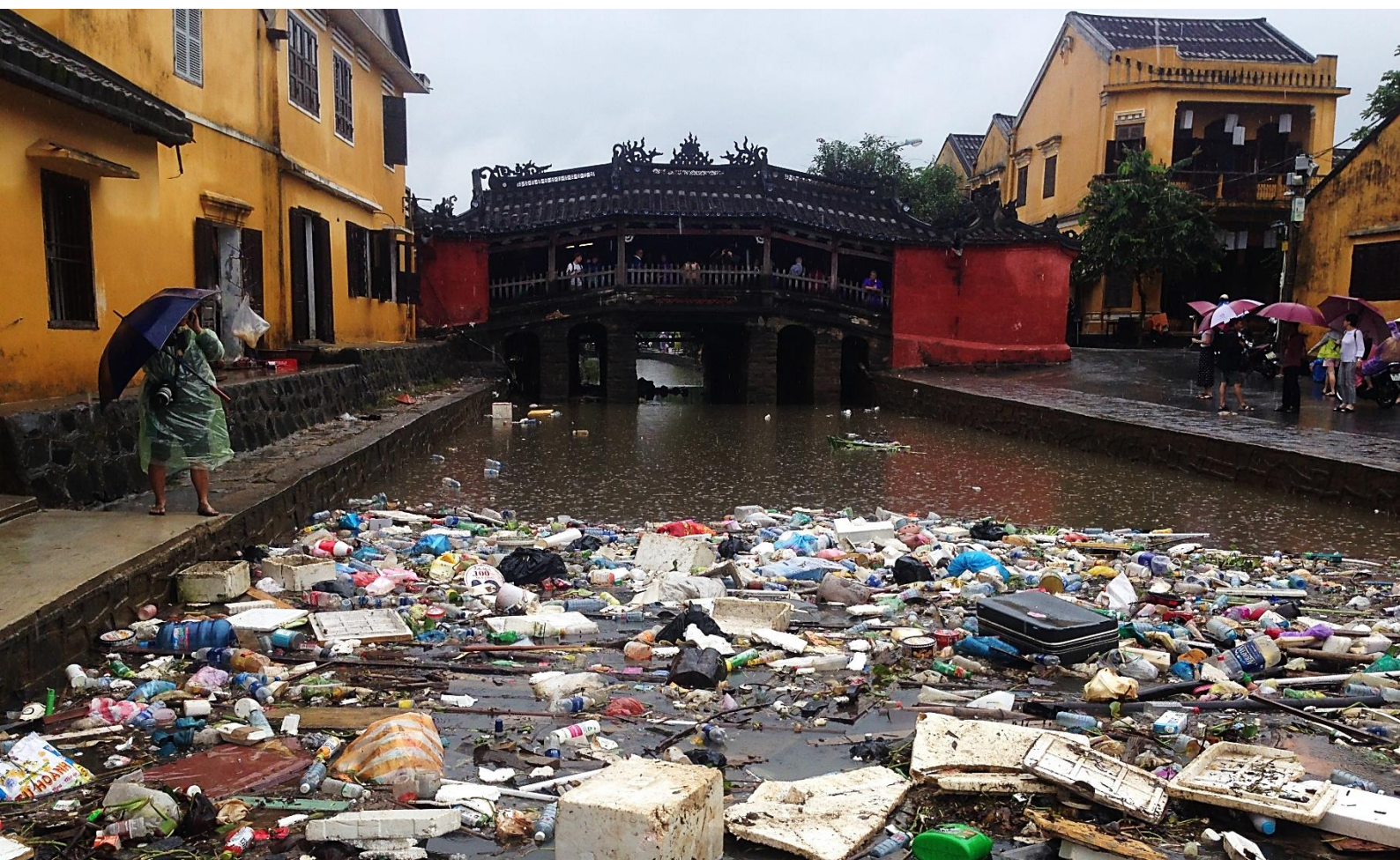




# Summary report municipal solid waste audit in Hoi An city 2020



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# Summary report municipal solid waste audit in Hoi An city 2020

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## **LIST OF ABBREVIATIONS**

MSW	: Municipal Solid Waste
HOI AN JSC	: Hoi An Public Works Joint Stock Company
MFA	: Material Flow Conceptual
IUCN	: International Union for Conservation of Nature
QD-TTg	: Prime Minister's Decision



## **Executive Summary**

The waste generation in Hoi An City has increased significantly as much as its economic growth. According to statistical data from Hoi An Public Works Joint Stock Company (shortened Hoi An JSC), the volume of municipal solid waste (shortened MSW) increased the average rate of 9% annual in the period of 2015 – 2019. In order to contribute towards the development of an environmental and ecological city, Hoi An has made efforts to classify and minimize solid waste over the years. The People's Committee of Hoi An City issued the Plan No. 1824 dated October 11<sup>th</sup> 2012 on implementation the program "Sorting waste at source". From 2012 till the date, despite having the numerous waste and environmental projects in Hoi An, there is still no project to assess comprehensively the MSW composition, including the plastic waste production from socio – economic activities.

Project “Municipal Solid Waste Audit in Hoi An City”, therefore, are implemented, This report provides information and data on the current situation, characteristics, and composition of solid waste and recycling systems, aiming to create the basis for future projects and management activities. The data are collected from sources, including: Department of Natural Resources and Environment in Hoi An City, the current state of waste generation report of Hoi An JSC, besides, data from other reports and projects in Hoi An City in the period of 2012 – 2020 were also synthesized. After that, the MSW audit and brand audit are implemented for 9 object groups, including: (i) 2 markets (Hoi An market, Ba Le market); (ii) 7 schools (from preschool to high school); (iii) 2 coffee shops; (iv) 5 convenient shops; (v) 15 households; (vi) 5 restaurants – hotels; (vii) 4 agencies; (viii) 1 waste transfer station in Cam Chau Ward; (ix) Cam Ha landfill. Moreover, the key informant interview method was performed with fishermen, farmers, and local artisans aiming to evaluate the waste produced by these activities.

### **Highlights from the report include:**

1. The key sources of waste generation in Hoi An City includes: households (45%), business premises (40%), markets (12%), schools & agencies (2,7%) and craft villages (0.3%)
2. The main composition items: Organic waste represented 66.77%, plastic waste (15.22%), paper (8.02%), textile (2.87%), Styrofoam (2.54%); metal (1.44%), glass (1.35%), other non – bioderadable waste (1.47%) and hazadous waste (0.32%)
3. The total waste generation was 8,909.42 tons per year (nylon and plastic waste 50.18%), of which 519.49 tons per year was recycled (accounting for 5.83%), deriving from plastic with the high value and big sizes
4. The total of recycling waste from informal collection activities was an average of 2,317.36 tons per year, accounting for 6.55% of the total

MSW waste in Hoi An. These represented 16.27% of total recycled waste and 62.46% of total scrap waste generation in the city

5. The result from brand audit activities showed that 88% of the material brands were made from plastic, metal accounted for 8%, and glass represented 4%. Notably, multi-layer packaging and single-layer packaging accounted for the highest percentage of total plastic materials
6. The most popular brands include: Vinamilk (31%), Coca-Cola (15%), Acecook (6%), Pepsico (6%), TH - True Milk (6%), Nestle (12%), Khanh Hoa Khatoco (2%)

In accordance with the situation above, some specific recommendations are made as the basis for the payment of collection fees under the Environmental Protection Law 2020 as follows::

Hoi An City should implement the radical MSW waste sorting, aiming to increase recycled wastes, along with improving the quality of the collection and treatment systems, including a composting plant.

1. Hoi An city should implement quickly and radically the waste classification at source activities, which aims to increase the volume of recycled waste and develop simultaneously the quality of MSW collection and treatment system, including the composting factory;
2. The city should have solutions for replacing and recycling low – value plastics, along with reducing the use of plastic bags and single - used plastics;
3. It is necessary to strengthen waste management from agricultural and fishing, construction, and public activities. These aim to ensure the transparency of the volume and composition of the sources in Hoi An city;

## 1. Introduction

Solid waste has been and remains an important environmental problem that needs to be addressed globally. According to The World Bank, the world generates 2.01 billion tons of municipal solid waste annually and is forecasted to be 3.4 billion tons by 2050.

Vietnam in recent years, with the speed on urbanization, has promoted strong socio-economic development and increase dramatic simultaneously the amount of waste generation. The total amount of generated waste in 2019 is 64,658 tons per year (urban area is 35,624 tons per day and rural area is 28,394 tons per day). According to the forecast, the growth rate of solid waste generation will reach 8.4% per year in urban areas, and the total increase forecasted is by 5% per year. The total amount of waste is estimated to reach 54 million tons by 2030<sup>1</sup>.

Vietnam also has made efforts to tackle the problem of waste. The Prime Minister approved Decision 491/QD-TTg dated May 7<sup>th</sup>, 2018 on the adjusted *The national strategy on integrated management of solid wastes up to 2025, with a vision toward 205*, and Decision 1746/QD-TTg dated December 4<sup>th</sup>, 2019 promulgating the national action plan on marine plastic debris management through 2030.

In order to contribute towards the environmental and ecological city, Hoi An has made efforts over the years to classify and minimize generated solid waste. On October 11<sup>th</sup>, 2012, the People's Committee of Hoi An city issued the Plan No. 1824 to implement the program "Sorting waste at source". Waste environmental projects are being implemented in Hoi An. However, there are still remaining issues: (i) studies on solid waste in Hoi An are still individual, (ii) there is a lack of specific information on the status of generation and solid waste composition characteristics of groups in the city, and (iii) lack of in-depth studies on solid waste collection and recycling system and assessment of the opportunities generated by waste for Hoi An.

This report provides the information and data on the current situation of 2019 & 2020, characteristics and composition of solid waste and recycling systems. This information provide data for the implementation of related projects and activities to gradually help Hoi An become an "eco city".

## 2. Overview of Hoi An City

Hoi An City in Quang Nam province is the urban area of grade III. The total land is 61,71 km<sup>2</sup>, located on the North bank of the Thu Bon river, with a geographical position of 15°15'26" - 15°55'15" North latitude and 108°17'08" - 108°23 '10" East longitude. The mainland part of the city covers an area of

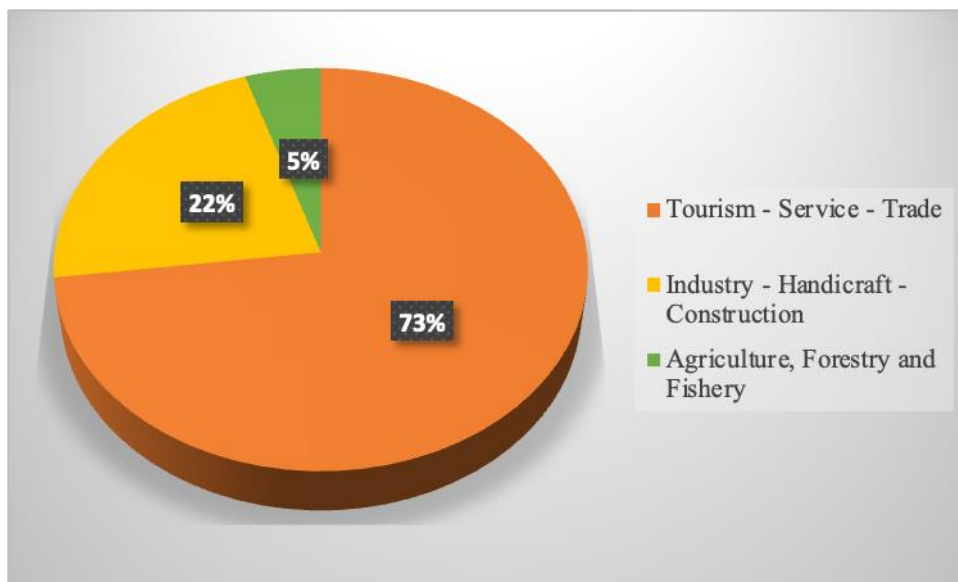
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<sup>1</sup> The report on current status of national environment in 2019 (Ministry of Natural Resource and Environment)

46.22 square kilometers (accounting for 74.9% of the total natural area of the city).

