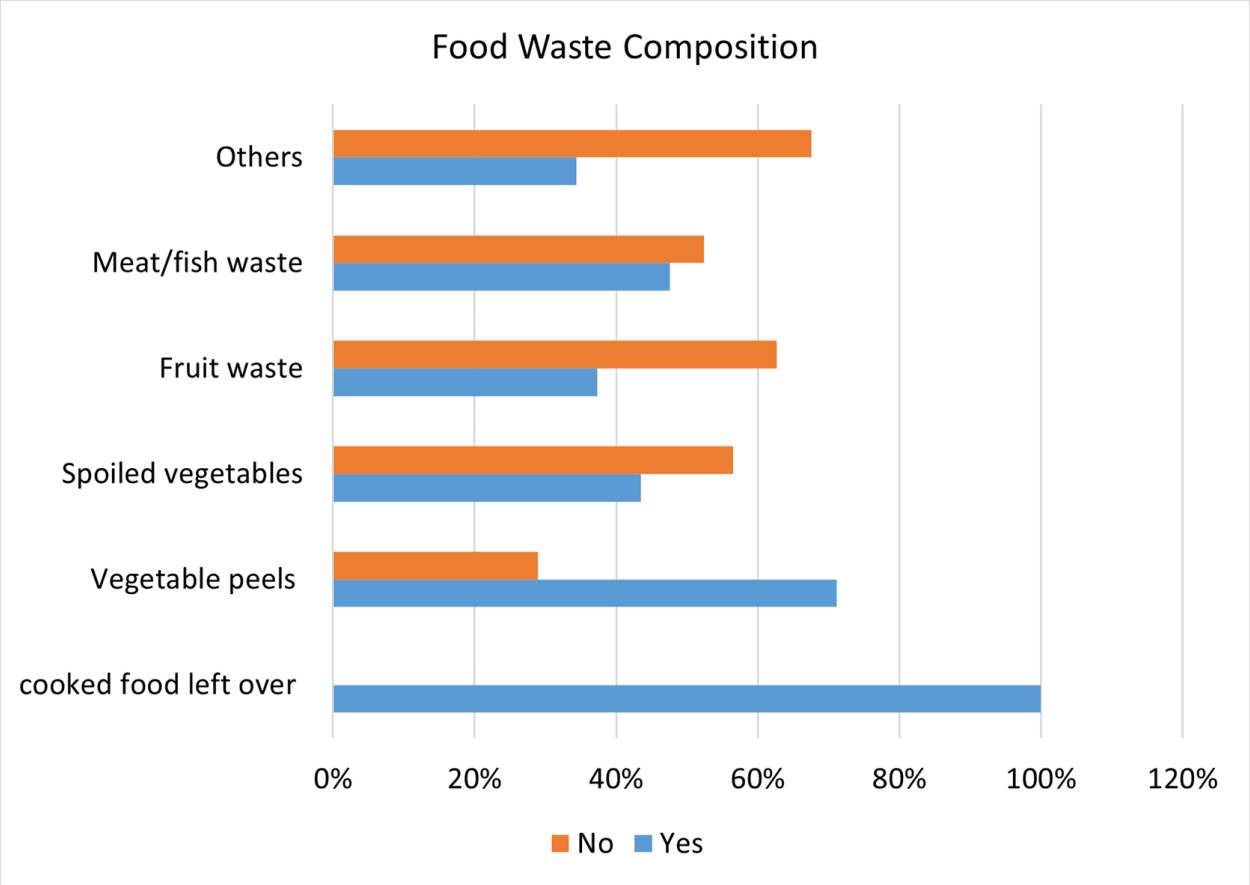


Figure 2: Food waste composition in Samdrup Jongkhar district

Table 2: Food waste composition in China and South East Asia

Waste Type	China Study	SE Asia Study
Cooked Leftovers/Prepared	~90.7 (overall high)	High (cereals/rice 52–57%)
Vegetable Peels/Prep	Fruits/Veg high (87.7% incidence)	Vegetables 37–63%
Spoiled Vegetables	Included in veg (13.2% proportion)	Similar in perishables
Fruit Waste	13.2% proportion (high incidence)	Fruits 1–32%
Meat/Fish	8.4% (69.5% incidence)	6–15%
Other	Snacks 7.5%	Legumes/Tofu 6–25%

