OKAYAMA UNIVERSITY

GRADUATE SCHOOL OF ENVIRONMENTAL AND LIFE SCIENCE

DOCTOR DISSERTATION

Solid Waste Management Practice-Oriented Planning for Tourism Industry towards Sustainability – A Case Study in Hoi An City, Vietnam

持続可能性を目指した観光産業の廃棄物マネジメント実践指向の計画－ベトナム・ホイアン市のケーススタディ

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and co-supervised by
Professor KATSUYA KAWAMOTO
and
Associate Professor YASUHIRO MATSUI

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Abstract

Worldwide, tourism has firmly developed to become one of the most dynamic industries. Undoubtedly, tourism brings many benefits to society regarding the economy, employment, and social welfare. However, the dark side of tourism development is the negative impacts on the environment, in which solid waste management (SWM) is one of the significant impacts. In Vietnam, Hoi An City (HAC), a small town in the centre, is known as a typical tourist city by the world cultural heritage values. During the last decade, the rapid development of the tourism industry in HAC has led to the significant increase of municipal solid waste amount and caused several urgent problems to the municipal SWM system. The overload of waste in the downtown, the disruption of the waste collection system, and the non-performance of treatment plants may be caused by the inefficiency of SWM practice at source. Therefore, the development of SWM practice is urgent and necessary in HAC. However, improving SWM practice in a minimalist direction that is usually applied in developing countries, or it should be planned according to the model that developed countries are implementing? In fact, there may be many gaps from planning projects to actual implementation. The feasibility of a planning project in SWM practice depends on many factors, in which the compatibility of the project with the actual conditions is essential. Therefore, the SWM practice scenarios in this study are planned based on four main factors, namely social acceptance, compatibility with the regional availability, economic optimisation, and emission mitigation. Also, the aim of this study is oriented planning in SWM practice for the tourism industry in HAC aims to reduce the current waste problems and contribute to improving municipal SWM system toward sustainability.

The studying process consists of fours main steps such as planning, sampling, analysis and modelling. First of all, the waste sources from the tourism industry were encrypted by groups and randomly selected for sampling. The sampling rate ranges from 10 to 25% of the sample population. Whereby, solid waste from 120 hotels, 55 restaurants, 110 shops, 27 handicraft production facility (HPF), five markets, waste from bins and street in the TA was collected in seven consecutive days in December 2016. The amount of waste was

measured by weighting by handi-scales. Also, the composition of waste was identified with 18 categories. The characterisation of samples was analysed at the laboratory of Okayama University after drying. Whereas, the feature of the tourism sectors and the information of SWM practice were collected by questionnaire survey. Data from the survey was statistically processed to assess the status and analyse the problems of the SWM system in the tourism industry.

The SWM practice models of the tourism industry in HAC were built, simulated and optimised aims to resolve the problems, reduce the challenges and bring the sustainable values to SWM system for the tourism industry. Analysis hierarchy process (AHP) was to assess the priority of multiple alternatives under different valuation criteria. Material flow analysis (MFA) was used to describe the flow of waste from generation to the disposal, also provide a systems-oriented view and support the priority-oriented decisions regarding waste management in the tourism industry in HAC. The models of SWM practice for accommodation, a TA and the whole of the tourism industry were built based on (i) the feature of commercial tourism sectors, (ii) the current status of the waste management system of each objective, (iii) the current, intentional and optimal practice rate of SWM practices, and (iv) ability of enhancing the waste collection system. These models of SWM practice were analysed and optimised based on seven main factors, namely (1) the consensus of stakeholders, (2) waste generation reduction, (3) waste recycling practice development, (4) the favourability of waste to treatment, (5) compatibility with the regional availability, (6) optimisation of economic, and (7) emission mitigation. Lastly, strategy-oriented planning of SWP practice for the tourism industry was analysed to choose the appropriate direction for SWM practice – the minimalism or enhancement towards sustainability. The core value that the sustainable SWM practice in the tourism industry is approaching is the balance in the integrated enhancement of economic affordability– environmental effectiveness – social acceptance.

This study indicates some findings:

Firstly, the status of the SWM system in the tourism industry is presented. Notably, the daily solid waste generation rate (SWGR) of each commercial sector is identified by 2.28 $kg.guest^{-1}$ for the hotels, 1.27 $kg.bill^{-1}$ for restaurants, 0.86 $kg.shop^{-1}$, 0.28 $kg.product^{-1}$ for HPF, 1.15$kg.stall^{-1}$ for markets, 0.066 $kg.tourist^{-1}$, and 1.68 kg per 100m of street. The differences in SWGR by the scale of hotels, the location of the restaurant and types of the market are statically significant. In term of tourist waste composition, organic waste accounts a significant proportion by around 60%, also the rate of recyclable materials ranges from 15 to 20%. The high rate of organic waste may cause high moisture (50% - 60%) and low calories value (HHV: 12 MJ/kg) of tourist waste. Furthermore, this study reveals that the rate of SWM practices that consists of separation at source, recycling practice and composting practice in the tourism industry is low. Many objective conditions (such as the lack of information, knowledge, guidance and support from the government) and subjective factors (such as the unnecessary for small waste generation, the disapproval because of odour, the disinterest due to the meaninglessness) are justified for the inefficiency of SWM practices. Consequently, the overload of waste in a TA, the disruption of waste collection in the downtown, the financial loss in the SWM system, and the non-performance of waste treatment plants are the urgent problems of SWM system in a tourism destination. Also, reducing these problems in the balance between social acceptance, environmental mitigation and optimal economic is the significant challenges of the tourism SWM system.

Additionally, the optimal models of the SWM practice are the findings of this study that may reduce the above problems and contribute to establishing oriented planning in sustainable SWM system for the tourism industry. Notably, the accommodation business (AB) that is one of the essential business activities of the tourism industry daily generates about 16.5 tons of solid waste (accounted for 35% of the total tourism waste). An optimal model of SWM practice for the AB shows that improving SWM practice at source by the intention rate toward the optimal rate may significantly enhance the recovery performance, reduce from 30 – 70% of waste generation, and bring a positive financial benefit for the hoteliers. Likewise, an appropriate model of integrated SWM system for the TA in the centre of the city is simulated. This model plans to enhance SWM practice at source, upgrade the quality of collection service corresponding to the actual demand of stakeholders, and the regional conditions in the TA. The highlight of this model is the solution to the SWM system's problem in the TA based on the integration between social consensus and governmental direction, the balance between the demand of stakeholders and the possible response of the SWM system.

Finally, the model of developing SWM practice for the tourism industry in a sustainable orientation (SOM) is simulated and proved to be more appropriate than the minimalist orientation model (MOM). The compatibility and suitability are analysed in the efficiency that these models bring.

(i) SOM model is more effective in minimising waste generation at source and enhancing recovery performance for recycling. Notably, the SOM model is estimated to reduce 12.3% and 26.3% of SWG in the first and the next five years of the project, respectively. Also, the recovery performance of recyclables gradually increases from 1.1 tons to 7.0 tons and 13.5 tons.

(ii) SOM model significantly contributes to improving waste characterisation in accordance with current treatment processes, meanwhile, the mixed waste in the MOM model causes obstacles.

(iii) SOM model is estimated and forecasted to emit less greenhouse gas (from 336 to 307 kg CO_{2-eq} per ton of treated waste) than that of MOM model (from 547 to 536 kg CO_{2-eq} per ton of treated waste).

(iv) The net economic benefit of MOM and SOM projects are positive. Whereby, return on investment is estimated in the first year of the project, and the positive net interest is estimated at approximately 3.3 and 2.8 times higher than that of the current SWM system, respectively.

According to the positive performance in waste management, social consensus, emission mitigation and economic optimisation, the SOM model of integrated SWM practice for the tourism industry is the optimal development model in accordance with the current situation of the SWM system in HAC towards sustainability.

Keywords: *Solid waste management, solid waste planning, tourism waste management practice, waste management in Vietnam, optimisation of waste management practice, sustainable solid waste management, waste management system of the tourism industry.*

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Abbreviation

AB	: Accommodation business
AHP	: Analytic hierarchy process
AP	: Application of sanction
BAU	: Business as usual
CBA	: Cost-benefit analysis
CBR	: Cost-benefit ratio
CG	: Co-ordination of the government
CH	: Consensus of hotels
CI	: Consistency index
CP	: Composting practice
CR	: Consistency ratio
DFR	: Development of a facility for recycling
DNC	: Danang city
EBO	: Economic benefit optimisation
EIM	: Environmental impact mitigation
ERS	: Economic benefit for recycling sectors
ES	: Economic benefit of society
ESH	: Economic benefit of hotels
GHG	: Greenhouse gas
HAC	: Hoi An City
HLC	: Ha Long City
HOM	: Homestays
HPF	: Handicraft production facility
HSH	: High-scale hotels
IE	: Intensification of Encouragement
LHV	: Low heating value
LSH	: Low-scale hotels
MFA	: Material flow analysis

MSH	: Midle-scale hotels
NDC	: New Delhi City
NGO	: Non-government organisation
PET	: Polyethylene terephthalate
PH	: Public health
PP	: Policy promulgation
PPC	: Phnom Penh City
PR	: Promulgation of regulation
RFC	: Recycling facility of the city
RFH	: Recycling facility of hotels
RP	: Recycling practice
RPE	: Recycling practice enhancement
RSC	: Recycling system of the city
SCI	: Social consensus improvement
SoN	: Support of NGOs
SP	: Separation practice
SSWM	: Sustainable solid waste management
SWC	: Solid waste composition
SWE	: Waste separation efficiency
SWG	: Solid waste generation
SWG	: Solid waste geeneration
SWGR	: Solid waste geeneration rate
SWM	: Solid waste management
TA	: Tourism area
TC	: Transfer coefficient
TCA	: Tourism commerical activities
TI	: Tourism industry
VIL	: Villas
WMP	: Waste management practice

Chapter 1
Introduction

1.1. Literature review

Recently, tourism, the smokeless industry, is one of the most dynamic industries all over the world *(Shamshiry et al., 2011)*. In developing countries, tourism is becoming a vital financial sector of the national economy. Undeniably, tourism brings many benefits to society regarding the economy, employment, and social welfare. Nevertheless, the dark side of tourism development is the negative impacts on the environment, in which the increase of solid waste generation (SWG) is the most apparent evidence *(Sharma 2016)*. Mateu-Sbert et al. (2013) reported that the number of tourist arrival in Menorca island (Spain) increases on average 1% causes an overall growth of the municipal solid waste (MSW) by 0.282%. In Malaysia, the solid waste amount generated from a tourist was estimated to be double more than that from per capita *(Shamshiry et al. 2011)*. This was a substantial challenge of SWM (SWM) in tourism destinations not only in Malaysia but also in developing countries.

The commonly commercial activities in the tourism industry are lodging, dining, shopping, and travelling. Also, solid waste is generated mainly from accommodations, restaurants, shops, markets, production facilities, and tourism destinations. While in the developed countries the tourism SWM system functions well and is sustainable, the developing countries are struggling to find suitable solutions to manage solid waste. Notably, the establishment and gradual implementation of sustainable SWM (SSWM) framework to the hotels in developed countries spent a long time with different features. Before 2000, reducing waste in the hospitality industry was noticed as an urgent need in some European cities where the tourism commerce firstly boomed in the world. Thus, the global frame of waste minimisation was established to support the hotels in approaching SSWM *(Cummings, 1992)*. However, the limited awareness about the benefits of improving SWM of the hoteliers and application of environmental regulations to the hospitality sectors were significant obstacles of the government at that time *(Kirk, 1995)*.

Until the first years of the 21st century, the perception of SSWM by the hoteliers was more positive, especially in chain-affiliated hotels *(Bohdanowicz, 2005)*. However, in fact, from attitude to action in SSWM practice of the hotel industry was still a gap *(Graci and Dodds, 2008)*. Therefore, finding out barriers that hindered SWM practices had been paying attention to. The tourism SWM in the developed countries so far has been improving towards a comprehensive and integrated SWM system with the interconnection between society, environment and economy *(Ezeah et al., 2015)*. In developing countries, on the other hand, SWM of the hospitality industry now is still a big problem. For example, in India, the lack of facilities, skills, methods, and regulation of SWM led to the poor of the SWM system of hotels and municipality *(Omidiani and S. Mohsen, 2016)*. Also, small hotels have not paid intention to SWM practice because of lack of funds and knowledge *(Malik and Kumar, 2012)*. A study on SWM practice of five-star hotels in Cairo, Egypt indicated that, although these hotels sorted waste at source successfully, reduce, reuse and recycle practices were not effective *(Ball and Taleb, 2011)*. Likewise, the SWM system of Vietnam is struggling to find a sustainable framework for accommodation business under pressure from the quick development of the tourism industry. Few studies only identified about waste audit and composition of the hotels *(Byer et al., 2006; Otoma et al., 2013; Trung and Kumar, 2005)*, whereas the situation of hotel SWM practice and its roles in municipal SWM have not mentioned yet.

Whereas, the tourism area welcomes a significant number of arrivals every day for shopping, visiting and entertainment. Also, a substantial amount of solid waste generation may cause the problems of the SWM and challenges faced by the government *(Sharma 2016)*. *Ezeah et al. (2015)* showed that the SWM system in the European TAs was constrained by many barriers, namely, limited infrastructure, population growth, and high amounts and variations of waste. Whereas in developing countries, a high tourism growth rate of 5.15% per year in TA has led to several challenges. As such, the landfill site overload on Green Island in Taiwan has become a severe problem. Transportation of waste to other places has also implored urgent and costly solution *(Chen et al. 2005)*. Similarly, other studies revealed that the increasing rate of waste has significant effects on the inefficient and unsustainable SWM system in the TA in Malaysia and Ukraine *(Murava and Korobeinykova 2016)*.

In brief, tourism waste is increasing in proportional to the rapid development of the tourism industry all over the world. In developing countries, while municipal SWM system is still sketchy, maximisation in waste collected for landfilling is the primary goal of the municipal SWM system to reduce pollutions. Especially in the tourism city, the significant amount of waste generated from tourism activities is the burden of the municipal SWM system; also the SWM in tourism area is significant challenges faced by the government. Thus, the development of the SWM system of the TI is necessary to establish an eco-tourism industry and contribute to reducing the burden of municipal SWM system. As the above mentions, the tourism SWM system is a part of the municipal SWM system. Therefore, the development of the SWM system in the TI should be based on the current status of municipal SWM system, the feature of the TI in implement SWM practice, the consensus of business sectors and society and the agreement of the government. Also, the sustainability in SWM, which should be considered in strategy-oriented planning is defined as the appropriation and compatibility of the SWM model with the region aim to reach the synchronous achievement of the environment – economic – society.

1.2. Research objectives

1.2.1. Overview of Hoi An City and the tourism industry

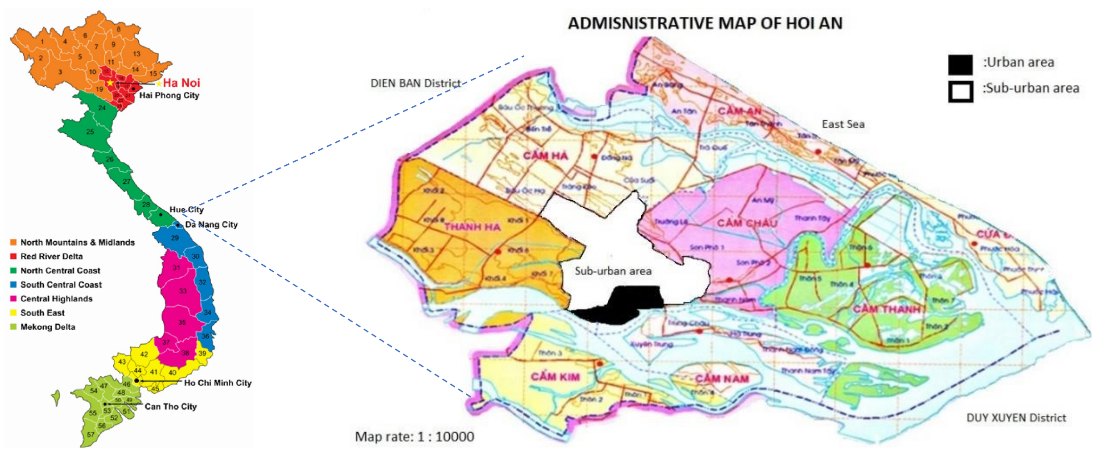


Figure 1.1. Location of Hoi An City in Vietnam

HAC has 13 administrative communes and wards with three regions such as ar urban, suburban and rural areas corresponding to the average population density by 8987, 2754 and 601 people/km^2, respectively. Hoi An was famous as an international trading port in the early 17th century, along with a complex of Chinese and Japanese architectural buildings. Thus, in 1998, HAC was recognised as a world cultural heritage by UNESCO.

Since then, HAC is known more worldwide, and the TI in HAC has been developing rapidly and become a key economic sector of the city.

The number of tourist come to Hoi An City in recent years

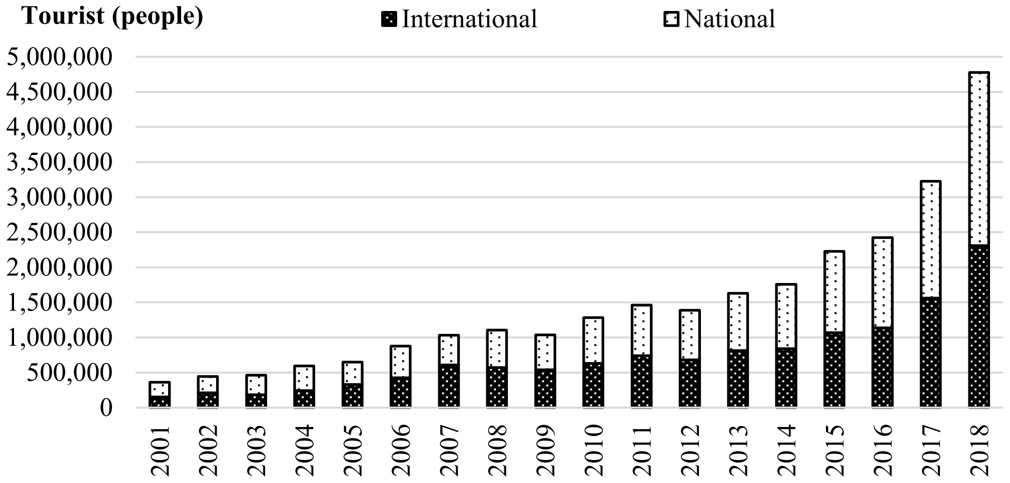


Figure 1.2. The growth of arrivals in HAC

During the last decade, the TI in HAC rapidly developed with the significant growth rate of arrivals. *Figure 1.2.* shows that the number of arrivals comes to HAC gradually climb in the first 10 years of the 21st century with the annual growth rate by 110%. Also, in the next 10 years, the annual growth rate of tourist increases quickly from 110% to 150% and reach 4,774,521 tourists in 2018. The growth of tourist number may lead to the speedy development of commercial business.

The development of accommodation business in the last decade

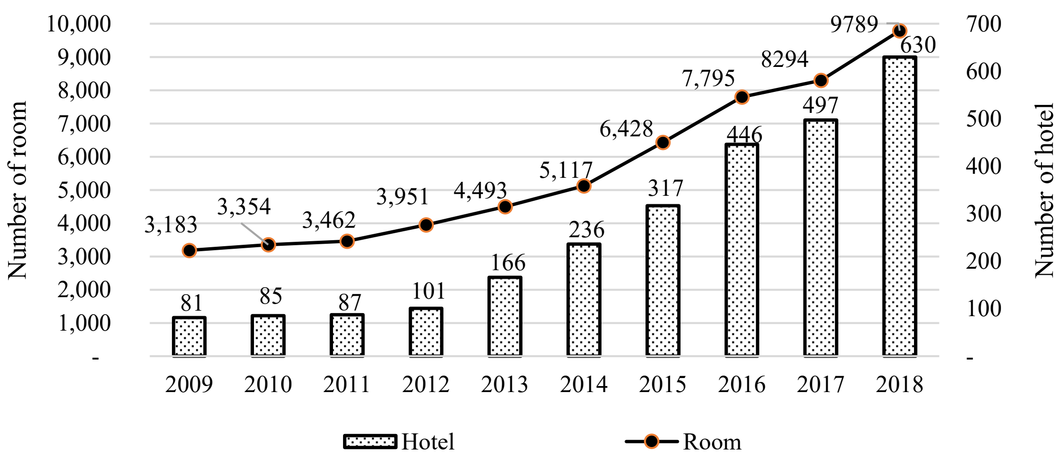


Figure 1.3. The development of the accommodation business in HAC

Figure 1.3 indicates the improvement of the accommodation business in HAC recently. It is clear that the number of hotels and rooms increase in proportion to the development of the tourist number to respond to the lodging demand of the tourist. In fact, the other commercial sectors as the restaurants, shops, and travelling service also widely develop. The development of the TI in HAC may cause to the increase of waste generation and its consequences.

1.2.2. SWM system in Hoi An City

Being a small and ancient town (61.71 km^2), the population of HAC is around 95,000 people, and it does not seem to significantly change in the last decade (*Figure 1.4*). However, there is a substantial change in annual SWG from the last ten years. Notably, the amount of annual SWG increase 1.7 times from 2009 to 2018, corresponding to the rapid development of the TI. This may be evidence of the negative impact of the TI in HAC on the urban and environment.

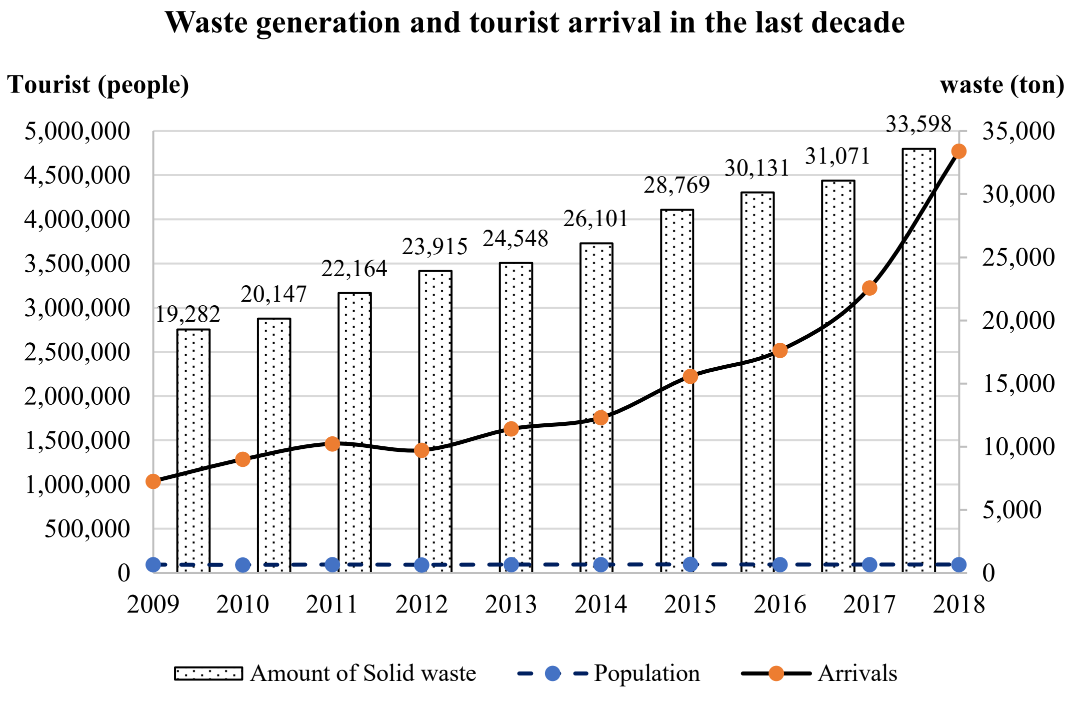


Figure 1.4. The increase of the tourist and solid waste generation

Taking a look at a detailed analysis of the relationship between the monthly SWG and tourism activities in 2018. *Figure 1.5* reveals that the number of tourists comes to HAC in the dry season (from March to August) is more than that in the rainy season. Besides, municipal solid waste generated in the dry season ranges from 2,783 to 3,130 tons, which are higher than that of other months.

In fact, HAC daily generated around 75 tons of waste from many sources such as households, tourism activities, hospitals, schools, offices and public areas. The municipal SWM system in HAC is one of the typical systems in Vietnam. Notably, about 95% of municipal waste is collected daily for treatment. Carts and trucks are the main means of the urban collection system. Waste is required for sorting at source since 2012 and collected separated trucks. Organic waste is collected four times per week while in-organic waste is collected three times per week with interchangeable schedules. Waste is transferred to the gathering point in the treatment area. Here, waste is separated again by labours and machines for composting and incineration. However, the efficiency of both treatment plants is not goos due to some technical problems. Thus, waste is dumped at the open site. Recently, the open dumping site is quite full, so waste is moved to Nui Thanh city in Quang Nam province (70km far) for landfilling.

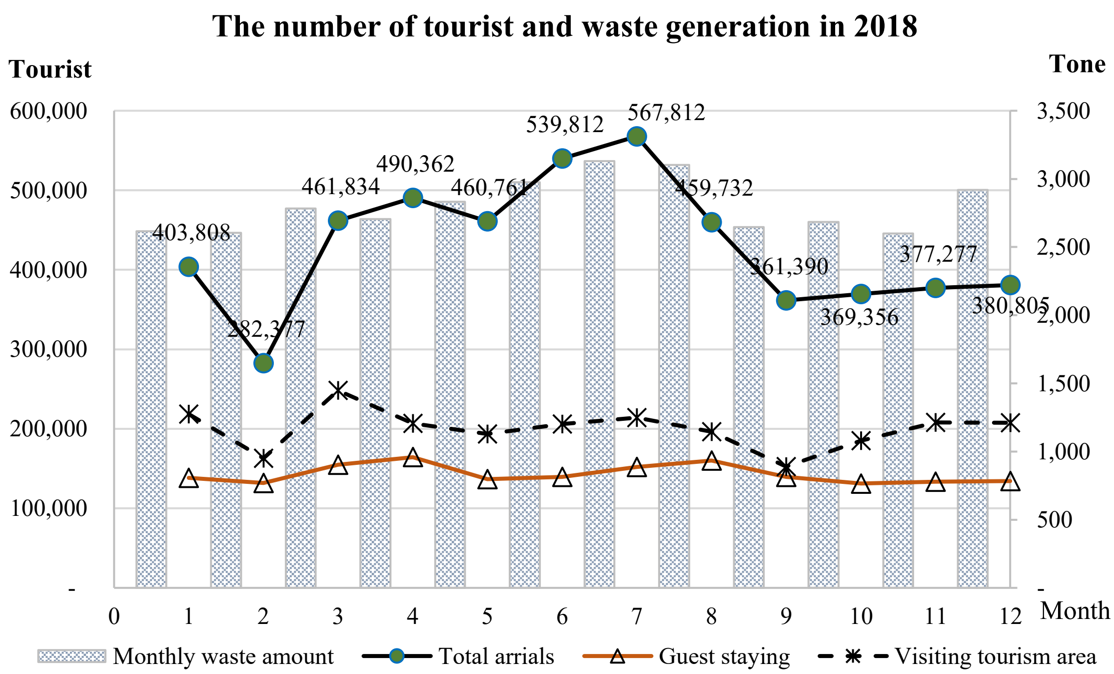


Figure 1.5. The number of tourist and waste generation in 2018

In term of recycling activities, informal sectors are the main factor who are conducting the recycling activities in HAC. *Figure 1.6* shows the path of recycling activity in HAC from generation to manufactures. In the structure of the recycling system in HAC, waste segregation is the first step, which plays an essential role in recycling strategy. Waste separation at source was implemented in HAC since 2012. Whereby, waste is sorted into the organic and inorganic waste and collected separately by the public work company. Although no regulation of recycling waste classification, recyclable waste as mainly papers, metals and plastics are also sorted by householders and commercial sectors (*Figure 1.7*). These recyclable materials are sold to itinerant buyers to get income. A part of recycling waste is picked out of trucks by collection crews. After transferring to disposal areas, mainly PET and metals are picked up again by scavengers. The collected recycling materials are sold to junk shops and moved to manufactures. The rest of recyclable waste goes to the landfill sites.