According to the result of the Population and Housing Census in 2019, the population of Hoi An is 98,599 people and there is a large disparity between the urban population and the rural population. The urban population is 72,898 people, accounting for 74%, and the rural population is 25,701 people, accounting for 26%, population density reaches 1,604 people/km<sup>2</sup>.

In 2019, the Tourism - Service - Trade industry continues to grow and plays a key role in the economic structure of Hoi An. The total production value of the industry is estimated at 8,563.6 billion VND. Industry - Handicraft and Construction industry has stable growth, total production value is estimated at 2,603.9 billion VND. In the Agriculture - Forestry - Fisheries group, the production value reached 613.32 billion VND.



**Figure 1.** Structure of total production value of economic sectors in Hoi An City (2019)

### **3. Objective and method research**

#### **3.1. Objects of solid waste audit**

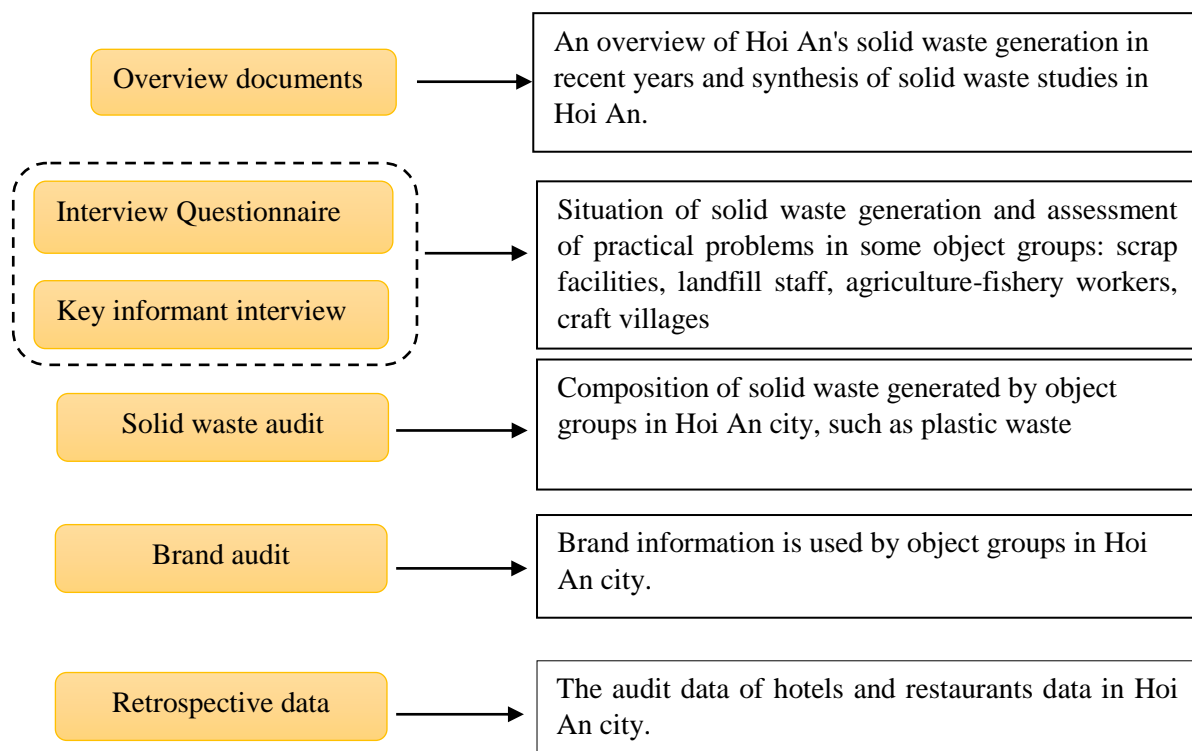
The auditing scope is composition waste in Hoi An City. The MSW and brand audit are conducted in sequence, with 9 object groups, including: (i) 2 markets (Hoi An market, Ba Le market); (ii) 7 schools (from preschool to high school); (iii) 2 coffee shops; (iv) 5 convenience stores; (v) 15 households; (vi) 5 restaurants – hotels; (vii) 4 agencies; (viii) 1 waste transfer station in Cam

Chau Ward; (ix) Cam Ha landfill. For the data of restaurant, is proposed to use the database in 2019 (the corporation between research team and Hoi An Department of Economy performed<sup>2</sup>). Additionally, the MSW composition includes construction and urban tree waste, however, these do not add into the object audit for the various reasons: (i) urban wastes are collected together with domestic waste so there are no exact statistics; (ii) construction waste did not identify and collected as most of them are reused for construction activities in accordance with Hoi An White Book.

For the object groups include farmers, fisheries, and artisans, are implemented the key informant interviews to determine the volume and composition waste due to low and intermittent waste generation daily. The number of samples include: 17 farming households, 15 livestock, 13 aqua-culture, and 18 fishing (fisherman) households.

### 3.2. Research methods

The methods used in the study are summarized in the diagram below:

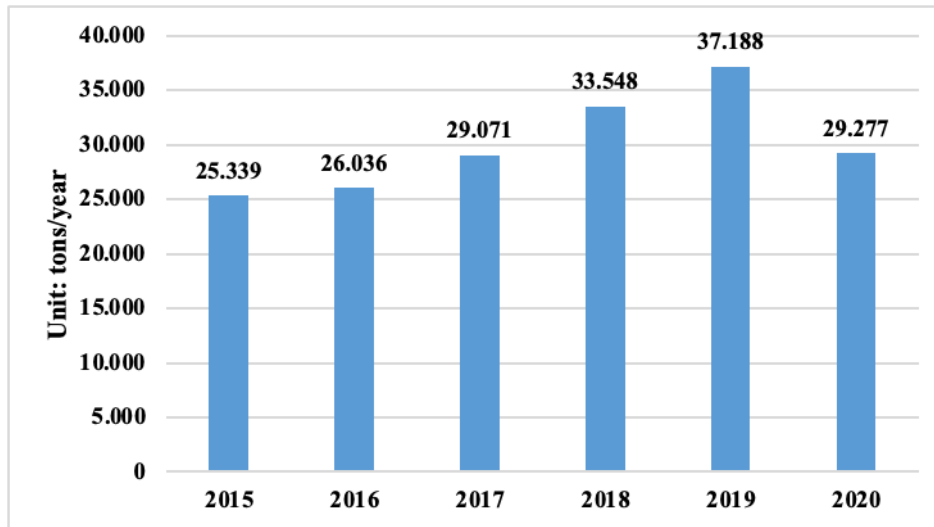


**Figure 2.** Research framework

<sup>2</sup> The audit method for restaurant and hotel in 2020 is performed exactly the same as 2019

#### 4. Overview of Hoi An solid waste generation

Data collected from Hoi An JSC on the total amount of solid waste collected in the city from 2015 to 2020. The volume of generated solid waste has steadily increased from 2015 to 2019. From 2016, the average annual average is about 3,700 tons / year (9% of the average annual growth rate). The decrease in Hoi An solid waste volume in 2020 is due to the impact of Covid-19 on the tourism industry (Figure 3).



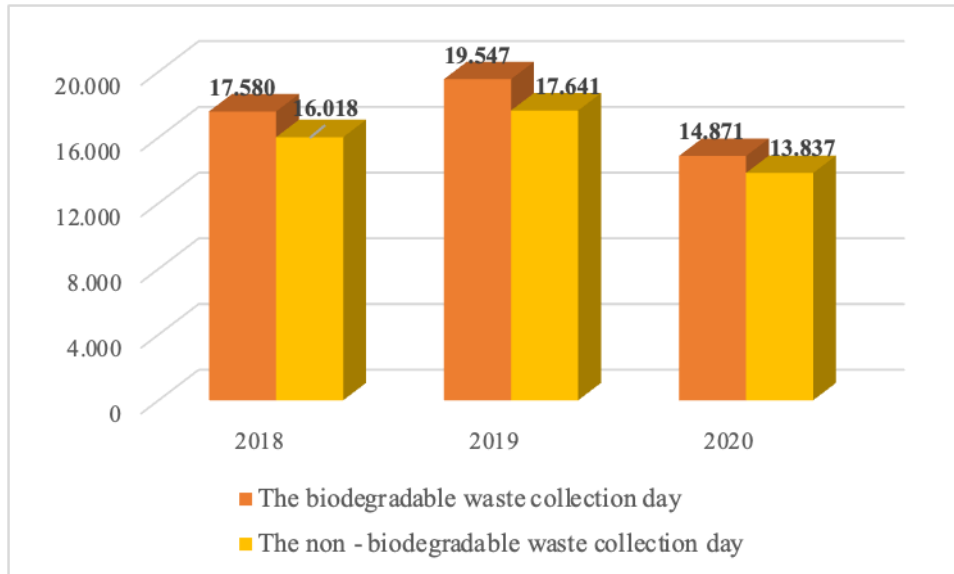
**Figure 3.** Total volume of MSW generation in Hoi An City from 2015 to 2020 (tons / year)

(Source: Hoi An URENCO, 2020)

The amount of waste between the collection date of easy-to-decompose and non-biodegradable waste from 2018 - 2020 does not have much difference, only about 1,000 tons (Figure 4)<sup>3</sup>. The limited and inefficient waste sorting is considered the main cause of this problem.

