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Solid Waste Management Practices in the Street Food Sector in Thu Duc District, Ho Chi Minh City

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Abstract

A survey on the solid waste management practices of the street food sector was conducted in Thủ Đức District, Ho Chi Minh City. All the street food vendors in the area were recorded, classified according to the nature of their stalls, and also categorized according to the type of food vended. A survey by interview was conducted with 62 random stalls to determine the solid waste management practices of the street food vendors and their customers. Waste samples from 32 different stalls were collected for weight and volume measurements as well as visual determination of waste composition. About 1158 stalls were recorded in the area, generating about 8.20 - 12.66 tons of wastes per day, roughly 3% – 5% of the total municipal solid waste in the district. Biodegradable waste accounted for about 89% by weight followed by non-biodegradable wastes, and recyclable wastes at 7% and 4% respectively. Reused grocery bags were the most common waste receptacle used by vendors. Segregation is limited to the materials that vendors can reuse or that the informal sector of recyclers buy and is prevalent only in stalls selling beverages, with plastic bottles and metal cans as the most recycled components. The rest of the wastes are commonly wrapped in bags or in burlap sacks for bulky wastes and left on roadsides awaiting collection.

Keywords: street food, street food vendors, mobile vendors, hawkers, street food vending, solid waste management, food waste

1. Introduction

Street vendors also known as hawkers, itinerant vendors, ambulant vendors, roadside vendors include all those who sell ready-to-eat or prepared-on-demand food in public spaces such as sidewalks, street corners, or in regulated spaces such as hawking zones. The vendors may have kiosks at fixed locations or pushcarts which are wheeled into their sales position daily, or they may go through the streets on foot, by bicycle, motorbikes, or wheeled pushcarts.

Street food vendors can be found anywhere in the world. They are mostly strictly regulated in developed countries, while in developing countries there is usually slack or no regulation at all. In Vietnam, street food vending does not require business permits based on Decision N°88/2006/ND-CP dated 29 August 2006 of the government on business registration. The readers are referred to the work of (Bhowmik, 2005) and (Dawson and Canet, 1991) for a review on street food vending in different countries, policies and legal aspects of street vood vending in Asia by (Jayasuriya, 1994), a global review on on street vending policies in general by (Bromley, 2000), and on street food vendors in Vietnam by (Jensen and Peppard, 2003; Lincoln, 2008) among others.

Street food is an integral part of the food culture in Vietnam and is one of those ubiquitous things in the country. It is popular among locals because it is accessible, convenient, and cheap. Many people on the other hand, have been attracted to engage in street food vending because it provides a good source of income for them, is easy to put up, and does not require business permits. However, wastes generated from these food stalls are a major cause of litter strewn in the streets. If not managed properly, it is not only aesthetically offensive but it also poses risks to public health and clean-up can be costly. Moreover, litter from these sources easily end up in sewers which can lead to clogging of drainage systems.

This research focused on the solid waste management (SWM) practices in the street food sector in Thủ Đức District, Ho Chi Minh City. Thủ Đức is a large city district of 0.5 million people covering an area of 49.76 km^2 in the northeast of Ho Chi Minh City, about 20 km from the city center. The district is divided into 12 wards shown in Figure 1.

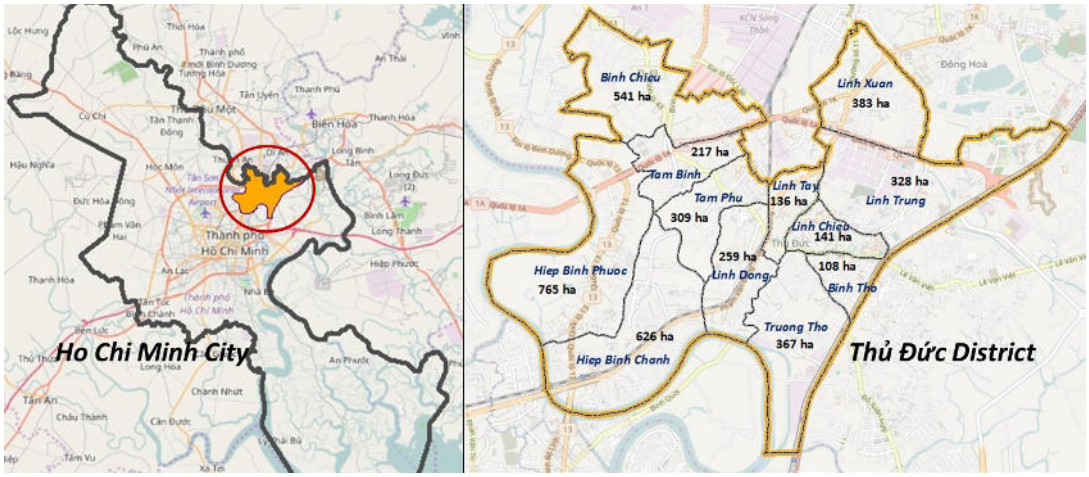

Figure 1. Study Area

Left: Map of Ho Chi Minh City (Encircled: Thủ Đức District). Right: Different wards of Thủ Đức District.

Presently, street food vendors in the area already flock near university campuses, student dormitories, workplaces, and other public areas. Students and workers who do not have time to prepare food at home or in their dormitories, rely on these stalls for everyday meals. The district has been planned to become the education district of Ho Chi Minh City where most big universities in the city center will put its branches. Once this plan is fully implemented, a proliferation of street food vendors is foreseen and the volume of waste that can be expected from these sector can be considerable.