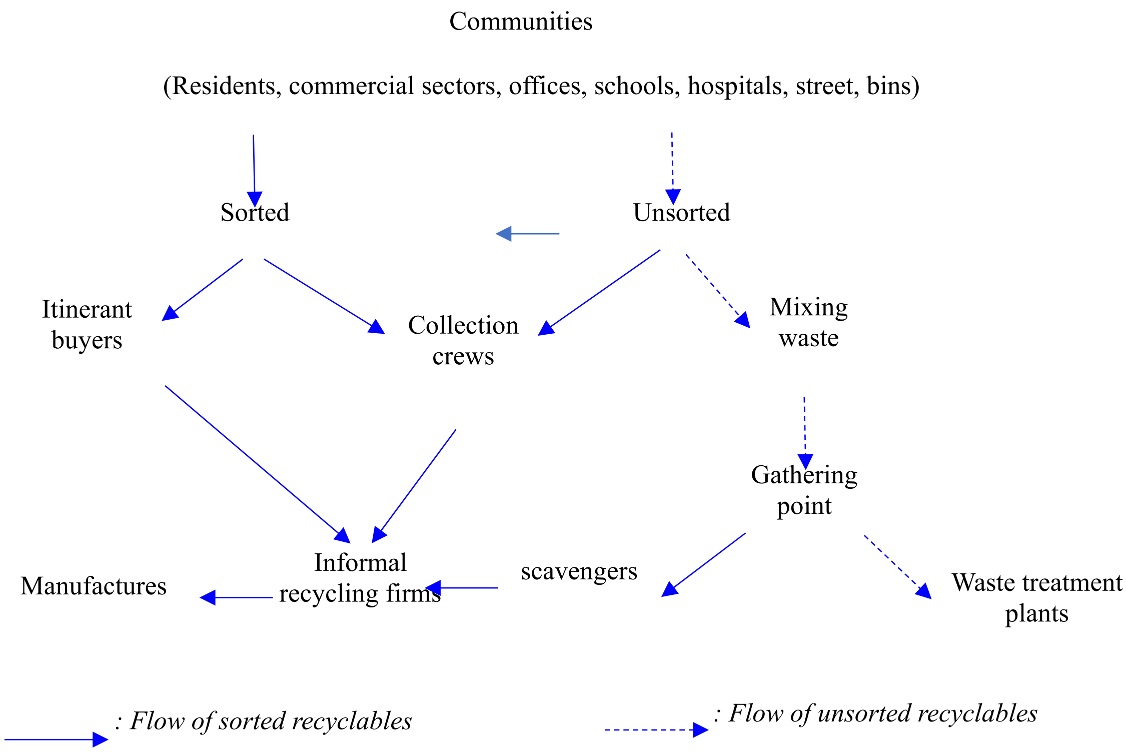


Figure 1.6. Waste recycling paths in Hoi An City

The recycling system in HAC consists of informal sectors and formal firms. The informal sectors, who are itinerant buyers, street picking, collection crews, scavengers and junk shops at treatment sites collect directly recycling material around the city. The formal sector is the public work company which operating waste collection and treatment in HAC. Until now, all of the recyclable materials were bought to recycling manufactures in Dien Ban industry zone and Danang cities.

Figure 1.7. Itinerant waste buyers in HAC

An itinerant waste buyer is a recycling collector who buys sorted dry recyclable waste from householders and commercial sectors and transfers to the junk shops for selling. In HAC, there are about 100 itinerant buyers. They buy recycling materials door to door by bicycles, tricyclics or *bikes* (Figure 1.7). At the public points, the recyclable materials from the mixed waste in the garbage bins or on the street are collected by street waste pickers. Both itinerant buyers and street waste pickers are poor and marginalized social groups. Trading recyclable materials bring them the main income.

(a) *(b)* *(c)* *(d)*

Figure 1.8. Recycling by collection crews (a &b), and by the pickers at the treatment plants (c&d)

For non-recycling practice at the source, the recyclable materials in the mixed waste are recovered by municipal waste collection crews when collecting by trucks or sweeping on the street (*Figure 1.8 (a & b)*). Sometimes, recycling waste is also given to collection crews by householders and commercial sectors for free. The rest of the recyclable materials in the mixed waste is transferred to the treatment area. Here, around 20 scavengers (*Figure 1.8 (c & d)*) pick recyclable waste again before treatment by composting, incinerator or dumping at the open landfill site.

Figure 1.9. Junk shops

Recyclable materials are sold to the junk shops which are informal commercial sectors. HAC has 17 informal junk shops, in which the recycling materials in 30% of shops are disassembled, separated and washed before compressing and packing for selling to manufactures (*Figure 1.9*). Whereas, the rest of junk shops try to minimize the volume of recyclables by hand and pack in the form of sacks (*Figure 1.9*).

In HAC, The Public Work Joint Stock Company, which is the formal firm response for collecting and treating municipal waste. Composting and incineration are the two main treatment methods. However, compost product has low quality with many impurities of plastic, metals, and glass, so farmers do not use that. Whereas, the new open incinerator is working with a capacity of 30 tons per day (30% of design capacity) so that it cannot handle the daily waste of the city. The rest of the waste is dumped at the open landfill sites. HAC has not any recycling factory for recovering recyclable materials.

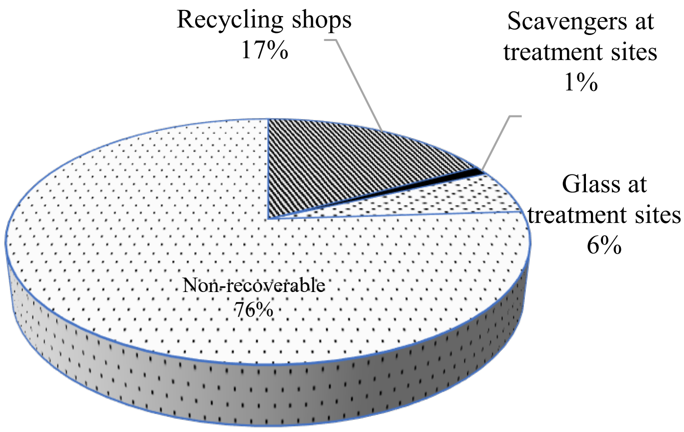


Figure 1.10. The recovery rate of recycled waste in HAC

The recovery rate of recycled waste is shown in *Figure 1.10*. In general, about 17.5 tons of dry recyclable waste (accounted for 25%) were generated per day, in which 24% of recyclable waste was recovered by junk shops (17%) and scavengers (1%). Glass was collected one ton/day which accounted for 6% of total recyclable waste. 76% of recycling waste was mixed into the garbage and have not recovered.

1.3. Objectives of the study

The overall aim of this dissertation is to strategy-oriented planning of optimal SWM practice for the TI in HAC toward the sustainable SWM system. The value of the optimisation in this model is the appropriation and compatibility with the region, the consensus of stakeholders, government and society, the efficiency in operation. The expected values of the optimal SWM practice model are the minimisation of waste generation, enhancement of recycling activities, the favourability of waste to treatment, and the contribution to reducing the current problems of municipal SWM system. The goal of long-term expectation of sustainable SWM practice model is the synchronous achievement of the environment effectiveness – economic affordability – society acceptance.

In this study, the specific targets are listed below.

(1) Identifying the current status of the SWM system of the TI. Whereby, the waste generation, composition and characterisation of the TI in HAC will be identified. The SWM practice and its barriers, obstacles will be analysed. Also, the current problems of tourism and municipal SWM system and the challenges faced by the government will be clarified.

(2) Developing the optimal model of SWM practice for the accommodation industry basing on enhancing waste separation and enhancing recycling practice at source.

(3) Improving the SWM system in the tourism area basing on enhancing SWM practice at source, upgrading the quality of the waste collection system and satisfying the supply-demand relationship in waste collection.

(4) Building the scenarios of SWM practice for the Ti in the minimalism and sustainability orientation. Analysing and assessing the feasibility and appropriation

of these scenarios to establish the strategy-oriented planning the SWM practice for the Ti in HAC towards sustainability.

The suggestions will be provided to the government for the decision-making process aims to develop the appropriate SWM system for the TI and the city as well.

1.4. Scope of the study

This study focuses on the SWM system of the TI in HAC, that is a tourism city in the centre of Vietnam.

- The commercial sectors in the TI include the accommodation, the restaurants, shops, markets, handicraft production facility (HPF), and tourism areas.
- The objectives that will be involved in this study are the stakeholder (owers and staffs of commercial sectors), the government (decision-makers, managers of environment division, head of waste management company), the experts (academic persons work at waste management), supporter (NGOs members) , the residents, and the tourists.

1.5. Outline of the study

To obtain the proposed objectives of the study, the dissertation contents, including 6 chapters as followed:

Chapter 1: Introduction. This chapter presents the literature review of SWM all over the world, the feature in SWM in the TI in developed and developing countries, the challenges and the gaps in improving SWM system in the TI towards sustainability. The study site, objectives and scope of the study also are presents in this chapter.

Chapter 2: Methodology. In this chapter, the methodologies used in this study are presented. Notably, waste sampling and analysis, statistical calculation, modelling methods, economic evaluation and environmental assessment are the main content of this chapter.

Chapter 3: The current status, problems and challenges of SWM system in the tourism industry in Hoi An City. The current status of the SWM system of the TI is a part of the results. In which, waste generation, physical and chemical characterisation are identified. The SWM practice at source is analysed clearly in each commercial sector. Lastly, the problems of the SWM system in the TI and the challenges faced by the government are clarified.

Chapter 4: The optimal solutions to SWM practice for the tourism industry and oriented planning towards sustainability. This is the main results of the study. Whereby, the solutions to the current problems that are presented in chapter 3 are built and analysed respectively. Then, the strategy-oriented planning in SWM practice for the TI in HAC is designed and optimised in the orientation of minimisation or sustainability.

Chapter 5: Conclusion and recommendations. This chapter will summarise the results of the study, also give recommendations and suggestion.

1.6. References

Ball, S., Taleb, M.A., 2011. Benchmarking waste disposal in the Egyptian hotel industry. Tourism and Hospitality Research 11, 1–18. https://doi.org/10.1057/thr.2010.16

Bohdanowicz, P., 2005. European Hoteliers' Environmental Attitudes: Greening the Business. Cornell Hotel and Restaurant Administration Quarterly 46, 188–204. https://doi.org/10.1177/0010880404273891

Byer, P.H., Hoang, C.P., Nguyen, T.T.T., Chopra, S., Maclaren, V., Haight, M., 2006. Household, hotel and market waste audits for composting in Vietnam and Laos. Waste Management & Research 24, 465–472. https://doi.org/10.1177/0734242X06068067

Chen, M.C., Ruijs, A., Wesseler, J., 2005. Solid waste management on small islands: the case of Green Island, Taiwan. Resources, Conservation and Recycling 45, 31–47. https://doi.org/10.1016/j.resconrec.2004.12.005

Cummings, L.E., 1992. Hospitality solid waste minimization: A global frame. International Journal of Hospitality Management 11, 255–267.

Ezeah, C., Fazakerley, J., Byrne, T., 2015. Tourism Waste Management in the European Union: Lessons Learned from Four Popular EU Tourist Destinations. American Journal of Climate Change 04, 431–445. https://doi.org/10.4236/ajcc.2015.45035

Ezio, R., Stefano, A., Irina, A.I., Tiberiu, A., 2014. Municipal solid Waste Management in Italian and Romanian Tourist areas. U.P.B. Sci. Bull, D 76, 277–288.

Graci, S., Dodds, R., 2008. Why Go Green? The Business Case for Environmental Commitment in the Canadian Hotel Industry. International Journal of Tourism and Hospitality Research 19, 251–270. https://doi.org/10.1080/13032917.2008.9687072

Kirk, D., 1995. Environmental management in hotels. International journal of contemporary hospitality management 7, 3–8. https://doi.org/10.1108/09596119510095325

MaLik, S., Kumar, S., 2012. Management of hotel waste: A case study of small hotels of Haryana State. Journal of Economic and Management 1, 43–55.

Mateu-Sbert, J., Ricci-Cabello, I., Villalonga-Olives, E., Cabeza-Irigoyen, E., 2013. The impact of tourism on municipal solid waste generation: The case of Menorca Island (Spain). Waste Management 33, 2589–2593. https://doi.org/10.1016/j.wasman.2013.08.007

Murava, I., Korobeinykova, Y., 2016. The Analysis Of The Waste Problem In Tourist Destinations On The Example Of Carpathian Region In Ukraine. Journal of Ecological Engineering 17, 43–51. https://doi.org/10.12911/22998993/62285

Omidiani, A., S. Mohsen, H.., 2016. Waste Management in Hotel Industry in India: A Review. International Journal of Scientific and Research Publications 6, 670–680.

Otoma, S., Hoang, H., Hong, H., Miyazaki, I., Diaz, R., 2013. A survey on municipal solid waste and residents' awareness in Da Nang city, Vietnam. Journal of Material Cycles and Waste Management 15, 187–194. https://doi.org/10.1007/s10163-012-0109-2

Shamshiry, E., Nadi, B., Bin Mokhtar, M., Komoo, I., Saadiah Hashim, H., Yahaya, N., 2011a. Integrated Models for Solid Waste Management in Tourism Regions: Langkawi Island, Malaysia. J Environ Public Health 2011. https://doi.org/10.1155/2011/709549

Shamshiry, E., Nadi, B., Bin Mokhtar, M., Komoo, I., Saadiah Hashim, H., Yahaya, N., 2011b. Integrated Models for Solid Waste Management in Tourism Regions: Langkawi Island, Malaysia. Journal of Environmental and Public Health 2011, 1–5. https://doi.org/10.1155/2011/709549

Sharma, R., 2016. Evaluating total carrying capacity of tourism using impact indicators. Global Journal of Environmental Science and Management 2, 187–196. https://doi.org/10.7508/gjesm.2016.02.009

Trung, D.N., Kumar, S., 2005. Resource use and waste management in Vietnam hotel industry. Journal of Cleaner Production 13, 109–116. https://doi.org/10.1016/j.jclepro.2003.12.014

Chapter 2

Methodology

2.1. Waste sampling and analysing methods

2.1.1. Waste sampling

The sampling survey is an essential task in planning studies. The samples in the survey must be representative of the sample population in the study. The sampling methods were used in this study are NT ENVIR 001 and NT ENVIR 004. The sampling process is described in *Figure 2.1*.

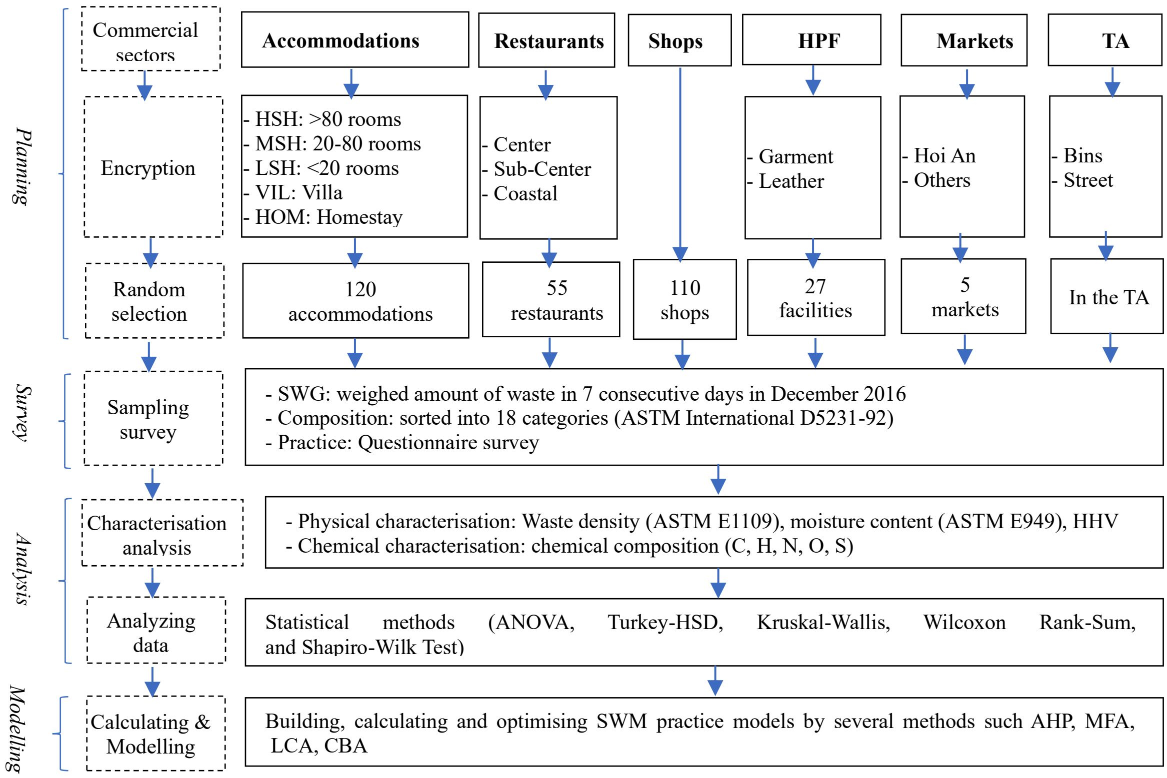


Figure 2.1. The process of sampling survey

Figure 2.1 shows that the first step of the sampling survey is planning. Whereby all commercial sectors were encrypted and separated into groups. Notably, the accommodation includes five sub-groups (shown in *Table 2.1*) based on the size and characteristics of the hotels. Whereas, 558 restaurants in HAC were divided into three sub-groups according to the location of the restaurants, such as the centre area, sub-centre area, and coastal area. Likewise, 272 HPF were sorted based on their features, such as garment and leather. Besides, Hoi An market, which is in the centre of HAC, is the shopping place of tourist. Hence, separately sampling waste from Hoi An market and the others aimed to identify the role of tourism activity in the market waste.

Table 2.1. The number of hotels in HAC for sampling

N^0	Types of hotels	Description	Total number	Number for sampling
1	HSH (High scale hotel)	> 80 rooms	27	7
2	MSH (Midle scale hotel)	20 – 80 rooms	81	22
3	LSH (Low scale hotel)	< 20 rooms	38	10
4	VIL (Villa)	Villas	80	22
5	HOM (Homestay)	Homestay	220	59
6	Total		446	120

The sampling process was conducted by students of Danang University in December 2016. Training of sampling, checking of measuring methods, and setting up sampling plan were the main tasks in the first week. Then, solid waste from organic and inorganic trash of commercial sectors was collected separately in seven consecutive days of the second week and transferred to the gathering area. Here, the weight of the samples was determined by handy electronic scales such as BONSO-393 (the capacity: 50kg, the graduation: 0.05kg) and DRETEC-KS-221 (the capacity: 2 kg, the graduation: 0.001 kg).

2.1.2. Waste Composition analysis

About 500 kg of a waste sample pile was mixed and reduced in volume to around 120 kg by coning and quartering method (*Figure 2.2*). The waste classification was carried out to identify the composition of the sample by the method of *ASTM D5231-92 2003*.

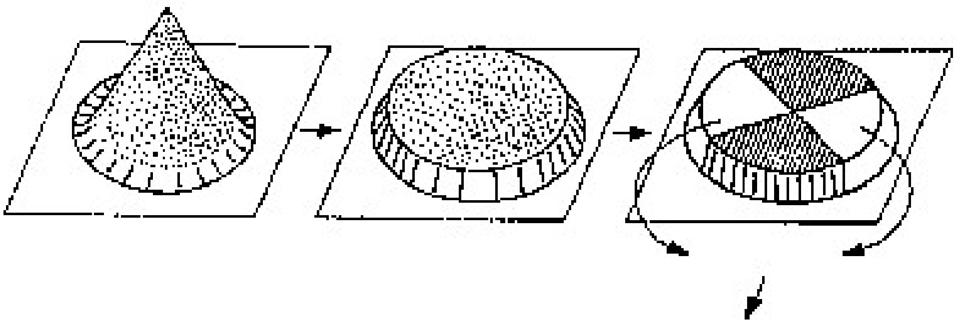


Figure 2.2. Corning and quartering method in concept and reality

Waste was sorted into 18 categories (*Table 2.2*). By separately analysing waste composition from biodegradable and inorganic waste, segregation efficiency of each waste category was identified by diving the amount of this waste in the correct trash with the total amount of this waste generated. Whereby the negative values of efficiency may be explained by the misclassification of waste.

Table 2.2. Categories of waste composition

N^0	Categories	Description
1	Paper	Print paper, newspaper, magazine
2	Cardboard	Paperboard, containerboard, cardstock
3	Garden waste	Leaf, grass, flower
4	Kitchen and food waste	Leftover food, vegetable.
5	Tissues	Tissue and toilet paper
6	PET	PET bottles
7	Nylon	All kind of nylon bags
8	Metal	All kinds of metal (iron, aluminium, copper, lead, ...)
9	Plastic	All kind of plastics do not contain toxic substances
10	Glass	All kinds do not contain toxic substances
11	Leather	
12	Rubber	
13	Textile	Tablecloths, clothes
14	Wood	Wooden furniture, branches
15	Nappy	Sanitary napkins, diapers,
16	Ceramic	Ceramic, minerals, light bulbs
17	Chemicals	Soap, cosmetic residues
18	Hazardous waste	Paint, varnishes, oils, pesticide, insecticide, fertilizer.

2.1.3. Questionnaire survey

In the third week, the face to face interview was conducted. Whereby, managers of commercial sectors were asked to collect information on the properties, current SWM practices in their business, and the barriers of SWM practices. Notably, the information about the features of facilities, type and level of services of the commercial sectors were collected. Also, the implementation of waste separation a source, reduction, recycling, and composting in their hotels was checked and asked by questionnaire survey. Waste reduction practice is the deployment of activities aim to reuse materials and reduce the amount of waste. Whereas, waste recycling and composting practices were identified as the operation of recycled activities in their facility, in which dry recycled materials were separated for recycling or the organic waste was sorted for composting at their hotels or not. Furthermore, the questionnaire survey was also used for collecting information on the policy from the government, opinions and suggestions from the experts, and recommendations from non-governmental organisations (NGOs).

2.1.4. Waste characteristic analysis

According to ASTM E1109 method, the density of solid waste was identified by diving the weight to the volume of the sample. Plastic buckets with the volume determination were used for measuring the volume of the samples. Secondly, the moisture content of waste was identified by ASTM E949. Whereby, the wet waste was dried in the drying machine at 105^0C in 24 hours or until the constant weight. The moisture of waste was calculated by *Eq. (2.1)*.

$$\text{Moisture (\%)} = \frac{m_1 - m_2}{m_1} \times 100\% \qquad (2.1)$$

Where m_1 is the weight of the wet waste; m_2 is the constant weight of the dry waste after drying.

The high heating value (HHV) of waste was calculated by Steuer's (*Eq. (2.2)*) from the elemental composition (C, H, O, N, S, Cl) (Christensen, 2011). These elemental components were analysed by 240 CHNS/O Series II System machine.

$$\text{HHV (kJ/kg)} = 81(\text{C-3/8*O}) + 57\text{*3/8*O} + 345(\text{H-O/10}) + 25\text{S-6}(9\text{H} + \text{W}) \qquad (2.2)$$

Where C, H, S, O, and M were the percentage of carbon, hydrogen, sulfur, oxygen, and moisture content in the the wet waste.

2.2. Statistical analysis

All data were synthesised into excel files to conduct statistical analysis by R software. Firstly, in order to verify the compatibility of the data for statistical tests, the combination between a normal bell-shaped as a graphical method and Shapiro-Wilk as a sensitive test used for testing the significant differences from normal. Shapiro-Wilk test is known as the most powerful test for all kinds of distribution *(Nornadiah Mohd Razali, 2011)*. Also, the differences in means of SWG rate between 5 independent groups of the hotels overall were compared and analysed by ANOVA to determine whether there are statistically significant differences. Besides, Tukey-HSD (Tukey Honestly Significant Difference) test was executed to clarify which groups have significant differences by comparing all pairs of the means of SWG rate. Finally, four influencing factors of SWG rate of the hotels were analysed individually by three corresponding tests.

Table 2.3. Influencing factors of SWG rate of the hotel industry and statistical methods

N^0	Objective factors	Describe	Methodologies
1	Capacity of hotels	Number of rooms	Simple linear regression
2	Price of room	Room price ($)	
3	Garden	0: No 1: Yes	Wilcoxon Rank-Sum Test
4	Restaurant	0: No restaurant 1: Only breakfast 2: Breakfast and dining	Kruskal-Wallis

In this study, the objective influencing factors of SWG rate were internal characteristics of the hotels. The first factor is the number of rooms in each accommodation in HAC, which does not change according to demand *(Ayia-Koi and Sackle-Sackey, 2015),* was arranged from 2 to 217 rooms corresponds to the scale of the hotels. Besides, the price of the room, which shows the quality of service and facilities of the hotels *(Hung et al., 2010),* was also considered the effect to SWG of the hotels. Additionally, garden and restaurant are the leading standards for ranking hotels in Vietnam and also the primary sources of waste *(Karim Zein et al., 2008; Omidiani and S. Mohsen, 2016; Pirani and Arafat, 2014)*. Depending on the scale of the hotels, the food service is different. In HAC, 25% of the hotels had restaurants with full service (includes breakfast and dining), while food service for only breakfast accounted for 55%. On the other hand, garden and green area are considered as an essential factor of accommodation business, also a waste source *(Wong and Kim, 2012)*. In HAC, 46% of the hotels have a garden, mainly are HSH, VIL, and MSH.

In order to identify the influence of these objective factors to SWG rate of the hotels, the statistical methods were used depending on the characteristics of factors. Notably, the correlation between the SWG rate as the continuous numeric variable and the capacity of hotels or the price of the room as the dependent numeric variables were tested by simple linear regression. Whereas, Kruskal-Wallis was used to test the difference between 3 restaurant service levels and SWG rate. Likewise, Wilcoxon Rank-Sum test was used to identify whether SWG rate of the hotels with garden and without garden was different or not.

2.3. Methods of building, assessment and optimising SWM practice models

2.3.1. Waste audit

Waste from the TA in the downtown of HAC was summarised from results of waste audit. Notably, waste generation and composition of commercial sectors were identified by sampling survey from 321 households, 120 hotels, 110 shops, 55 restaurants, 27 handicraft product facilities, and five markets *(Giang et al., 2017a; Song Toan et al., 2019, 2018b)*. The average value of waste generation for each source was calculated by Eq. (2.3) and the amount of waste by categories was evaluated by Eq. (2.4).

$$SWG_i = SWGR_i \times n_i \tag{2.3}$$

$$SWG_{ji} = P_{ji} \times SWG_i \tag{2.4}$$

Where, n_i is the number of source *i*, P_{ji} is the proportion of waste category *j* in source *i*.