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<sup>3</sup> Domestic waste from households, agencies, hotels, restaurants, markets are classified and placed in the right places, then is collected daily at fix time by motor or hand-pushed collection vehicles, based on the schedules: Monday, Wednesday, Friday, Sunday collecting biodegradable waste, and Tuesday, Thursday and Saturday collecting non-biodegradable waste. Biodegradable waste are organic wastes (leftovers, gardening products, papers, tea grounds and coffee); non-biodegradable waste is the remaining, mainly inorganic forms such as metal, glass, cronois, nylon ... (the Garbage Classification leaflet of Hoi An City's Department of Natural Resources & Environment)



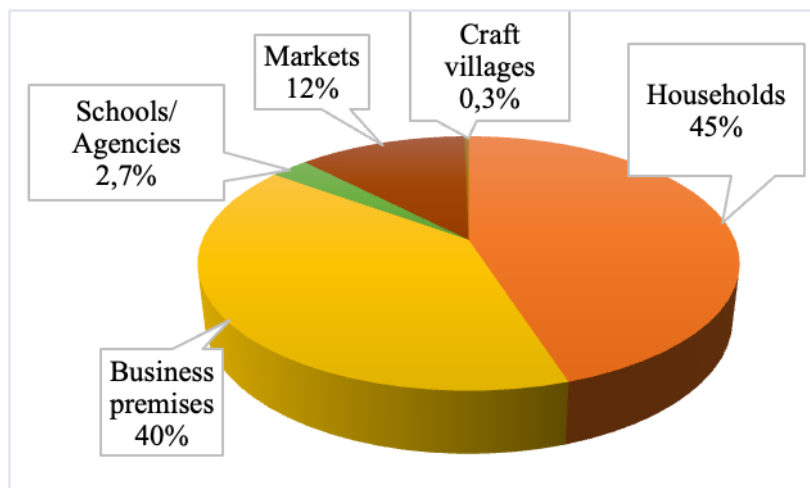
**Figure 4.** The total volume of waste between of biodegradable and non-biodegradable waste collection date in the period of 2018 - 2020 (unit: tons/year)

(Source: Hoi An URENCO, 2020)

## 5. Results of MSW audit

### 5.1. Results of MSW audit at source

The rate of MSW generation from the different sources in Hoi An City is presented in Figure 5, as follows:

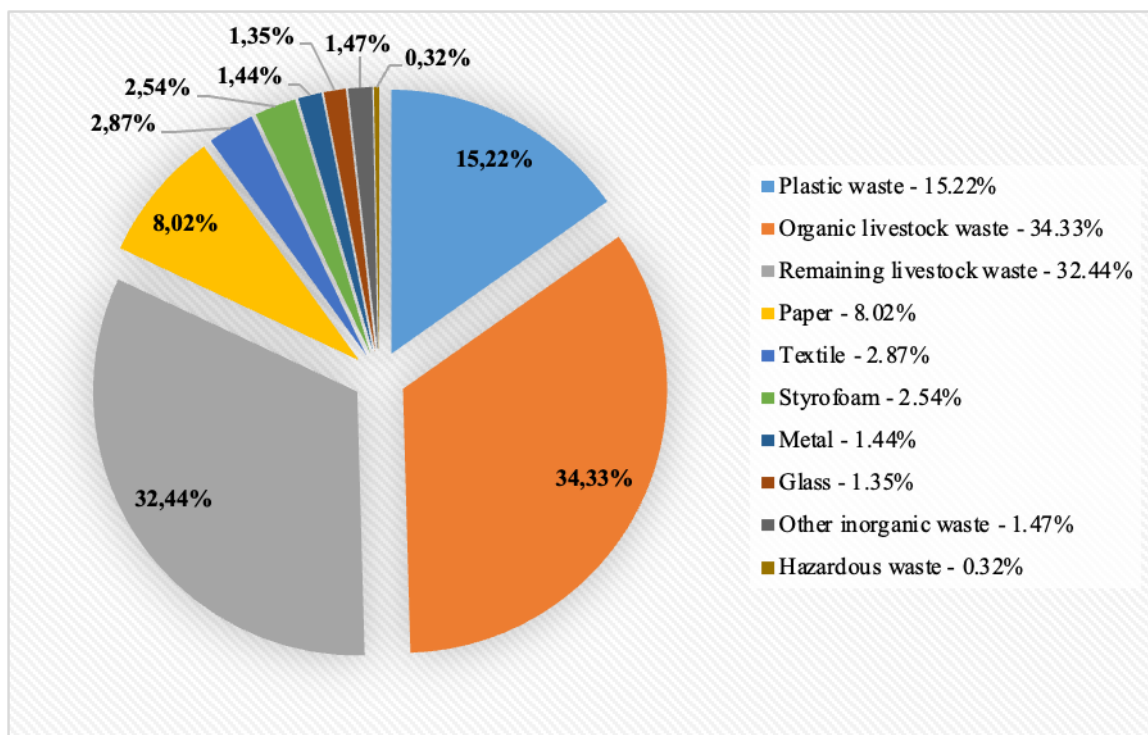


**Figure 5.** The rate of MSW generation at source in Hoi An City (unit: %)



Households and businesses contribute the largest amount of solid waste in Hoi An City, with 45% and 40%, respectively, followed by the market (12%) and others (Figure 6). The result of survey of agriculture and fishing households showed that the waste generation was pretty small while the onsite treatment of waste was large (disposed at the sea or farm). The remaining volume of waste is collected together with domestic waste. Thus, these are just analysed through MFA instead of being added into the waste generation sources (Figure 15). Notably, the amount of construction waste has not been managed properly, most of such waste is treated or disposed of on vacant land in the suburbs by local people. In this survey, the waste derived from street sweeping and pruning activities is collected as a part of domestic waste thus there is not separate data for this source.

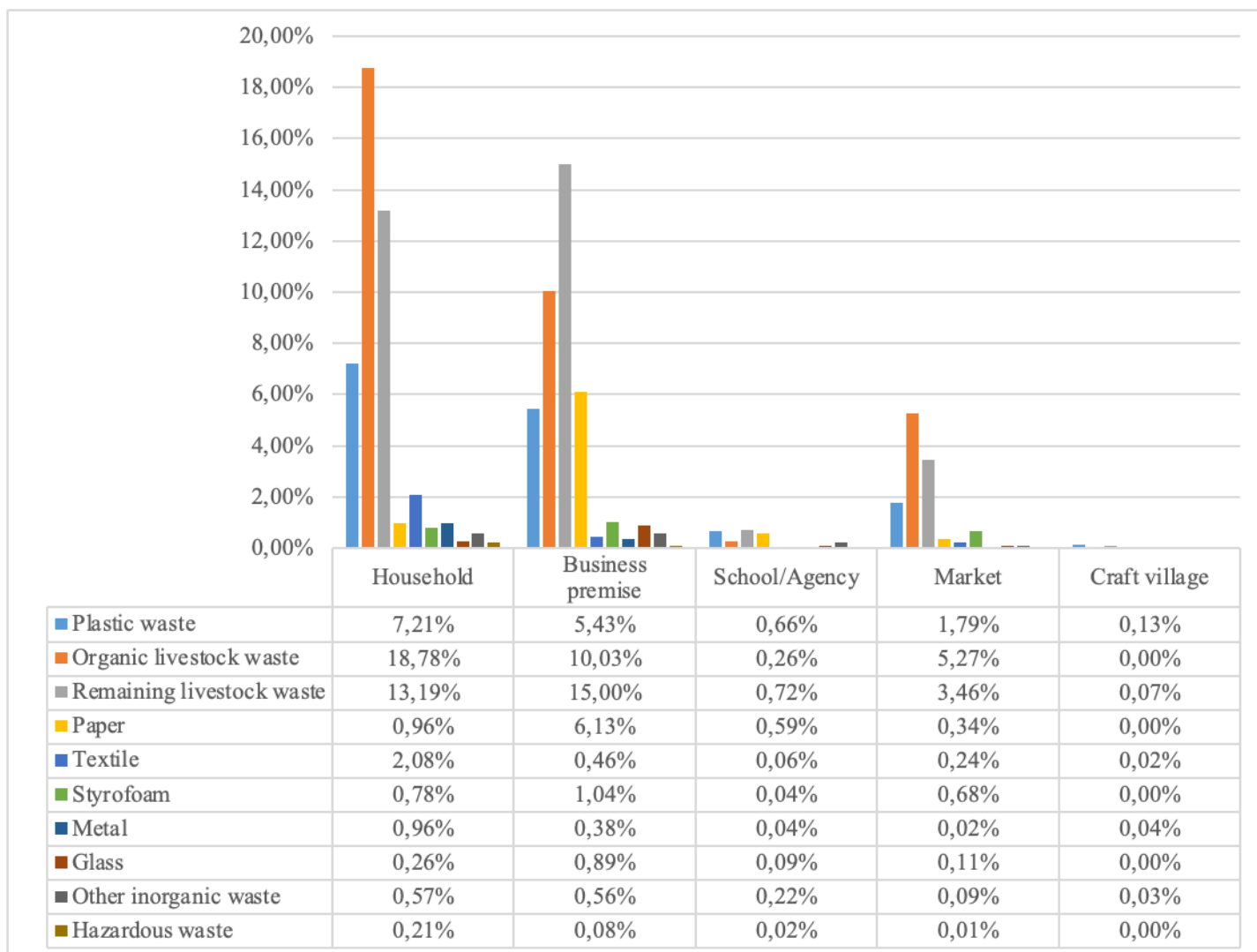
The auditing result shows that the proportion of total organic waste are highest, accounting for 66.77%. Next, plastic waste represents 15.22% and types of paper (8.02%). The others include textiles, Styrofoam, glass, and other inorganic ranging from 1.44 – 2.87%. Hazardous waste generated from daily life (mainly batteries, light bulbs, medical masks, and medicine) accounted for 0.32% and is collected together with other types of solid waste. The rate of waste composition is represented in Figure 6.



**Figure 6.** The rate of MSW composition in Hoi An City (unit: %)<sup>4</sup>

<sup>4</sup> The statistics are analysed in accordance with practical data audit of research team (2020)

The MSW composition generation of each group are described in Figure 7. For the agriculture – forest – fishery industry group, the waste produced intermittently and was on site treatment, therefore, these are not audited and sorted as other sources.



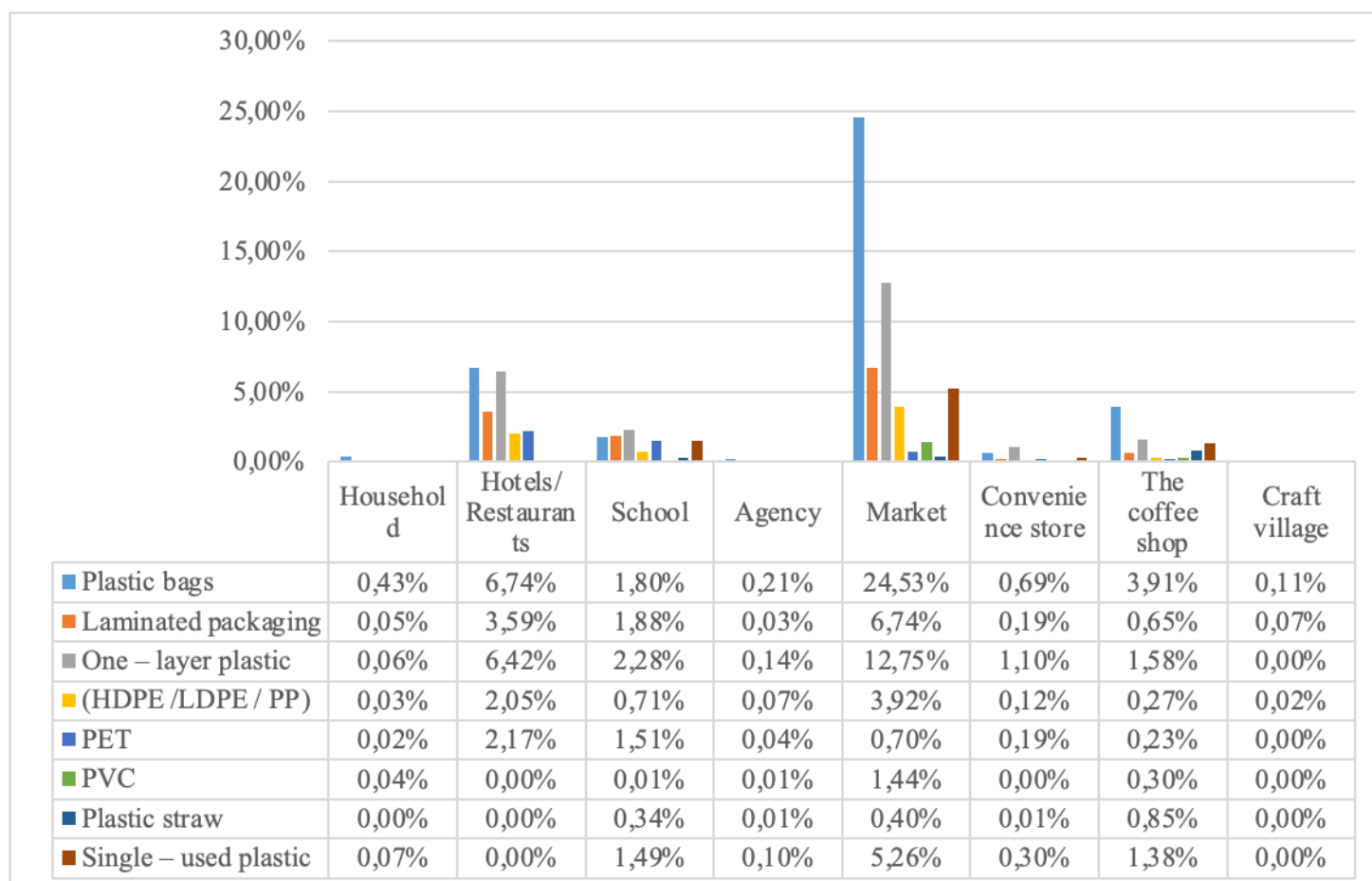
**Figure 7.** The average rate of MSW generation for object groups in Hoi An City in 2020

The results of waste composition analysis show:

- ✚ Plastic waste: Households and business establishments, emitted 2,551.48 and 1,922.39 tons/year respectively, are the two groups of plastic waste emitters, accounting for 83.08% of the total generated plastic waste
- ✚ Organic livestock: Households generate the most organic livestock waste 6,646.27 tons/year, accounting for 54.69% of the total amount of organic livestock waste. Next are business establishments accounting for 29.23% and markets at 15.34%.