There is a need for reviewing the current SWM practices in this sector in order to recognize the good practices, to identify the opportunities of waste reduction and of turning waste to resources, and also to determine the challenges and issues on the current system so they can be addressed properly and the whole system be made more efficient and sustainable even when volumes of waste expand. The study in the area can serve as a model for other districts or cities in Vietnam. It has applications in strengthening policies for the improvement of SWM in the street food sector. The outcome of this study could also be of interest to other organizations, consultants involved in waste management, NGOs, urban planners, and other stakeholders.

The general objective of the study is to determine the solid waste management practices in the street food sector in Ho Chi Minh City. It also aims to identify the problems and issues in the current system and to propose recommendations in relation to the issues identified.

2. Method

2.1 Profiling of street food vendors

To estimate the volume of waste coming from the street food sector, an inventory of the street food vendors in the district was carried out per ward between 8 am to 5 pm. The nature of food stalls and the types of food sold were noted and their exact locations were determined by marking them on a map.

2.1.1 Nature of food stalls

Street food vendors were divided into three groups according to the nature of their stalls. Example of each type is shown in Figure 2.

a) **Fixed** stalls are those kiosks put up in front of the vendors' own or rented space. This also includes kiosks that remain on a fixed spot the entire time and locked up when not operating like the one shown in Figure 2 top row right.
b) **Semi-fixed** stalls are those mobile kiosks, or wheeled pushcarts that are set up on the same spot on a daily basis
c) **Mobile stalls** are those where food are carried by vendors either on their backs, or on pushcarts, or mounted on motorbikes/bicycles as they move around the city.

Figure 2. Different type of street food vendors according to the nature of food stalls

Top row: Fixed stalls; middle row: semi-fixed stalls; bottom row: mobile vendors.

2.1.2 Food categories

Street food vendors were also categorized according to the types of food sold and the similarities in the type and volume of expected wastes produced.

a) **Noodle meals** – stalls selling food served with any kind of noodles, either with soup like *PHỞ* or without like *BÁNH ƯỚT*
b) **Rice, other meals** – stalls selling rice meals like *CƠM TẤM*; porridge (*CHÁO*); and also includes those selling seafood and shells, and grilled pork, duck, chicken, and fish
c) **Sugarcane and coconut juice** – stalls selling *NƯỚC MÍA*, *NƯỚC DỪA*
d) **Coffee, tea, and soft drinks** – stalls selling a variety of hot and cold drinks including coffee, tea or milk tea, soft drinks, water, and other bottled or canned drinks
e) **Snacks and sandwiches** – stalls selling sandwiches (*BÁNH MÌ*), and other snacks that are fried (ex. *BÁNH XÈO*), grilled (ex. *BÁNH TRÁNG NƯỚNG*), rolled (ex. *gỏi cuốn*), or steamed (ex. *bánh bao*)
f) **Corn** – stalls selling boiled corn only. Some stalls sell a few grilled corn along with other grilled snacks and these stalls were counted in the 'snacks and sandwiches group'.
g) **Fruits and desserts** – stalls selling fruits, fruit juices, fruit shakes, and desserts like sweet soup (*chè bánh lọt*)

2.2 Determination of waste generation rates and waste composition

Waste samples were collected from randomly chosen stalls within Thủ Đức District. The survey was carried out for 7 consecutive days. The samples were collected at 10-11 am for those who operate during daytime only and at 6-9 pm for those who operate the whole day. Vendors were asked to put their biodegradable, recyclable, and non-biodegradable wastes in separate bags the author provided. The waste samples were measured at the stall. Weights were taken using a weighing scale with 60 kg capacity. Volumes were measured by taking the dimensions of the waste containers up to the level filled with waste. Photos were taken for visual characterization of the wastes produced. Wastes from five food stalls for each of the six food categories were surveyed plus two stalls for corn vendors, making a total of 32 food stalls.

2.3 Survey and observation of the SWM practices in the street food sector

A survey was conducted to determine the SWM practices of the street food vendors. This was done through interviews. Survey questionnaires were prepared both in English and Vietnamese and during the interview, the Vietnamese survey form was used and the interview was administered by a Vietnamese. Most of the questions requires a yes-no answer or requires selecting an answer from the choices. Some also required worded answers. During data processing all the answers were transferred to the English questionnaire and any worded answers were translated into English. Around 4-6 vendors from each ward were interviewed totaling to 62 interviews. During the interviews and street food vendors profiling, the actual waste management practices of street food vendors were also observed.

3. Results and Discussions

3.1 Street food vendor profiles

Around 1158 street food stalls were recorded during the profiling in which 51% were fixed, 35% were semi fixed, and 14% were mobile. The exact locations of the vendors at the time they were sighted are shown in Figure 3. The distribution of stalls according to the different food categories is presented in Figure 4. It can be noted that food stalls belonging to the category 'sugarcane and coconut juice' has the most number. The actual number of stalls may still be greater as it is impossible to account all the vendors during the profiling. Some may have closed or opened their stalls beyond the time of survey. The numbers also do not include the stalls which open only at night.