2.3.2. Analytic hierarchy process method

The analytic hierarchy process (AHP) is a mathematical method which is used to assess the priority of multiple alternatives under different valuation criteria *(Kim et al., 2013)*. In this study, the AHP method was used for analysing and dealing with the complex decision making of recycling practice enhancement (RPE). RPE is identified as the expected improvement in recycling practices, which consists of the rate and the effectiveness of waste recycling. Fifteen experts on waste management in HAC were chosen for the survey and are described in *Table 2.4.*

Table 2.4. Environmental management experts interviewed in the AHP method

Experts	The role of them in the decision-making process	Number of experts
The authorities	The persons who can promulgate waste regulation	2
Staffs of Environmental Division	The persons who directly manage solid waste in HAC	4
Staffs of Public Work Company	The persons who operate waste collection system and treatment in HAC	3
The experts	Lecturers of University or doctor of environment who are working or studying solid waste for HAC	4
NGOs	Social members who are working on environmental and social activities in HAC	2

To identify the important factors for the development of waste recycling towards establishing a strategy for sustainable recycling practices for the hotel industry in HAC, the hierarchy model was built with three levels of importance of relevant factors. Six criteria, including WMP, social consensus improvement (SCI), development of a facility for recycling (DFR), environmental impacts mitigation (EIM), economic benefit optimisation (EBO), and policy promulgation (PP), were considered directly related to the goal of RPE. Also, three sub-criteria of each criterion were considered as the secondary relevant factors (*Table 4.2*). The goal of RPE is the maximisation of recycling practice rate, enhancement of recycling practice effectiveness, and optimisation of economic benefits from recycling by improving influencing factors.

Table 2.5. Explanation of abbreviations in the hierarchy structure model

Criteria	Sub-Criteria
WMP: Waste Management Practice	SP: Separation Practice RP: Recycling Practice CP: Composting Practice

SCI: Social consensus improvement	CH: Consensus of Hotels SoN: Support of NGOs CG: Co-ordination of the government
DFR: Development of facility for recycling	RFH: Recycling Facility of Hotel RFC: Recycling Facility of City RSC: Recycling System of City
EIM: Environmental impacts mitigation	GHG: Greenhouse Gas Emission Odour PH: Public Health
EBO: Economic benefits optimisation	EHS: Economic Benefit for Hotel Sectors ES: Economic Benefit for Society ERS: Economic Benefit for Recycling Sectors
PP: Policy Promulgation	IE: Intensification of Encouragement PR: Promulgation of Regulation AP: Application of Sanction

Five scenarios (S) were built, analysed, and compared as alternatives of the RPE strategy. The hierarchy structure of RPE is illustrated in *Table 2.5* and *Figure 2.3*.

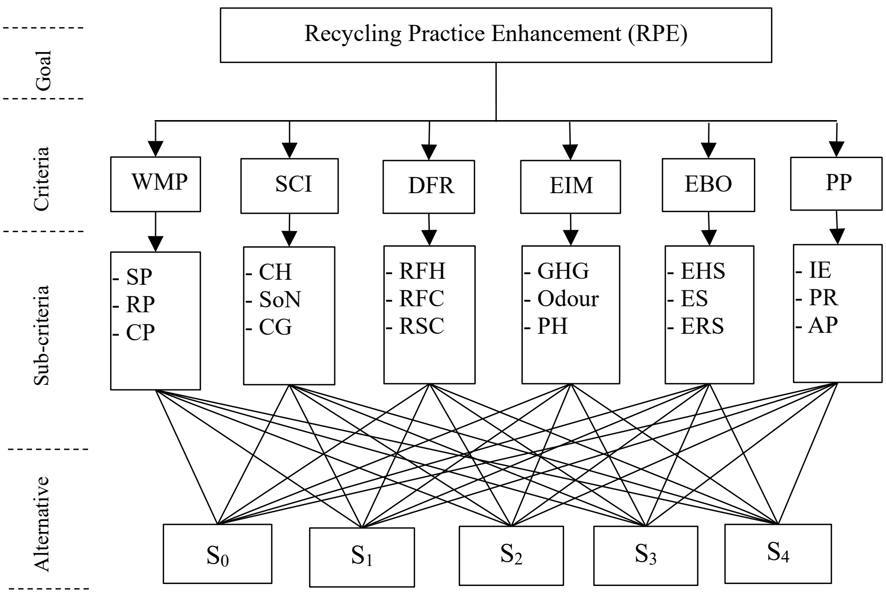


Figure 2.3. Hierarchy structure model for enhancing recycling practices in hotel industry

The AHP method was conducted in three steps:

<u>Step 1</u>: The authors established a pairwise comparison matrix (A) of each hierarchy. Next, the relative weights were obtained between each indicator using eigenvectors, as shown in the formula below:

$$A = (a_{ij}) = \begin{bmatrix} a_{11} & \cdots & a_{n1} \\ \vdots & \ddots & \vdots \\ a_{1n} & \cdots & a_{nn} \end{bmatrix} \quad (i, j = 1, 2, \ldots, n) \qquad (2.5)$$

Where a_{ij} is the coefficient of the element in line *i* in comparison with the element in column *j* in the pairwise comparison matrix, and *n* is the number of elements compared.

<u>Step 2</u>: Computing the maximum eigenvalue (λ_{max}):

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{w_i} \qquad (2.6)$$

Where *w* is the eigenvector.

<u>Step 3</u>: Consistency test. The consistency index (CI) and the consistency ratio (CR) was calculated. The accepted upper limit for the CR is 0.1. If the CR exceeded this value, the evaluation procedure had to be repeated to improve consistency *(Shamshiry et al., 2015)*.

$$CI = \frac{\lambda_{max} - n}{n-1} \qquad (2.7)$$

$$CR = \frac{CI}{RI} \qquad (2.8)$$

The pairwise comparison scale of criteria and sub-criteria (*Table 4.3*) ranges from 1 to 9 depending on the important level between two compared criteria through the evaluation of experts.

Table 2.6. Pairwise comparison scale

Intensity of importance	Explanation
1	Two criteria contribute equally to the objective
3	Experience and judgment slightly favour one over another
5	Experience and judgment strongly favour one over another
7	The criterion is strongly favoured, and its dominance is demonstrated

	in practice
9	The importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Used to represent a compromise between the priorities listed above

2.3.3. Building scenarios of waste management practices for recycling strategies

Gardens and restaurants were the two primary sources of solid waste in the hotel industry in HAC *(Song Toan et al., 2018b)*. Also, the attitude and intention of recycling were determined as the most critical factors of recycling activities in HAC *(Nguyen et al., 2017)*. Thus, five scenarios were built based on waste characterisation, features of the hotels, current WMP, intentions of hoteliers regarding WMP, as well as the suggestion of experts from the AHP analysis results.

The waste characterisation, the status of WMP, features of the hotels, and waste management intentions of the hoteliers that were used for building the scenarios are shown in *Table 2.7.*

Table 2.7 Waste characterisation and present SWM practices of the hotels in HAC

	Items		HSH	MSH	LSH	VIL	HOM	Reference
1	SWG (kg/day)		6,556.14	5,464.26	171.20	748.8	618.20	*(Song Toan et al., 2018b)*
2	Number of the hotels		27	81	38	80	220	Survey
3	Garden (%)		94	44.4	0	43	25	
4	Restaurant (%)	Dining	100	37	0			
		Breakfast		63	27	93	73	
		No restaurant			73	7	27	
5	Waste composition (%)	Paper	3.66	10.21	11.19	5.71	12.55	*(Song Toan et al., 2018b)*
		Plastic	8.32	12.95	14.92	17.13	19.79	
		Metal	0.24	2.05	0.64	2.41	1.4	
		Glass	0.95	1.96	2.75	2.54	2.62	

		Organic	68.58	65.06	42.77	56.77	46.60	
6	Present waste separation rate (%)		100	87	36	83	21	
7	Present waste separation efficiency – WSE_0 (%)	Paper	69.4	71.6	82.8	73.7	35.9	Survey
		Plastic	46.7	92.6	67.6	65.4	36.0	
		Metal	33.3	97.6	36.0	87.5	37.2	
		Glass	99.7	72.6	100	82.7	59.6	
		Organic	82.3	55.5	41.7	62.0	86.1	
8	Present recycling practice rate (%)		53	60	7	33	30	*(Song Toan et al., 2018b)*
9	Present composting practice rate (%)		0	0	0	0	0.8	

To analyse recycling practice, the WSE by categories was focused on paper, plastic, metal, glass and organic waste. Table 4 indicated that organic waste was sorted in green trash of HOM and HSH with the higher efficiency (86.1% and 82.3%) than such of VIL, MSH and LSH. This might be justified by some objective factors such as no-space for storing waste in a hotel, the odour of waste. On the contrary, the efficiency of sorting recyclable materials such as paper, metal, glass and plastic in VIL, MSH and LSH was higher than such of HSH and HOM. Economic benefit from selling recyclable materials was explained as a positive motivation for sorting and recycling practice by hoteliers. Otherwise, the misclassification which was identified by the WSE less than 50% mainly detected in HOM (paper, plastic and metal) and HSH (plastic and metal).

The scenarios of recycling practices of the hotel industry were built based on the assumptions of WMP, which will be changed in the positive trend and feasibly analysed with practical conditions of the hotels in HAC.

- *Scenario 0 ($S0_{AB}$): No WMP in the hotels.* This scenario assumes that the hotel waste is not classified or recycled. Solid waste is mixed, collected by trucks and transferred to the disposals. This scenario plays a comparative role in the effectiveness of implementing and not implementing WMP.

- *Scenario 1 ($S1_{AB}$): Present WMP by actual rates (Business as usual - BAU).* This scenario provides the present issues of hotel waste which are caused due to the fact of WMP in the hotels.
- *Scenario 2 ($S2_{AB}$): WMP by intention.* This scenario assumes that WMP rates are the intention rate of hotels in separation, recycling and composting practices, which were identified by questionnaire survey. This scenario will reveal that the role of hotels in willing to practice waste management. However, the efficiency of separation does not change.
- *Scenario 3 ($S3_{AB}$): WMP by the intention and recycling regulation promulgation*. The differences between S2 and S3 are the recycling rate and composting rate due to the promulgation of recycling regulation. Whereby, recycling practice is obligatory for the hotels with catering services. While composting practice is requested for hotels have a garden. In addition to the consensus of the hotels in WMP, the role of the government in the promulgation of waste regulation will be analysed in this scenario. In this case, the efficiency separation is usually.
- *Scenario 4 ($S4_{AB}$): WMP by the optimisation and integration*. The optimal scenario is built based on the combination of the integrated factors towards a sustainable model such as the willingness of hotels, the role of government and the consensus of society. In this scenario, WMP rates are optimal rate by 100%. Also, WSE increases based on the support of stakeholders such as, NGOs, and social organisations. Whereby, the expected WSE will not change if its present value higher than 90%, increase 10% and 20% for the range of present WSE from 70% – 90% and 50% – 70%, respectively. For misclassification case (WSE < 50%), the expected WSE is assumed by its complement from present value.

The assumption of the scenarios is summarised in *Table 2.8.*

Table 2.8. Assumptions of scenarios

Scenarios	Parameters			HSH	MSH	LSH	VIL	HOM
$S0_{AB}$	No waste management practice in the hotels							
$S1_{AB}$	Present waste separation rate (%)			100	87	36	83	21
	WSE_0	(%)	Paper	69.4	71.6	82.8	73.7	35.9

		Plastic	46.7	92.6	67.6	65.4	36.0
		Metal	33.3	97.6	36.0	87.5	37.2
		Glass	99.7	72.6	100	82.7	59.6
		Organic	82.3	55.5	41.7	62.0	86.1
	Present recycling practice rate (%)		53	60	7	33	30
	Present composting practice rate (%)		0	0	0	0	0.8
$S2_{AB}$	Waste separation rate (%)		100	100	100	100	100
	WSE_0 (%)		Same S1				
	Intention of recycling practice rate (%)		100	82	21	54	37
	Intention of Composting practice rate (%)		45	26	0	22	18
$S3_{AB}$	Waste separation rate (%)		100	100	100	100	100
	WSE_0 (%)		Same S1				
	Recycling practice rate with regulation (%)		100	100	27	93	73
	Composting practice rate with regulation (%)		94	44.4	0	43	25
$S4_{AB}$	Waste separation rate (%)		100	100	100	100	100
	Optimal waste separation efficiency – WSE^* (%) [1]	Paper	83.2	85.9	91.1	88.4	64.1
		Plastic	66.7	97.6	64.0	96.3	62.8
		Metal	53.3	92.6	81.1	78.5	64.0
		Glass	99.7	87.1	100.0	91.0	71.5
		Organic	90.5	66.0	58.3	74.4	94.8
	Optimal recycling practice rate (%)		100	100	100	100	100
	Optimal composting practice rate (%)		100	100	100	100	100

(1) $WSE^* = WSE_0$, if $WSE_0 > 90\%$: $= 1.1 \times WSE_0$, if $70\% < WSE_0 > 90\%$: $= 1.2 \times WSE_0$, if $50\% < WSE_0 > 70\%$: $= 100 - WSE_0$, if $50\% < WSE_0$

2.3.4. Evaluating the amount of recyclable materials

This study focused on evaluating the recycling potential and the benefits to the hotels from recycling so that the boundaries of waste flow extend from waste generation to waste collection (*Figure 2.4*). The amount of recyclable waste for recycling significantly depended on waste separation rate, WSE, and recycling rate of the hotels. Thus, the amount of recyclable materials can be identified by *Eq. (2.9)*.

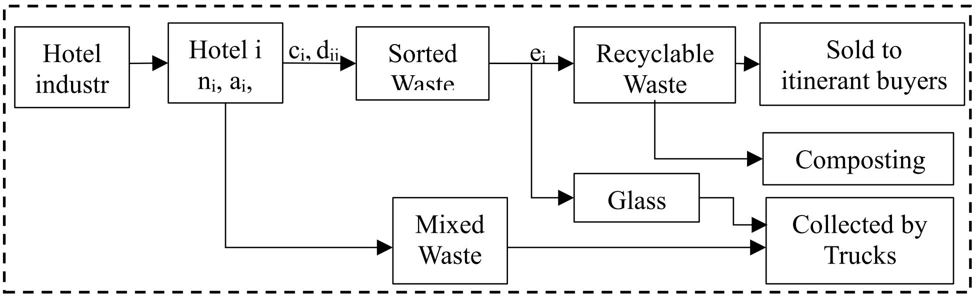


Figure 2.4. Boundaries of recyclable waste in the hotels

$$m_j = \sum m_{ij} = \sum \frac{(a_i \times n \times b_{ij} \times c_i \times d_{ij})}{1000} \quad (2.9)$$

Where:

- i: Types of hotels
- j: The components of the waste
- m_j: The amount of component j which is available for recycling (tons per day)
- m_{ij}: The amount of component j of hotel i available for recycling (tons per day)
- a_i: SWGR of hotel i (kg per hotel per day)
- n: The number of the hotel i
- b_{ij}: Percentage of waste component j of hotel i (%)
- c_i: Waste separation practice of hotel i (%)
- d_{ij}: Waste separation performance of component j of hotel i (%)

2.3.5. Financial benefits of recycling

The hoteliers receive income from selling the recyclable materials to itinerant buyers with selling prices of US $634/ton for metals, US $95/ton for plastics, and the US $90/ton for the paper *(Hoi An Public Work Company, 2017)*. Also, the tipping fee, which is shown in Table 6, is regulated by the government with the rule of "pay as you throw" (PAYT).

Table 2.9. The tipping fee for accommodation sectors in HAC (Quang Nam, 2016)

SWG/hotel	Tipping fee ($)
Hotel	
< 1.5 m^3/month	11.00/month
> 1.5 m^3/month	8.50/m^3
Family business	
< 0.5 m^3/month	3.35/month
0.5 – 0.8 m^3/month	4.46/month
0.8 – 1.0 m^3/month	5.58/month

Therefore, if recycling practices reduce SWG of hotels, the economic benefits to the hotels from recycling can be calculated using *Eq. (2.10).*

$$E\ (\%) = \frac{E_S + E_T}{T} \quad (2.10)$$

Where:

- E: Economic benefit from recycling (%)
- E_S: Economic benefit from selling recyclable materials ($)
- E_T: Economic benefit from reducing waste generation ($)
- T: Tipping fee without recycling practices ($)

2.3.6. Waste flow analysis

The flow of solid waste was described by Material Flow Analysis (MFA) method with STAN software. MFA is a descriptive method with a defined space and time (Cencic, 2016). In this study, MFA is used to provide a systems-oriented view and support the priority-oriented decisions regarding waste management in the TA in HAC. In order to simulate by STAN, the graphical model was defined with spacing boundary by the TA in downtown and timing boundary by day. The amount of waste in processes of waste flow was described in *Figure 4.6* and calculated by mass-balance principle. The transfer coefficients (TC) of a process was identified by *Eq. (2.11) & (2.12)*. Also, the simulation results were presented in the form of a Sankey diagram.

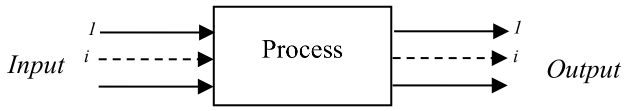


Figure 2.5. The transfer diagram of waste in a process

$$TC_i = \frac{O_i}{\sum I_i} \quad (2.11), \qquad \text{and} \qquad \sum TC_i = 1 \quad (2.12)$$

Where, O_i is the waste amount of output *(i)*, I_i is the waste amount of input *(i)*.

2.3.7. Building scenarios of a SWM system

The seven scenarios of the SWM system in TA were designed based on the current status of the waste management system, improvement of SWM practices, and enhancement of the waste collection system (*Table 2.10*). Whereby, the current status of the SWM system was described in S0 **TA**. According to the agreement in supply-demand service between business sectors and the government, and the conformance to tourism activities, the SWM system in S1 **TA**, S2 **TA**, and S3 **TA** was developed with the assumption of non-separation practice regulation. Whereas, S4 **TA**, S5 **TA**, and S6 **TA** were built based on improvement of waste separation at source practice that waste is required to sort into three types such as bio-waste (kitchen waste, garden waste, and tissue paper), recyclable materials (plastic, metal, cardboard, paper, and glass), and the residues. Therefore, at a collection point on the street, three bins with the corresponding symbols will be set up for sorting by tourists. Besides, the waste collection system was upgraded based on calculating the number of street bins, carts, labours, and route of trucks corresponding to waste management practices in different scenarios.

Table 2.10. Scenarios of the SWM system in the tourism area in HAC

Scenarios	Separation rate	Separation efficiency	Recycling rate	Waste collection system
$S0_{TA}$			BAU	
$S1_{TA}$			Current	
$S2_{TA}$	Non-separation		Intention	Improvement
$S3_{TA}$			Optimisation	
$S4_{TA}$		Current		
$S5_{TA}$		Intention		
$S6_{TA}$		Optimisation		

The current and intention of waste separation and recycling practices were identified by questionnaire survey. Current waste segregation efficiency that was measured by sorting waste from the trash of organic waste (green trash) and inorganic waste (orange trash) was calculated by *Eq. (2.13)*.

$$SWE(\%) = \frac{m_{xy}}{\sum m_x} \tag{2.13}$$

where m_{xy} is the amount of waste category *(x)* that was detected in the correct trash *(y)*, m_x is the total amount of waste category *(x)* from two trash. In S6, under the support of Non-Government Organisations (NGOs) and regulation of local government, the improvement coefficient of SWE was estimated to be 1.2 and 1.1 for the range of 50% – 70% and 70% - 90%, respectively. There is no change for SWE >90% *(Pham Phu et al., 2019)*.

In order to assess the performance of an SWM system in the TA of HAC, some criteria were used such as the increase of recycling practice, the consensus of society, the favourability of waste for existing treatments and the economic optimisation. The optimal economic in SWM system for TA was analysed by Cost-Benefit Analysis (CBA) method by *Eq. (2.14), (2.15) & (2.16)*.

$$CBA = B - C \tag{2.14}$$

where $B = B_r + B_f$ (2.15)

and $C = C_i + C_s + C_f + C_t$ (2.16)

where B_r and B_f are the benefits from selling recyclable materials and tipping fee, respectively. Notably, the market value of recyclable material is \$133, \$156, \$170, and \$400 per ton for papers, plastics, PET bottles, and metals, respectively *(Song Toan et al., 2018a)*. Also, the tipping fee for the residents in downtown and business sectors were defined by 07/2016/QD-UBND regulation of Quang Nam government *(Quang Nam Province, 2016)*. Likewise, the cost for investment, salary, fuel and treatment was denoted by C_i, C_s, C_f, and C_t in *Eq. (2.16)*. Whereby the investment cost includes buying street bins and carts. The fuel cost for waste transportation from waste transferring points to the disposals is reported at \$8.71/route (about 10km), while the treatment cost is around

$20/ton of waste. The CBA in the project of improving the SWM system in TA of HAC is assumed in the period of 5-years operation.

2.4. Conclusions

This study was conducted by the process with four steps such as planning the survey, sampling survey, analysis and modelling. In each step, the specific methods were used as listed below:

(1) Waste sampling survey was conducted by NT ENVIR 001 and NT ENVIR 004. In which the sample size accounts for around 20% of the population of the sample. The composition of waste is identified by the method of ASTM D5231-92. Whereby waste was sorted into 18 categories. The physical characterisation of waste was measured by ASTM E1109, ASTM E949.

(2) In order to verify the data obtained from the survey and clarify the SWMG rate of waste sources, some statistical methods were used such as ANOVA, Tukey-HSD and Kruskal-Wallis.

(3) The models of SWM practice were built based on the status of the SWM system, the SWM practice rate, the consensus of stakeholders, the consultation of the experts.

(4) The models of SWM practice were analysed, assessed and optimised by some methods such as analytic hierarchy process (AHP), material flow analysis (MFA), cost-benefit analysis (CBA) and life cycle assessment (LCA).

2.5. References

ASTM International D5231-92, 2003. Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste.

Ayia-Koi, A., Sackle-Sackey, A., 2015. Capacity Management Issues in the Hotel Industry of Cape Coast Metropolis. Journal of Tourist, Hospitality and Sports 11, 1–9.

Cencic, O., 2016. Nonlinear data reconciliation in material flow analysis with software STAN. Sustainable Environment Research 26, 291–298. https://doi.org/10.1016/j.serj.2016.06.002

Christensen, T.H., 2011. Solid waste technology & management. Wiley, Chichester, West Sussex, U.K. ; Hoboken, N.J.

Giang, H.M., Takeshi, F., Song Toan, P.P., 2017. Municipal Waste Generation and Composition In A Tourist City - Hoi An, Vietnam. Journal of JSCE 5, 123–132.

Hoi An Public Work Company, 2017. Data collection.

Hung, W.-T., Shang, J.-K., Wang, F.-C., 2010. Pricing determinants in the hotel industry: Quantile regression analysis. International Journal of Hospitality Management 29, 378–384. https://doi.org/10.1016/j.ijhm.2009.09.001

Karim Zein, Majdoulaine Semlali Wazner, Grégoire Meylan, 2008. Best Environmental Practices for the Hotel Industry. Sustainable Business Associates.

Kim, M., Jang, Y.-C., Lee, S., 2013. Application of Delphi-AHP methods to select the priorities of WEEE for recycling in a waste management decision-making tool. Journal of Environmental Management 128, 941–948. https://doi.org/10.1016/j.jenvman.2013.06.049

Nguyen, T., Nguyen, H., Lobo, A., Dao, T., 2017. Encouraging Vietnamese Household Recycling Behavior: Insights and Implications. Sustainability 9, 179–194. https://doi.org/10.3390/su9020179

Nornadiah Mohd Razali, Y.B.W., 2011. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Journal of Statistical Modeling and Analytics 2, 21–23.

Omidiani, A., S. Mohsen, H.., 2016. Waste Management in Hotel Industry in India: A Review. International Journal of Scientific and Research Publications 6, 670–680.

Pham Phu, S.T., Fujiwara, T., Hoang, M.G., Pham, V.D., Tran, M.T., 2019. Waste separation at source and recycling potential of the hotel industry in Hoi An city, Vietnam. Journal of Material Cycles and Waste Management 21, 23–34. https://doi.org/10.1007/s10163-018-0807-5

Pirani, S.I., Arafat, H.A., 2014. Solid waste management in the hospitality industry: A review. Journal of Environmental Management 146, 320–336. https://doi.org/10.1016/j.jenvman.2014.07.038

Quang Nam Province, 2016. Regulation of waste collection fee in Quang Nam province.

Shamshiry, E., Mokhtar, M.B., Abdulai, A.M., Komoo, I., 2015. Using the Analytic Hierarchy Process to Enhance Sustainable Solid Waste Management: Case Study of Langkawi Island, Malaysia: Sustainable Solid Waste Management. Environmental Quality Management 24, 51–64. https://doi.org/10.1002/tqem.21404

Song Toan, P.P., Fujiwara, T., Dinh, P.V., Hoa, K.T., 2018a. Waste Recycling System for a Tourism City in Vietnam: Situation and Sustainable Strategy Approach – Case Study in Hoi An City, Vietnam. IOP Conference Series: Earth and Environmental Science 159, 342–349. https://doi.org/10.1088/1755-1315/159/1/012046

Song Toan, P.P., Minh Giang, H., Takeshi, F., 2018b. Analyzing solid waste management practices for the hotel industry. Global Journal of Environmental Science and Management 4, 19–30. https://doi.org/10.22034/gjesm.2018.04.01.003

Song Toan, P.P., Takeshi, F., Giang, H.M., Dinh, P.V., 2019. An analysis of the commercial waste characterisation in a tourism city in Vietnam. Int. J. Environment and Waste Management 23, 319–335. https://doi.org/10.1504/IJEWM.2019.099015

Wong, K.K.F., Kim, S., 2012. Exploring the Differences in Hotel Guests' Willingness-to-Pay for Hotel Rooms With Different Views. International Journal of Hospitality & Tourism Administration 13, 67–93. https://doi.org/10.1080/15256480.2012.640219

Chapter 3

The current status, problems and challenges of solid waste management system in the tourism industry in Hoi An City

Recently, the rapid development of the tourism industry in HAC has led to a significant increase in the amount of MSW *(Song Toan et al. 2018b)*, whereas the tourism commercial activities (TCA) accounted for 65% of the total MSW *(Giang et al. 2017a)*. From a city point of view, SWM in the tourist business is a significant part of municipal SWM, and sustainable SWM for the hospitality industry should be the primary task. Also, identification of the status and problems of SWM in the tourism industry and analysis of the challenges in sustainable tourism SWM faced by the government of HAC are urgent and necessary. Hence, this chapter aims to

(i) Identify the SWG rate of commercial sectors in the tourism industry,

(ii) Measure the waste composition and characterisation of tourist waste,

(iii) Analyse the current problems of tourism SWM system and its challenges

The clarification of the status of tourism SWM system, the understanding of barriers, obstacles in implementing waste management practices may be necessary for finding the appropriate solutions to the SWM system of the tourism industry in HAC.

3.1. The solid waste generation rate

The SWG rate was identified by diving the solid waste amount produced from the hotels with the number of tourists stayed there in a day. Graphical methods, numerical methods and formal normality test used to check the normality assumption of the data.

