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An Analysis of Biodegradable Solid Waste Flow in Vietnam

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This study aimed to analyse biodegradable solid waste (BSW) flows and identify the stakeholders of BSW recycling in cities of central Vietnam. Sampling survey and social survey were conducted to collect data. Material flow analysis was utilised to analyse the flow of the BSW. Results denoted that the generated BSW flowed in five directions namely home husbandry, home composting, formal collecting without separation, segregated collection by informal sectors and leakage to the environment. Proportions of such waste streams are not the same across city types, waste management systems, and consumer markets. The daily biodegradable waste generation amounts were estimated at 612.12 tons in Danang city (DNC), 318.65 tons in Hue city (HUC), and 65.28 tons in Hoi An city (HAC). Most of biodegradable waste was managed by the formal waste collection system with 89 %, 73 %, and 88 % for DNC, HUC, and HAC. Interestingly, HAC was the only area operating composting facility with 49 % of biodegradable waste being recycled. The study also revealed an unsung informal sector of the BSW, operating in an unforeseen routine compared with itinerant recyclable-waste buyers.

1. Introduction

The existing linear economy has led to eco-and-waste disposal systems collapsing with serious environmental, economic and social consequences (Riba et al., 2020). It is estimated that global waste will rise by 70 % by 2050 without urgent action (Kaza et al., 2018). As a result, the circular and low-carbon economy is attracting global attention due to its advantages in resource use and lower pollution rate (Kuah and Wang, 2020).

The transformation from a conventional economy to a circular and low-carbon economy requires a proper waste management system. Solid waste management is still a challenge for conurbations, especially in low-developed and developing countries. Biodegradable solid waste (BSW) accounts for a large proportion of municipal solid waste (MSW), showing considerable potential for recycling capacity toward a circular and low-carbon economy (Song Toan et al., 2021b).

Landfill is still a ubiquitous treatment method for BSW in low and developing countries. The insights into municipal biodegradable waste management play a crucial role in enhancing waste management toward the circular and low-carbon economy. Recycling flow of BSW is still vague due to the limited number of studies, encountering difficulties in promoting recycling system toward circular and low-carbon economy.

Vietnam is a developing country in Southeast Asia. In Vietnam, the concept of circular economy was first introduced in the Vietnamese Law on Environmental Protection 2020, being effective from January 1, 2022. The new environmental law mentioned that MSW must be separated into three types namely food waste, recyclable waste, and other waste. Vietnam is also facing a plethora of problems and challenges from biodegradable solid waste management (BSWM) namely low efficiency of waste segregation at source and unsuccessful composting projects (MONRE, 2019). The flow of BSW has not been clearly identified in Vietnam. The aims of this research were to i) illustrate and analyse the municipal biodegradable waste flows as well as ii) identify the stakeholders of BSW recycling within the recycling system in central Vietnam.

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2. Methodology

2.1 Study sites

This study was conducted in three cities in central Vietnam namely Danang city (DNC), Hue city (HUC), and Hoi An city (HAC). The locations of three study sites were illustrated in Figure 1. These three cities were representing three distinct types of municipalities in Vietnam due to the procedure of Vietnam on urban classification (NASC, 2016). To be specific, DNC, HUC, and HAC were classified as Type I of nation, Type I of province, and Type III. The conurbations of DNC, HUC, and HAC are centres for economic, social, cultural, and tourism development in central Vietnam, being transfer stations of international and national traffic networks.