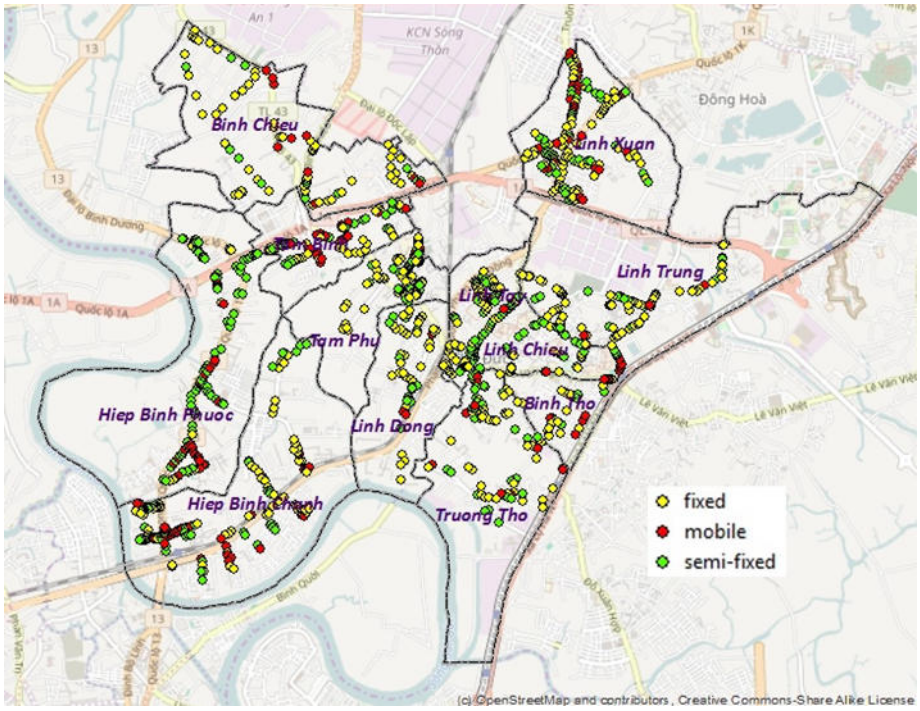

Figure 3. Street food vendors in Thủ Đức District, Ho Chi Minh City

According to the nature of their stalls, street food vendors were classified as fixed, semi-fixed, or mobile.

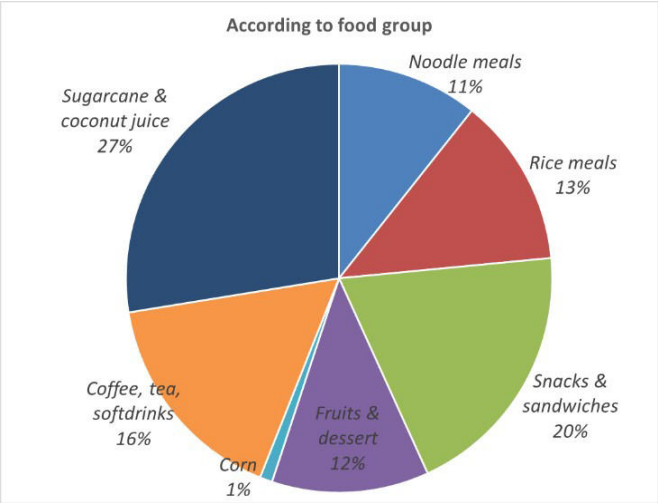

Figure 4. Distribution of street food vendor groups according to food groups

According to the type of food being vended, categories were: rice meals; noodle meals; sugarcane and coconut juice; coffee, tea, and soft drinks; snacks and sandwiches; corn; or fruits and desserts.

3.1.1 Typical food sold for different types of stall

Based on Figure 5 most mobile vendors sold fruits, dessert, snacks, and sandwiches. Semi-fixed vendors and fixed vendors almost sold anything but a large chunk of them sold sugarcane and coconut juice. Many vendors of coffee, tea, and soft drinks, and noodle and rice meals have fixed stalls, probably because they have the space to accommodate customers who often tend to stay at the stall while consuming their food and drinks.

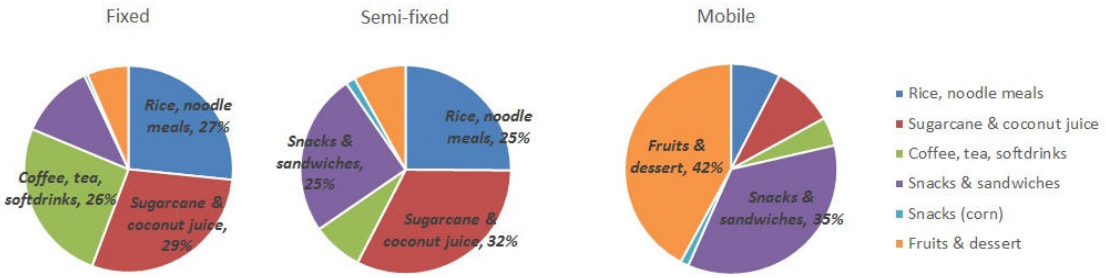

Figure 5. Distribution of stalls from different food categories per type of stall

3.1.2 Vending hours

Mobile vendors normally sold for a few hours each day. Since they move around, they only carried a reasonable amount of food to peddle. Semi-fixed stalls' vending hours depended on the food they were selling. Fixed vendors generally sold from morning till evening but it also depended on the food they were selling.