Figure 3.1 showed the SWG rate density of five groups of hotels liked the normal bell-shaped curve with various features. The SWG rate distribution curve of Villa group closed to mesokurtic distribution and be left-skewed (kurtosis coefficient: 2.94 and skewness coefficient: -0.56). While the SWG rate distribution shapes of HSH, MSH was platykurtic and LSH, HOM were leptokurtic (*Table 3.1*). However, Shapiro-Wilk test reaffirmed that SWG rate distribution of 5 groups of the hotel closed to the normal distribution with W values approximately 1 and P-value higher than 0.05 (*Table 3.2*). Therefore, the SWG rate density of the hotels came from a normally distributed population.

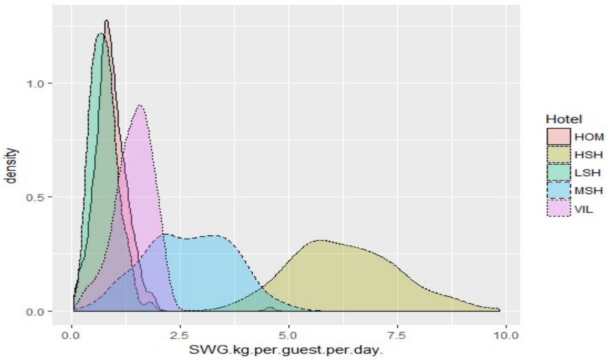


Figure 3.1. Density of SWG rate

Table 3.1. Skewness and Kurtosis coefficient

	HSH	MSH	LSH	VIL	HOM
Skewness	0.37	-0.03	0.63	-0.56	2.75
Kurtosis	2.87	2.29	3.56	2.94	24.94

Table 3.2. Results of Shapiro-Wilk test

	HSH	MSH	LSH	VIL	HOM
P-value	0.37	0.15	0.06	0.13	0.07
W	0.99	0.99	0.97	0.97	0.99

Several studies reported that the daily SWG from a hotel guest varied with the wide range from 0.23 to 13 kg *(Edmundo Mufioz, 2015; Jonathan F.K. Earle and Jo M. Townsend, 1991)* and differed at the various durations and regions (Daniel Hoornweg and Perinaz Bhada-Tata, 2012). Notably, while the range of solid waste amount daily produced by European hotels was 1.5 to 3.1 kg per guest *(Bohdanowicz, 2005),* that by Asian hotels was 0.59 to 9.2 kg.guest^{-1}.day^{-1} *(Tang, 2004; Chan and Lam, 2001)*. For HAC, our previous survey revealed that SWG rate of the hotel in the dry season ranged from 0.05 to 6.07 kg.room^{-1}.day^{-1} *(Giang et al., 2017a)*, while that in the wet season ranged from 0.04 to 7.02 kg.guest^{-1}.day^{-1}, and mostly distributed between 0.8 and 3.33 kg.guest^{-1}.day^{-1}. In brief, the hotel industry in HAC generated averagely 2.28 kg.guest^{-1}.day^{-1} in the rainy season which was higher than waste produced in the dry season (0.6 kg.room^{-1}.day^{-1}) and slightly lower than the median value of SWG from the hotels in the world.

Additionally, the SWG rate from different types of accommodation is not the same *(Edmundo Mufioz, 2015; Pirani and Arafat, 2014)*. *Trung and Kumar (2005)* mentioned that the overall benchmark of SWG rate of high-size hotels in Vietnam was about 13.5 to 32.3 kg.guest^{-1}.day^{-1}, while the SWG rate from mid-scale hotels ranged from 0.7 to 17.9 kg.guest^{-1}.day^{-1}. For HAC, our preliminary survey indicated that in dry season four-stars hotel generated averagely 4 kg.room^{-1}.day^{-1}, and the smaller hotels produced about 0.35 kg.room^{-1}.day^{-1} *(H. M. Giang et al., 2017-a)*. Therefore, the SWG rate from all kinds of hotel in the rainy season was newly identified. In particular, *Figure 3.2* indicated that the interquartile and dispersion ranges of SWG distribution in HSH and MSH groups were wider than other ones, while median and mean of SWG in each group of data were slightly similar. This was explained that the range of capacity of HSH (80 to 217 rooms) and MSH (20 to 80 rooms) were bigger than the others. Hence, the more abundant the accommodation, the larger the interquartile ranges.

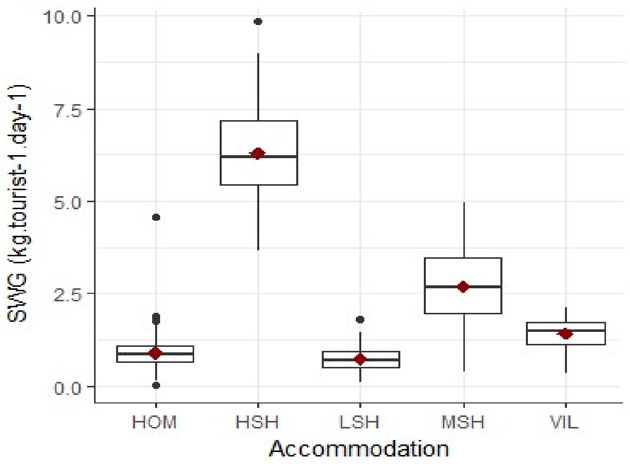


Figure 3.2. Boxplot of SWG rate

Table 3.3. Results of ANOVA analysis

	Df [(1)]	SS [(2)]	MS [(3)]	F [(4)]	P [(5)]
Between groups of hotels	4	2686.7	671.7	1187	2.10^{-16}
Within groups of hotels	681	385.4	0.6		

(1) Degree of freedom; (2) Sum of Square; (3) Mean square; (4) F-value; (5) P-value

Moreover, the box plot in *Figure 3.2* also illustrated that the mean of SWG rate per day of HSH (6.29 $kg.guest^{-1}$) was higher than such of MSH and VIL with 2.69 and 1.34 $kg.tourist^{-1}$, respectively. Also, HOM and LSH generated daily with the SWG rate by 0.88 and 0.74 $kg.guest^{-1}$, respectively. Moreover, the statistically significant differences in SWG rate between these groups of hotels in HAC were confirmed by the results of the ANOVA Test in *Table 3.3*. Notably, P-value was less than 0.05, and the signal was much higher than noises with 1,187 of F-value. The variation of facilities, the level of the hotels, quality and quantity of services may lead to the differences in SWG rates of hotel groups.

Furthermore, the graphical display in *Figure 3.3* showed that 95% family-wise confidence interval in the second row, which was comparing LSH and HOM went from -0.413 of low range to 0.088 of up range and contained 0 (dotted circle). Hence, the means of SWG rates of hotel-groups were all detectable differences from each other except for a pair of LSH and HOM. The similarity in SWG rate of LSH and HOM could be caused by the resemblance in lodging commerce as the individual household businesses.

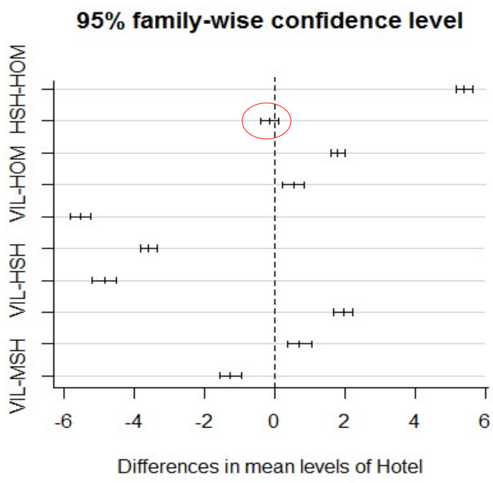
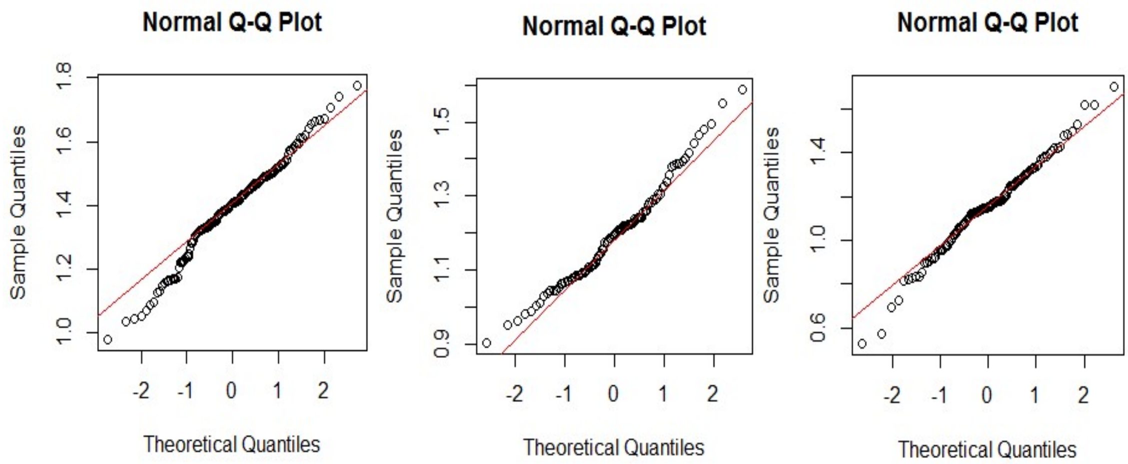


Figure 3.3. The difference in SWG rate of the hotel pairs

For other commercial sectors, the SWG rate was calculated by diving the daily waste amount of a sector to the number of products. The unit of products was identified by a bill for the restaurants, a shop, a stall for the markets, a product for HPF.



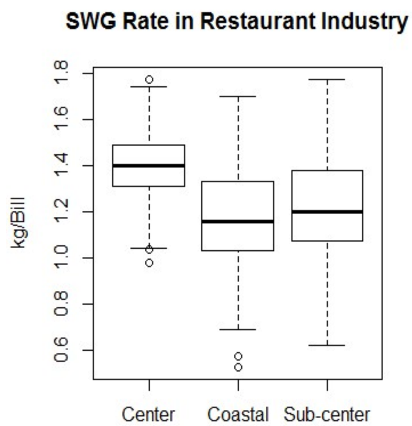
Centre *Sub-Centre* *Coastal*

Figure 3.4. The normal plot of solid waste generation rate distribution in the restaurants

Figure 3.4 showed that the quantiles of empirical SWG rate of restaurants in three areas (scatter plot) follow and close to theoretically ideal normal distribution (red lines).

Notably, the SWG rate quantile of the restaurant in the coastal zone closed to the normal distribution and was light left-skewed (negative skewness coefficient). While the distribution of SWG rate population of restaurants in the centre and sub-centre were light-tailed and right-skewed, respectively. However, the results of Shapiro-Wilk test showed that P-value was higher than 0.05, which meant that although the distribution of their sample quantiles was distinctive, SWG rate distribution from restaurant industry came from the normally distributed population.

(a)

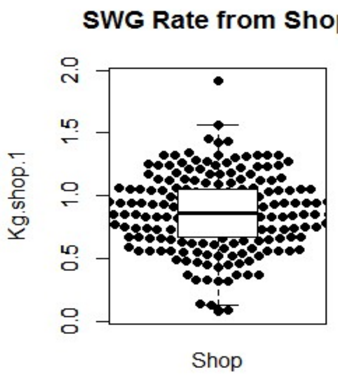


(b)

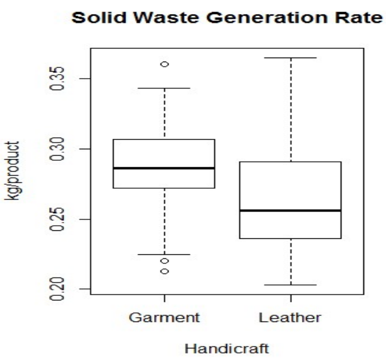
Figure 3.5. Solid waste generation rate of the restaurants

Figure 3.5 (a) indicated that the SWG rate of the restaurant industry in HAC ranged from 0.53 to 1.78 kg per bill, and the average SWG rate was 1.27 kg per bill. Comparing to other countries, SWG rate of the restaurants in HAC was higher than that in Hong Kong (0.751 kg/meal) *(Chan and Lam, 2001)* and lower than such in Phnom Penh, Cambodia (4.83 – 3.36 kg/table) *(Mongtoeun et al. 2014)*. These differences could be explained by the features of restaurants and foods, the culinary culture of the guests, and the SWM effectiveness of the restaurants. Furthermore, *Figure 3.5 (b)* indicates that the SWG rate of restaurants in different areas was diverse. Notably, the mean of SWG rate of restaurants in the centre was higher (1.39 $kg.bill^{-1}$) than that in sub-centre (1.20 $kg.bill^{-1}$) and the coastal area (1.15 $kg.bill^{-1}$). Also, the amount of waste was generated from a restaurant in the centre area (30.9 $kg.day^{-1}$) more than that in the sub-centre (23.9 $kg.day^{-1}$) and coastal areas (22.6 $kg.day^{-1}$). The differences in SWG rate of the restaurant in several areas were proved to be statistically significant due to ANOVA analysis results.

Particularly, P-value was less than 0.05 (<2.10^{-16}), and the signal was much higher than the noises by 81 of F-value. Apart from the reasons mentioned above, the activities in tourism areas could influence business activities, and indirectly influence the SWG of the restaurants. Moreover, the differences in SWG could be caused by the weather. Notably, a survey in August (summer season) indicated that SWG rate of a restaurant ranged from 7.68 to 89.3 kg.day^{-1} and got average SWG rate at 26.18 kg.day^{-1} (Giang et al. 2017a). Whereas, this study showed that the range of restaurant SWG rate was wider from 2.87 to 145.23 kg.day^{-1} and reached at the average SWG rate by 29.28 kg.day^{-1}. Besides, the limited sample size (6 restaurants in the centre and coastal areas) in the summer survey could cause the short range of SWG rate.



(a)



(b)

Figure 3.6. Solid waste generation rate of shops and handicraft production facilities

For shops, *Figure 3.6 (a)* showed that the daily SWG rate of shops in HAC ranged from 0.75 to 1.92 kg.shop^{-1} and got an average SWG rate of 0.86 kg/shop. Comparing to SWG rate of clothing shops in Phnom Penh, Cambodia, the SWG rate of shops in HAC was lower by 0.58 times *(Mongtoeun et al. 2014)*. Generally, shops are a form of a family business and associates with household activity. However, to assess waste generation from commercial activities, shops were collected for sampling in this study completely separated from the family activities. This could be the reason for the differences in SWG rate of shops in HAC and other places. In HPF, garment and leather production, which are the traditional handicrafts of HAC produce and provide products to the shops. The size of these facilities ranges from 7 to 50 workers with capacity from 20 to 100 products per day. The average SWG rate of these facilities was identified by 0.28 kg.product^{-1} for garment production and 0.26 kg.product^{-1} for leather production (*Figure 3.6 (b)*).

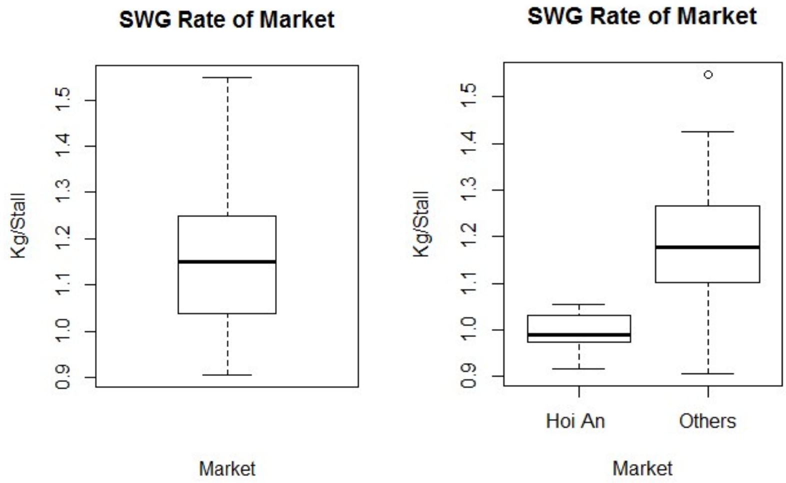


Figure 3.7. Solid waste generation rate of the markets

In term of the market waste, *Figure 3.7* showed that a stall in the markets in HAC could generate from 0.91 to 1.56 kg of waste per day. Also, the average SWG rate was 1.15 kg.stall^{-1}.day^{-1}. The traditional markets in Vietnam are the integrated combination of the various types of business items such as food, butcher, vegetables, garments, mechanic materials, fresh flowers, accessible fashion, dining and beverage stalls. *Matsui et al. (2015)* presented that SWG rate of various stalls was different. Whereby the fresh food and vegetable stalls generated more waste than the shops selling materials and services business. Hence, the difference in SWG rate of Hoi An market and the others could be justified by these reasons. Notably, the average amount of waste generated from a stall in Hoi An market (1.00 kg.day^{-1}) was lower than that in the others (1.19 kg.day^{-1}) (*Figure 3.7*). Hoi An market is the biggest market located in the centre of HAC. Comparing to other markets, the number of garments, speciality products, and souvenir stalls accounts for about 50% of total stalls, primarily serve the shopping activities of tourists. Hence, the SWG rate of the markets could be influenced by the types of business and not dependent on tourism activities.

3.2. Solid waste composition

Figure 3.8 described in detail the waste composition of HAC's hotel industry. Notably, biodegradable waste accounted for the highest percentage of 58.5%, includes kitchen waste (35.5%), garden waste (15.5%) and tissue paper (7.5%). Also, recyclable waste accounted for about one-fourth of total waste which consists 1.2% of metal, 4.2% of cardboard, 12.9% of plastic including plastic bags, 0.8% of PET bottles, 2% of glass and 4.7% of the paper. The other components belong to combustible and incombustible waste have the proportions less than 3.5% for each element.

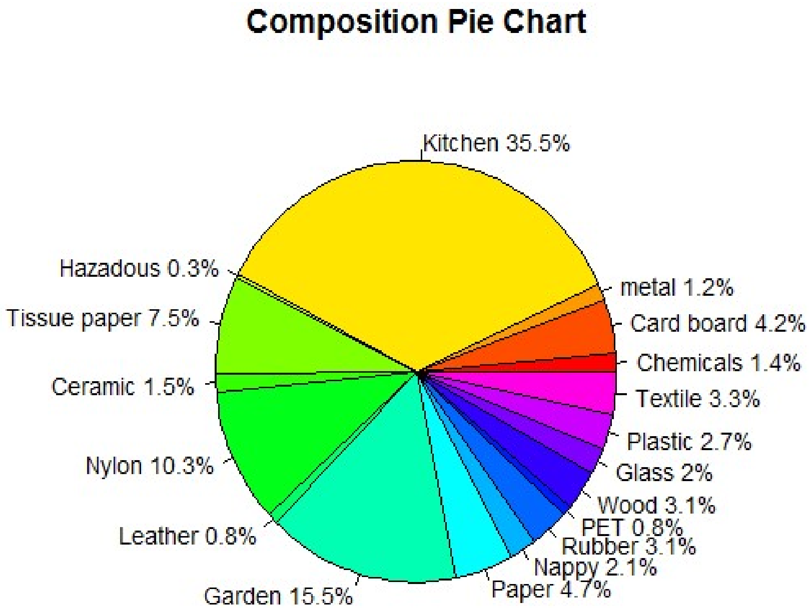


Figure 3.8. SWC of accommodation business

Taking an overview of the hotel's SWC, *Table 3.4* presented that differences in SWC of the hotels were not only influenced by geographical location, economic level, cultural norms and climate but also may be explained by the specification of tourism business. In comparison with other countries in the world, the biodegradable waste of the hotels in HAC was higher than that in developed countries and lower than that in cities of Asia. Also, the hotel business in developed countries has a higher rate of recycling waste for two times. Whereas comparing to SWC in the lodging business in Vietnam, the differences in components of waste were relative. These differences could be caused by regional tourism characteristics as a type of guest or the culinary.

Table 3.4. Comparison of SWC in HAC and other cities

Main categories	Vietnam				Asia		Developed countries [6]
	HLC [1]	DNC [2]	HAC [3]	HAC	PPC [4]	NDC [5]	
Oganic waste (%)	64.3	62.8	56.2	58.5	61.2 - 70	61.2	37 – 46
Recycling waste (%)	5.7	23.7	33.4	25.8	22.64 - 28.33	3.8	43.7 – 54.4

HLC: Ha Long City, DNC: Da Nang City, PPC: Phnom Penh City, NDC: New Delhi City, [1]: (Byer et al., 2006), [2]: (Otoma et al., 2013), [3]: (Giang et al., 2017a), [4]: (Mongtoeun et al., 2014), [5]: (Omidiani and S. Mohsen, 2016), [6]: (Pirani and Arafat, 2014).

Moreover, this study also revealed that in the wet season, the proportions of garden waste and recycling waste of the hotels in HAC were higher and kitchen waste was lower than that in the dry season *(Giang et al., 2017a)*. HAC's hotel industry achieved on average 95% of occupancy capacity in two tourism seasons, in which international guest accounted for 82% in the wet season and 38% in the dry season. The differences in the living culture, foods, and enjoyment of services of the guest may be explained that the more the number of the foreign guest, the higher the rate of recycling waste and the less the proportion of food waste. Consequently, in addition to climate, the variety of arrivals and tourism activities by seasonality could be the reasons for these differences in SWC.

Furthermore, *Table 3.5* indicated that SWC of five groups of hotels were not the same. The majority of HSH, MSH, and VIL are located in rural and suburban areas, have a substantial green area. Besides, the higher the scale of hotels, the more the services. Consequently, the differences in organic waste and recyclable waste could be caused by the features of the hotels as facilities and services. Whereby, the bigger hotels, the higher proportion of biodegradable waste and the less recycling waste percentages. These characterisations of the waste composition of the hotel industry in HAC may be considered for minimising SWG by suitable composting and recycling practice.

Table 3.5. Waste composition of 5 groups of hotels in HAC

N^0	Categories (%)	HSH	MSH	LSH	VIL	HOM
1	Paper	3.02	3.7	9.51	2.41	5.8

2	Cardboard	0.64	6.51	1.68	3.3	6.75
3	Kitchen + Food	33.97	44.04	36.82	37.35	24.43
4	Garden	27.7	13.78	0.69	12.97	13.7
5	Tissue paper	6.91	7.24	5.26	6.45	8.47
6	Plastic	8.32	12.95	14.92	17.13	19.79
7	Combustible	14.95	6.41	27.23	14.85	15.26
8	metal	0.24	2.05	0.64	2.41	1.4
9	Glass	0.95	1.96	2.75	2.54	2.62
10	Ceramic	3.24	0.98	0.11	0.43	1.27
11	Hazardous	0.06	0.38	0.39	0.16	0.51

For other commercial tourism businesses, *Figure 3.9* indicated that biodegradable waste accounted for 66.8% of total waste, in which the percentage of food waste, garden or vegetable waste, and tissue were 45.0%, 10.1%, and 11.7%, respectively. Besides, recycling waste is also a significant component by 20.1% of total waste, mainly consists plastics (9.4%), papers (5.6%), metals (1.1%), and glass (3.3%). The rest of the commercial waste included combustible waste, incombustible waste, and hazardous waste with a percentage of 11.3%, 1.8%, and 1.4%, respectively. This results revealed that the high rate of biodegradable and recyclable waste could be the features of commercial waste in a tourism city. The commercial waste composition also entirely suitable for current treatment plants in HAC. Furthermore, the development of recycling and home-composting for commercial sectors should be considered to study as the optimal solutions for minimising waste generation at source, reducing waste to the landfill and improving the quality of waste to the incinerator.

The composition of each commercial business was reported in detail in *Table 3.6*. The characteristic of the waste in the food industry was revealed with the high rate of the biodegradable waste by three-fourths of total waste. Whereby, kitchen waste was the primary component with the highest percentage (47.5%), followed by tissue paper (15.3%) and garden waste (13.1%). Besides, recyclables, which accounted for 18% of total waste consisted cardboard (1.2%), glass (4.3%), paper (2.8%), nylon (7.1%), plastic (1.5%) and metal (1.1%). *(Mongtoeun et al., 2014)* indicated that organic waste of the restaurant business in Phnom Penh city, Cambodia ranged from 63.12% to 73.13%, also recycling waste ranged from 21% to 33.25%. In general, SWC of the restaurant industry in the tourist city in developing countries as Vietnam and Cambodia was quite similar.

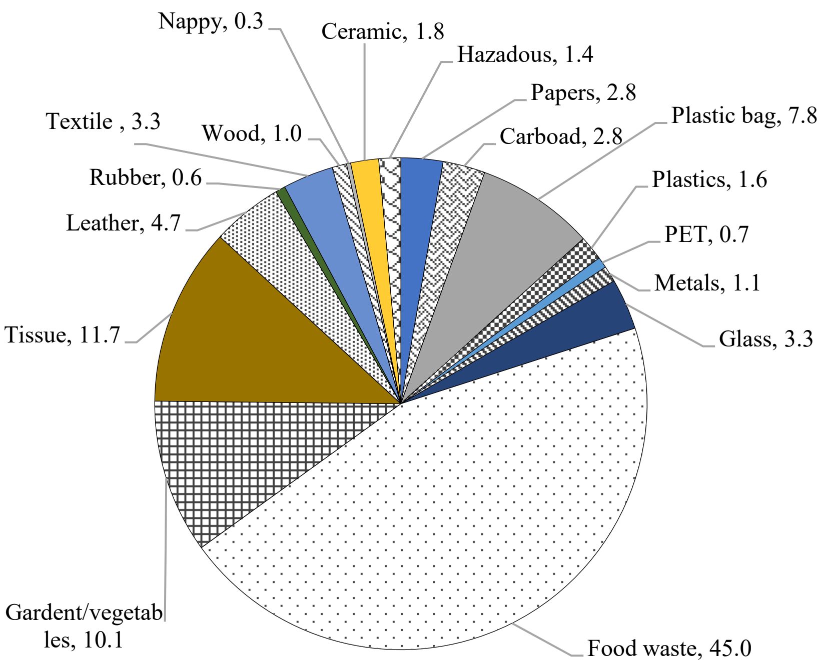


Figure 3.9. The composition of commercial waste (unit: %)

In Hoi An, the composition of the restaurant waste in various areas was slightly different. Table 3.8 showed that the biodegradable waste proportion of restaurants in the centre (79.9%) was higher than that in sub-centre (77.3%) and coastal area (71.1%). Meanwhile, the percentage of recycling materials of these groups of restaurants was inversely proportional to the rate of biodegradables. These differences in the area, garden, food, types of guest, and the number of the bills sold per day could be justified the dissimilarity of the waste composition of the restaurants in HAC.

For the market waste, biodegradable waste, cardboard, and plastic bag were three primary components by 41%, 24%, and 14% of total waste, respectively. A previous study on the solid waste of markets in Hue city (Vietnam) revealed that biodegradable waste, plastic, and paper waste were the principal components *(Matsui et al., 2015)*. Furthermore, this study presented the differences in waste composition in the tourism market and the traditional market. Whereby tourism activities could be a reason for the multi-component of market waste *(Table 3.6)*. Comparing to waste composition of traditional markets, Hoi An market had higher percentages of cardboard, leather and textile, and the lower proportion of biodegradable waste. The abundance of types of the stalls, especially garment, souvenirs and speciality food businesses could create more cardboard, leather or textile which accounted for the significant proportions in the waste of tourism market.