- ✚ Paper: Business establishments generate the most paper waste, averaging 2,168.07 tons / year, accounting for 76.38% of total paper waste
- ✚ Styrofoam: Business establishments (average production of 368.22 tons/year) and households (average generation of 277.13 tons/year) are the two groups of objects that generate the most styrofoam
- ✚ Metal: Households and business establishments generate the most metal waste, averaging 339.24 and 133.24 tons/year respectively, accounting for 1.3% total amount of waste . In which households accounted for 66.42% and business establishments accounted for 26.09% of the total amount of metal waste emitted
- ✚ Glass: Business establishments have the highest emission of glass waste, averaging 314.5 tons/year, accounting for 65.99% of total glass waste.
- ✚ Hazard: The households generate the highest hazardous waste, averaging 73.26 tons / year, accounting for 65.59% of the total amount of hazardous waste emitted. Next is households and then schools, business establishments.

### **Plastic waste audit at the sources in Hoi An City**



**Figure 8.** The result of plastic waste audit in Hoi An City.

The audit result shows that low – value plastic<sup>5</sup> is the most common composition, accounting for the highest proportion, and the market and restaurant/ hotel are the focal points for plastic waste in Hoi An City, as follows:

✚ Plastic bags: markets produce the highest plastic waste, accounting for 24.53% of the amount audited. Next, the production proportion of restaurants/ hotels represent 6.74%

✚ The laminated packaging: markets represent the highest proportion of waste generation, at 6.74% of the total volume of MSW audit, equivalent to 1.8kg. Next, restaurants/ hotels represent 3.59%. Additionally, the school had an emission rate of 1.88% of the amount audited

✚ One–layer plastic: the markets represent the highest proportion of waste generation, at 12.75% of total volume of MSW audit. Next, restaurants/ hotels represent 6.42 %. Additionally, the schools have an emission rate of 2.28% of the amount audited

✚ Single – used plastic: the markets are the highest emission group with 5.26% of the amount audited. Then, schools account for 1.49% with the main kinds of waste such as plastic cups, forks, etc.

✚ HDPE/ LDPE/ PP: restaurant/ hotel had the highest generation rate, at 2.05%, with the main kinds of waste, such as shampoo bottles, plastic cans, cleaning tools, etc.

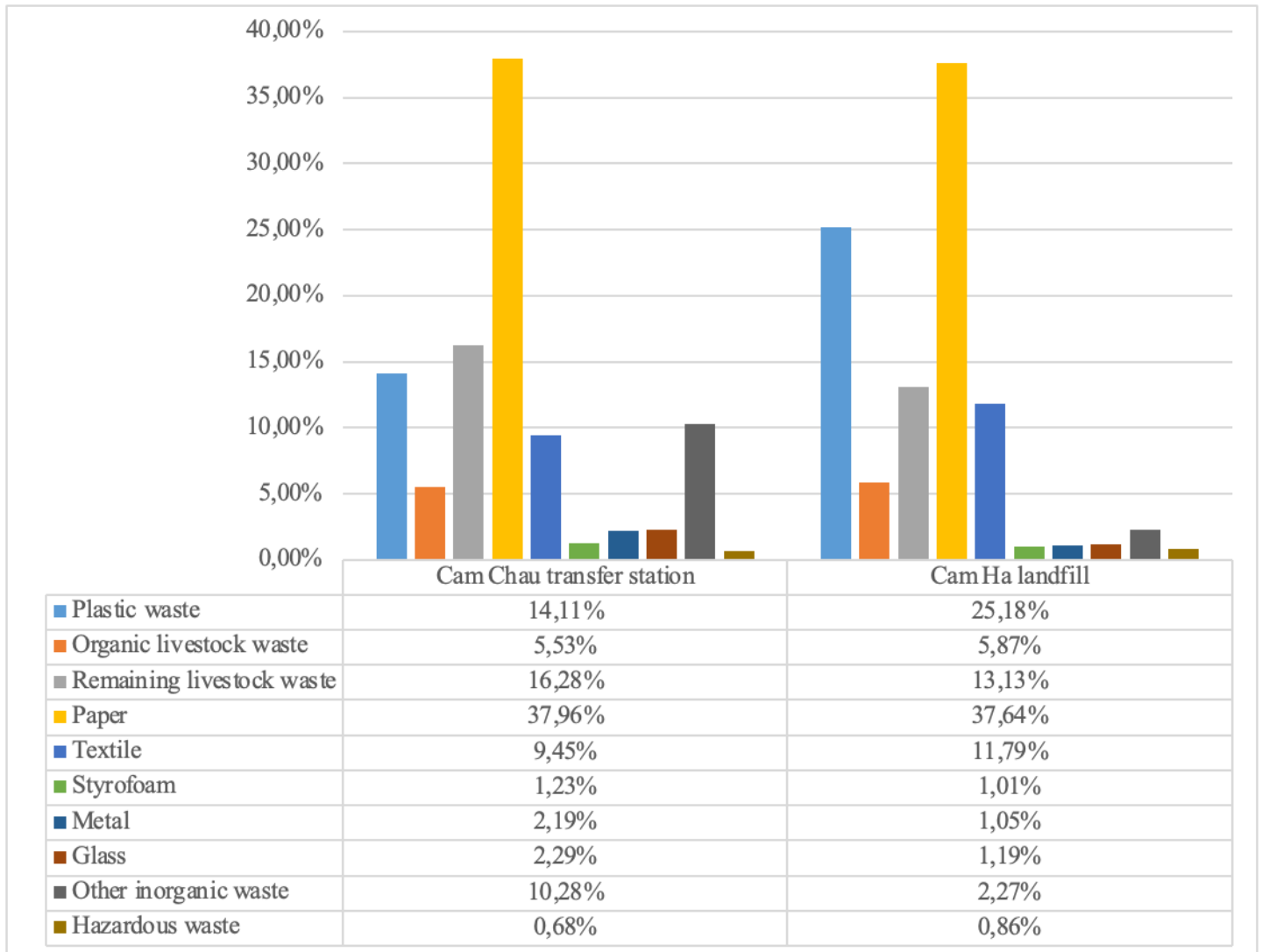
✚ PET: restaurants/hotels have the highest generation rate, at 3.19%. Next is school, with 2.17%. The main types of waste are plastic beverage bottles.

## **5.2.The result of MSW audit in landfills in Hoi An City**

The audit activity is conducted not only at the waste generation sources, but also at the Cam Chau transfer station and Cam Ha landfill. The key findings are presented in the bar chart below:

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<sup>5</sup> Low-value plastics in this report are understood to be the plastics that are rarely purchased by the scarp yards because of their low recyclability (<https://www.greenqueen.com.hk/global-waste-crisis-lets-talk-about-low-value-plastics/>)

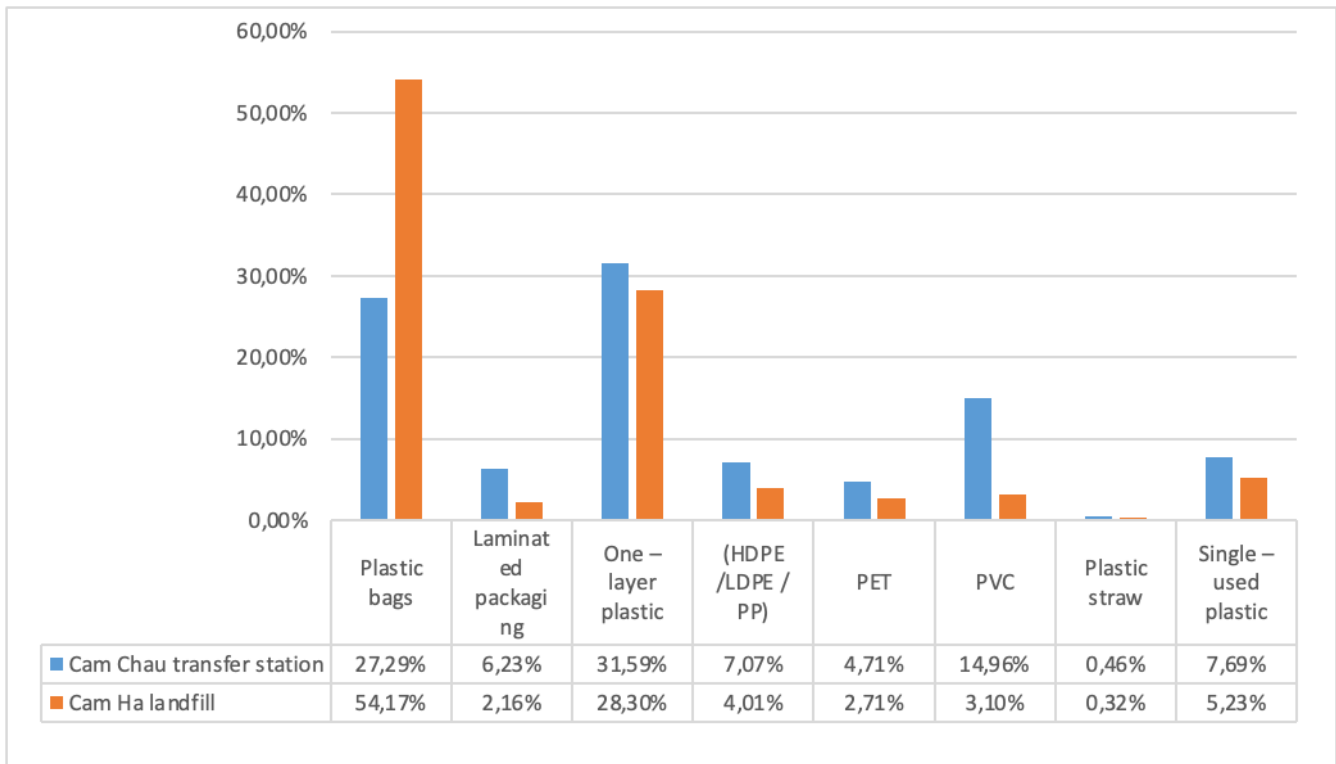


**Figure 9.** The percentage of MSW component generation at landfill.

The result audit shows that:

- Organic waste: represented simultaneously the highest percentage at both the Cam Ha landfill and Cam Chau transfer station, with 54.24% and 50.77%, respectively.