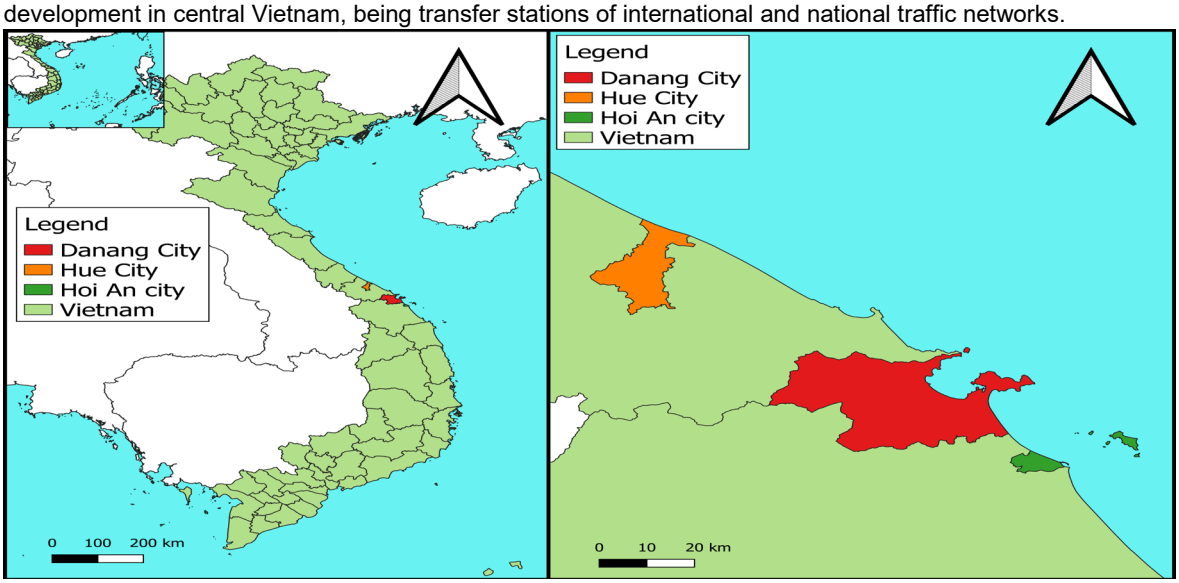

Figure 1: Map of three study sites in central Vietnam

2.2 Method

The survey was conducted from February, 2023 to March, 2023 in three study sites — DNC, HUC, and HAC. The aim of this survey was to collect all needed data on MBSW in central Vietnam. A sampling survey was conducted at Hoi An solid waste treatment facility for identifying the composition of input waste. The process of waste sampling was similar to previous research in HAC (Song Toan et al., 2019) and DNC (Song Toan et al., 2021b). The daily amount of leftovers consumed by a pig was identified at 0.5 kg for one pig a day due to a literature review (de Haer and Merks, 2010), survey results, and experts' opinions. The daily home-composting of a household was estimated at 0.79 kg (Eades et al., 2020). The data on biodegradable waste flow were also collected and estimated from reports and papers of governmental agencies in HAC (PCHAC, 2021), HUC (PCTTHP, 2023), Danang Urban Environment Company (DURENCO), Hue Urban Environment And Public Works Joint Stock Company (HEPCO), NGOs (WWF Vietnam, 2021), and previous study (Song Toan et al., 2021b).

In-depth interviews were conducted with representatives and key persons in charge of waste management from governmental departments and service companies — offering collection, transportation, and treatment of waste. Labour force of informal sector — recycling municipal biodegradable waste — was also accentuated as an important component of the municipal recycling system of biodegradable waste.

Material flow analysis (MFA) — using STAN 2.7 software — was conducted to have an illustration of municipal biodegradable waste within three study sites, DNC, HUC, and HAC. This method has been widely utilized in studies of solid waste management recently for tourism destination (Song Toan et al., 2022b) or HAC (Song Toan et al., 2022a).

3. Result and discussion

3.1 Municipal biodegradable solid waste flow in central Vietnam

Figure 2 denotes five main outputs of municipal bio-degradable waste in central Vietnam namely home husbandry, home composting, collection and transportation, informal sector and leakages. Interestingly, Hoi An was the only area operating a composting facility in three municipalities surveyed. Landfilling was the major waste treatment method in DNC and HUC. Notably, leakage was still recorded among three study sites in central Vietnam.

Table 1 denotes the daily biodegradable waste generation in DNC (612.12 t), HUC (318.65 t), and HAC (65.28 t). The numbers were in proportion to the scale of area and population among three municipalities with the largest figures for DNC and the smallest figures for HAC.