Breakfast meals like baguette sandwiches (*BÁNH MÌ*), and noodle meals were served as early as 4 am to about 10 am. Stalls which offer lunch meals were open from about 10:30 am to 2:00 pm. Some noodle and rice meals vendors with fixed stalls offered breakfast, lunch, and dinner in which case they were practically open the whole day. Vendors selling drinks like *NƯỚC MÍA*, *NƯỚC DỪA*, coffee, tea, and other drinks were usually open the whole day also. Those selling snacks normally opened in the afternoon until about 8 pm.

3.1.3 Location

Mobile vendors tended to limit themselves to certain streets in certain wards. They flocked outside of schools and offices during break time. They stayed near or along busy streets during rush hours and near establishments

like the public market, hospitals, on certain times of the day and went on with their usual route for the rest of the time. Every day, they tended to keep the same schedule, same route, and spots occupied to gain loyal customers. Semi-fixed stalls normally took one spot where they set-up their stalls every day. A few also took two spots at different times of the day and were inclined to follow this schedule daily. Fixed stalls were for those who sold food in front of their own or rented space and thus did not change locations.

Plotting the location of each stall surveyed on the map enabled us to identify where the street food vendors tended to concentrate. The map showed that street food vendors mostly positioned themselves near roadways and concentrated near establishments like hospitals and schools.

3.2 Waste composition and waste generation rates

Different waste streams were produced according to the different activities involved in street food vending. Firstly, wastes were produced during food preparation. The wastes generated in this activity were the non-edible parts of the ingredients, wrappings or containers of the ingredients, vegetable peelings, etc. For mobile vendors who sold snacks like, cendol (*chè bánh lọt*) and dumplings, they normally pre-cook or pre-prepare the food already thus most of the wastes remained at their homes. Sometimes they still needed to do little preparation during selling like peeling fruits and vegetables and adding some other ingredient from cans like milk thus wastes were still generated. Those selling fruits and fruit juices generated wastes during selling since they peeled the fruits upon order to preserve its freshness. For semi-fixed vendors selling noodle meals, rice meals, and sandwiches, the food were also normally pre-cooked and pre-prepared. Wastes were still produced since they still have to slice meat, use ingredients from cans or jars (canned fish, preserved fruit, flavorings), and slice or prepare the vegetables during selling. For those selling snacks and sugarcane or coconut juice, everything was prepared during selling thus wastes were generated at the stall. For fixed vendors, all food preparation wastes were produced at the stall. Secondly, wastes were produced during and after consumption of food either with the food leftovers from the costumers or with the use of eating utensils.

Additionally, wastes also came from food packaging which included paper plates and cups; Styrofoam plates and cups; plastic cups, spoon and fork; wooden chopsticks; drinking straw; paper wrapping; paper napkins; and plastic bags.

Table 1 summarizes the different wastes produced according to the different food categories described in Section 2.1.2. Pictures of waste samples taken during the survey are presented in Figure 6 to Figure 8. Aside from the ones listed, street food stores may have cardboard boxes and burlap sacks if they buy some of their ingredients in bulk.

Table 1. Typical wastes produced from different food groups

Food groups	Biodegradable wastes	Recyclable wastes	Non-biodegradable wastes
Noodle meals	food preparation wastes, banana leaf wrappers leftovers, paper napkins, paper plates, chopsticks	plastic wrappers and bags	Styrofoam packaging,
Rice, other meals	food preparation wastes, banana leaf wrappers leftovers, paper napkins, chopsticks	plastic wrappers and bags	Styrofoam packaging
Sugarcane and coconut juice	sugarcane bagasse, coconut husks	plastic cups, straw, plastic wrappers and bags	
Coffee, tea, and soft drinks	coffee grounds, tea leaves, used tea bags	plastic bottles, glass bottles, tin cans, milk cartons, plastic cups, straw, plastic wrappers and bags , cardboard boxes	
Snacks and sandwiches	food preparation wastes, banana leaf wrappers leftovers, paper wrapping, paper napkins	tin cans, plastic wrappers and bags	Styrofoam packaging
Corn	corn husks, corn cobs	plastic wrappers and bags	
Fruits and dessert	fruit peelings, fruit pulp, seeds, leftover	glass jars, tin cans, milk cartons, plastic wrappers and bags	

As described in Section 2.2, the determination of waste composition was done by visual analysis of the waste collected and also with the help of photos taken during waste sampling.

Figure 6. Typical biodegradable wastes from each food group

Top row (L - R) banana leaf wrappings and vegetables from stalls selling noodle meals; eggshells, and leftover food from rice meals vendors; fruit peelings from fruits & dessert sellers; used coffee grounds from coffee, tea, soft drink sellers. Bottom row (L – R) paper napkins and food wrapping from stalls selling snacks & sandwiches; corn husks and cob from stalls selling corn; and sugarcane bagasse and coconut husks from sugarcane & coconut juice vendors

Figure 7. Recyclable waste stream

Recyclable wastes included tin cans, plastic bottles, milk cartons, plastic cups, straw, plastic wrappers and plastic bags

Figure 8. Non-biodegradable waste stream mostly composed of Styrofoam packaging

Waste generation rates from each food category were determined from the waste sample collection described in Section 2.2. The results are summarized in
and the percentages are shown in Figure 9.