Table 3.6. The waste composition of commercial businesses in Hoi An City

The waste composition of commercial sectors (%)								
Categories	Restaurants			Markets		Shops	Handicraft Production Facilities	
	CEN	SUB-CEN	Coastal	Hoi An market	Others		Garment	Leather
Papers	2.8	2.9	2.5	3.3	2.2	4.3	4.2	0.4
Cardboard	1.4	1.4	0.6	**23.7**	**11.0**	0.9	0.3	-
Plastic bag	**4.9**	**8.8**	**7.4**	13.8	12.0	**11.6**	**13.1**	0.5
Plastics	2.0	1.1	1.5	1.2	2.3	**6.8**	3.6	0.9
PET	1.2	0.6	0.5	0.5	1.0	1.5	0.2	-
Metals	1.3	1.0	1.1	1.0	-	1.4	1.8	0.3
Glass	2.1	4.6	6.5	1.3	-	0.3	0.9	-
Food waste	**58.4**	**37.1**	**48.1**	**11.1**	**29.6**	**56.8**	**38.0**	0.9
Garden/vegetables	**-**	**27.9**	**9.5**	**34.4**	**40.0**	1.2	1.7	-
Tissue	**21.5**	**6.1**	**19.7**	0.8	-	1.6	3.1	-
Leather	0.3	-	-	**2.7**	**-**	0.3	-	**81.0**
Rubber	0.1	1.4	0.3	0.3	0.0	1.0	0.7	1.4
Textile	0.7	0.5	1.0	**3.7**	**1.7**	**7.1**	**27.1**	**13.6**
Wood	1.8	1.4	0.3	0.3	0.2	0.4	0.1	0.6
Nappy	0.3	0.7	0.3	0.1	-	0.2	0.1	-
Ceramic	0.4	4.4	0.2	1.0	0.0	4.0	4.2	-
Hazardous	0.8	0.1	0.5	0.8	0.0	0.6	1.0	0.3
Total	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Intern of the waste composition of shops, food waste, plastical materials, and textile accounted for 82.3% of total waste. These components were mainly generated from the dining activities by using the available food of the salesman, which was the primary source of shop waste. Besides, a significant percentage of textile was the feature of the tailor shop waste. These components were also found in a study in Phnom Penh, Cambodia with the percentages by 51.2% for food waste and 21.86% for the plastic bag *(Mongtoeun et al., 2014)*. In addition, there was a slight similarity to the shop waste, 81.8 % of total waste from garment production facilities was food waste, plastic materials, and textile, in which textile accounted for 27.1% of total waste. Food waste and plastic materials generated from the side meals of workers. In contrast to the waste composition of garment production, leather was the main component of leather production facilities with the highest proportion of 81.0%, following by textile of 13.6%. In summary, the high percentage of textile and leather were the waste features of garment and leather productions, while biodegradable waste and plastic materials were the main waste components from shops and garment production.

3.3. Solid waste characterisation

The waste composition could cause the differences in waste characterisations, namely the density, the moisture content, and HHV of waste. *Table 3.7* revealed that the density (D) and moisture of waste of the restaurants and markets were significantly higher than that of shops and HPF. Specifically, the density and moisture of the restaurant waste in the centre and sub-centre areas were higher than such in the coastal area. Also, waste of the traditional markets had a higher density and moisture than that of Hoi An market. Looking back to the waste composition of commercial sectors, these differences in the density and moisture of waste could be explained by the rate of biodegradable waste. Also, this was the explanation of the low density and moisture of waste from shops and handicraft production facilities. Otherwise, the HHV of waste from leather and garment productions, shops, markets, and restaurants decreased in order. The dissimilarity of HHV was explained that the lower percentage of biodegradable waste, the lower of the moisture, and the higher proportion of combustible waste, the higher of HHV value. The high rate of biodegradable waste and the high moisture content of waste were the favourable conditions for composing. Also, the high heating value and the low moisture content of waste was the ideal conditions for incineration. However, separation waste to optimise the efficiency of waste treatment solutions was the significant challenge of

SWM, also the critical factor of SWM development towards sustainability in developing countries.

Table 3.7. Waste characterisations of commercial sectors

Characterisation	Restaurants			Markets		Shops	HPF	
	Center	Sub-center	Coastal	HA Market	Others		Garment	Leather
D (kg/m^3)	255	252	204	215	239	117	92	132
Moisture (%)	59.9	64.5	57.7	58.6	61.3	48.8	32.3	22.2
HHV (kJ/kg)	14,453	13,966	14,284	15,131	15,054	15,889	17,546	18,686

In brief, SWG of the commercial industry in HAC was estimated around 24,562 tons per day, accounted for 35.1% of total municipal waste. Whereby, solid waste generated from restaurants with the highest rate by 74.5%, following by 11.4% from HPF, 10.2% from markets, and 3.9% from shops. Also, waste composition and characterisations of commercial businesses were analysed and compared to clarify the features of waste in each type of business. This study showed that commercial waste has the potential for recycling due to the high percentage of biodegradable waste (66.8%) and recyclable materials (20.1%). Furthermore, waste characterisation provided favourable information about the moisture and HHV of waste aim to improve the efficiency of thermal treatment in HAC. Also, the concentration of carbon (C) and nitrogen (N) in a biodegradable waste of the restaurant was around 41% and 1.5%, respectively, and carbon to nitrogen ratio ranged from 26.9 to 28.3. These chemical data were proved that biodegradable waste of restaurants was favourable for developing home composting systems.

After all, inefficient management of SWM could significantly impact on both environment and economic *(Abila and Kantola, 2017)*. For HAC, to become an eco-tourism city, environmental issues, especially SWM, should be improved and maintained toward sustainability. Although waste separation at source was implemented in the city from 2012, the effectiveness of separation was still low. In the context of increasing the municipal waste due to tourist activities, the current waste separation program which had lack of consideration for incentive regulation for waste separation in tourist sources could be a cause of low separation efficiency. Notably, *Song Toan et al., (2018a)* revealed that the commercial sectors lack knowledge and skills of waste separation. No punishment is applied for the hotels without separating waste. Also, the hotels said that they do not like implement separation waste because of no motivation, support and encouragement from the government.

Furthermore, the recycling program and system of HAC is still simple. Recycling activities have not encouraged, and the regulation has not promulgation *(Song Toan et al., 2018c)*. Thus, the effectiveness of SWM at tourist sources should be considered as a wedge to study to minimise waste to the landfill, reducing environmental impacts, and optimising the operating cost of the waste management system. According to the generation rate and composition of solid waste from commercial sectors, some suggestions were given to improve waste management in HAC. Firstly, the effectiveness in waste segregation at tourist sources should be enhanced by combining between encouragement, support and regulation. Notably, the indicators in source separation such as the amount of waste component, recycling percentages, container types, collection frequencies, waste collection rate and tipping fee should be studied in a holistic combination *(Suomi et al., 2017)*. Furthermore, application of the home-composting model for restaurants with garden, especially restaurant in sub-centre and coastal areas should be planned and implemented to minimise waste generation, reduce the odour, and decrease the pathogenicity. Besides, improving the efficiency of the recycling system should be studied and expanded to create more benefits from recycling system to society and environment. Finally, waste regulation should be considered and promulgated by the government. The cooperation between the government, communities, business sectors and stakeholders should be established and more cohesive to support residents, hoteliers, restaurants to implement solid waste practices.

3.4. Solid waste management practice

SWM practices are the fundamentals of SWM hierarchy *(Cummings, 1992)*. *Figure 3.9* illustrated the situation of SWM practices of the hotels in HAC with four activities such as segregation, reduction, recycling and composting. In particular, waste separation at source, which conducted from 2012 had the highest practice rate with 76%. However, the proportions of waste sorting practice in the hotels were different with 100% for HSH, 87% for MSH, 83% for VIL, 36% for LSH and 21% for HOM (*Figure 3.9*). These data indicated that the higher the scale of the hotels, the higher the proportion of waste sorting practice. Additionally, this study also revealed that the waste sorting efficiencies were proportional to the percentages of waste sorting practice by 64.6% for HSH, 37.3% for MSH, 33.4% for VIL, 7.7% for HOM and 6.9% for LSH.

According to the waste sorting guideline of HAC, kitchen waste, garden waste and paper are the components of organic waste, which accounted for 58.5% of total waste. The rest of the waste is the inorganic waste. In general, most of the waste categories were sorted into the correct trash with the efficiency ranged from 34.7% to 93%. Specifically, the separation efficiency of the chemical residue was the highest (93%), followed by glass (77.5%), textile (77.0%), metal (74.8%), PET bottle and garden waste (72.2%), which were a mainly recyclable waste. This was the advantages of improving recycling practice in the hotels. In contrast, 73.1% of tissue paper and 73.9% of paper were detected in the inorganic trash, while wood, ceramic waste, and rubber had sorting efficiencies of - 93.2 %, -47.0% of - 25.8 %, respectively. These misclassifications were the obstacles to recycling practice and treatment. Thus, training separation skills for the hoteliers is one of the solutions should be considered.

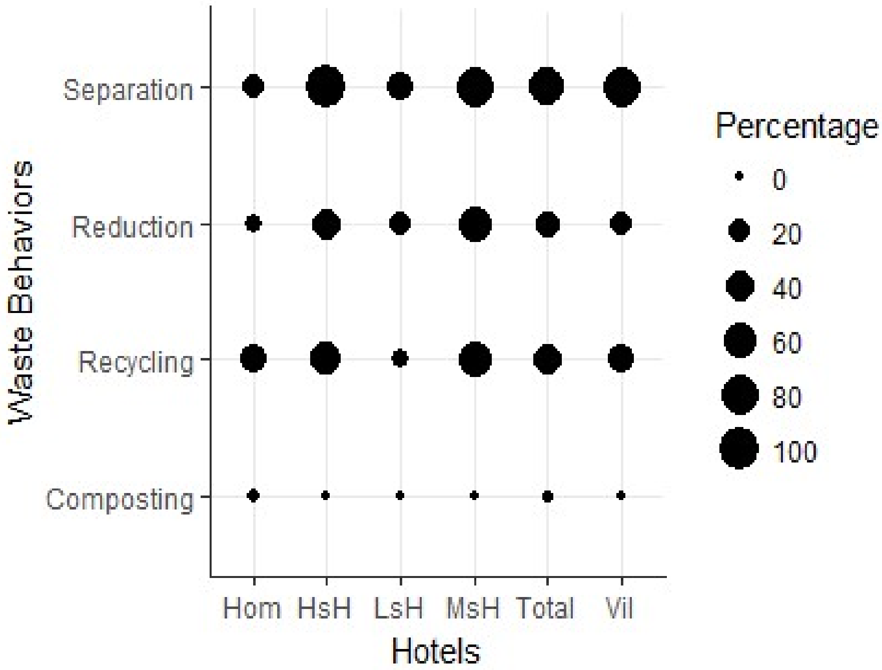


Figure 3.9. The status of WMPs

The restriction of waste sorting practice and efficiency in the hotel industry in HAC could be caused by some specific barriers. Notably, 65% of the hoteliers misunderstood the way of sorting waste by composition led to the misclassification of waste. Besides, most of LSH and HOM said that segregation for a small amount of waste is unnecessary and do not affect to sorting efficiency of the city. In fact, the daily waste of these sectors was wrapped in a small plastic bag and directly dumped to the trucks. Consequently, the proportions of waste sorting practice of LSH (6.9%) and HOM (7.7%) were low. Moreover, the inappropriate collection system and the odours from the waste storing (especially hotels with no garden or negligible garden) were the significant barriers to sorting waste.

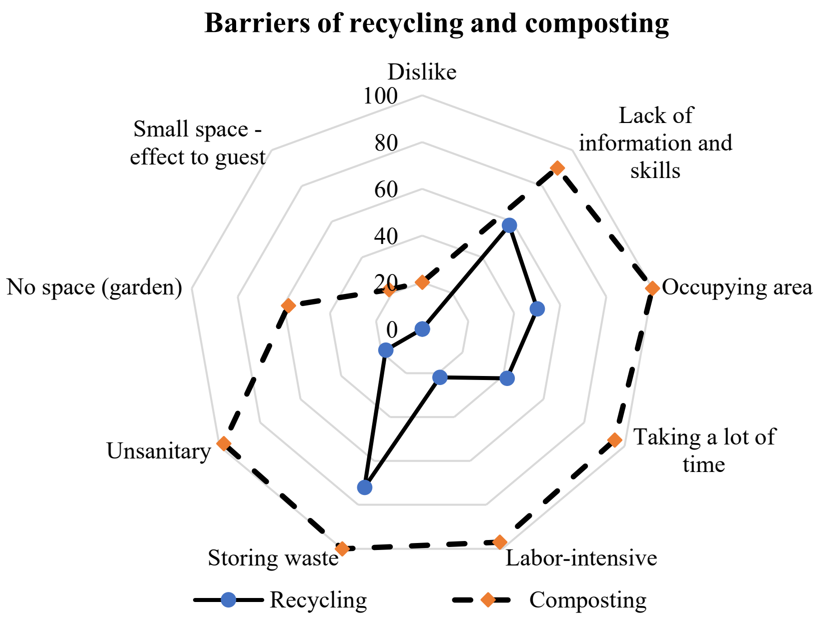


Figure 3.10. Barriers to recycling and composting practices

Also, waste recycling and reduction are the momentous solutions of the waste management hierarchy and bring many benefits to business sectors and society *(Milanez et al., 2015)*. However, the proportions of the hotels in HAC implemented waste recycling and reduction were still low with 39% and 29%, respectively. This study indicated that 60% of MSH and 53% of HSH deployed recycling, followed by VIL (33%) and HOM (30%). The lowest percentage of recycling practice belonged to LSH (7%). Furthermore, waste reduction practice of HAC's hotels was responded by 50% of MSH and HSH, around 10% to 20% of the hotels in LSH, VIL, and HOM. Although the majority of hoteliers understood the social and environmental roles (62% of hoteliers) and economic benefits (83% of hoteliers) of recycling, the rate of recycling practice was still low. This could be explained by 37% of the hoteliers did not care about income from selling recycling materials, especially family businesses as LSH, HOM, and VIL. Moreover, the unfavorability from recycling which shown in *Figure 3.10* against recycling practice at the hotels. Notably, 72% of hoteliers said that they disliked storing waste in their hotels, while 58% of the hotels thought that they lacked information and skills of recycling. Moreover, a part of hotel's managers explained that recycling practice occupied the significant area (50%), took more time and labours (42 and 22%) and was unsanitary (18%). These obstacles may be due to the unspecific recycling plans, the unconvinced recycling motivations of the hoteliers, and unclear recycling instructions from the government.

The composting, the organic waste recycling solutions, is a process of sorting, storing and biological treatment of the organic waste for a long time. In HAC, composting in place did not get the consensus from hoteliers (0.8% of the hoteliers) and was justified by unfavorability of implementation of composting. Notably, the majority of the hoteliers said that they could not implement composting because of the lack of skills and information (90%). Also, significant occupancy of the area (100%), loss of time (95%), labour-intensiveness (97%), indisposition of waste storing (99%) and unsanitariness (98%) are shown in *Figure 3.10* were the main reasons why they refused to do composting at their hotels.

In general, SWG from the hotel industry, which accounted for about 22% of total waste is a significant waste source in HAC. Moreover, with the rapid development of arrivals and tourism business, SWM of accommodation business is playing an essential role in sustainable municipal SWM. Thus, minimising SWG from the hotels should be studied to contribute to reducing waste generation for the city. According to the 07/2016/QĐ-UBND regulation of waste collection fee for accommodation businesses of Quang Nam province, VIL and HOM pay the lower fee as a household has a business than that for LSH, MSH, and HSH *(Quang Nam Province, 2016)*. Whereas, the SWG rate of VIL was higher than such of HOM and LSH. Therefore, this study provides information for decision-makers to consider adjusting the appropriate tipping fee for the hotels. Also, with the high proportion of biodegradable waste (58%), especially in HSH, MSH, and VIL, composting in the hotels is a potential solution should be studied and encouraged to reduce waste generation. Besides, regulation and other integrated solutions for enhancing waste sorting rate and efficiency in small hotels, HOM and VIL should be considered to promulgate by the government. Simultaneously, the cost-benefit analysis for recycling practice should be studied to promote the recycling motivation of the hotels. Furthermore, support and incentive policies, as well as recognition as a “Green Hotel Certification” by the government may bring positive impacts to the development of sustainable SWMPs for the hotel industry in HAC.

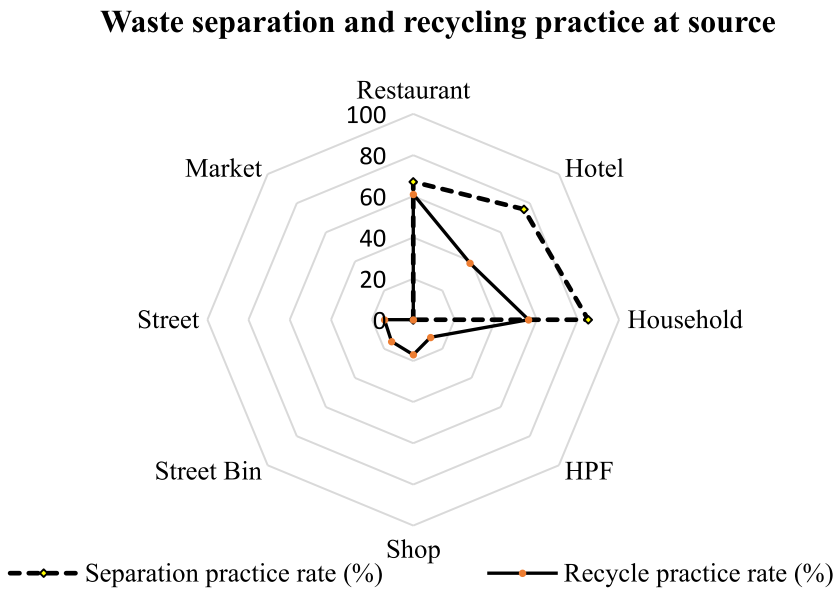


Figure 3.11. Waste separation and recycling practice rates.

In HAC, waste separation practice has been promoted since 2012 and obtained some positive results with about 24% of recyclable materials recovered from MSW *(Song Toan et al. 2018a)*. However, the SWM practice at source in the TA is struggling to find suitable solutions. *Figure 3.11* reveals that SWM practice in the TA is implemented mainly by three sectors, such as restaurants, hotels, and households. In this area, waste separation and recycling seem to go hand in hand. Notably, the rates of waste separation and recycling are 67% and 61% for the restaurant business, 76% and 39% for the hotel industry, and 85% and 56% for households, respectively. Other business sectors unwillingly implement waste separation at source and justify that by no need of separation of small waste amounts, no space for storing waste, and lack of facilities.

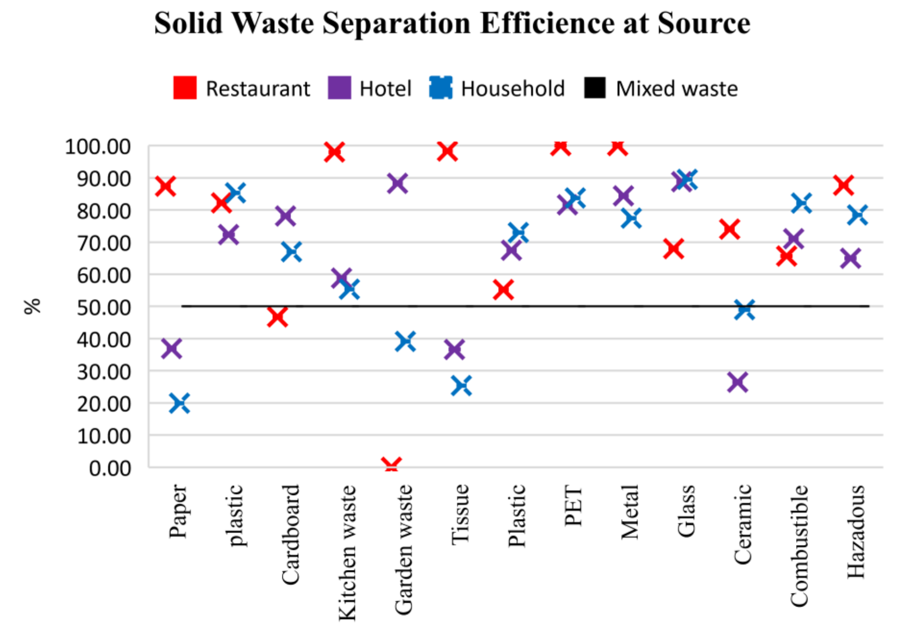


Figure 3.12. Efficient waste separation at sources.

For restaurants, hotels, and households, solid waste separation efficiency by waste categories is presented in *Figure 3.12*, where the majority of waste items are sorted correctly with the efficiency ranging from 60% to 90%, while paper, garden waste, tissue, and ceramic waste are typically misclassified (<50%). Misclassification is caused by a lack of knowledge, information, and general waste separation training. Low efficiency of waste separation belongs to plastic (55.21%), glass (68.00%), and combustible waste (65.69%) for restaurants, kitchen waste (58.78%), plastic (67.42%), and hazardous waste (65.02%) for hotels, and cardboard (67.00%), and kitchen waste (55.33%) for households.

3.5. The current problems and challenges of tourism waste management practice

3.5.1. Solid waste generation and its challenges

The SWG rate from eight sources in TA is presented above, where a general household generated approximately 1.111 $kg.day^{-1}$ that is equivalent to 0.223 $kg.capita^{-1}.day^{-1}$. There is a significant difference in the SWG rate between distinct areas in HAC. Notably, the average SWG rate in TA is 0.203 $kg.capita^{-1}.day^{-1}$, which is higher than that of the rural area (0.120 $kg.capita^{-1}.day^{-1}$) and lower than that of the suburban area (0.264 $kg.capita^{-1}.day^{-1}$). Also, the SWG rate of households with businesses is proved to be more than that of households without businesses *(Giang et al. 2017b)*. Besides, the mean SWG rate of the food business is around 30.9 $kg.restaurant^{-1}$ due to the substantial indifference in the size of restaurants in the TA. Whereas for the hospitality sector, the SWG rate is proportional to the size of a hotel. Notably, the larger a hotel, the higher the SWG rate is. For the TA, food industry, accommodations business, and households contribute 46%, 22% and 13% of waste, respectively.

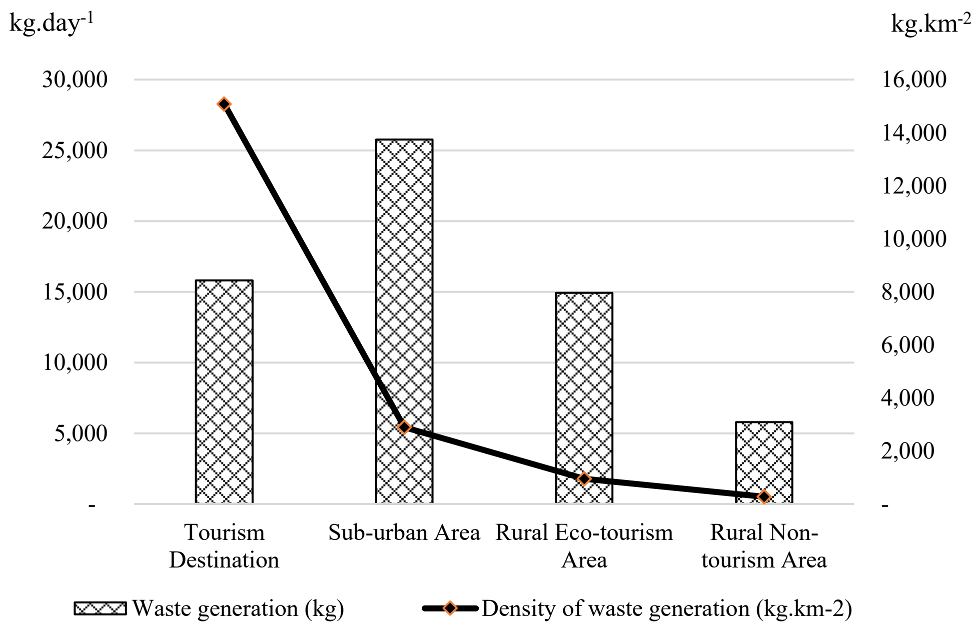


Figure 3.13. Waste density in various areas in Hoi An City.

Additionally, trading activities in the souvenir shops, Hoi An market, and clothing stores generated about 2.377 $tons.day^{-1}$ of waste that is equivalent to 16% of the total waste amount of the TA. Notably, the daily SWG rate of souvenir shops is around 0.86 $kg.shop^{-1}$ and is generated by the activities of staffs members without living there. Typically, one to two sellers occupy the shop; hence, the amount of waste from souvenir shops is not high. Besides, clothing stores produced daily around 20.02 $kg.store^{-1}$. In general, these clothing stores are associated with family and garment manufacturing activities and respond to the shopping demands of the customers in a short time. At the riverbank, where the trading port was formerly located, a busy market (Hoi An market) is now situated. About 1000 stalls are subdivided into four areas, such as civil stores, dining area, food stores, and garment stores. Hoi An market also serves as a tourist shopping centre. The average SWG rate of a stall is 0.995 kg.day^{-1}. Lastly, waste generated from public areas (i.e., streets, street bins) accounts for 3% of the total municipal waste of TA. Notably, visitors produce around 0.066 kg of waste per day as calculated from street bins, whereas, street waste density is about 1.677 kg per 100m.

Table 3.8. Comparison of waste generation density between tourism destinations.

Tourist Destination	**The density of waste generation (t.km^{-2}.day^{-1})**	**Refereces**
Chernivtsi, Ukraine	0.063	*(Murava and Korobeinykova, 2016)*
Zakarpattia, Ukraine	0.050	
Lviv, Ukraine	0.060	
Ivano-Frankivsk, Ukraine	0.043	
Mallorca, Spain	0.406	*(Ezeah et al., 2015)*
Mexican Caribbean, Mexico	0.037	*(Von Bertrab et al., 2009)*
Mediterranean, Spain	0.385	*(Mateu-Sbert et al., 2013)*
Green Island, Taiwan	0.578	*(Chen et al., 2005)*
Hoi An, Vietnam	**1.489**	
TA in Hoi An, Vietnam	**15.08**	

With a high population density of 9,090 people.km^{-2} and concentration and abundance of tourism trading activities in the downtown area, a large amount of waste generated daily from the TA is inevitable. It puts high pressure on the Vietnamese government. *Figure 3.13* indicates that the density of waste generation in the TA is the highest (15.08 tons.km^{-2}). It is 5, 16 and 56 times higher than that of the suburban area, rural eco-tourism area, and rural non-tourism area of HAC, respectively. In comparison the density of waste generation in the TAs in Ukraine, Spain, Mexico, and Taiwan range from 0.154 to 0.578 tons.km^{-2}.day and is lower than that in HAC, Vietnam (*Table 3.8*). The difference in the SWG rate of TAs may be justified by many reasons including disparity of social and tourism features, indigenous cultural characteristics, tourism structure, the effectiveness of the SWM system, and awareness of local communities. For HAC, a large amount of waste generated daily in a small area of the TA in downtown proves to be a significant challenge to the SWM system.

3.5.2. Solid waste characterisation and its challenges

Waste characterisation from eight sources is illustrated in *Figure 3.14*, where, kitchen waste is the primary waste component and its proportion ranges from 35.5 to 58.38% for most of the sources, except for the street waste (8.89%) and tourist waste (10.44%). This may be the cause of a significant proportion of kitchen waste (46.80%) in the total municipal waste of the TA. In comparison to suburban and rural areas, the rate of kitchen waste in the TA is higher by 1.3 times. Also, one of the waste composition features in the TA is the high percentage of tissue waste (11.54%) that is produced by the dining and hospitality industries.