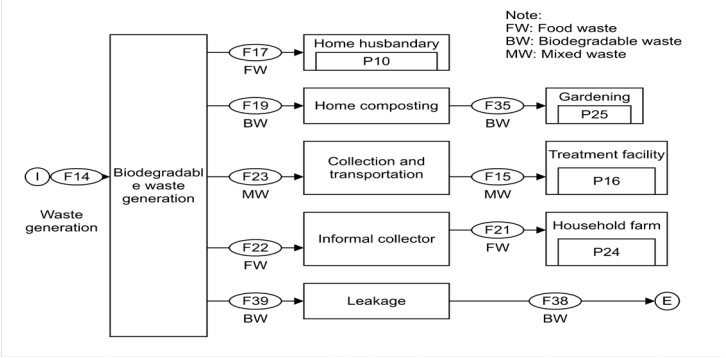

Figure 2: Municipal bio-degradable flow of municipalities in central Vietnam

Table 1: The general information and daily estimated biodegradable waste generation in three municipalities

	Danang city	Hue city	Hoi An city
Daily amount of biodegradable waste (t/d)	612.12	318.65	65.28
Area (km^2)	1,284.73	266,461	63.55
Population (people)	1,195,490	491,346	100,530

3.1.1 General features

The vast majority of biodegradable waste in study sites was managed by the formal waste management system with 89 %, 73 %, and 88 % for DNC, HUC, and HAC (Figure 3). The oriented plannings are all environmentally-friendly development in DNC (PCDC, 2021), HUC (PCTTHP, 2023), and HAC (PCHAC, 2021). The proportion of municipal biodegradable waste managed by the formal waste management system will be increased gradually. All amounts of biodegradable waste officially managed in DNC, HUC and a big amount of HAC (42 %) were collected as mixed waste and managed by landfill treatment. Landfill is also an ubiquitous treatment method for biodegradable waste in other cities of Vietnam (MONRE, 2019) and other countries such as Serbia (Vujovic et al., 2020). In Vietnam, the orientations of national strategy and local planning are reducing landfilling (PMSRV, 2018) and increasing the circulation of MSW (PM, 2022). While DNC and HUC are heading toward WtE (Waste-to-Energy) projects, Hoi An is being consistent with composting treatment. The national strategy on solid waste management encourages inter-regional management (PMSRV, 2018). The HAC has the potential to become a centre for waste treatment by composting for the whole central Vietnam, heading toward circular economy. In HAC, approximately 42 % of municipal biodegradable waste — being formally collected — was transported to landfill as mixed waste while about 40 % of input for composting facility is inorganic material (Figure 3 and survey results). This denoted the low efficiency and effectiveness of solid waste separation at source program in HAC. The negative results of solid waste separation at source program could be explained due to improper collection frequency (Cuong et al., 2021a), improper time frame (Cuong et al., 2021b), lack of space, small waste amounts for separating, and limited facilities (Song Toan et al., 2019). The importance of solid waste separation at source program was also denoted in solid waste-related studies about waste collection (Cuong et al., 2022) or plannings for tourism destination (Song Toan et al., 2022b) and whole city (Song Toan et al., 2022a) in HAC. The proper implementation of solid waste separation at source is the key factor in increasing the recycling rate and quality of input for composting facility in HAC, being a prerequisite to become a centre for waste treatment by composting for central Vietnam.

Home composting played a marginal role in the recycling of biodegradable waste among three cities. Home composting was mainly practised by households having a garden in suburban or rural areas. Distribution of home composting is also similar to Spain where home compost is mainly ultilised in rural area (Vazquez and Soto, 2017). It would be a challenge for households in urban areas for implementing home composting due to limited space. Home composting is expected to increase in the near future due to the simplicity and convenience of new technology (Song Toan et al., 2021a), contributing directly to circulation of municipal BSW in central Vietnam.