Table 2. Amount of waste produced per day

Food Group	Ave. weight (kg/day/stall)	Ave. volume (L/day/stall)	No. of Stalls	Total Weight (tons/day)	Total Volume (m^3/day)
Noodle meals	6.10 - 27.24	40.16 - 62.37	124	0.76 - 3.38	4.98 - 7.73
Rice meals	7.51 19.91	50. 99 - 83.93	148	1.11 - 2.95	7.55 - 12.42
Snacks & sandwiches	1.88	11.30	228	0.43	2.58
Fruits & dessert	5.51	17.42	138	0.76	2.40
Corn	8.31	77.60	11	0.09	0.85
Coffee, tea, soft drinks	4.64	109.59	190	0.88	20.82
Sugarcane & coconut juice	13.07	109.42	319	4.17	34.91
Total			1158	8.20 - 12.66	74.09 - 81.72

To estimate the total weight and volume of waste from the street food sector, the waste generation rates were multiplied with the number of stalls belonging to each food category.

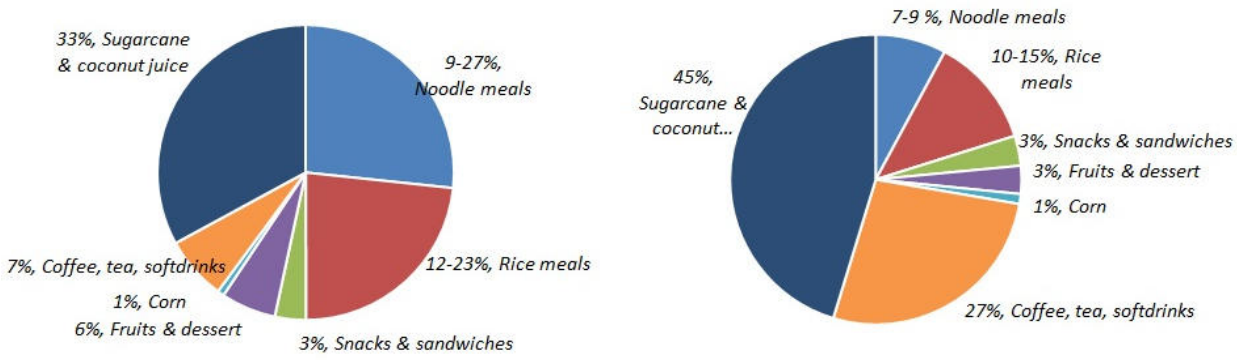

Figure 9. Amount of waste produced by food category

Left: Percentage by weight. Right: Percentage by volume

Due to the huge number of stalls selling sugarcane or coconut juice, and also by the weight of the sugarcane bagasse and coconut husks, wastes from these food category occupied the biggest share of waste. Wastes from 'coffee, tea and soft drinks' vendors may not have weighed that much but the plastic bottles, tin cans, and plastic cups occupied space thus in terms of volume, they were second to 'sugarcane and coconut juice' stalls. 'Snacks,

sandwiches, and desserts' were mostly pre-prepared thus the waste from these food groups were lower. Wastes from boiled corn vendors were heavy and bulky however, stalls selling this food were the fewest in the area.

The range of values for the food category 'noodle meals' and 'rice meals' was due to the two streams of biodegradable wastes that were identified during the survey. The smaller value was the relatively dry food wastes, while the larger value included food wastes rich in liquid components like noodle soup or food sauces. To compute the weight of solid waste, it was assumed that 50% of the liquid-rich-waste was water. It was observed that some stalls kept the liquid-rich waste for animal feed while others drained the liquid part and put the rest in the garbage containers.

Figure 10 below shows the distribution of waste according to the three waste classes namely, biodegradable, recyclable, and non-biodegradable. As can be expected biodegradable wastes took the largest share in terms of weight and volume. The recyclable wastes mostly came from the 'coffee, tea, and soft drinks' food category and is composed of plastics and metal cans which are not heavy but has bigger volume. From the data in Table 2, about 540 kg (from 2.84 kg/stall/day x 190 stalls) of "clean" recyclables can be recovered daily. Other recyclables were mixed with the food waste and thus becomes contaminated rendering it difficult to sell. Non-recyclables were mostly Styrofoam products.

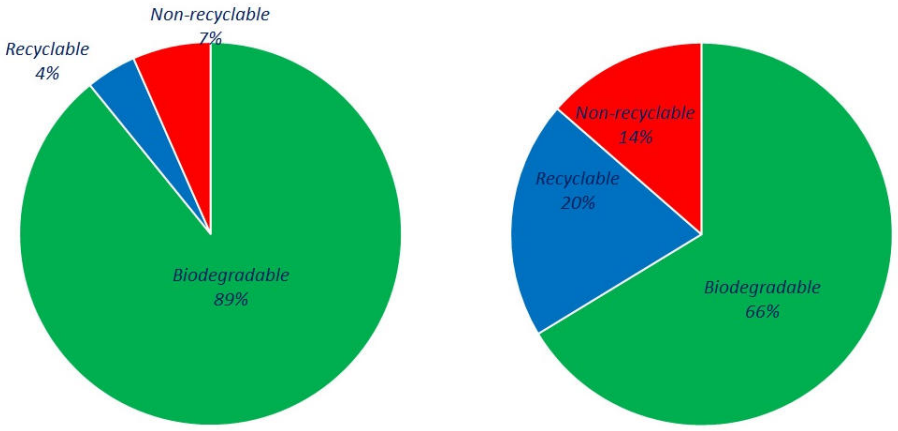

Figure 10. Distribution of waste according to type of waste

Left: Percentage by weight. Right: Percentage by volume

From Table 2, the estimated total weight of waste is about 8.20 - 12.66 tons per day. Thus with the current population of 0.5 million in Thủ Đức, and a typical waste generation rate of 0.6 kg/person/day (Tran et al., 2014) the solid waste generated from street food stalls is estimated to be 3% to 5% of the municipal solid waste. The values can be higher given that the stalls selling overnight was not accounted for. Nevertheless, this values suggest the significance of the street food sector in terms of solid waste quantities produced.