3.3 Existing Community Practices in the community

The existing practices and methods of waste management observed vary from region to region, and they are more or less associated with the nature of livelihood activities and availability of services. Statistically, the disposal of kitchen waste in kitchen gardens is the most prevailing practice, accounting for 30.3% of overall practices, especially in Lauri (40.0%), SJ Thromde (31.8%), and Langchenphu (28.6%). This demonstrates the traditional knowledge and understanding of reusing and treating kitchen waste as valuable products. The practice of feeding kitchen waste to domestic livestock accounts for 13.0%, especially in agrarian areas like Pemathang (33.3%) and Phuntshothang (20.4%), signifying the close association and interdependence between waste management practices and agricultural livelihood activities. The practice of burning kitchen waste is still very common, accounting for 27.8% of overall practices, especially in SJ Thromde (34.7%) and Langchenphu (28.6%). This shows the scarcity of space and availability of infrastructures for composting kitchen waste. The process of blending kitchen waste with other wastes is responsible for 19.7% of the total processes, pointing to the lack of awareness regarding waste segregation. Though it is low, open dumping of waste is common in some areas, including Pemathang (15.2%) and Langchenphu (14.3%), at 9.2% overall practices.

Table 3: Composting practice in the community

Composting type in the region	Feed to livestock (%)	Dispose in kitchen garden (%)	Open dumping (%)	Burning (%)	Mixed with general waste (%)
Phuntshothang	20.4	22.2	9.3	24.1	24.1
Lauri	17.5	40.0	7.5	17.5	17.5
Martshala	10.9	28.3	10.9	26.1	23.9
Langchenphu	4.8	28.6	14.3	28.6	23.8
Pemathang	33.3	27.3	15.2	12.1	12.1
SJ Thromde	7.4	31.8	7.4	34.7	18.8
Overall (%)	**13.0**	**30.3**	**9.2**	**27.8**	**19.7**

3.4 Community Awareness and Perception of Sustainable Waste Management

The crosstabulation analysis indicates that awareness of the environmental problems caused by improper food waste disposal was present among a substantial proportion of respondents. Among those who reported being aware, composting practices were distributed across pit composting (36 households), heap composting (41 households), and in-vessel composting (4 households), while a considerable number (54 households) did not practice composting at all. Similarly, among respondents

who were not aware of environmental consequences, many households also practiced pit composting (70) and heap composting (56), with a notable proportion (98 households) not practicing composting. This distribution suggests that composting behavior was observed among both aware and non-aware groups.

Table 4: Crosstabulation of respondents' awareness of environmental problems caused by improper food waste disposal and type of composting practiced

Awareness of environmental problems	**Pit composting**	**Heap composting**	**Vessel composting**	**Not at all**	**Total**
Yes	36	41	4	54	135
No	70	56	11	98	235
Total	106	97	15	152	370

The Chi-square test of independence further confirmed that there was no statistically significant association between awareness of environmental problems and the type of composting practiced ($\chi^2 = 2.375$, $df = 3$, $p = 0.498$). The absence of significance indicates that community awareness and perception alone did not meaningfully influence the adoption or selection of composting methods. Since all expected cell counts met the Chi-square assumptions, the result is statistically reliable. Therefore, the findings show that while community awareness of improper food waste disposal exists, practical constraints, access to facilities, and technical capacity likely play a more decisive role in shaping sustainable waste management practices than awareness alone.

Table 5: Chi-square test of independence showing the association between awareness of environmental problems and type of composting practiced

Chi-Square Tests	**Value**	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	2.375	3	0.498
Likelihood Ratio	2.382	3	0.497
Linear-by-Linear Association	0.021	1	0.885
N of Valid Cases		370	

Note: 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.47.

3.5 Community Participation in Kitchen Waste Management

The figure presents the percentage distribution of respondents' perceptions toward shared community composting across six regions. Overall, agreement (agree + strongly agree) exceeds 50% in all regions, indicating a generally positive community perception. In SJ Thromde, approximately 55–60% of respondents expressed agreement, with around 15% strongly agreeing, while neutral responses accounted for roughly 20%. Similarly, Pemathang showed close to 60% agreement, though a slightly higher neutral proportion (about 25%) suggests moderate uncertainty despite positive inclination. In Martshala and Lauri, agreement levels ranged between 50–55%, with neutral responses comprising nearly 20–25%, reflecting cautious acceptance of shared composting initiatives. Langchenphu and Phuntshothang displayed comparatively higher neutral responses (around 30%), while agreement remained above 50%, indicating awareness but limited practical exposure. Across all regions, strong disagreement remained consistently low (below 10%), highlighting minimal resistance. Statistically, the dominance of agreement categories across regions demonstrates strong

community readiness for shared composting, reinforcing the potential for successful implementation when supported by institutional and technical interventions.