3.1.2 Heterogeneous characteristics

The informal sector recycled one-fifth of the total amount of biodegradable waste in HUC (Figure 3). Leakage of biodegradable waste into the environment was recorded among three municipalities with 4 % (DNC), 1 %

(HUC), and 3 % (HAC) (Figure 3). Large percentages of food waste (informal sector and home husbandry) were recycled in HUC (25 %) in comparison to DNC (5 %) and HAC (8 %) (Figure 3). Hue is the area that local authority focuses on separation of food waste at source (PCTTHP, 2023). Spiritual life was considered as a salient part of Hue people. Disposing of leftovers was considered an act, being contradictory to social norms in HUC. These characteristics of Hue social conditions could be the explanation for large percentage of food waste recycled and small percentage of leakage of food waste in HUC in comparison to DNC and HAC (Figure 3). These characteristics of HUC were also an advantage for conducting solid waste separation at source (biodegradable waste and food waste).

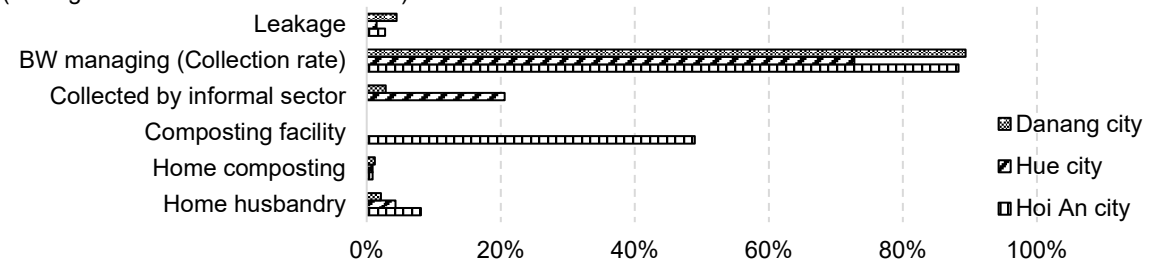

Figure 3: Statistics on municipal bio-degradable systems of municipalities in central Vietnam

Hoi An was the only area operating composting facility with 49 % of biodegradable waste recycled. Composting is still an important oriented planning of HAC for MSW treatment (PCHAC, 2021). Local authority has been making an effort to enhance the quality of product and develop the market for the output of composting factory. Composting product was not widely accepted by the farmer in HAC due to low quality and pieces of glass in the final product. The pivotal reason for this problem was the low efficiency of solid waste separation at source in HAC. Enhancing efficiency of solid waste separation at source should be prioritised in solid waste management strategy toward low-carbon and circular economy.

3.2 Informal sector as an important stakeholder

It was undeniable that informal sector is an important component of municipal biodegradable recycling system in central Vietnam despite environmental pollution. Food losses are unavoidable in the food supply industry (Luciano et al., 2020). Leftover is also generated in the daily life of human beings. Demand for low-price input of household husbandry is also recorded in central Vietnam. The existence of informal sector — collecting leftovers — is inevitable. In general, food waste from generators (households, business sectors, offices, schools, hospitals and others) was collected and transported to final consumers (swine farms and fish farms) by food waste collectors or brokers. At farms, basing on farming methods, the food waste could be refined or cooked before feeding.

3.2.1 Environmental aspect

Local authorities were prohibiting husbandry within the urban areas for the protection of urban aesthetics. Environmental pollution of pig rearing and fish aquaculture were recorded such as leachate and odour due to improper management. Husbandry activities were mainly in suburban or rural areas. In DNC, pig rearing and fish farming were mainly conducted in rural areas with an appreciable distance from food waste generators. In HUC and HAC, husbandry was conducted in the neighbourhood regions, being in close proximity to cities. This was inevitably a trade-off between local environmental pollution and waste reduction at landfills. As a result, local authorities should consider the proper mechanism for the operation informal sector in accordance with the big picture of MSW management system. The role of informal sector — municipal biodegradable waste — in the environment will be accentuated especially in the context of overload at landfills in not only central Vietnam but also the whole country.