3.3 Waste management practices

For the general structure of SWM in Vietnam, the readers are referred to the works of Ngo and Pham (2011) and Tran et al. (2014) among others.

The waste management practices in the street food sector was determined via survey with randomly selected vendors and also by direct observation.

Table 3 summarizes the result of the survey.

Table 3. Survey results

1. Provision of chairs and tables	
Provided	64%
Not provided	36%
2. Where customers normally put their waste	
Leave on the table	44%
In waste bins provided	13%
Bring with them	41%
Others	0%
No answer	3%
3. Waste containers used in handling wastes	
Garbage bins or plastic containers	38%
Reused grocery bags	53%
Cardboard boxes	0%
Woven baskets	3%
Burlap sacks	0%
Reused ice boxes	0%
None	6%
4. Practice of waste segregation?	
Yes	21%
No	75%
Answer	4%
5. Willingness to segregate wastes in the future	
Yes	29%
No	64%
No answer	7%
6. Practice of recycling/reuse	
Yes	43%
No	57%
No answer	0%
7. Method of recycling (if item 8 = Yes)	
Reused/recycled by the store owner	17%
Sold to recyclers/junkshops	83%
8. Waste collection	
Yes	61%
N o	39%
9. Willingness to pay for collection (If item 10 = No)	
Yes	36%
N o	64%
No answer	0%
10. Method used in waste disposal	
Left at the roadside	41%
Brought home	28%
Burned	10%
Buried	3%
Thrown somewhere else	17%
11. Awareness of any solid waste management laws	
Yes	11%
No	71%
No answer	18%

Around 4-6 vendors from each ward were interviewed totaling to 62 interviews.

3.3.1 Waste containers on site

From the survey conducted, almost half of the respondents said that customers left their wastes on the table. Forty percent said that customers brought the wastes with them - probably coming from stalls with no seating capacities. The rest said their customers mostly put their waste in the waste bins provided.

The physical arrangements in the store dictated how customers managed their wastes. Stores selling noddle meals, rice meals, snacks, coffee, tea, and soft drinks normally provided tables and chairs for customers. If bins were provided per table, most customers used them to put their wastes into or at least left their wastes on the table. If not, customers left their wastes on the table or dropped them to the ground (see Figure 11). Tables were cleared each time a new customer comes while wastes on the ground were only cleaned up once the vendors were not busy serving anymore. Indeed, during the busiest periods, some stalls looked cluttered. If there were no tables but only chairs, customers normally asked the storeowner where to put the wastes or left them on the ground and vendors cleaned them up. For stalls which did not have tables and/or chairs, customers bring their wastes with them.

Figure 11. Availability of waste containers in the stall, Left: A stall which provides trash cans for customers. Right: Stall without provided garbage containers

Different waste containers in different sizes were used by the vendors to store their waste. The most commonly used waste receptacle were reused grocery bags. Half of the respondents in the survey confirmed this, probably because reused grocery bags are cheap and convenient to use. This was usually seen in almost all stalls except those selling sugarcane and coconut juice. Around 40% responded that they use garbage bins and reused plastic containers. This was usually seen in stalls selling rice and noodle meals where sturdy containers are needed to store leftover food especially the liquid-rich waste. Burlap sacks, big wooden baskets, crates, and ice boxes were normally used by stalls selling corn, sugarcane and coconut juice because these containers can handle the weight and bulk of the wastes from this food groups. Cardboard boxes, straw bags, and large garbage bags were usually observed in stalls selling 'coffee, tea, and soft drinks'. These containers can handle light but bulky waste items like plastic bottles. Containers seen on site are presented in Figure 12. Some group of vendors took the initiative to put common disposal boxes Figure 13 (left) in their area. There were also stalls however which did not store their wastes in containers during the period of selling as shown in Figure 13 (right). However, they did clean up their area when they closed their stalls.

Figure 12. Common waste receptacles used in street food stalls:

Top (L-R) grocery bags, woven bamboo baskets, paint containers, plastic straw bags, crates. Bottom (L-R) cardboard boxes, burlap sacks, ice boxes, plastic barrels, commercial garbage baskets

Figure 13. Waste handling at source

Left: Common waste bin for a group of street food stalls. Right: Stalls where wastes are not kept in containers

3.3.2 Segregation and recycling

Seventy five percent of the respondents did not practice segregation and out of that number, only 30% expressed willingness to segregate in the future. Segregation in general, was limited to items that they can reuse such as grocery bags or those that they can sell to itinerant buyers or junkshops namely, cardboard, plastic bottles, and metal cans. If their wastes do not contain these items, the store owners did not find the need to segregate their wastes at all. Thus segregation is mostly observed only in stalls selling 'coffee, tea, and soft drinks'.

Around 43% answered that they practice reuse/recycling, of which 83% of them sold their recyclables to itinerant buyers or junkshops. Some did not have or have very little recyclable items in their waste streams so they did not bother segregating these items anymore. Thus it is also common to find non-biodegradable items in their food wastes. Because of the cheap price of recyclables, vendors normally store them for some time before selling them in bulk.