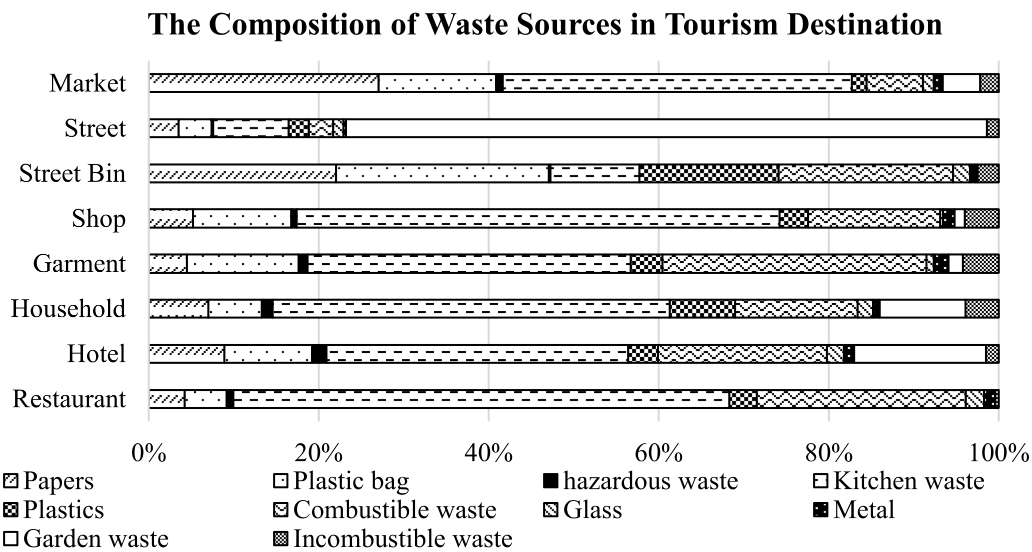


Figure 3.14. Comparison of the waste composition by sources in the tourism destination.

Additionally, the proportion of recyclable waste accounts for 12.85% of TA waste. Notably, tourist and market waste has a high percentage of recyclable materials in it with 39.11% and 22.34%, respectively, followed by the hotel waste, household waste, waste from clothing stores and shops with the proportion of recyclable waste around 11%. A high proportion of recyclable waste in the TA shows that collecting market value material for recycling has not yet attracted the attention of enterprises and the government. It can be also noted that the TA waste has a high recycling potential.

The moisture content of solid waste in sources ranges from 42.1% to 47.0%, except for the restaurant waste with 50.4% and street bin waste with 31.3%. Likewise, the density of waste in the TA ranges from 0.115 to 0.139 $ton.m^{-3}$, whereas the restaurant, household, and hotel waste have higher densities of 0.232, 0.204 and 0.198 $ton.m^{-3}$, respectively. Furthermore, the difference in physical waste components may be caused by dissimilarity in chemical components (i.e., C, H, N) that are the critical factors for HHV. Comparison of waste characteristics from the TA in Crete to the TA in HAC shows that the MSW composition in HAC has a higher proportion of organic waste (30.1% and 40.6%, respectively) and a lower rate of recyclables (36% and 48%, respectively). Consequently, the moisture content is higher than that in other TAs (30.1% and 40.8%, respectively) (Gidarakos et al. 2006). Whereas, in a tourist region of Malaysia, Langkawi, the rate of the waste composition is similar to that in the TA of HAC *(Shamshiry et al. 2011).*

Composition and characteristics of MSW in the TA indicate the challenges that the government is facing and a necessity to establish a waste management system in the future. Elevated rates of biodegradable waste (67.02%) with high moisture (54.2% – 61.8%) cause unpleasant odours and leachate during storage, collection, and transportation of waste in the TA, which has a negative effect on tourism and landscape. Also, these components may be the cause of high moisture content in MSW of the TA (46.79%) and low HHV (16.866 $kJ.kg^{-1}$). Both of these parameters are unfavourable to incineration. However, physical and chemical waste characterisation in the TA indicates the advantages of solid waste in the system. Firstly, a significant proportion of recyclable waste (14.68%) reveals the potential for waste reduction by enhancing recycling practices. Secondly, high moisture content and a suitable concentration of C and N in biodegradable waste create suitable conditions for composting or anaerobic digestion *(Dinh et al. 2018; Pham Van et al. 2018)*. Since low moisture and high HHV are favourable for incineration, they may be achieved by separation practices, collection, transportation, and disposals systems that are synchronised and implemented efficiently.

3.5.3. SWM practice at the source and its challenges

Although the SWM practices are known to be critical on route to sustainability, optimisation in the SWM practice has never been easy. Therefore, the status of the SWM practice in the TA may present significant challenges. The first challenge is to enhance waste separation rate and efficiency. Waste separation practices have not yet been efficient for the resident and business sectors in the TA due to the inconvenience of keeping organic waste in a small business area. To prevent odours and contamination in a small catering business area, a substantial daily amount of waste is likely to be thrown away. This challenge is difficult to combat with collection services. Secondly, recycling practices may face some obstacles. Although the proportion of recyclable materials is high (14.68%) and the benefits of recycling are undeniable, the recycling rate in the TA is only around 50%. Barriers to the recycling practice are presented by the lack of space for storing recycling materials, lack of care for a negligible income from selling the recycling materials, and lack of itinerant buyers that might enter the TA. Also, the restaurant owners explain that the trading activities of recyclable materials affect their business so that the recyclable materials are usually dumped into the garbage or are given to collection crews for free. Lastly, while the household composting practice is considered an unsuitable solution for a crowded and confined urban area, waste minimisation by reducing and reusing practices also present significant challenges for the SWM. As for the business sector where its profitability is the primary concern, things that negatively affect business operations are rejected. Therefore, improvement of awareness and implementation of the 3R program presents a substantial challenge.

The SWM practice in the TA of the developing countries also faces many difficulties and challenges. Notably, waste separation at source in Carpathian destination in Ukraine was never implemented as it did not get approved by the commercial sector. Consequently, waste recycling practice and disposals encountered many disadvantages *(Murava and Korobeinykova 2016)*. The SWM practice in the TAs of developed countries is more efficient due to a stable and efficient SWM system. For example, on the Spanish island of Mallorca, a door-to-door waste source segregation system was implemented and allowed for recycling> 75% of waste. Furthermore, on Tenerife, one of Europe's most popular tourist destinations, solid waste was sorted at source strictly for recycling and composting. The waste residues are landfilled unsanitary conditions *(Ezeah et al. 2015)*.

Although the reality shows some difficulties in the implementation of the waste management practice in the TA of HAC, there are some highlights from the SWM practice intentions. The results of the questionnaire survey indicated that most of the business sectors are willing to cooperate with the government to protect the environment in the TA by finding suitable solutions for the SWM. Additionally, waste sorting practice may be improved if waste is collected daily by separate trucks or carts. Businesses are willing to sort recyclable waste for recycling if it is collected every day by a specialised collection route. Moreover, street bins for separate waste collection can be introduced since 95% of tourists are willing to pay an environmental fee included in the plane ticket price to protect the TA environment. Thus, suitable solutions to manage solid waste in the TA can be found based on local features, the demand of business sectors, and the effectiveness of the SWM system.

3.5.4. The solid waste collection system and its challenges

The daily solid waste collection system in the TA is illustrated by the timed waste collection flow (*Figure 3.15*) and the waste flow (*Figure 3.15*), in which solid waste from eight sources is mainly collected by carts and trucks. According to the waste collection regulations, mixed waste from street bins and the streets themselves is collected two times per day by blue and green-yellow carts, respectively. Market waste is collected daily by a mixed truck by the end of the afternoon. The remaining waste is collected separately based on the segregation practice at source. Biodegradable and nonbiodegradable waste are collected alternatively four and three times per week by trucks from 6:30 AM, respectively.

Figure 3.16 reveals that separated trucks moved approximately 4.490 tons/day of biodegradable waste and 4.067 $ton.day^{-1}$ of non-biodegradable waste to the same gathering point. It may be explained by the low rate of waste sorting at source. Likewise, mixed waste from carts and markets is also transferred to the gathering point at the disposal area. This signifies waste segregation at source and a rotating collection system have no value.

Meanwhile, the recyclable waste is saved by the collection crews on the collection route with the rate of 3 - 4% for carts and 2 - 3% for trucks. This recyclable waste is then moved to the junk shops for selling. The financial benefit from selling recyclable materials belongs to the collection crews and signified a “spoil” on that working day.

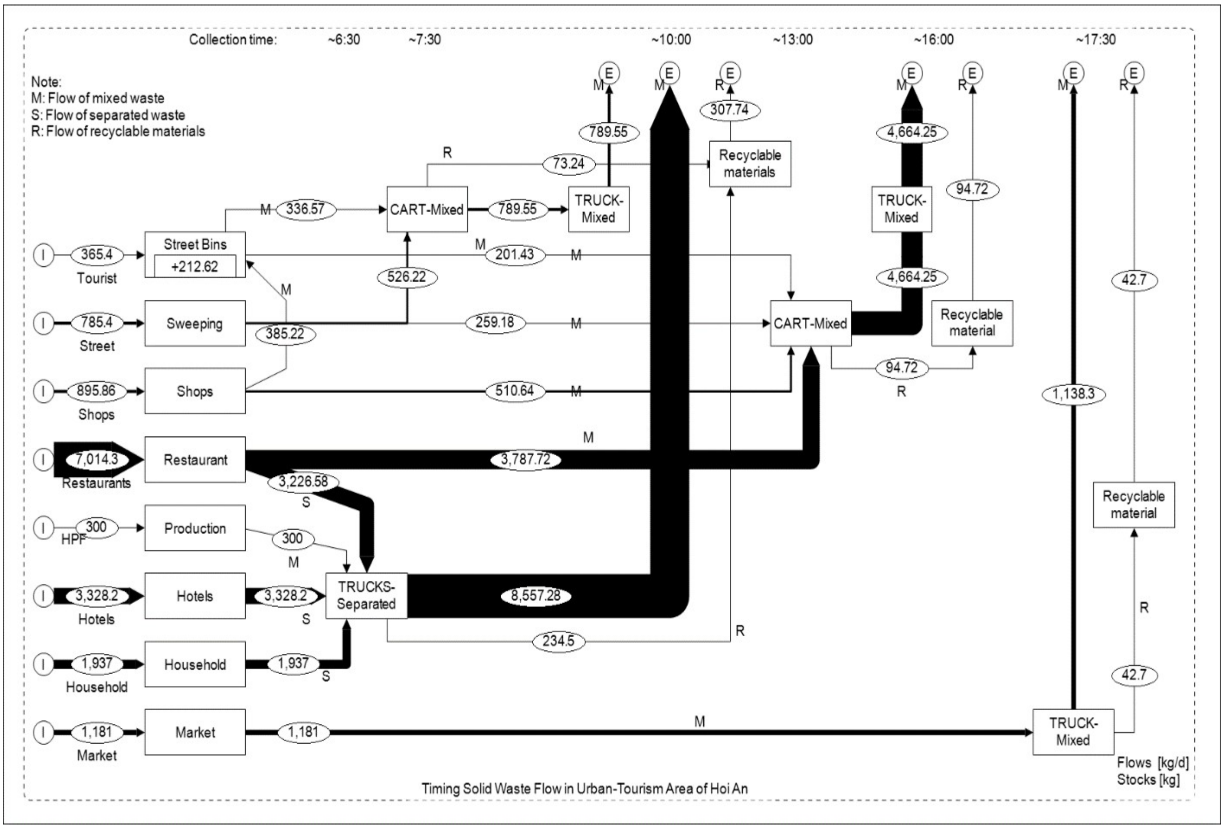


Figure 3.15. The flow of municipal solid waste by time in a tourism destination.

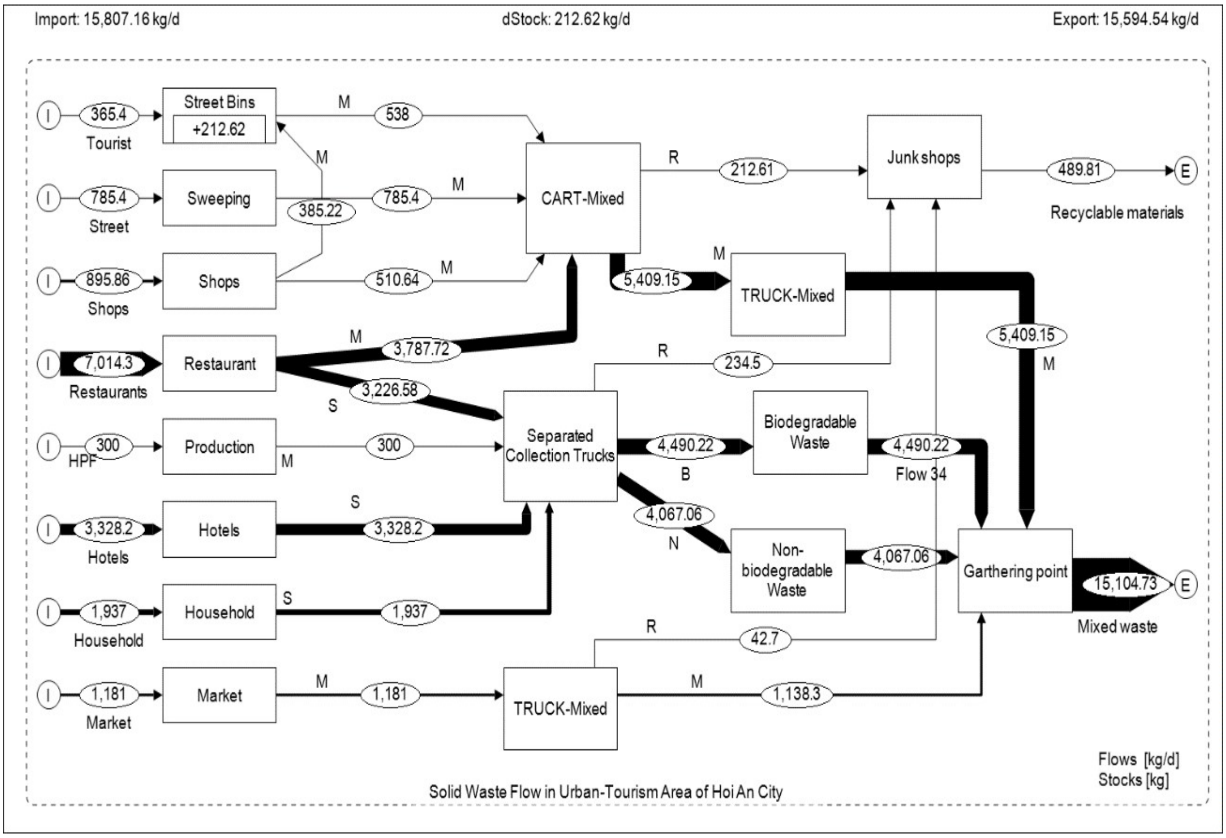


Figure 3.16. The flow of municipal solid waste in a tourism destination.

Other unpleasant consequences of solid waste collection system in the TA are revealed by shops and restaurants (*Figure 3.16*). Solid waste from shops is sneakily thrown into the street bins at night and into the carts with the approximate rates instead of putting waste into the collecting trucks. Consequently, the daily waste amount in street bins doubles and causes overloading. The justification is given by the inappropriate collecting time (by 6:30 AM) while shops operate from 10:00 to 22:00.

Additionally, about half of all the restaurant waste is collected by trucks in the morning and the other half is thrown illegally into carts, which function for collecting street waste from sweeping and from street bins in the afternoon. This illegal waste collection occurs under a tacit deal between collectors and restaurant owners and leads to anarchy in the solid waste collection system in the TA. Namely, the carts spend time collecting waste from the restaurants instead of picking waste from the street bins. Its produces brimming of waste in the cart before the end of the route. Hence, street bins full of waste are ignored, not collected, and are stocked with waste with about 212.62 $kg.day^{-1}$ (*Figure 3.16*). This phenomenon occurs every day and negatively affect the hygiene and landscape of the TA. It is negatively viewed about 80% of visitors. This challenge to the waste collection system and to the SWM system in the TA is still to be overcome.

This illegal cooperation in the waste collection does not only induce the anarchy in the waste collection system but also causes loss of a substantial amount of money for the restaurants and the government. According to the collection fee regulation by the government, the tipping fee for a restaurant on average is \$28.78 $month^{-1}$ based on the actual waste generation from a restaurant *(Quang Nam Province 2016)*. However, the restaurant pays about \$22.54 $month^{-1}$ less based on the waste amount estimated when waste-collecting happens by trucks. This means that the financial loss of the SWM system is about \$17,007 $year^{-1}$. For a restaurant, the total monthly tipping fee is around \$35.04, which includes the collection fee by a truck (for the government) and by carts (\$12.50 for a collection worker). Thus, the calculated financial loss is \$75.08 $year^{-1}$ for a restaurant. Even though the higher the amount of services in SWC, the higher the tipping fee is, the illegal deal in waste collection causes a severe gap and presents a substantial challenge to the SWM system in the TA.

Finally, the facilities and operation of the waste collection system also form significant limitations to the SWM system in the TA. Although solid waste from tourists is supposed to be sorted into two separated bins, such as organic and inorganic bins, it is collected and thrown into the same cart tank by garbage collectors. This way, waste is mixed by collection crews after being separated by tourists. This collecting activity visually negates the efforts of residents and tourists in waste classification and leads to the distrust of the sustainable waste management strategy that is implemented by the city. Likewise, this adverse effect is spreading widely within the tourist area. The majority of residents and traders reveal that their separation at source is not meaningful when waste is gathered and mixed at the end of the waste flow. This also explains the low rate of waste segregation practices.

3.5.5. The waste disposals and its limitations

After collecting by carts, solid waste is gathered to the transferring points at the edge of the TA. Then, waste is loaded alternately into the compaction trucks with capacity by $9m^3$ and transferred to the disposal with the distance around 10km for around route. Before entering the treatment area, the amount of tourism waste is evaluated by an electronic bridge-scale. The daily recorded data from the bridge-scale shows that the compaction ratio of waste in the trucks from the TA is around 1.3 lower than such of designing.

Waste disposal is the final step in the SWM system *(Alwaeli 2015)*. If landfilling is the typical disposal practice in most of the developing countries, waste treatment process implemented in HAC is a complete processing model with a composting facility, incinerator, and a dumping site. However, only 50% of the waste amount is treated due to the inefficient operation of the composting facility (10 $tons.day^{-1}$) and incinerator (operating at 30% of designed capacity). Non-separation of waste at source may be one of the barriers to efficient waste treatment. Notably, plastic waste is mixed with compost so that it cannot be used as a fertiliser. Likewise, high organic content in waste is a reason for high moisture and low calorie-value of waste that is not favourable for burning. As a result, around 40 tons of waste (about 50% of MSW) is dumped in the open site without any sanitary system. Inevitably, the accumulation of waste overtime at the dumping site will cause a significant impact on the environment and challenge the government. Hence, in addition to upgrading equipment and applying suitable technology, enhancement of the SWM practice at source is necessary in order to improve the treatment plant.

In the last decade, the rapid growth of the tourism industry in Vietnam has led to a quick increase in municipal solid waste in HAC. Waste generation in HAC contributes two-thirds of the amount of MSW and is estimated to be continuously claimed in the context of the no-halting sign of the tourism industry development. Inevitably, waste management practices, collection system, and recycling activities should be sufficiently improved. Waste disposal should be enhanced to lead to sustainability in waste management. Sanitation in the TA has to ensure cleanliness and prevent pollution from tourists. Hence, a suitable model of the SWM system should be implemented on the way to sustainability and in order to adapt to the rapid development of the tourism industry in HAC.

Worldwide, there are some common points of waste management challenges in the TA, namely, high waste generation from an abundance of commercial activities, limitations on waste collection place and time, and strict hygiene requirements in the TA. However, the difference in the tourism feature, local culture, even social awareness might lead to a variety in the SWM system. Therefore, this study also suggests that two primary factors that should be considered to develop an SWM system for the TA are social consensus and suitability of the SWM system to regional feature. Whereby, current status and challenges of the waste management system should be understood, a feature of the TA and ability of disposal should be evaluated, obstacles in waste practice implementation and waste collection demand of stakeholders should be examined, and the response of stakeholders should be noted. Also, evaluation of a sustainable SWM system of the TA should be addressed to be social acceptance (including stakeholders and tourists), efficiency in operation (including environmental and economic), and favourability to treatment (in accordance with existing regional technology).

3.6. Conclusions and recommendations

This study indicated that solid waste generated from the tourism industry in HAC accounted for 65% of the municipal waste. Whereby the generation rate of each waste source in tourism waste is 33% from tourism area, 27% from accommodation business, 19% from restaurants, 10% from markets, and 11% from other commercial activities. Furthermore, the SWG rate, waste composition, and characterisation of the tourism industry also provided in detail.

(1) The average SWG rate of the hotel's industry in HAC was 2.28 $kg.guest^{-1}.day^{-1}$. Besides, the difference in SWG rate between types of hotels was statistically significant. Whereby, the higher the scale of the hotels, the higher the SWG rate. This study also proved that internal objective factors as the capacity of the hotels, cost of the room, garden, and restaurant were highly correlated with SWG rate.

(2) 84.3% of hotel waste was organic and recyclable waste. Also, SWC of the hotels in the wet season compared with the dry seasons was slightly different. Mainly, in the wet season the percentages of kitchen waste (35.5%), glass (2%) and plastic (13.8%) were lower, and the rate of garden waste (15.5%), combustible waste (13.8%) and incombustible waste (1.5%) were higher than that of the dry season. Furthermore, this study also revealed that the waste composition of various hotels was a little different. Whereby, the higher scale hotels, the higher percentage of biodegradable waste, the less proportion of recyclable waste.

(3) The average SWG rate of commercial sectors was identified by 1.27 kg/bill for restaurants, 0.86 kg/ shop/day for shops business, 1.15 kg/stall/day for markets, 0.28 kg/product for garment production, and 0.26 kg/product for leather production. In each commercial business, the differences in SWG rate was proved and explained. Whereby, the restaurants in the centre daily generated more waste than that in the sub-centre and coastal areas.

(4) The composition of commercial waste in Hoi An tourism city were analysed by 66.8% for biodegradable, 20.1% for recycling, 11.3% for combustible, 1.8% for

incombustible, and 1.4% for hazardous waste. The waste composition features of each type of business were identified and compared. Notably, the biodegradable and recycling waste were the primary components of the restaurant industry (76.9% and 18%), markets (41% and 38%), and shop business (58% and 26.8%). Whereas, waste from manufacturing was the features of waste composition in handicraft production facilities.

(5) The characterisation of commercial waste was measured, compared and analysed in detail. Whereby, the density and moisture of waste of the restaurants were higher than that of markets, shops, and HPF, while the heating value of waste was variable in the opposite direction. Furthermore, this study also indicated that home-composting model was feasible to applicate for restaurant waste due to the favourable concentration of carbon and nitrogen of biodegradable waste.

(6) SWM of the hotels in HAC initially reaped quite positive achievements with the rate of hotels that deployed SWM practices were 76% for sorting, 39% for recycling, 29% for reduction and 0.8% for composting. Whereby, the higher the scale of hotels, the more attention in SWM practices. Moreover, the performance of sorting practice of the hotel was pretty high for chemical residue (93%) followed by glass (77.5%), textile (77.0%), metal (74.8%), PET bottle and garden waste (72.2%) except for some misclassifications for paper and combustible waste. The situation of SWM practices of the hotels was explained by many subjective and objective causes by hoteliers such as unfavorite waste storing, lack of SWM information and skills, occupying the significant area, taking more time and labours, and being unsanitary.

(7) Waste management practices in the TA of HAC are not well responded to, except for the households, restaurants, and hotels. Low rates and inefficiency in waste separation practices are justified by a small downtown, odour, and lack of necessity due to a small waste amount. Low recycling efficiency explained by inconvenience in storing recyclable materials and lack a recycling collection service. In order to develop an efficient SWM system in the TA, waste segregation practices should be improved, and

waste recycling should be enhanced. These practices present significant challenges for the government.

(8) The overload of waste in street bins and distemper waste collection in the TA of HAC are the urgent problems of the SWM system and may be caused by the illegal throw of waste into street bins by shops owners and illegal collection of restaurant waste by carts. The tacit deal in this illegal collection brings small income for collection crews but causes a significant financial loss to the SWM system (\$17,007 $year^{-1}$) and restaurants (\$75.08 $restaurant^{-1}.year^{-1}$). This gap in the SWM system in HAC also signifies a significant challenge for the government to reach a sustainability goal in the SWM.

(9) Mixing of waste after separation causes the denial of waste segregation effort at source and leads to the distrust of residents and tourists to a waste management program in the TA of HAC. Inappropriate collection time and manner, and dissatisfaction in waste collection demands from a business sector cause non-cooperation of stakeholders and disruption in the waste collection system. Thus, a balance in waste collection demands from a business sector and timely response of the collection system should be found. It is also a substantial challenge that the waste collection system currently faces.

(10) The inefficiency of waste treatment plants and the overload of open dumping sites in HAC due to the unsuitable technology of treatment facilities and the unfavorability of waste characterisation are the substantial problems for the SWM system. Improvement in these restrictions may cause a significant challenge for the government.

The growth of the tourism industry is essential for the socio-economic development of the country. However, the increase in the waste amount from tourism activities is inevitable. Thus, the study on finding the appropriate solutions to reduce the problems and enhance the performance of SWM practice at source is an urgent task.

3.7. Reference

Abila, B., Kantola, J., 2017. Proposed solutions in municipal solid-waste management. International Journal of Environment and Waste Management 19, 297–317.

Alwaeli, M., 2015. An overview of municipal solid waste management in Poland. The current situation, problems and challenges. Environment Protection Engineering 41.

ASTM International D5231-92, 2003. Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste.

Ayia-Koi, A., Sackle-Sackey, A., 2015. Capacity Management Issues in the Hotel Industry of Cape Coast Metropolis. Journal of Tourist, Hospitality and Sports 11, 1–9.

Ball, S., Taleb, M.A., 2011. Benchmarking waste disposal in the Egyptian hotel industry. Tourism and Hospitality Research 11, 1–18. https://doi.org/10.1057/thr.2010.16

Bohdanowicz, P., 2005. European Hoteliers' Environmental Attitudes: Greening the Business. Cornell Hotel and Restaurant Administration Quarterly 46, 188–204. https://doi.org/10.1177/0010880404273891

Byer, P.H., Hoang, C.P., Nguyen, T.T.T., Chopra, S., Maclaren, V., Haight, M., 2006. Household, hotel and market waste audits for composting in Vietnam and Laos. Waste Management & Research 24, 465–472. https://doi.org/10.1177/0734242X06068067

Chan, W.W., Lam, J., 2001. Environmental accounting of municipal solid waste originating from rooms and restaurants in the Hong Kong hotel industry. Journal of Hospitality & Tourism Research 25, 371–385.

Chen, M.C., Ruijs, A., Wesseler, J., 2005. Solid waste management on small islands: the case of Green Island, Taiwan. Resources, Conservation and Recycling 45, 31–47. https://doi.org/10.1016/j.resconrec.2004.12.005

Christensen, T.H., 2011. Solid waste technology & management. Wiley, Chichester, West Sussex, U.K. ; Hoboken, N.J.

Cummings, L.E., 1992. Hospitality solid waste minimization: A global frame. International Journal of Hospitality Management 11, 255–267.