Plastic waste: ranked second in the list of the waste’s component generation, among them, there is different between the two dumps, with Cam Chau transfer station of 14.11% and Cam Ha landfill of 25.18 %. The plastic waste components are described in Figure 10.

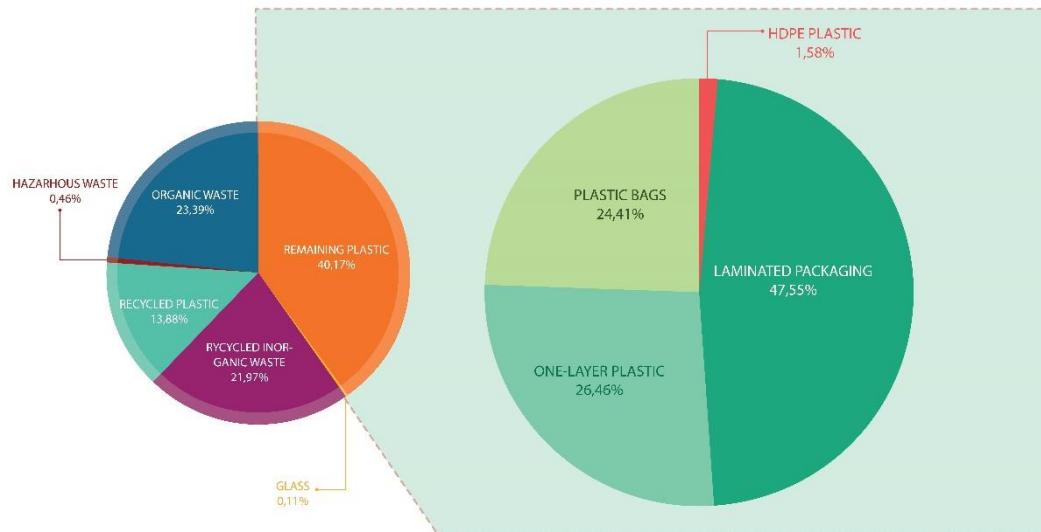


**Figure 10.** The plastic waste component in two dumps.

The analysed results show that the rate of recycled plastic waste still appears in two dumps, such as HDPE/LDPE/PP from boxes, bottles, jars of soap, cosmetics, and condiments, etc. PET mainly comes from types of waste such as plastic beverage bottles and the small amount of PVC comes from damaged home appliances (broken water pipes and wires). The data reflects the fact that the classification activities before collection have not been radically implemented.

### **5.3.MSW audit of agriculture – fishery activities**

The results of survey and in-depth interviews show that although agriculture-fisheries sectors doesn’t contribute substantially to the overall plastic waste volume of the city, they have high plastic leakage rate into the environment. The proportion of waste composition is presented as Figure 11.



**Figure 11.** Percentage of waste component from agriculture – fishery activities

The analysed results show that there are 6 main generated waste groups, including: organic waste (23.39%), types of recyclable plastic (13.38%), remaining types of plastic (40.17%), recyclable inorganic waste<sup>6</sup> (21.97%), hazardous waste (0.46%), and glass (0.11%). The generated volume of each group is as follows:

- Recyclable plastic waste (PET, HDPE, hard plastic in the form of bottles, plastic cans and agriculture - fishery gear), produced 24.33 kg per household per year
- The remaining plastic generated 70.41 kg/household/year, including PVC pipes, covering film, tarpaulins, plastic ropes, etc. Among them, multi – packaging plastic ranked the top, with 8.5 kg/household/year.
- The recyclable - inorganic waste: the average volume generation is 38.51 kg/household/year, mainly metal
- Hazardous waste: generated 0.81 kg per household per year. The main types of waste are bottles and pesticide packaging from agricultural activities. Notably, there was a considerable number of bottles uncollected and disposed directly into the environment though the local government arranged tanks to collect them.
- The survey result show that the rate of inorganic release into the environment is fairly high. For cultivation activities, 20 – 25% (equivalent to 46.778 tons/year) of waste is disposed on the farm (pesticide bottles and bottles, packaging of all kinds). For livestock activities, 35-40% (equivalent to 137.53 tons/year) of waste is thrown at livestock farms. Fishing activities disposed of 55 – 60% of waste at sea (equivalent to 0.69 tons/year), mainly plastic packaging and bottles containing fishermen’s necessities.

<sup>6</sup> Mostly metal



## 6. The brand audit results

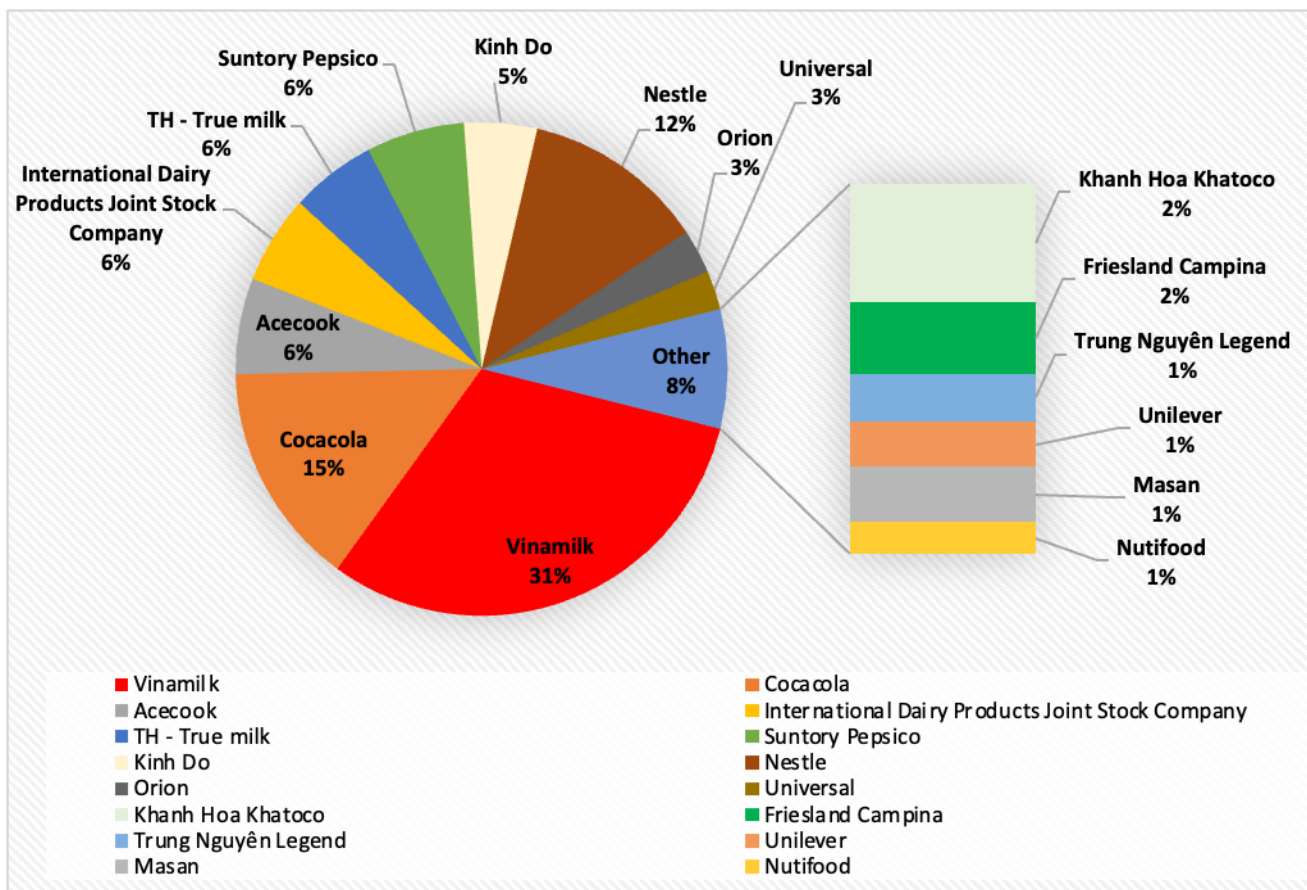
The brand assessment was carried out after waste auditing, which was classified following 3 groups, including: brands, manufacturers, materials. 1400 samples were audited and divided into 100 popular brands in Hoi An city, as Table 1 follows:

**Table 1.** The list of popular brands of object groups in Hoi An City.

Audit Object	Provider
15 households	Vinamilk, Unicharm, Khanh Hoa Khatoco, Vinataba, Sai Gon Ve Wong, Visalco, Masan, Suntory Pepsico, Acecook, Kinh Do, Asia Foods, Vinataba, Trung Nguyen Legend, My Hao, P&G, FrieslandCampina, Nestle, Unilever, Liwayway.
5 restaurants, hotels	Thai Binh Duong Trade Company Limited, Coca-Cola, Suntory Pepsico, Nestle, Heineken Vietnam Brewery, SABECO, Acecook, Vinamilk, Vikoda, Vissan, Orion Vina, Paldo Vina, CJ Food, Grand Universal Trading VN, Cholimex, Calofic
2 coffee shops	Vinamilk, Suntory Pepsico, Hung Phat Tea, Red Bull Gmbh, Vedan Vietnam, Khanh Hoa Khatoco, Vinataba, Vikoda, British American Tabaco, Nutifood, TH True Milk, Tan Tuong Khang Manufacturing-Trade Company Limited, Super Coffeemix VN, Trung Nguyen Legend, Phuong Nguyen Coffee, Ecological Products Joint Stock company.
5 convenience stores	Khanh Hoa Khatoco, Vinataba, Vinamilk, TH True Milk, Nestle, Suntory Pepsico, Coca-Cola, Acecook, Dan Gia Huy Manufacturing-Trade Company Limited, Bao Minh Candy, Liwayway, Lotte.
2 markets	Masan, Sai Gon Ve Wong, Visalco, Suntory Pepsico, Coca-Cola, Vinamilk, Trung Nguyen Legend, Vinataba, Khanh Hoa Khatoco.
7 schools	Vinamilk, Nestle, International Dairy Products Joint Stock Company, Oishi, TH True Milk, Friesland Campina VN, Nutifood, Cao Loi Hung Candy, Acecook, Southern One-One Food Joint Stock Company, Thien Ha Kameda, Kinh Do, Abbott Nutrition Vietnam, Orion, Nutricare, Hai Ha Confectionery JSC, Tan Hiep Phat Group, Huu Nghi Food, Friesland Campina, Universal Robina Corporation