3.3.3 Waste collection and disposal

In general, waste stream coming from the street food sector is considered a municipal waste. Thus collection was done by the same ones collecting household wastes.

From the survey conducted, 60% of the respondents said that their wastes were collected. The typical fee for collection in the area was 25,000 VND (1.11 USD) per month. Sixty five percent of those whose wastes were not collected were not willing to pay for waste collection. The frequency of collection varied. Some respondents said collection in general was daily, however, it was not uncommon for collectors to miss on some days. In other areas, collection was every two days. The time of collection also varied in different areas.

Forty one percent of the respondents left their wastes on roadsides for community collection (Figure 14), while 28% brought their wastes home, and 17% threw their wastes somewhere else. This is true for most mobile vendors, who threw their wastes in public garbage bins along the streets where they peddle. A small group of vendors either buried or burned their wastes near to the places where they sell.

Figure 14. Waste from street food stalls left on roadsides awaiting collection

There are two units responsible for the collection and transport of wastes in Thủ Đức District, the Public Services Company and the private waste collectors. The Public Services Company is affiliated with the People's Committee of Thủ Đức District. They perform the following functions: sweep the streets; collect household wastes located in major roads using specialized garbage trucks which are regularly maintained; transport the wastes to landfill; collect and transport garbage in ward markets; contract with industrial production facilities for collection and transportation of industrial wastes; and also manage the activities of the private waste collectors. There are more than a hundred private solid waste collectors operating in the smaller streets in the different wards in the district. These collectors use vehicles of different capacities. They are able to go through small streets where the garbage trucks of the Public Services Company cannot go. Some of the collection vehicles seen in the area are shown in Figure 15.

Figure 15. Different garbage collection vehicles spotted in the area during data collection

Garbage vehicle on the upper left are from the Public Service Company, while the other three are from different private solid waste collectors.

In general, only the recyclables from the stalls selling beverages and other reusable materials from all types of stalls were observed to be separated from the source. The rest of the wastes were collected, brought to the transfer stations where recovery of more recyclables are being done, and ultimately to the landfills. When workers collect the waste, they also do a quick segregation of wastes. The magnitude of recovery of recyclables by the collectors and at the transfer stations or landfills was not determined in this study as the wastes were mixed already with household wastes.

3.4 Strengths, weaknesses of the current SWM practices in the street food sector and some recommendations

3.4.1 Waste Generation rates

Customary habits can affect waste generation rates. It was observed that in stalls selling meals, washable plastic bowls, glasses, and wooden chopsticks were normally used, avoiding the generation of packaging wastes. Waste water was produced though because washing of plates was also done at their locations. A general observation for stalls with no tables and chairs was that the food packaging was redundant leading to more wastes generated. Moreover, these packaging were almost always made of plastics. For example, in buying the popular snack - fish balls, the different sauces (sweet sauce and hot sauce), the side dish (kimchi), and the fish balls on stick are wrapped in individual Styrofoam boxes and/or plastic bags, and placed altogether in a bigger plastic bag.

The use of unnecessary packaging should be minimized. Boxes can be redesigned to contain everything in one box and there is no need to put the box in extra plastic bags. The use of packaging made of biodegradable or renewable materials should also be prioritized instead of Styrofoam boxes. The challenge though is that minimizing packaging can be difficult to implement because of cultural habits of making it convenient for customers to carry and eat their meals. Aside from this, there are almost no affordable biodegradable or renewable packaging materials available in the market. The government needs to encourage manufacturers by giving financial incentives to companies making these products.

3.4.2 Waste containers on site

Vietnamese people in general have traditional habits that ultimately contribute to recycling. For one, they store all grocery bags for reuse, normally for storing their wastes. The use of grocery bags may be convenient to use for the stall owners but it does not encourage customers to dispose their wastes properly. With a few exceptions, waste baskets for customers were lacking in most stalls.

A sturdy waste receptacle with cover is preferable. Waste baskets with provisions for segregation should be made available and it should be placed in the store where customers can see it easily. Moreover, the vendors can remind their customers to put the wastes in the storage bins. However, this can be a challenge as it needs a change in habits on the part of the customers as well who are used to leaving their wastes on the table or dropping them to the ground.

3.4.3 Segregation and recycling

It is an integral part of any SWM strategy to adapt waste reduction and resource-recovery-based solutions. If vendors can do solid waste separation at source, the amount of waste going to landfills can be significantly reduced.

The high proportion of organic matter in street food waste provides potential for composting or biogas recovery. However, because segregation was not properly done by street food vendors, most of the food wastes in the stores were mixed with the non-biodegradable wastes rendering the food waste impure for biological processing.

Aside from composting, food wastes can also be collected as animal feed. Food residue recycling by swine breeders in Da Nang can be one example. Food wastes were collected from hotels, restaurants, and households in the urban center, transported to piggeries, cooked well, and fed to swine. The food wastes were purchased at 32 to 556 Viet Nam Dong per kilogram. From the survey conducted, swine breeders commented that food residue reduce breeding costs, has ‘‘higher nutritional value’’, and that the use of it is environmentally friendly (Kato et al., 2012). Utilizing food wastes as animal feed, requires careful separation of the food wastes from the rest of the biodegradable wastes.