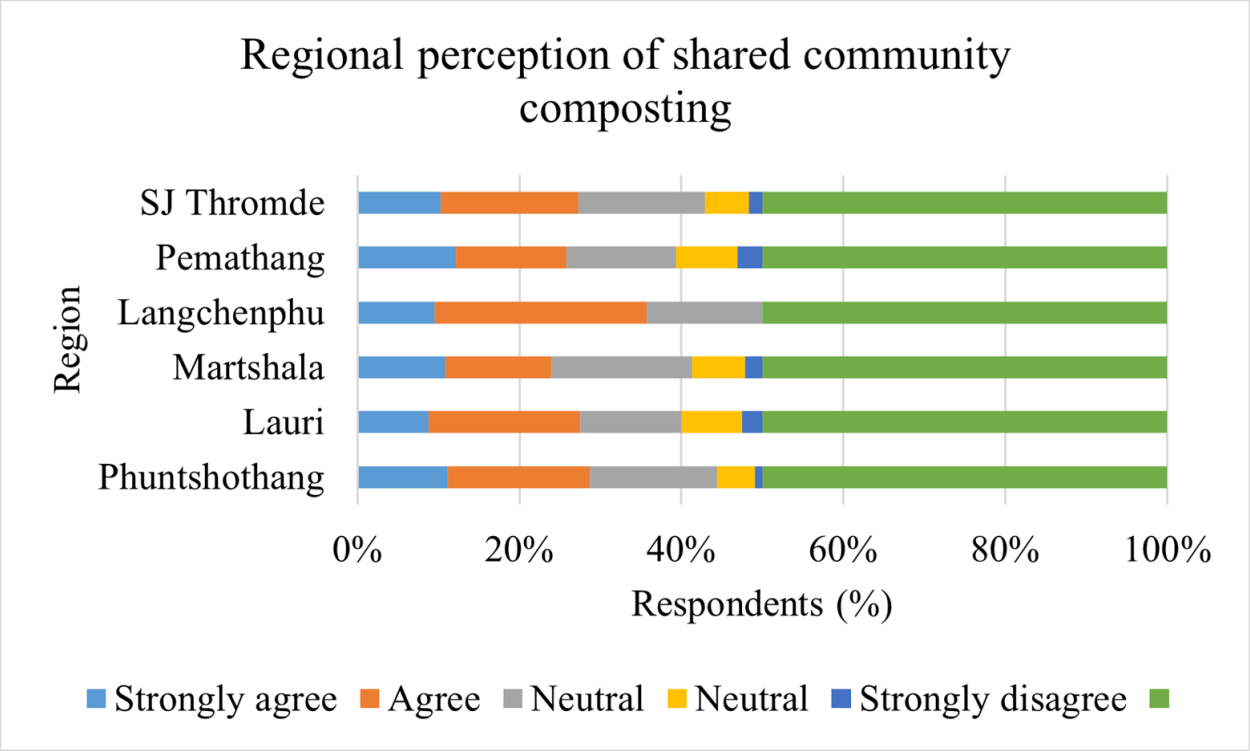


Figure 3: Respondents' perceptions toward shared community composting

4 Significance of the Study

This study is important because it contributes significant empirical findings on the generation and management of food waste from households, specifically in the Samdrup Jongkhar Dzongkhag of Bhutan, which has limited research. The findings of the study bridge an important gap in knowledge on waste management in Bhutan. The results of this study are also valuable for an understanding of the dominance of biodegradable wastes and the current practices of traditional methods of waste decomposition, such as kitchen gardens and feeding scraps to livestock, as well as unhealthy practices such as burning and mixing.

However, most importantly, the present study has demonstrated that awareness by itself does not have a substantial impact on behavior change with reference to composting. The positive community perception with regard to communal initiatives on composting has vast potential for successfully scalable initiatives on community-based interventions. These findings have vast implications for policy makers and local administrations to formulate appropriate waste management initiatives that correlate with national sustainable development agendas and the concept of Gross National Happiness. This piece of research could pave a path for ensuring the development of environmentally conscious behavior, reduction of greenhouse emissions, and community resilience.

5 Conclusion

This study provides a comprehensive assessment of household kitchen food waste generation and management practices in Samdrup Jongkhar district. The findings show that food waste streams are

dominated by biodegradable materials, particularly cooked food leftovers and vegetable peels, indicating strong potential for composting-based waste management. While traditional practices such as disposing waste in kitchen gardens and feeding livestock remain prevalent, environmentally harmful practices like burning and mixing food waste with general waste persist, especially in urban and semi-urban areas. Community awareness of the environmental impacts of improper waste disposal exists; however, statistical analysis confirms that awareness alone does not significantly influence composting behavior. Instead, access to facilities, technical capacity, and practical constraints play a more decisive role. Importantly, community perceptions toward shared composting initiatives are largely positive across all regions, demonstrating readiness for collective action. Strengthening institutional support, improving infrastructure, and promoting practical community-based composting systems are therefore essential for achieving sustainable kitchen food waste management in the district.

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