Daniel Hoornweg, Perinaz Bhada-Tata, 2012. What a Waste - A Global Review of Solid Waste Management. World Bank.

Dinh, P.., Giang, H.M., Song Toan, P.., Takeshi, F., 2018. Kinetics of carbon dioxide, methane and hydrolysis in co-digestion of food and vegetable waste. Global J. Environ. Sci. Manage 4, 401–412. https://doi.org/10.22034/gjesm.2018.04.00

Edmundo Mufioz, R.N., 2015. Waste management in touristic regions. Waste Manag Res 33, 593–594. https://doi.org/10.1177/0734242X15594982

Ezeah, C., Fazakerley, J., Byrne, T., 2015. Tourism Waste Management in the European Union: Lessons Learned from Four Popular EU Tourist Destinations. American Journal of Climate Change 04, 431–445. https://doi.org/10.4236/ajcc.2015.45035

Giang, H.M., Takeshi, F., Song Toan, P.P., 2017a. Municipal Waste Generation and Composition In A Tourist City - Hoi An, Vietnam. Journal of JSCE 5, 123–132.

Giang, H.M., Takeshi, F., Song Toan, P.P., Kim Thai, N.T., 2017b. Predicting waste generation using Bayesian model averaging. Global Journal of Environmental Science and Management 3, 385–402. https://doi.org/10.22034/gjesm.2017.03.04.00

Gidarakos, E., Havas, G., Ntzamilis, P., 2006. Municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete. Waste Management 26, 668–679. https://doi.org/10.1016/j.wasman.2005.07.018

Graci, S., Dodds, R., 2008. Why Go Green? The Business Case for Environmental Commitment in the Canadian Hotel Industry. International Journal of Tourism and Hospitality Research 19, 251–270. https://doi.org/10.1080/13032917.2008.9687072

Hung, W.-T., Shang, J.-K., Wang, F.-C., 2010. Pricing determinants in the hotel industry: Quantile regression analysis. International Journal of Hospitality Management 29, 378–384. https://doi.org/10.1016/j.ijhm.2009.09.001

Jonathan, F.K.., Townsend, J.M., 1991. Florida's Pilot Hotel/Motel Recycling Project. University of Florida.

Karim Zein, Majdoulaine Semlali Wazner, Grégoire Meylan, 2008. Best Environmental Practices for the Hotel Industry. Sustainable Business Associates.

Kirk, D., 1995. Environmental management in hotels. International journal of contemporary hospitality management 7, 3–8. https://doi.org/10.1108/09596119510095325

Losanwe, I., 2013. Environmentally Friendly Luxury Hotel: case: Grand Palace Hotel, Riga, Latvia.

MaLik, S., Kumar, S., 2012. Management of hotel waste: A case study of small hotels of Haryana State. Journal of Economic and Management 1, 43–55.

Mateu-Sbert, J., Ricci-Cabello, I., Villalonga-Olives, E., Cabeza-Irigoyen, E., 2013. The impact of tourism on municipal solid waste generation: The case of Menorca Island (Spain). Waste Management 33, 2589–2593. https://doi.org/10.1016/j.wasman.2013.08.007

Matsui, Y., Trang, D.T.T., Thanh, N.P., 2015. Estimation of Waste Generation and Recycling Potential from Traditional Market: A Case Study in Hue City, Vietnam. Journal of Environmental Protection 06, 308–320. https://doi.org/10.4236/jep.2015.64031

Milanez, B., Hargrave, J., Luedemann, G., 2015. Urban environmental services: valuing the environmental benefits of solid waste recycling in Brazil. International Journal of Environment and Waste Management 15, 67–85.

Mongtoeun, Y., Takeshi, F., Sour, S., 2014. Current status of commercial solid waste generation, composition and management in Phnom Penh city, Cambodia. Journal of Environmental and Waste Management 1, 31–38.

Murava, I., Korobeinykova, Y., 2016. The Analysis Of The Waste Problem In Tourist Destinations On The Example Of Carpathian Region In Ukraine. Journal of Ecological Engineering 17, 43–51. https://doi.org/10.12911/22998993/62285

Nornadiah Mohd Razali, Y.B.W., 2011. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Journal of Statistical Modeling and Analytics 2, 21–23.

Omidiani, A., S. Mohsen, H.., 2016. Waste Management in Hotel Industry in India: A Review. International Journal of Scientific and Research Publications 6, 670–680.

Otoma, S., Hoang, H., Hong, H., Miyazaki, I., Diaz, R., 2013. A survey on municipal solid waste and residents' awareness in Da Nang city, Vietnam. Journal of Material Cycles and Waste Management 15, 187–194. https://doi.org/10.1007/s10163-012-0109-2

Pham Van, D., Hoang, M.G., Pham Phu, S.T., Fujiwara, T., 2018. A new kinetic model for biogas production from co-digestion by batch mode. Global Journal of Environmental Science and Management 4, 251–262. https://doi.org/10.22034/gjesm.2018.03.001

Pirani, S.I., Arafat, H.A., 2014. Solid waste management in the hospitality industry: A review. Journal of Environmental Management 146, 320–336. https://doi.org/10.1016/j.jenvman.2014.07.038

Quang Nam Province, 2016. Regulation of waste collection fee in Quang Nam province.

Shamshiry, E., Nadi, B., Bin Mokhtar, M., Komoo, I., Saadiah Hashim, H., Yahaya, N., 2011. Integrated Models for Solid Waste Management in Tourism Regions: Langkawi Island, Malaysia. J Environ Public Health 2011. https://doi.org/10.1155/2011/709549

Sharma, R., 2016. Evaluating total carrying capacity of tourism using impact indicators. Global Journal of Environmental Science and Management 2, 187–196. https://doi.org/10.7508/gjesm.2016.02.009

Song Toan, P.P., Fujiwara, T., Dinh, P.V., Hoa, K.T., 2018a. Waste Recycling System for a Tourism City in Vietnam: Situation and Sustainable Strategy Approach – Case Study in Hoi An City, Vietnam. IOP Conference Series: Earth and Environmental Science 159, 342–349. https://doi.org/10.1088/1755-1315/159/1/012046

Song Toan, P.P., Minh Giang, H., Takeshi, F., 2018b. Analyzing solid waste management practices for the hotel industry. Global Journal of Environmental Science and Management 4, 19–30. https://doi.org/10.22034/gjesm.2018.04.01.003

Song Toan, P.P., Takeshi, F., Dinh, P.V., Hoa, K.T., 2018c. Waste Recycling System for a Tourism City in Vietnam: Situation and Sustainable Strategy Approach - Case Study in Hoi An City, Vietnam. IOP Conf. Series: Earth and Environmental Science 159, 1–8. https://doi.org/10.1088/1755-159/1/012046

Suomi, R., Serkkola, A., Korhonen, P., 2017. Monitoring indicators for source segregation in municipal solid waste management. International Journal of Environment and Waste

Management 19, 164–180.

Tang, J., 2004. A case study of a hotel solid waste management program in Bali, Indonesia (Master). University of Waterloo, Canada.

Trung, D.N., Kumar, S., 2005. Resource use and waste management in Vietnam hotel industry. Journal of Cleaner Production 13, 109–116. https://doi.org/10.1016/j.jclepro.2003.12.014

Von Bertrab, A., Hernández, J.D., Macht, A., Rodríguez, M., 2009. Public-Private Partnerships as a Means to Consolidate Integrated Solid Waste Management Initiatives in Tourism Destinations: The Case of the Mexican Caribbean. International Solid Waste Associaton.

Wong, K.K.F., Kim, S., 2012. Exploring the Differences in Hotel Guests' Willingness-to-Pay for Hotel Rooms With Different Views. International Journal of Hospitality & Tourism Administration 13, 67–93. https://doi.org/10.1080/15256480.2012.640219

Chapter 4

The optimal solutions to solid waste management practice for the tourism industry and oriented planning towards sustainability

The current status, problems and challenges of the SWM system in the tourism industry in HAC are presented in *Chapter 3*. Whereby, the rapid increase of municipal waste, the overload of waste in the tourism area (TA), the disruption of the waste collection system and the inefficient in the waste treatment process are the specific problems of the tourism SWM system. These problems are caused by the non-performance of SWM practice at source to the end of the waste flow. Thus, improvement of SWM practice is considered as a radical solution to solve these problems. In which, enhancement of waste separation at source that is a priority. It may provide homogenous material for composting and obtains the higher calorific value of waste for incineration. This would also help minimise the amount of waste transported to the dumping site. For municipal SWM, which encompasses the functions of collection, transfer, treatment, recycling, resource recovery and disposal of municipal solid waste, these problems should be addressed synchronously, in which the primary waste sources of tourism waste and hotel waste should be considered urgently.

For the accommodation business (AB), *Chapter 3* indicated that hotel waste presents favourable conditions for improving recycling practices and developing sustainable SWM. Mainly, 84.3% of hotel waste was a recyclable and compostable waste. Also, the status of WMP in hotels was positive, with 76% conducting source-separation, 39% conducting recycling, and 0.8% conducting home composting (Song Toan et al., 2018b; Toan et al., 2017). However, there are many barriers, which mainly include internal subjective and objective views of the hotels against WMP. Notably, a significant percentage of hoteliers said that they dislike storing waste (72%) and had a lack of information and skills (58%). Other hoteliers thought that waste recycling occupied a significant area (50%), was time and labour consuming (42%), and was unsanitary (18%) (Song Toan et al., 2018b). Hence, solutions for enhancing awareness and motivation about WMP for the hoteliers should be considered. This chapter will analyse waste separation at source and the potential for recycling in the hotel industry. Also, the micro-benefits to the hotels will be evaluated to improve the current waste separation practices and recycling motivation of the hoteliers.

In addition, the TA in the centre of the city (*Figure 4.1*) is an ancient town for sightseeing and shopping of tourists contains a densely populated area and bustling commercial activities. The TA welcomes around 6,000 tourists per day and daily generates about 15.08 tons of waste that is the most severe problem of waste management of HAC. Also, the SWM system in the TA is dealing with many difficulties, barriers and obstacles. Notably, a large amount of waste generated daily in a small area in downtown with the restrictions on waste collection facilities and limitations on waste collection time presents substantial challenges to manage waste from the TA. Furthermore, SWM practices in the TA are not well responded by residents and commercial sectors. Low rate and inefficiency in waste segregation at source cause certain barriers to recycling and treatment. The overload of waste in street bins and disruption to waste collection activities are the urgent problems of the SWM system in the TA that may be caused by the illegal throw of waste into street bins by shops owners and illegal collection of restaurant waste by carts. The tacit deal in this illegal collection causes a significant financial loss to the SWM system (estimated by $17,007/year).

Figure 4.1. The location of the tourist area in Hoi An City

Generally, waste management practices at source have not considered instead of increasing the rate of waste collected to landfill. Especially, releasing waste out of the TA is always the priority. In HAC, waste separation at source has implemented since 2012, but its efficiency is still low. Waste is required to sort into two types such as biowaste (kitchen waste, garden waste, and tissue paper) and non-bio waste, and collected separately by a different schedule. The biowaste is collected four times per week on Monday, Wednesday, Friday, and Sunday, while the remaining days of the week are for collecting non-bio waste. Storing waste at source due to the collection schedule has brought many inconveniences to commercial activities in the small area in downtown. Therefore, the illegal collection and disruption in operating waste management system may be the inevitable results of an SWM model without the factor "social acceptance".

Undeniably, the level of sanitation in the TA may significantly impact tourism and the development of the tourism industry in the long term. The efficiency of the SWM system in the TA also substantially affect the integrated municipal SWM system of HAC. Hence, the enhancement of the SWM system in the TA is necessary and urgent tasks. This chapter aims to establish an optimal model of the SWM system in the TA to reduce its obstacles, barriers, and problems. The results of this study may contribute to enhance the efficiency of municipal SWM system of HAC, also support local government in the decision-making process of SWM strategies toward sustainability.

4.1. Minimising waste generation from accommodation business by enhancing separation practice and optimising recycling activities

4.1.1. Identification of factors that drive recycling practices

The comparison matrix (*Table 4.1*) shows the relative priorities for RPE. The results of the AHP indicated that WMP, PP, and EBO were the three strongest essential factors to RPE, with weighted percentages of 37.75%, 24.96%, and 15.11%, respectively, in which WMP was the highest priority concerning RPE. Also, EIM contributed to 12.21% of the decision-making process for RPE for the hotel industry. The CR of this test was 0.059 less than 0.1, so the judgments matrix was considered reasonably consistent.

Table 4.1. Paired comparison matrix of priorities for recycling practice efficiency

	WMP	SCI	EBO	EIM	DFR	PP	Normalize principal Eigenvector	Rank
WMP	1	4	3	5	7	2	37.75%	**1**
SCI	1/4	1	1/5	1/3	1	1/3	5.30%	5
EBO	1/3	5	1	1/2	3	1	15.11%	**3**
EIM	1/5	3	2	1	2	1/5	12.21%	4
DFR	1/7	1	1/3	1/2	1	1/6	4.67%	6
PP	1/2	3	1	5	6	1	24.96%	**2**

The importance of sub-criteria in relation to the criteria was identified by the weights of the secondary criteria in *Figure 4.2*. Regarding WMP, segregation practice was the most important factor with the highest weighted percentage of 55.8%, followed by recycling practice and composting practice with weighted percentages of 32% and 12.2%, respectively. This shows the necessity and importance of sorting waste and the high priority of separation for improving recycling practices. Besides, waste management experts suggested that promulgation of the regulation (50%) and intensification of encouragement (41.5%) should be prioritised for promulgating waste regulation towards RPE. While waste regulation can be gradually promulgated by the government, WMP should also be encouraged by recognising the efforts of hoteliers through "Green Hotels Award" certificates or by admission to the "Green Hotel Association". Likewise, the economic benefit to the hotel sectors (EHS) was the sub-criteria with the highest priority, with a 61% weighted percentage in EBO criteria. EHS is expected to be a significant motivation for the hoteliers to enhance recycling practices. Thus, WMP, the promulgation of the regulation, and EBO are important criteria that play a significant role in the development of RPE.

Although SCI and DFR had low weighted percentages, they may significantly contribute to improving the recycling system of HAC. In term of a macro view, GHG emissions should be estimated, and recycling facilities should be considered for investment. Also, the support of stakeholders, such as business sectors, the government, and NGOs, should be promoted.

For the secondary relationship of RPE, the CR of these AHP tests was less than 0.1.

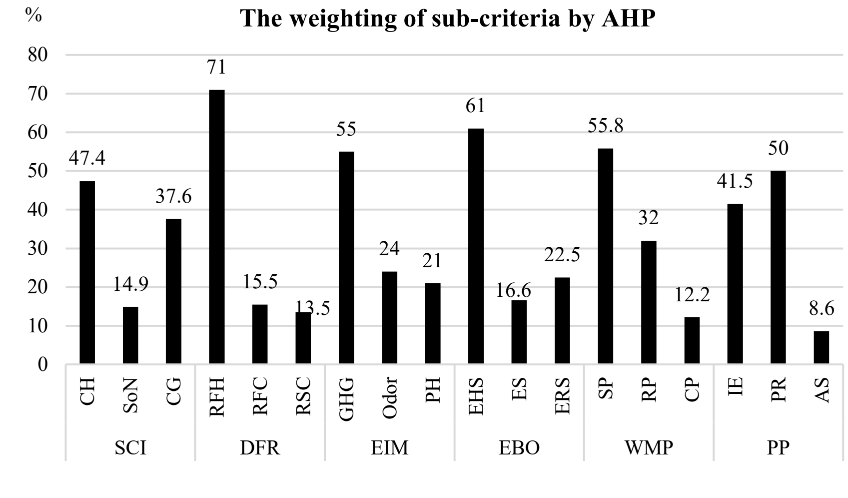


Figure 4.2. The weighting of sub-criteria by AHP model

According to the status of the recycling market and WMP in HAC, experts provided a priority rank of materials for recycling using the AHP method, which was conducted by pairwise comparison of recyclable waste. *Figure 4.3* shows the priority of materials for recycling. It appeared that the rank of priority was proportional to the commercial value of the recycled materials. Although organic waste cannot be sold, recycling by composting was recommended to minimise waste and to reuse compost as a fertiliser.

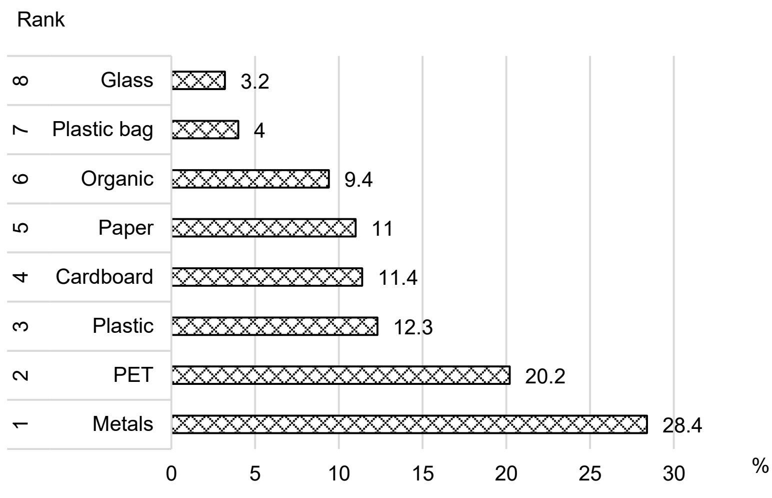


Figure 4.3. The weight and rank of recyclable waste for recycling

By the priority of materials for recycling, waste should be sorted into 3 primary kinds of waste, including organic waste (kitchen waste, garden waste, and tissue paper), recyclable waste (metal, PET, plastic, cardboard, paper, and glass), and inorganic waste (plastic bags and other waste). By this separation method, organic waste would be treated daily by composting at the hotels, recyclable waste, except for glass, would be sold to itinerant buyers, and the inorganic waste would be collected by trucks. Nevertheless, the recycling potential significantly depends on the rate and efficiency of waste segregation practice, recycling practices, and suitable conditions in hotels for recycling.

4.1.2. Evaluation of waste reduction by recycling

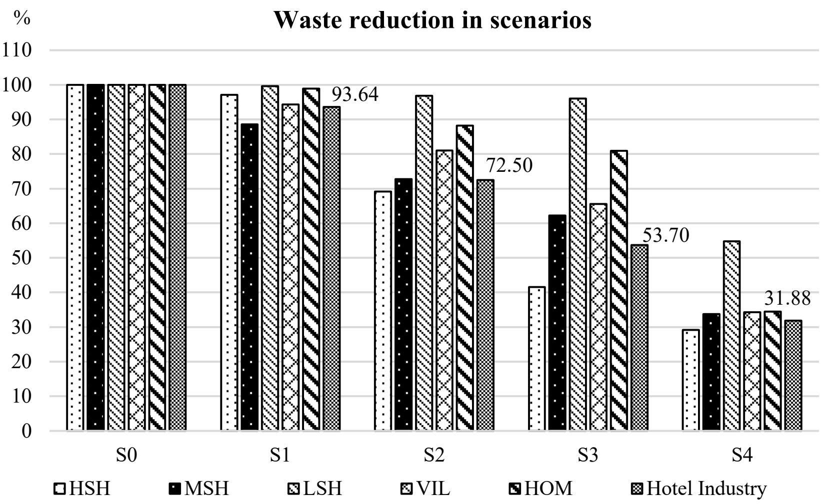


Figure 4.4. The percentage of waste collected by trucks in the scenarios

Waste minimisation is one of the most important goals of recycling. *Figure 4.4* illustrated the proportions of the hotel waste that was collected daily by trucks in five recycling scenarios. In general, the waste reduction rate of the hotels increased proportionally with the rate of recycling practice from $S0_{AB}$ to $S4_{AB}$. In $S2_{AB}$ and $S3_{AB}$, the amount of waste in LSH and HOM slightly decreased compared to that in S1, also compared to the other hotels in the same scenario. This was explained by the low solid waste practice intentions of LSH and HOM and the lack of space for recycling. Whereas, the amount of waste in HSH, MSH, and VIL was estimated to significantly reduce by 30.8%, 27.2% and 19.0% in S2, 58.5%, 37.7%

and 34.4% in S3, respectively. Furthermore, the peak of the waste reduction rate was at 68.12% for the hotel industry in the optimal scenario S4. Whereby, about 7 tons of organic waste was handled by composting at the hotels with garden and around 2.2 tons of recyclable materials are sold to itinerant buyers. The substantial amount of waste from the hotels was reduced by the recycling may contribute to minimise waste collected by truck and reduce the cost from the collection system. The progression of waste reduction from $S1_{AB}$ to $S4_{AB}$ was the expected trend of waste management for the hotel industry towards sustainable recycling practices and waste management.

4.1.3. The characteristics of waste after the implementation of recycling

The separation of recyclable materials for recycling and organic waste for composting at the hotels led to changes in the composition and characterisation of the mixed waste. Notably, *Figure 4.5* showed that the moisture content of the hotel waste decreased from 48.2% to 32.9% from S1 to S4, while HHV increased from 16,311 kJ/kg to 18,457 kJ/kg, respectively. In fact, the current mixed waste from the hotels in S1 was detrimental to the disposal. The segregation of organic waste as the wet materials might cause the reduction of moisture and the increase of HHV of waste. The changes of waste characteristics in different scenarios indicated that the higher rate of recycling practice, the lower moisture content and the higher HHV of the mixed waste.

Furthermore, the waste classification might significantly reduce the proportion of non-biodegradable impurities in the organic waste which has obstructed the biodegradation during the composting process *(Song Toan et al., 2017)*. The analysis results also showed that the moisture content and carbon to nitrogen ratio (C/N) of organic waste in the hotels ranged from 57% to 60% and 23.4 to 27.6, respectively. These characterisations of the organic waste satisfied the optimal conditions for composting, which are moisture content of around 40-60% and C/N of 20-30 *(Atalia et al., 2015)*. Likewise, *Dinh et al. (2018)* proved that anaerobic digestion of food and vegetable waste was also a feasible solution should be considered when the classification of waste towards the purity *(Dinh et al., 2018a, 2018b; Pham Van et al., 2018)*.

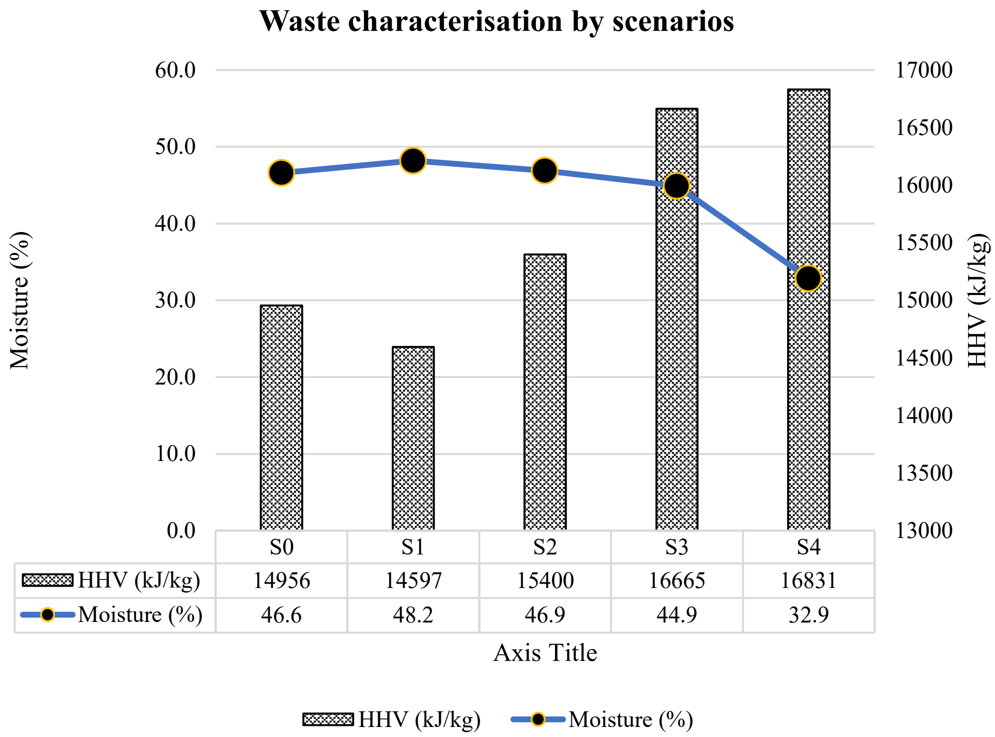


Figure 4.5. The moisture and low heating value of mixed waste in the scenarios

In fact, the hotel waste was collected and treated together with the municipal waste, which had high moisture and low HHV *(Giang et al., 2016)*. Also, the high moisture and low HHV were the unfavourable factors for combustion. Furthermore, the traditional incinerator that has been using in HAC was a simple technology and low quality. Consequently, the inefficiency of this incinerator was expressed in the maximum operating capacity at 30% of the designed capacity and the inability to control exhaust gas emissions. Likewise, the composting facility has been struggling to find suitable solutions for purifying the organic waste aim to improve the quality of compost product. Undeniably, waste separation and recycling practice had important roles in SWM. It not only significantly reduced waste amount generated at source, but also improved the waste characteristics that contribute to optimising waste treatment processes. Also, enhancement of waste segregation and recycling practices in the hotel industry might significantly contribute to reduce the restriction of treatment, develop a municipal SWM system for HAC.

4.1.4. The economic benefits to the hotel industry by recycling

In this study, the economic benefits to the hoteliers from recycling were considered for analysis. *Figure 4.6* showed that the economic benefits to the hotel industry from recycling increased proportionally to the rate of recycling practice in different scenarios. First, the tipping fee, which was paid by the hotels through a PAYT regulation, decreased inversely proportionally to the increase in recycling rate because of the reduction in waste generation. Selling recyclable materials brought a significant income to the hotel industry of \$3,400.00/month, \$5,680.00/month, \$6,926.00/month, and \$ 8,265.00/month for S1 **AB**, S2 **AB**, S3 **AB**, and S4 **AB**, respectively.

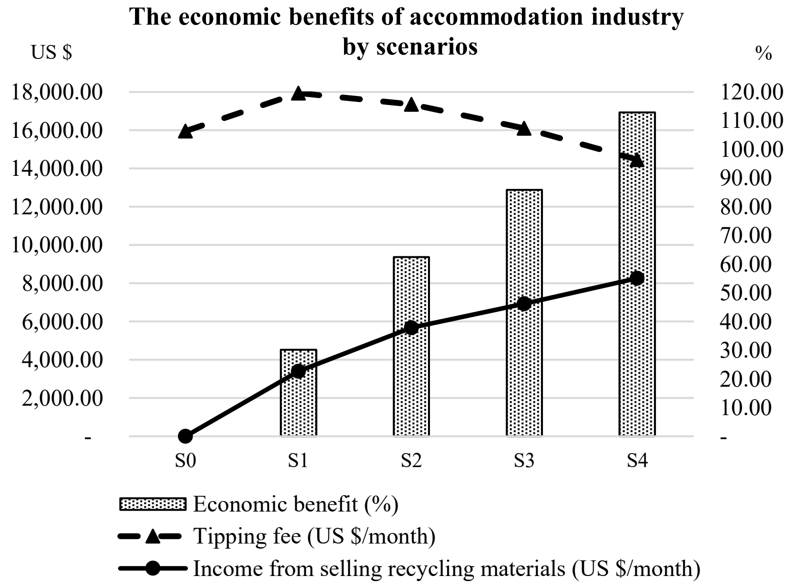


Figure 4.6. The economic benefits of the hotel industry in different scenarios

The consonance between reduction in tipping fee and an increase in income from improving recycling practices brings significant economic benefits to the hotel industry. Particularly, the commercial profits obtained from S1 **AB**, S2 **AB**, S3 **AB**, and S4 **AB** were 30.1%, 62.4%, 86.0%, and 114.0%, respectively. In S4, the income from selling recyclable materials was higher than the tipping fee. This means that the hotel industry could earn \$2,064.00 from the optimal recycling solution (S4 **AB**). Furthermore, the hotels could save money from using compost instead of buying fertiliser.