Reuse and recycling is practiced in the street food sector. However, as mentioned previously, it is limited to items that they can reuse or sell. And also if the quantity is too little, they also do not bother storing them anymore. The collection of recyclable materials in general, is driven by the informal sector. Itinerant buyers go door-to-door to buy recyclables and sell them to junkshops. In many instances, itinerant buyers determine their own purchase price (Mehra et al. 1996). A separate collection of organic wastes for composting or for use as animal feed was not observed. Some vendors though, on their own initiatives, practice composting or use their food wastes as animal feed. Sometimes other people ask it from them to use as animal feed.

To make segregation and recycling successful, the entire reuse and recycling industry have to be strengthened. The informal sector can widen the range of materials that they can collect and buy to include not only recyclables but also food wastes for animal feed and the rest of the biodegradable wastes for composting. The collection system have to be planned.

The market for recyclables is established already but there is still work to be done to develop the markets for composts and animal feed. If separation at source is improved and if a strong market for composting fertilizers and/or turning food residue to animal feed is developed, the effectiveness and success of reuse and recycling can be achieved.

3.4.4 Waste collection and disposal

It has become the norm for street vendors to leave their bags of garbage on the pavement awaiting collection. Some are in the habit of putting it next to drainage inlets like shown in Figure 14. There are many times though when this bags left on roadsides stay there for a long time before being collected. People have the belief that the municipal sweepers would somehow collect and dispose it anyway (Richardson, 2003). With street food stalls sporadically located in the district, trails of waste bags left by the vendors are also seen. This can be an eyesore for some time until they are collected or until workers from the public company sweep the streets which they normally do at night.

One of the problems related to this is that the schedule of collection in areas served by the private solid waste collectors is not fixed. In some areas, collection is not daily. This problem is somehow expected due to the fact that more than a hundred different private companies collects the wastes in the different parts of the district. All of them have different policies and working styles and due to the large number, it may be impossible for the authorities to monitor each one of them. To fix this, uniform rules for these private companies must be imposed. Collection routes and collection schedule must be laid out and should be made known to all stakeholders, and strictly followed. Sanctions or cancellation of contracts must be done should the private collectors do not adhere to the rules. The number of contracts can also be limited to manageable size.

A common waste storage site can be assigned in the area where vendors can bring their garbage especially if they close down much earlier than the scheduled waste collection. Aside from this, 100% daily collection should be targeted. In this way, the streets are kept clean. Also, the rather dispersed waste bags on the streets can be avoided if street food vendors can be organized to form hawker areas. It keeps the source of waste in a smaller space and waste removal systems can be put in place easily.

The use of different small collection vehicles that various private solid waste collectors use may solve problems of accessing smaller streets but they are not specialized garbage vehicles and do not guarantee safety and environmental hygiene. There should at least be a minimum requirement for vehicles used in garbage collection. For example, too old or too open vehicles must not be allowed anymore. There should also be a provision to keep the liquids from wastes from flowing out of the vehicles.

There are still vendors who practice burying or burning of their wastes near their stalls, mostly they are not willing to pay for the collection of their wastes. According to the survey, seventy percent of the respondents do not know any SWM laws although some of them said that they just know that they must dispose their wastes in any way. The practice of burning and burying can only happen and continue due to ignorance of the law, ignorance of its environmental effects, or due to the absence of consistent enforcement and realistic penalties.

4. Conclusions

In this study, 589 fixed, 410 semi-fixed, and 159 mobile street food vendors were identified within the administrative area of Thủ Đức District, Ho Chi Minh City. The estimated total amount of waste produced by these vendors according to the waste sampling done was about 8.20-12.66 tons/day. This amount makes the food sector a significant contributor of pollution in the city. The compositions of wastes in the street food sector - 89% biodegradable, 4% recyclable, and 7% of Styrofoam products - shows that in fact, none of it should end up in landfills. Food wastes can be used as animal feed or together with the rest of biodegradable wastes can be composted or used for biogas recovery. The rest of the wastes can be reused and/or recycled. However these potentials are not yet fully realized at the present.

There is also much improvement that can be done in terms of waste handling at source. The unavailability or non-visibility of waste containers at the stall does not encourage customers to handle their wastes properly. Most customers leave their wastes on the table or drop them on the ground. During the busiest part of the selling period some stalls were littered. This is not only aesthetically offensive, but is also unhygienic.

With confirmation from 53% of the responders in the survey, reused grocery bags were the most popular waste receptacles used by vendors to keep their wastes. At the end of their selling period, most of these bags of wastes are left on the roadside awaiting collection (41%) if not brought home (28%), thrown somewhere else (17%) or buried or burned. Some issues were also found in the collection system particularly in the frequency, consistency, and in the vehicles used by private companies.

A street food vending solid waste management system that includes handling and disposal of waste in a way that avoids contamination of food and the environment is needed in the study area. Careful planning for each aspect which can only be achieved after consultation with all stakeholders, a sound legal framework to support it, and a strict implementation are key factors in an effective SWM strategy. Integrating informal waste collectors into the formal waste management organizations is an important option as they are seen to play a key role especially in the reuse/recycle aspect. There is also a need to include the vendors in the mapping out of the solid waste management strategy. Their responsibilities as well as the benefits of the program for them should be made clear. If vendors can see that it is something that can directly benefit them then perhaps they would be more willing to cooperate. Penalties for violators must be put into place but incentives for compliance are also important to encourage people to abide by the rules.

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