3.2.2 Social acceptance

Food waste was collected by food waste collectors, or brokers (big scale) and then transported to final consumers (fish farmers and pig farmers). Normally, there were three practices — Public tenders, oral contracts and free giveaways — for contract of municipal biodegradable waste collection between waste collectors and waste generators. Regarding public tenders, this practice was mainly conducted with waste generators with large amount of food waste generation such as hotels and restaurants serving tourism activities. Oral contracts and free giveaways were popular with waste generators with small amount of food waste generation namely households. Oral contract was prioritised and in favour due to its flexibility and no requirements of complex procedures. These results were similar to the output of another study on food waste in DNC (Kato et al., 2020).

Household pig farm and fish farm were normally detrimental to surroundings due to the leachate and odour from sewage and manure of husbandry and aquaculture. Citizens from surroundings normally took a negative attitude toward the operation of informal husbandry and aquaculture. Social acceptance of informal sector should be based on a comprehensive view of stakeholders.

3.2.3 Economic aspect

Informal sector contributed as a factor adding value to food waste in central Vietnam. Recycling food waste was bringing economic benefits to both waste generators and final consumers (farms). Waste generators received an additional amount of money while the final consumers could have the input at a low-price compared with industrial food waste. The activities of informal sector were mainly basing on the human ties between waste generators and food waste collectors. The leftover was normally given to food waste collectors at no cost (Kato et al., 2020).

Due to the result of the survey, the final price of food waste — including transportation and initial separation — fluctuated between 10,000 Vietnam dong (VND) and 30,000 VND for a can of 21 kg in central Vietnam. Present value added to food waste could reach 9 billion VND and 34 billion VND on a yearly basis for DNC and HUC. These numbers could be achieved if the quality of leftover is good enough — no toothpicks and seashells, limited bouillon, being collected within 24 h. Again, the importance of solid waste separation at source and collection system was denoted for leftover supply chain.

The economic benefit from operation of informal sector (food waste) was irrefutable, especially at the time that the new environmental law comes into force. Informal sector was an important factor contributing directly to the concept of circular and low-carbon economy in central Vietnam. The economic and environmental impact of informal activities should be considered for the planning of solid waste management system. The integration of informal sector into formal system could be a tendency for municipal areas in central Vietnam. There are a host of challenges and problems in the integration of informal sector into formal system. Firstly, the existing information on activities of informal sector has been in a limited situation. The operation of informal sector was mainly basing on unformal social relationships, which are hard to officially quantify by detailed numbers. Secondly, suitable procedures were needed for the flexible working regime of informal sector. The waste workers of informal sector themselves paid priority for the flexible working time while formal system normally required a fixed working time. Special working regimes and mechanisms for waste workers as informal sectors should be considered by managers. Finally, the operation of informal sector was dependent on a variety of factors namely swine diseases and market demand. For example, the total population of swine decreased considerably from 68,000 in 2016 (Kato et al., 2020) to nearly 13,700 in 2022 (HVDARD, 2023) due to African Swine Fever and COVID 19 in DNC, indirectly decreasing phenomenally activity of informal sector in DNC. This was also a challenge for integration of informal sector into the formal planning of solid waste management toward a circular and low-carbon economy.

4. Conclusions

This research made the contribution as one of the first efforts to analyse flow of BSW and identify the role of stakeholders — especially informal sectors — within the recycling system of biodegradable waste in central Vietnam. This study denoted that there were five main outputs of municipal bio-degradable waste in central Vietnam namely home husbandry, home composting, collection and transportation, informal sector and leakages. The daily biodegradable waste generation amounts were 612.12 t (DNC), 318.65 t (HUC), and 65.28 t (HAC). The vast majority of biodegradable waste in study sites was managed by the formal waste management system with 89 %, 73 %, and 88 % for DNC, HUC, and HAC. Hoi An was the only area operating composting facility with 49 % of biodegradable waste being recycled. Informal sector was an undeniable component of recycling system in central Vietnam. The results of this research could be the base for policy enforcement as well as monitoring and planning of informal sector and waste management systems in Vietnam and other developing countries toward circular and low-carbon economy.

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