Audit Object	Provider
	Vietnam, Anco Family Food, Perfetti Van Melle, Thien Long Group Joint Stock Company
4 administrative agencies	Suntory Pepsico, Coca-Cola, Khanh Hoa Khatoco, Vinataba, Plus Vietnam Industrial Co., Ltd
Cam Chau Transfer station	Vinamilk, Acecook, FrieslandCampina, Kinh Đô, Suntory Pepsico, Vinataba, Khanh Hoa Khatoco, TH True Milk, Uniben, International Dairy Products Joint Stock Company, Kimberly-Clark, Unicharm, Unilever, Coca-Cola.
Cam Ha Landfill	Uniben, Acecook, Mai Tu Hoanh Private Enterprise, Masan, Nestle, Suntory Pepsico, Unilever, Kameda, Vinamilk, TH True Milk, Trung Nguyen Legend, Heineken Vietnam Brewery, Red Bull GmbH, P&G, Masan, Friesland Campina, International Dairy Products Joint Stock Company.
Cultivated activities	Binh Dien Fertilizer Joint Stock Company, Trang Nong Trading Company Limited, Hoa Nong Trading Limited Company, Lion Agrevo Joint Stock Company
Livestock activities	De Heus Company Limited, Lai Thieu Feed Mill Co.,Ltd, Vietnam Veterinary Products Joint Stock Company
Fishing activities	Acecook, Red Bull GmbH, Khanh Hoa Khatoco, Tan Hung Phat Co.,Ltd
Aquaculture activities	Viet Hoa Aquatic Feed Joint - Venture Co., Ltd, Cargill Vietnam Co., Ltd, De Heus Company Limited, Bio-Pharmachemie Joint Venture Company, Sheng Long Bio - Tech International Co., Ltd

The percentage of 16 popular brands of audit objects in Hoi An City presented in Figure 12, as follow:

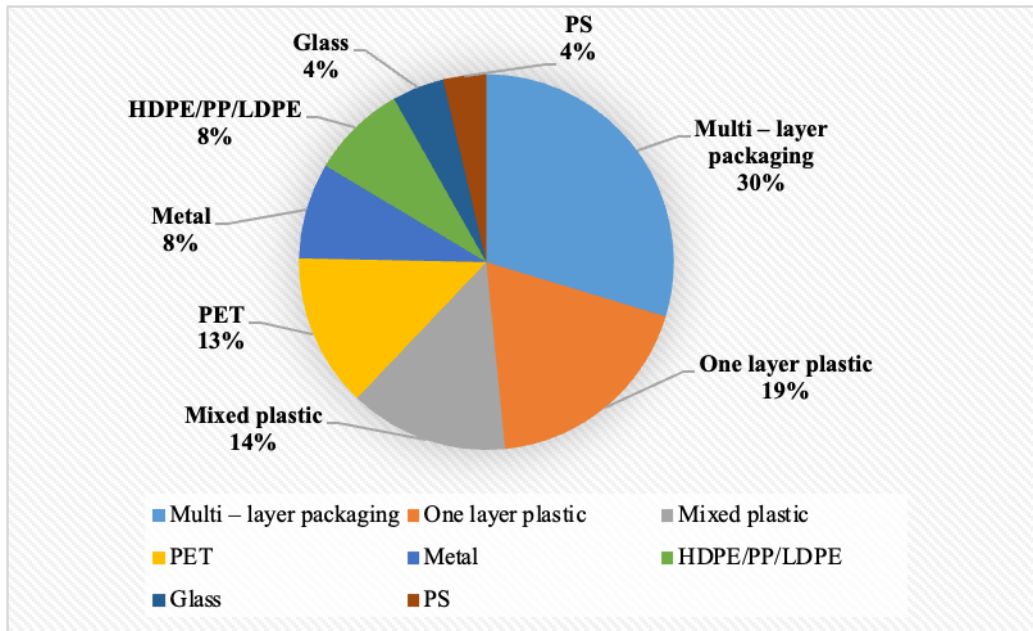


**Figure 12.** The proportion of 16 popular brands in the waste component in Hoi An City

It can be seen from Figure 12 that almost all brand groups are related to beverages, in which Vinamilk of 31% is at the on top of the list. Next, the other beverage brands include Coca - Cola (15%), Suntory Pepsico (6%), TH - True Milk (6%); and Nestle (12%), etc. Besides, dry food or snack foods have a variety of brands, including 4 popular brands, : Acecook (6%); Kinh Do (5%); Orion (3%), Masan (1%). In addition, tobacco products also contributed significantly to the total waste composition, such as Khanh Hoa Khatoco (2%). The materials of popular brands are mainly laminated packaging and single- used plastic, accounting for an average percentage of 49%. Firstly, multi-layer packaging<sup>7</sup> represented 30%, and one-layer plastic<sup>8</sup> accounted for 19%. These mainly came from daily necessities of life, food, fertilizer and seed packaging in agriculture – fishery activities. Mixed plastics had an average percentage of 14%, including: milk cartons, diapers, tampons, etc. PET accounted for 13%, which was key types of waste, such as beverage bottles and spice boxes. 8% of the metal came from the beverage cans. A small amount of material is HDPE/PP/LDPE, PS and glass (Figure 13).

<sup>7</sup> The packaging type is made up of many different materials. Depending on the purpose of use, it can be composed of many layers of plastic, or combined between plastic and other materials such as paper, metal, etc.

<sup>8</sup> One – layer packaging is a thin, clear plastic bag, which mainly made from one homogenous type of plastic.



**Figure 13.** The percentage of material brands by audit objects in Hoi An City (unit: %)

### 7. The result of the scrap waste investigation from informal collections:

17 scrap yards have been active in Hoi An city and 1 scrap yard has been active in the Cam Ha landfill with a total of 140 informal collectors. The survey results of scrap junk in Hoi An city and the Cam Ha landfill are represented in this section. The result of the questionnaire and the key informant interviews method on scrap procurement at the wrecking yard in Hoi An City is presented in Table 2, as follows:

**Table 2.** The volume of types of procured scrap waste at the wrecking yards in Hoi An City (unit: tons/year).

Scrap	Paper	Iron, Steel	Aluminum	Copper	Plastic <sup>9</sup>	Nylon	Net	Acquy	Plastic beer box
<b>Total (tons/year)</b>	719.05	664.3	209.87	11.09	337.63	3.65	16.42	25.55	2.19

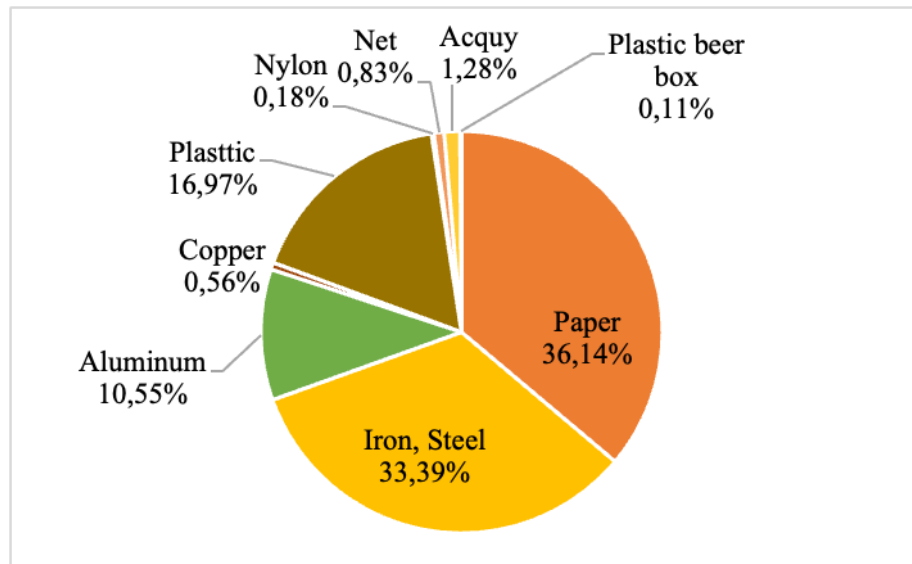
The scrap waste<sup>10</sup> after being sorted at sources was procured directly by the informal collectors (using the handcart, motorbike, and bicycle) or collected by formal collectors (Figure 17). The average volume of procured scraps was

<sup>9</sup> The procured plastic types are mainly PET, PP, and a small amount of HDPE and LDPE.

<sup>10</sup> Scrap waste: materials are recovered, classified, selected from materials and products that have been rejected from the production or consumption process. They are used as raw materials for another production process.

1,989.76 tons per year by the junk yards. Iron, steel, and paper were the most procured, accounting for 69.53% of the total amount of purchased scrap.

The net and nylon only represent 1.01% of the total amount of procured scrap because they have a low purchase price and have to be cleaned before procurement.



**Figure 14.** The proportion of purchase scraps at the wrecking yards in Hoi An City.

In addition to wrecking yards, MSW is also recycled through waste classification and scrap collection by informal collectors at the Cam Ha landfill. This activity was performed by the informal team at Cam Ha landfill. Table 3 describes the results of survey and interview activities on scrap collection at the landfill:

**Table 3.** The volume of material types collected for recycling at the Cam Ha Landfill (unit: tons/year)

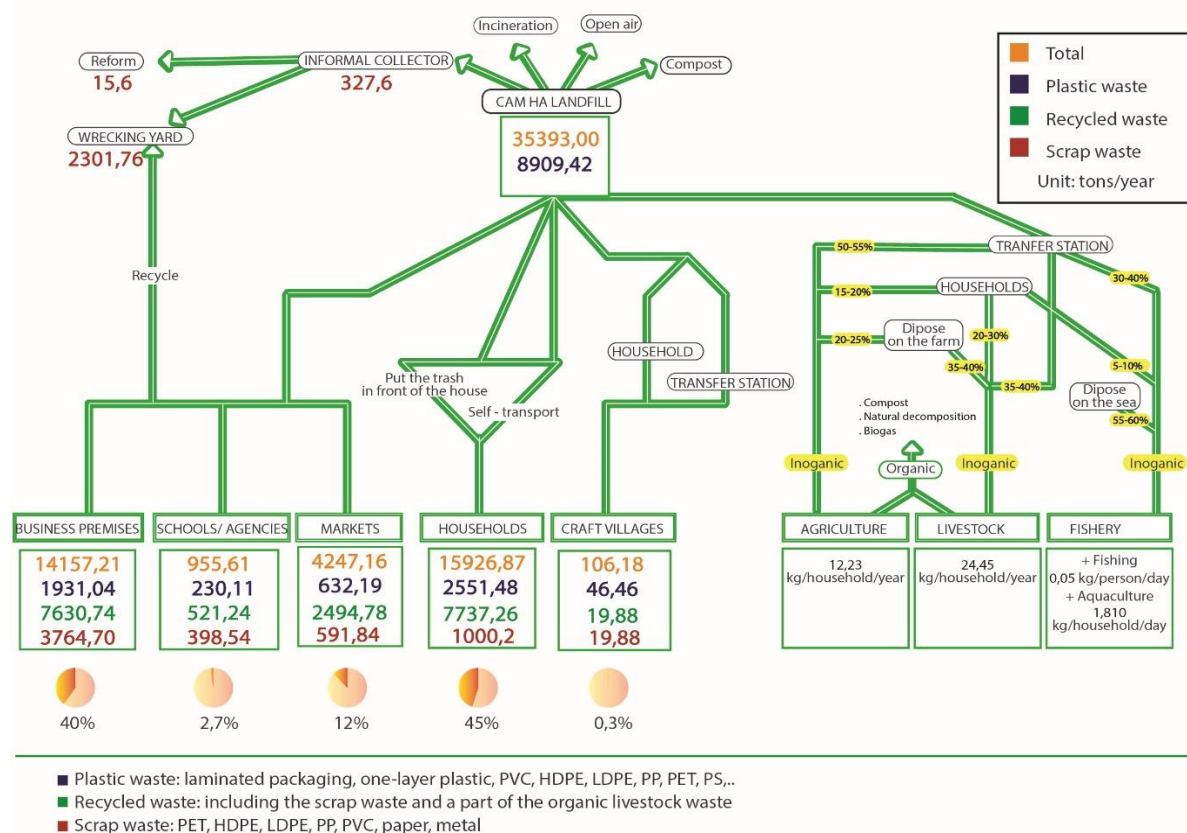
Scrap	Paper	Metal	Plastic	Nylon <sup>11</sup>	Cement bags
<b>Total (tons/year)</b>	24	144	48	15.6	96

<sup>11</sup> Although Nylon is also plastic, Nylon is categorized separately because the price of this scrap is low; Plastic safes or nets can also be categorized as plastic but the collectors still sort them separately for resale purpose (Plastic safes will sell in whole to the manufacturer; nets are also sorted separately since the collectors can take out the wire from the nets for resell)

The average volume of recycled waste was 327.6 tons per year from junk classification and collection at the Cam Ha landfill. Notably, the scrap yard in Cam Ha landfill is the only place that procures nylon and provides it to the Hoi An Reform organisation to recycle... The average volume of recycled MSW was 2,317.36 tons per year, accounting for 6.55% of total MSW volume in Hoi An City, in which an average volume of 519.49 tons per year represented 9.6% of total plastic waste in Hoi An City.

## 8. Material Flow Conceptual Framework

The analysed result of the material flow conceptual framework (shortened name - MFA) within Hoi An City is presented in Figure 15



**Figure 15.** Material Flow Conceptual Framework (MFA) in Hoi An City  
(unit: tons/year)

The average volume of recycled MSW was 2,317.36 tons per year, in which 2,301.76 tons is collected by junk yards and the remaining 15.6 tons is procured by the Reform organisation. Besides, the interview results from informal collector groups at landfill show that 327.6 tons of scrap waste is collected per year. In other words, a large amount of scraps are uncollected and the collector group is not able to separate and collect them completely.

It can be seen from Figure 15 that the total of plastic waste was 8,909.42 tons per year. 5,391.28 tons per year are derived from sources, including:



households, business premises, administrative agencies, and craft villages. The remaining difference could derive from agriculture – fishery activities, small business households, and some other activities that have not been audited, such as construction waste, sweeping street waste, and standard errors arise due to the small size of samples.

For agriculture – fishery activities, the result of an in – depth interview shows that the inorganic volume from fishery activities is the highest and is mainly disposed of the sea at a relatively high rate of 55-60% (0.69 tons/year). For the agriculture – aquaculture activities, the remaining waste is mostly discharged on the farm, with 20 – 25% of the inorganic agriculture waste (46.78 tons/year) and 35 – 40% of the inorganic livestock waste (137.53 tons/year).

## **9. Conclusion and Recommendation**

- The MSW generation increased by 1.28%, which was higher than the rate of growth in the population, at 1.04% between 2017 – 2019. In 2020, those decreased due to the impact of COVID – 19.

- There was no difference between the volume of biodegradable waste and non – biodegradable waste collection dates. The audit result shows that the waste classification performed ineffectively.

- The organic waste accounted for 66,77% of total MSW generation in Hoi An City (equivalent to 56 tons per day), of which 34.33% of livestock organic waste is used for composting to provide agriculture activity in Hoi An.

- The volume of recycled waste (including 66.03%. of the livestock organic waste; 2.59% of glass; 5.3% of PET; 5.8% of HDPE/LDPE/PP; 15.42% of paper; 2.78% of metal) was estimated at 18,403.9tons per year, accounting for 51.99% of total MSW generation. Those are huge waste sources if local government has an effective recycled method.

- The rate of inorganic waste leakage from agriculture – fishery activities was pretty high, including: (i) 20 – 25% (equal to 46.78 tons/year) disposed on the farms; 35 – 40% (equal to 137.53 tons/year) disposed on the livestock farms; (iii) 55 – 60% (equal to 0.69 tons/year) disposed on the sea. Therefore, it is necessary to have solutions to collect those solid wastes, especially plastic waste leakage to natural environment.

- Households and business premises are the key object groups that produced MSW in Hoi An City, accounting for 85% of MSW generated the city. Those groups generated mostly plastic, organic and recycled waste. However, the waste classification at the source of the two subjects has not been thoroughly implemented. The specialised researches were conducted to assess the current status of waste generation for two object groups.

- Schools, agencies produce an average of 232.98 tons of plastic waste per year and 14.14 tons of Styrofoam per year. Thus, the classification



activities could be performed in the school and strengthen green consumption, reducing the use of nylon bags, Styrofoam and single-use plastic waste.

- The total of recycled waste from informal collection<sup>12</sup> was estimated at 2,317.36 tons per year, accounting for 6.55% of total MSW, 16.27% of total recycled waste, and 62.46% of total scrap waste generation in Hoi An City<sup>13</sup>. The purchase of scrap activities accounts for 85.7% in urban areas and represents 14.3% at the Cam Ha landfill.

- The audit results within 7 days (biodegrade waste and non – biodegrade waste collection dates) and the provided data by URENCO show that there was no difference between the volume of biodegrade waste and non – biodegrade waste collection dates. In other words, the waste classification has not yet been implemented comprehensively and synchronously.

- The brand audit results show that plastic represents 88%, metal (8%), and glass (4%). Notably, laminated packaging and one – layer plastic accounted for the highest percentage of total plastic material.

- The popular brands are consumed significantly, including: Vinamilk (31%), Coca-Cola (15%), Acecook (6%), Pepsico (6%), TH True Milk (6%), Nestle (12%), Khanh Hoa Khatoco (2%).

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<sup>12</sup> Mainly paper, metal, plastic, cement bags, etc. (Table 4)

<sup>13</sup> The recycled waste only reached 16,27%, of which, the scrap waste (including iron, steel, high – value plastics, paper, etc.) represented 62,46%. The recycled waste of 16,27% is quite small when compared with potential sorting waste at source due to a large amount of organic waste not use for composting. Additionally, low – value plastic groups, such as nylon, single – use plastic, packaging, etc. have not been recycled (except for the Cam Ha landfill and Reform project, but the data is unstable and in the pilot period. For uncollected scrap types, 38% of the high – value waste group could be collected and recycled completely.

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Appendix 1

Brand audit form

<b>WASTE ASSESSMENT AND BRAND AUDIT</b>					
<i>BRAND AUDIT FORM</i>					
<b>Site:</b>					
<b>Date:</b>					
<b>Product</b>	<b>Variant, size</b>	<b>Materials</b>	<b>Manufacturer</b>	<b>No. of pieces</b>	<b>Total</b>

## Appendix 2

**Table 4.** The total volume of MSW generation of object groups within Hoi An City in 2020.

	Volume	Rate (%)
<b>Households</b>	15,926.85	45%
<b>Business premises</b>	14,157.20	40%
<b>School, Agency</b>	955.61	2.7%
<b>Market</b>	4,247.16	12%
<b>Craft village</b>	106,18	0.3%

**Table 5.** The average volume of MSW generation of object groups within Hoi An City in 2020. (unit: tons/year)

<b>Municipal Solid Waste</b>	<b>Household</b>	<b>Business premise</b>	<b>School, Agency</b>	<b>Market</b>	<b>Craft village</b>	<b>Total (tons/year)</b>
Plastic waste (tons/year)	2,551.48	1,922.39	232.98	632.19	46.46	5,385.50
Plastic waste (%)	47.38	35.70	4.33	11.74	0.86	100.00
Organic livestock (tons/year)	6,646.27	3,551.54	90.45	1,863.87	0.00	12,152.13
Organic livestock (%)	54.69	29.23	0.74	15.34	0.00	100.00
Remaining organic waste (tons/year)	4,668.16	5,308.91	255.96	1,222.97	25.06	11,481.05
Remaining organic waste (%)	40.66	46.24	2.23	10.65	0.22	100.00
Paper (tons/year)	340.83	2,168.07	207.65	121.89	0.00	2,838.45
Paper (%)	12.01	76.38	7.32	4.29	0.00	100.00
Textile (tons/year)	737.41	163.82	20.74	86.22	8.02	1,016.20
Textile (%)	72.57	16.12	2.04	8.48	0.79	100.00

Styrofoam (tons/year)	277.13	368.22	14.14	240.18	0.00	899.67
Styrofoam (%)	30.80	40.93	1.57	26.70	0.00	100.00
Metal (tons/year)	339.24	133.24	14.81	7.86	15.57	510.72
Metal (%)	66.42	26.09	2.90	1.54	3.05	100.00
Glass (tons/year)	90.78	314.50	32.25	39.07	0.00	476.60
Glass (%)	19.05	65.99	6.77	8.20	0.00	100.00
Other inorganic waste (tons/year)	202.27	198.20	79.27	30.15	11.07	520.97
Other inorganic waste (%)	38.83	38.04	15.22	5.79	2.13	100.00
Hazardous waste (tons/year)	73.26	27.37	7.45	3.61	0.00	111.70
Hazardous waste (%)	65.59	24.50	6.67	3.23	0.00	100.00



**Table 6.** Plastic component audit in Hoi An City (g/day)

	Household	Restaurant/ Hotel	School	Agency	Market	Convenience store	Coffee shop	Craft village
Plastic bags	114.55	1,801.00	479.99	55.02	6,550.00	184.00	1,044.14	28.82
Laminated packaging	14.68	958.97	502.74	9.25	1,800.00	49.80	173.36	19.18
One – layer plastic	15.81	1,713.30	609.01	36.07	3,405.00	294.52	421.43	0.00
(HDPE /LDPE / PP)	8.36	546.33	190.15	19.65	1,046.43	32.00	73.00	5.79
PET	4.57	579.60	403.19	9.78	187.86	50.89	60.65	0.00
PVC	10.86	0.00	2.93	1.36	385.72	0.77	79.29	0.94
Plastic straw	0.22	0.500	90.69	1.43	105.72	1.54	227.36	0.00
Single – used plastic	18.53	0.00	397.94	27.05	1,403.57	79.34	368.43	0.00

**Table 7.** The volume of generated waste in Cam Chau transfer station and Cam Ha landfill (unit: g/day)

	Cam Chau transfer station	Cam Ha landfill
Plastic waste	10,311.43	25,165.72
Paper/ carton	4,041.43	5,868.57
Organic livestock	11,902.14	13,118.57
Remaining organic waste	27,745.72	37,620
Textile	6,907.14	11,780
Styrofoam	900	1,012.86
Metal/Can	1,602.57	1,054.29

<b>Glass</b>	1,671.43	1,192.86
<b>Other inorganic waste</b>	7,514.29	2,267.14
<b>Hazard</b>	500	862.86
<b>Total</b>	<b>73,096.15</b>	<b>99,942.87</b>

**Table 8.** The volume of generated plastic in Cam Chau transfer station and Cam Ha landfill (unit: g/day)

	<b>Cam Chau transfer station</b>	<b>Cam Ha landfill</b>
<b>Plastic bags</b>	2,814.29	13,632.86
<b>Laminated packaging</b>	642.86	542.86
<b>One – layer plastic</b>	3,257.14	7,121.43
<b>(HDPE /LDPE / PP)</b>	728.57	1,008.57
<b>PET</b>	485.71	682.86
<b>PVC</b>	1,542.86	780
<b>Plastic straw</b>	47.14	81.43
<b>Single – used plastic</b>	792.86	1,315.71
<b>Total</b>	<b>10,311.43</b>	<b>25,165.72</b>

**Table 9.** The volume of generated waste from agriculture – fishery activity (unit: kg/household/year)

	<b>Cultivation</b>	<b>Livestock</b>	<b>Aquaculture</b>	<b>Fishing</b>	<b>The average volume</b>	<b>Rate (%)</b>
<b>Plastic bags</b>	0.3	0.16	17	0	4.365	9.96%
<b>One layer packaging</b>	6.2	6.63	5.3	0.8	4.7325	10.80%
<b>Multi - layer packaging</b>	1.72	12.01	19.54	0.75	8.505	19.41%
<b>HDPE</b>	0	0	0.6	0.53	0.2825	0.64%

<b>PET</b>	0	0	23.2	0	5.8	13.24%
<b>Metal</b>	3.2	6.4	28.2	0.71	9.6275	21.97%
<b>Glass</b>	0	0.19	0	0.01	0.05	0.11%
<b>Paper</b>	0	0	38.8	0	9.7	22.14%
<b>Organic</b>	0	0	2.2	0	0.55	1.26%
<b>Hazardous waste</b>	0.81	0	0	0	0.2025	0.46%

**Table 10.** The percentage of popular brands in the MSW composition in Hoi An City

<b>Brand</b>	<b>Frequency of appearance</b>	<b>Rate</b>
Vinamilk	1810	31%
Cocacola	855	15%
Acecook	367	6%
International Dairy Products Joint Stock Company	338	6%
TH - True milk	328	6%
Suntory Pepsico	377	6%
Kinh Do	279	5%
Nestle	700	12%
Orion	168	3%
Universal	149	3%
Khanh Hoa Khatoco	145	2%
FrieslandCampina	89	2%
Trung Nguyen Legend	58	1%

Unilever	56	1%
Masan	68	1%
Nutifood	39	1%

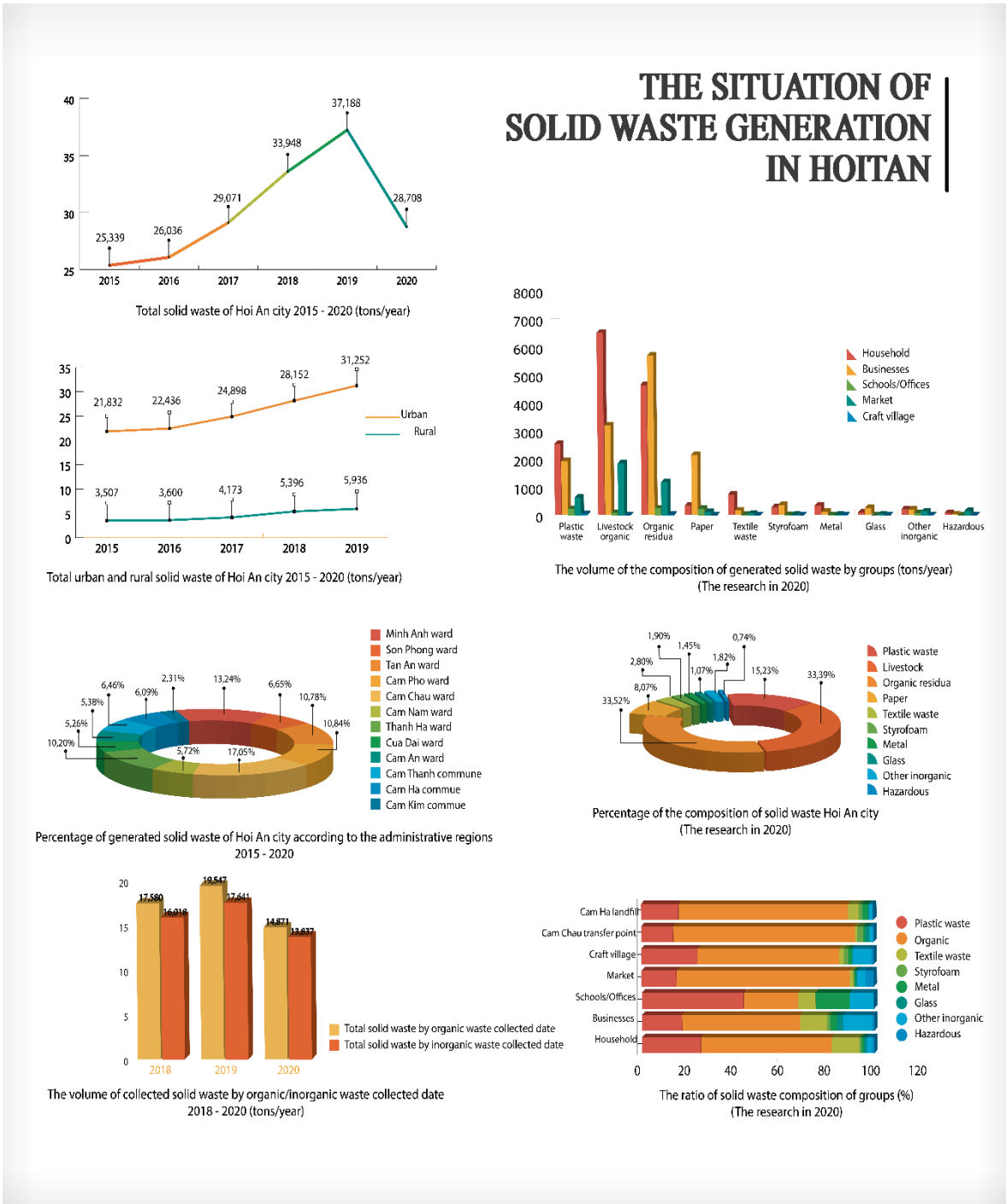
**Table 11.** The composition of brand materials within Hoi An City (unit: %)

<b>Material</b>	<b>Frequency of appearance</b>	<b>Rate</b>
<b>Laminated Packaging</b>	582	30%
<b>1 layer plastic</b>	367	19%
<b>Mixed plastic</b>	269	14%
<b>PET plastic</b>	259	13%
<b>Metal</b>	162	8%
<b>HDPE/PP/LDPE</b>	161	8%
<b>Glass</b>	88	4%
<b>PS plastic</b>	73	4%

**Table 12.** Description and use of plastic types

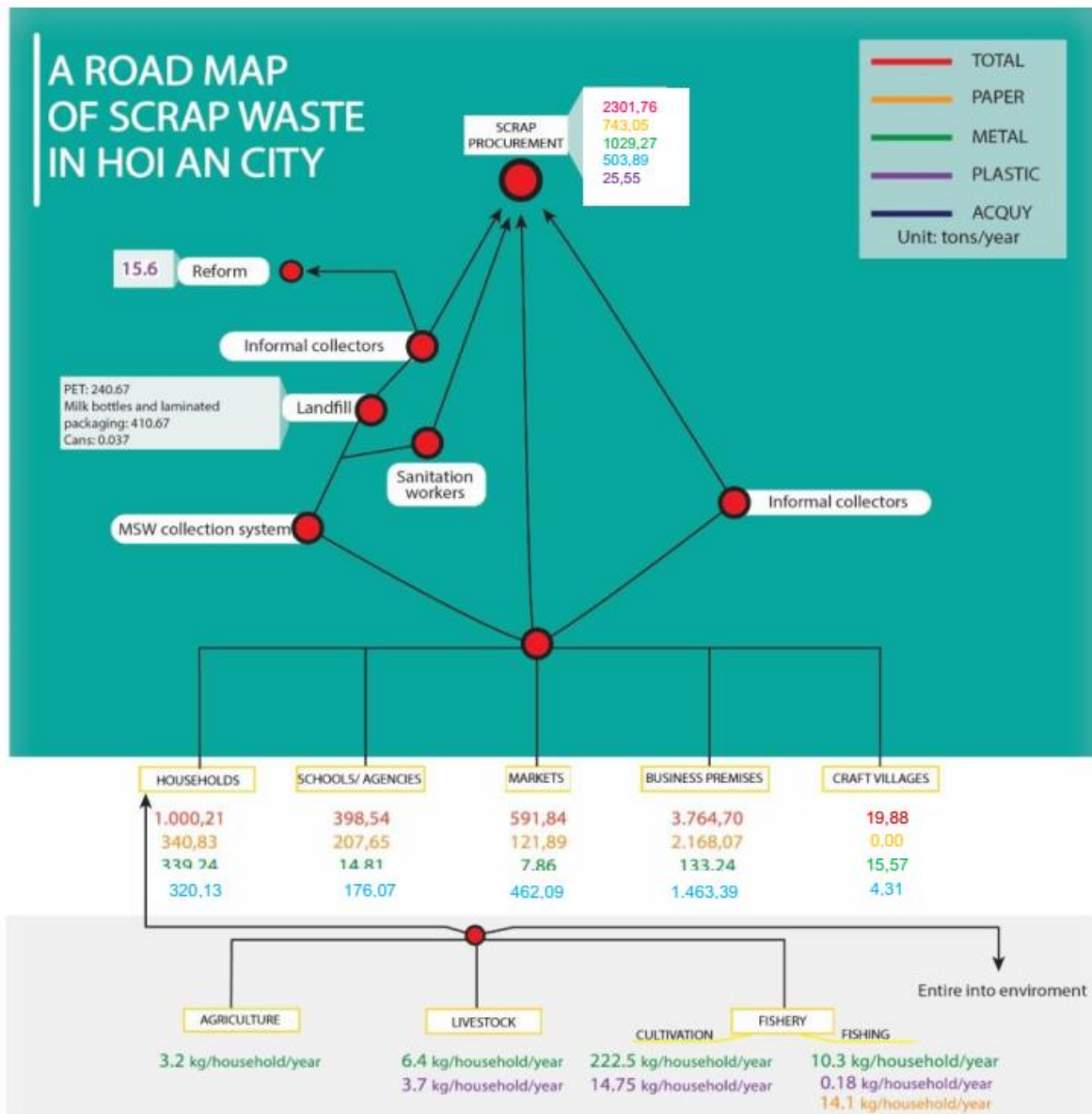
<b>Types of plastic</b>	<b>Description</b>	<b>Use</b>
<b>Plastic bag</b>	Thin, light and flexible glossy bags with rotating carry	Used to store, package. Used extensively due to low cost and convenience
<b>Laminated Packaging</b>	Packaging type is made up of many different materials such as paper, aluminum, plastic. Each material layer has different properties and functions such as paper, metal,...	Often used in the food industry. Types of packaging for confectionery, instant noodles, rice, chemical cosmetics

<b>1 layer plastic</b>	This package is thin, clear, using the same type of plastic	Often used to store and package food.
<b>Single Use Plastic</b>	Products are made of PET, PS or PP plastic for one-time use	Keeps food, water, spoon products, plastic cups and plates
<b>HDPE plastic</b>	HDPE: High Density Poly Ethylene is a plastic with high durability, good heat resistance, and less corrosion	Used as household utensils, bottles, bottles for cleaning products, children's toys, water pipes
<b>LDPE plastic</b>	LDPE: Low Density Poly Ethylene is a thermoplastic, lightweight, corrosion resistant	Used as containers, plastic bags, food storage boxes, medical equipment
<b>PP plastic</b>	PP: Colorless, transparent, heat-resistant polypropylene	Used as food storage boxes, car accessories, bottles, toys
<b>PS plastic</b>	PS: Polystyrene is a thermoplastic resin	Using children's toys, components, plastic cups, plastic trays, packaging materials, disposable plastic
<b>PET plastic</b>	PolyEthylene Terephthalate is highly durable, transparent	Types of beverage bottles, food containers, some chemical cosmetics
<b>PVC resin</b>	Polyvinyl chloride is a good insulating resin	Used as plumbing, packaging materials, packaging, food wrap, interior equipment



**Figure 16.** The current status of MSW generation in Hoi An City

(Source: Hoi An URENCO)



**Figure 17.** A road map of scrap waste in Hoi An City



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