In developing countries, the composition of solid waste was not significantly different. In general, the organic waste and recyclable waste account for 60% to 75% of total waste (Pirani and Arafat, 2014), which was the necessary condition for recycling. However, the difference in WMP was one of the main reasons for the success of the SWM system. In this study, the role of waste separation in recycling practices and the importance of recycling practices in waste management were confirmed.

For a tourism city, the optimal recycling practice of the hotel industry would act as a small pilot model of sustainable SWM, which may significantly contribute to sustainable integrated municipal SWM for the city. Especially in the phase of rapid growth, sustainable SWM of the tourism industry and hospitality businesses are essential. This study pointed out that recycling practices may significantly reduce waste generation, optimise the waste characterisations for composting and incineration, create economic benefits for the hotels, improve environmental problems such as odour and leachate, and produce positive outcomes for the businesses. However, this study indicated that to enhance recycling practices in the hotel industry, the synchronous combination of solutions involving techniques, education, training, and regulation is essential. These solutions aim to improve the recycling motivation of the hoteliers, develop hoteliers' awareness and skills regarding WMP, and establish a monitoring and management system for recycling activities based on the consensus and cooperation of the government, businesses, and stakeholders.

For HAC, although there are still many internal barriers and objective obstacles impeding recycling, this study revealed that SWM in the hotel industry has high recycling potential. The development from scenario $S1_{AB}$ to $S4_{AB}$ was also the expected path of RPE, which is the goal of the hotel industry. The status of SWM and recycling practices in the hotel industry were analysed. The roles of the critical factors related to RPE were identified. Some scenarios of optimal recycling practices were estimated, and benefits from recycling were identified. This information is useful to decision-makers in decision-making processes on waste management and recycling programs. Also, the recycling practice model should be studied and expanded to commercial sectors, the restaurant industry, and tourism destinations in HAC towards synchronously developing a recycling system for the tourism industry.

Simultaneously, a macro view of recycling potential should be studied for HAC to identify the optimal solutions for recycling system development towards a sustainable SWM system.

4.2. Optimising SWM system for a tourism area

4.2.1. Waste flow analysis

The flow of waste aims to describe the happenings of the SWM system in the TA. In the context of the inefficiency of waste separation practice at source, the low performance of waste collection system, and disapproval of commercial sectors in SWM operation process; the unnecessary in waste classification is considered as an alternative to waste management system improvement ($S1_{TA}$, $S2_{TA}$ and $S3_{TA}$) towards suitability. Whereby, *Figure 4.7* presents the mixed waste flow of municipal SWM system in the TA with non-separation practice at source and enhancement of recycling activities. Notably, the mixed waste from eight sources in the TA is collected daily by trucks and carts. The trucks collect waste from households, hotels, handicraft production facilities and restaurants in the morning. While, in the time for tourism (vehicles are not allowed), waste from street and bins is collected by carts. For the restaurants, the mixed waste is collected one more time by carts in the afternoon based on their collection demand. The higher the service usage, the higher the tipping fee.

When waste collection demand of households and business sectors is responded, the requirement of recycling practice at source from the government will be promulgated compulsorily. Whereby, recyclable materials such as papers, cardboard, plastics, PET bottles, metals and glass are sorted at sources and collected daily by recycling carts. Furthermore, the recyclables are recovered again from the mixed waste by collection crews during collecting route and scavengers at the gathering point. The differences between scenarios of the SWM system are the rate of recycling practice. Notably, the recycling practice rate was designed in $S1_{TA}$ by the present recycling rate and estimated to be improved to $S2_{TA}$ and $S3_{TA}$ by the intentional and optimal rates of recycling practice, respectively. This lead to a significant difference in the volume of recyclables collected daily. The higher the recycling practice rate, the higher the amount of recyclable waste.

The gaps in the SWM system in the TA may be solved by improving waste collection system in $S1_{TA}$, $S2_{TA}$ and $S3_{TA}$. Notably, enhancing the quantity and redesigning the density of street bins net may reduce the overload of tourism waste at bins. Secondly, the illegal collection activities are replaced by an official collection service that may bring some positive effects to the SWM system in the TA such as the fairness in collection activities, the transparency in finance flow, and satisfaction in waste collection demand. Furthermore, the minimalism in waste management practice in the TA may create some advantages in the deployment of SWM practices such as the simplicity, more efficiency in collection, and high consensus from communities and commercial sectors. In general, the models of the SWM system in the TA in S1, S2, and S3 seems entirely appropriate with developing countries where waste treatment technology is still rudimentary. However, in term of sustainable SWM system for eco-society, the environmental impact should be considered in addition to economic and social aspects. In which, the process of an SWM system from generation to disposals significantly impacts the environment.

Indisputably, the SWM practices substantially affect the efficiency of an SWM system. Thus, to establish an integrated SWM system towards sustainability, improvement of SWM practices should be considered. For the TA of HAC, three scenarios ($S4_{TA}$, $S5_{TA}$, and $S6_{TA}$) of the SWM system were design based on developing a collection system and enhancing separation practice at source gradually. In particular, a complicated model of the SWM system was illustrated in *Figure 4.8* with the boundary of the TA. In order to compare to $S1_{TA}$, $S2_{TA}$, and $S3_{TA}$, there are some different points in waste flow in S4, S5, and S6. Notably, waste is collected separately corresponding to classification at source, as such biodegradable waste is collected by trucks in the morning while carts collect combustible waste and recyclable material separately. The regulation of waste separation is promulgated strictly to support the deployment process of waste segregation practice at source. Hereby, waste may be rejected for collection if being detected in mixing. As such, sanction may be applied if violations are repeated.

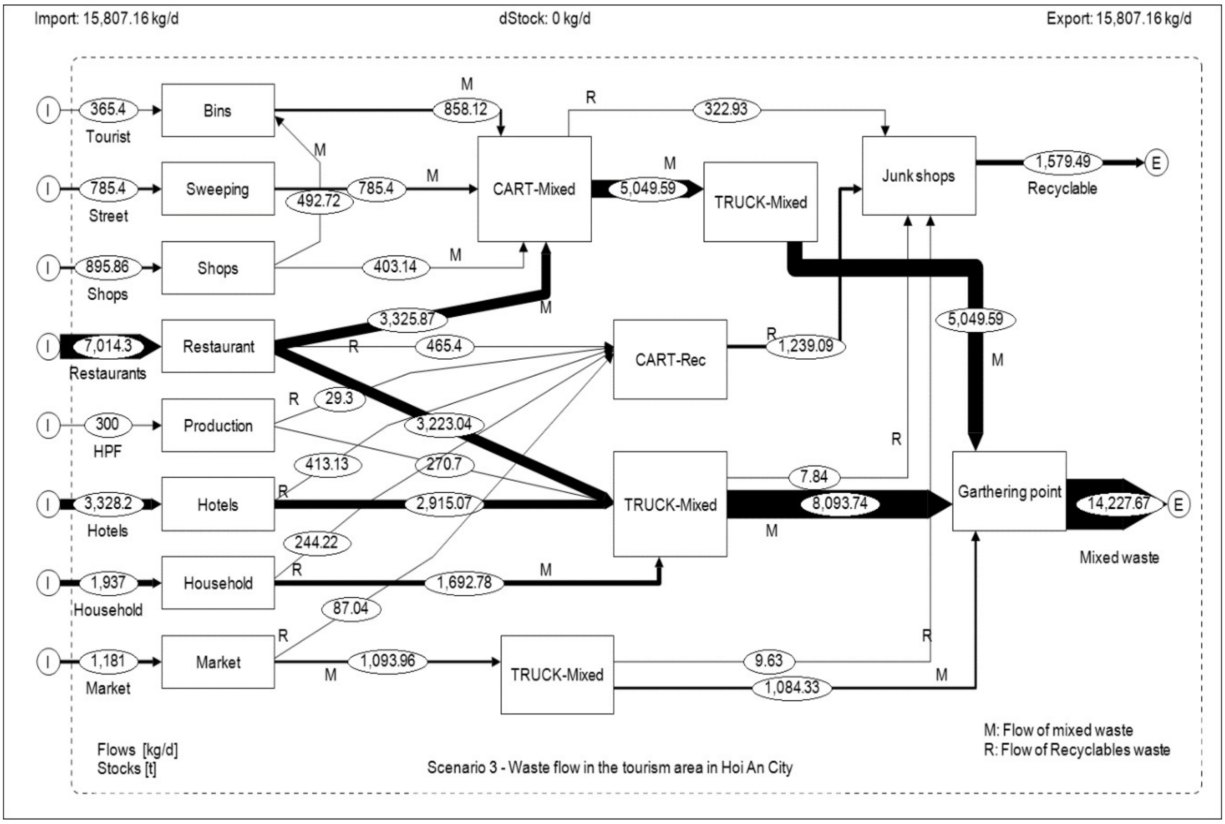


Figure 4.7. The waste flow of the SWM system in scenario 3

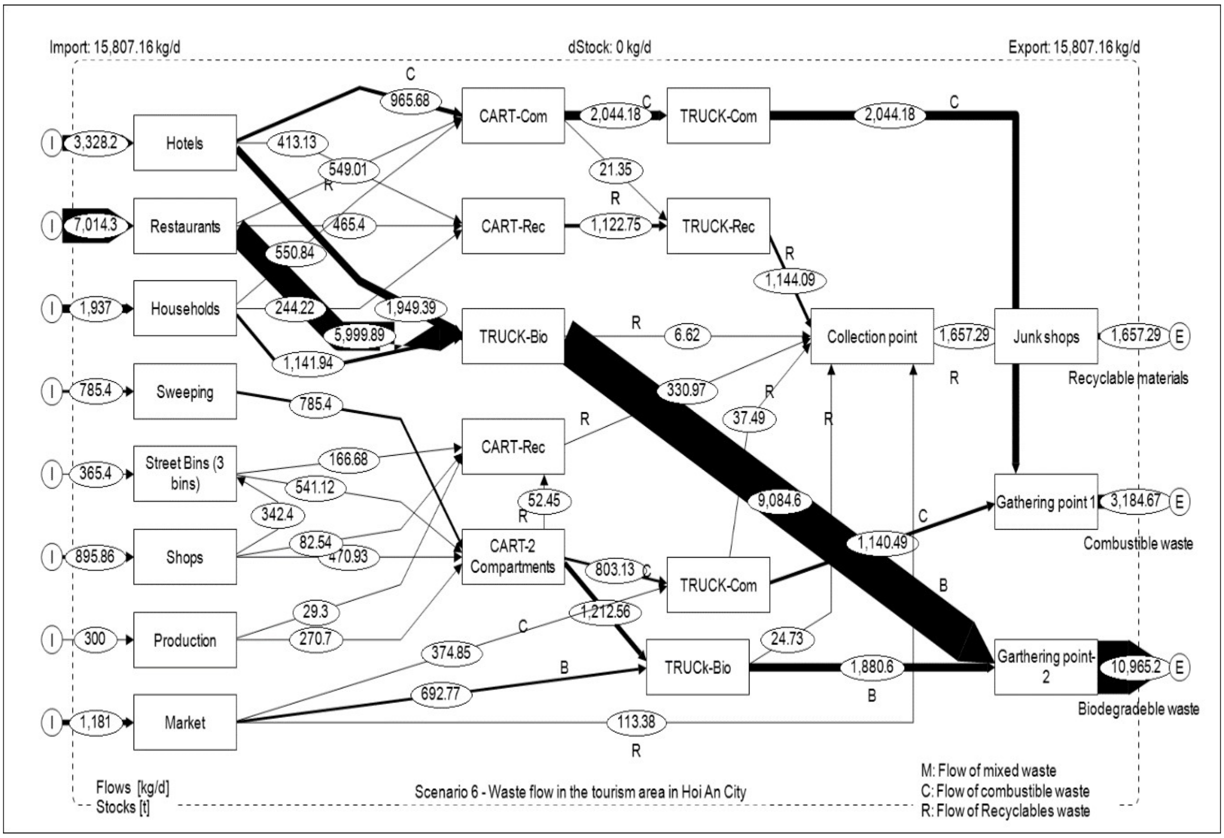


Figure 4.8. The waste flow of the SWM system in scenario 6

The specific feature of the TA contains the respective SWM system. In Santiago Del Teide waste is sorted into recyclables (glass, bottles, paper and card recycling) and the residues, and stored in 660-litre containers that located along the street. In the tourism centre, waste is transferred by an underground collection system to the transfer stations to avoid odour and vermin. The collection time in the TA is from 10:00 PM to 5:00 AM to avoid traffic and disrupting tourist *(Ezeah et al., 2015)*. Likewise, in Kefalonia in Greece, waste is separated into dry-recyclables and non-recyclable waste by distinguishing colour containers such as blue and green, respectively, that are placed at communal collection points along the street. The daily collection service begins at 3-5 AM *(Ezeah et al., 2015)*. Whereas, in a tourism region in Malaysia, Langkawi island, solid waste that is not sorted at source and transferred for landfilling under no sanitary condition. Recycling practice has not been considered *(Shamshiry et al., 2011)*. The differences in the level of the SWM system in various countries are undeniable, one thing that each system is aiming for is the optimal solutions corresponding to its existing conditions. For the SWM system in the TA of HAC, six models were estimated based on the combination of the practical issues of the SWM system, acceptability of society, and approval of the local government aims to feasibility in implementation. However, the optimal model of the SWM system should be accessed by analysing the performance that the model brings.

4.2.2. Optimising integrated SWM practice models

4.2.2.1.Analysing the waste collection performance

The differences in the amount of waste collected from the TA by various scenarios are presented in *Figure 4.8*. Although waste separation practice is required in HAC currently, the low rate of waste management practice and inefficiency of the SWM system have led to the mixture of waste in $S0_{TA}$, which is also similar in $S2_{TA}$, $S3_{TA}$ and $S4_{TA}$ by the assumption of non-separation. Whereas, in $S4_{TA}$, $S5_{TA}$, and $S6_{TA}$ solid waste is collected separately due to the assumption of waste management practice enhancement. Notably, the amount of bio-waste is sorted at 8.4, 10.3, and 11.0 ton/day corresponds to the decrease of non-bio-waste from 6.7 ton/day to 4.2 and 3.1 ton/day. The rate and purity of sorted waste are proportional to waste management practices rate and the efficiency of the collection system. Whereby, the growth of organic waste amount and decrease of non-bio waste volume from S4 TA to S6 TA approaching its original proportions in municipal waste of the TA.

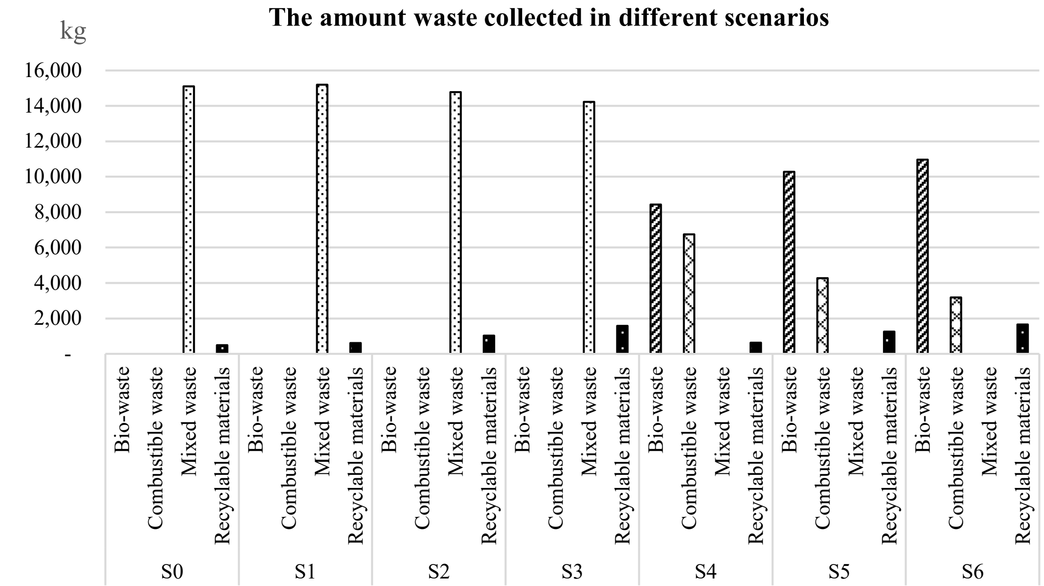


Figure 4.8. Amount of waste collected from tourism area by various scenarios

Improving the recovery rate of recyclable materials is a primary strategy for establishing a sustainable SWM system. *Figure 4.9* shows that the amount of recyclable material increase from 490 kg/day to 610, 1029, and 1579 kg/day equivalent to the recovery rate by 27.1%, 33.8%, 57% and 87.5% in S0 TA, S1 TA, S2 TA, and S3 TA, respectively. The higher the recycling practice rate, the higher the recovery rate of recyclable materials. Likewise, the recovery performance of recyclable material reaches 34.9%, 69.6% and 91.8% in S4 TA, S5 TA and S6 TA, respectively that is slightly higher than that of S1, S2, and S3. These differences are explained that the synchronous implementation of SWM practices at source may bring higher efficiency in recycling activities.

Furthermore, the performance of recyclable recovery not only depend on the SWM practice but also be different due to the type of recyclables. Particularly, *Figure 4.9* presents five types of recyclable waste are favoured for recycling by the users due to its marketable value except to glass. Although glass is non-marketable value in Vietnam, segregation of glass is suggested for recycling due to its negative impacts on treatment processes. The recovery performance by category is estimated in the range of 21% to 56%

for S1 and S4, 36% to 87% for S2 and S5, and 58% to 94% for S3 $_{TA}$ and S6 $_{TA}$, respectively. In which, the lowest and highest recovery performances belonged to papers and metals.

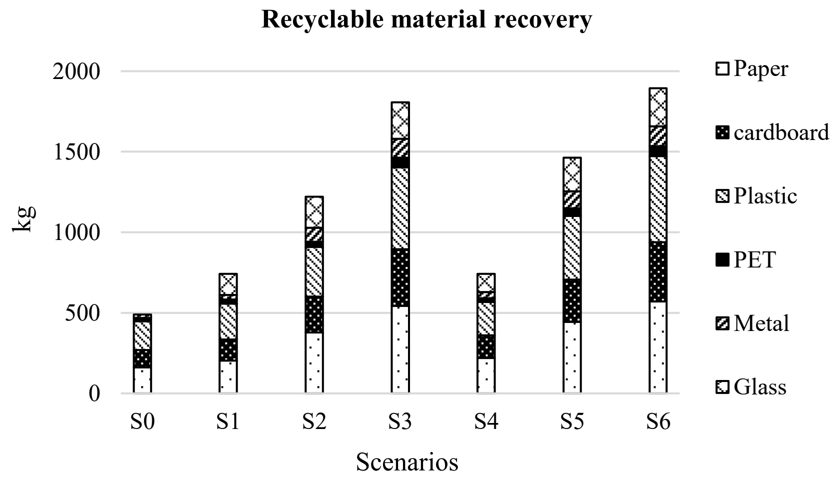


Figure 4.9. Amount of recyclable material recovered in different scenarios

Worldwide, recycling is known as an important factor of sustainable SWM system. *Alexis et al. (2008)* reported that waste segregation and collection, municipal SWM plan, and local recycled-material market are the essential elements influencing recycling system in developing countries *(Troschinetz and Mihelcic, 2009)*. Likewise, this study indicates that enhancement in the waste collection system and development of waste management practice might significantly enhance the waste collection performance and the recovery rate of recyclables. Furthermore, the increase in amount and purity of waste by separation might bring favourable conditions for treatment processes.

4.2.2.2.Analysing the waste characteristics

The characteristics of solid waste in scenarios are different due to the mixture and separation of waste. *Figure 4.9* describes the moisture content and HHV of waste collected from the TA in various scenarios. There is a slight decrease in HHV and insignificant growth in the moisture of waste in the TA from S0 $_{TA}$ to S3 $_{TA}$. The removal of recyclables may not bring substantial changes in characteristics of mixed waste, whereby, the fluctuation ranges from 47% to 51% for moisture and from16,4 to 16,9 MJ/kg for HHV. However, the significant changes in characteristics of waste are shown clearly at S4, S5 and S6 by segregation at source. Whereby, the moisture of non-bio-waste drops at 42.9%, 36% and 28.7% corresponding to HHV reaches at 16.0, 18.0 and 19.8 MJ/kg in S4, S5 and S6, respectively. Also, the characteristics of the bio-waste changes in a reverse trend, as such the purer the bio-waste composition, the higher the moisture content, and the lower the HHV is.

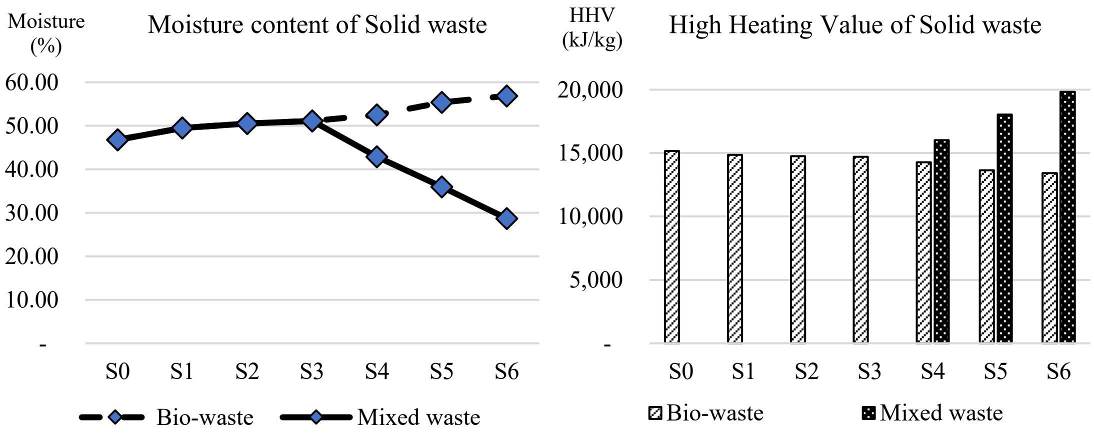


Figure.4.9. Characteristics of solid waste by scenarios

In general, the positive changes in waste characteristics may be proportional to the level of the waste management system, in which the rate of waste management practice and efficiency of waste collection system are the primary factors. The characteristics of mixed waste in $S0_{TA}$, $S1_{TA}$, $S2_{TA}$ and $S3_{TA}$ show the significant challenges that bring to the treatment process. Whereby, the principal problem of composting is a mixture of non-biodegradable waste, and obstacles of burning are the low HHV and high moisture. However, these challenges seem to be solved in $S4_{TA}$, $S5_{TA}$ and $S6_{TA}$ by enhancing the SWM system. Thereby, the wet organic waste is favourable for composting, or anaerobic digestion and dry non-bio-waste with the high HHV (around 20 MJ/kg) is suitable for incineration *(Dinh et al., 2020, 2018b, 2018a; Pham Van et al., 2018*). Therefore, the performance of the SWM system of the TA substantially affects the efficiency of treatment facilities, also might contribute to reducing obstacles of the municipal waste management system.

4.2.2.3.Analysing the cost-benefits

The economy is one of the essential factors of sustainable development. In this study, the optimisation of economic benefit is also the primary criteria to assess projects of the SWM system in the TA. *Figure 4.10* shows the net benefits of the SWM system in the TA by scenarios in the first five years of the project. The dark light of the net benefits graph is the negative net benefits trend of the SWM system in S0 TA. This means that to operate the current SWM system, the costs are higher than revenues, that is explained by the loss of income from illegal collection activities between collection crews and commercial sectors. Furthermore, the inefficiency of the current SWM system in the TA of HAC is proved by the benefit-cost ratio (BCR) in S0 TA is 0.81 less than 1.0. Correspondingly, reality shows that the government is subsidising the full cost of municipal waste disposal.

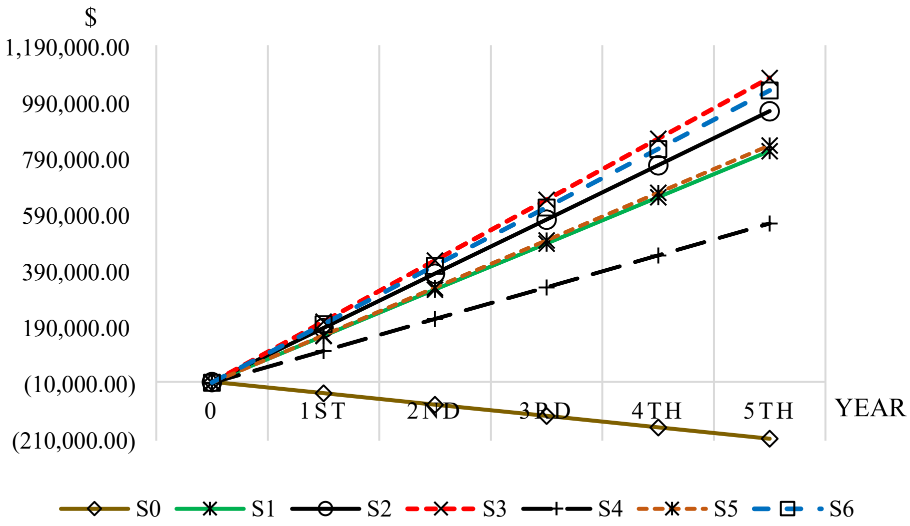


Figure 4.10. Net benefits of the SWM system in the tourism area by scenarios

Moreover, *Figure 4.17* also indicates that the SWM system in S1 TA to S6 TA might create positive net benefit values with the BCRs range from 1.44 to 1.99, which are higher than 1.0. While the SWM system in S4 TA has the lowest BCR (1.38), the difference in BCR between other scenarios is not significant. *Figure 4.17* reveals that the net benefit of the SWM system in S3 and S4 reaches about $ 990,030 and $945,064 after five years of deployment. This might indicate that the higher the rate SWM practice, the higher the net benefit of the SWM system. The improvement of BCR in scenarios might be explained by optimising revenues corresponding to the quality of the collection system. Notably, the income from selling recycling materials increase to 124.6% for S1 TA and 350.3% for S6TA according to the recycling practice rate. Besides, the acceptable tipping fee which is reached agreement from the service users increased more 20% for S1 TA, S2 TA and S3 TA and 10% for S4 TA, S5 TA and S6 TA. The tourist who is entering the TA willing to pay 1% of the ticket price to contribute to protecting the environment. The environmental cost should be added to the ticket price. For a tourist, 1% of a ticket price (about $0.052) may be a small money, however, for a significant number of arrival per day (around 6,000 tourists), the environmental cost from tourists is substantial revenue (accounted for 33% to 35% of total income) for the SWM system. The optimal tipping fee was accepted by users due to the satisfaction with the expected service quality.

In developing countries, the inconsistency between stakeholders and government in the waste collection is quite common and has proved by many studies. *Lilliana et al. (2013)* presented that although the service users are willing to pay and participate in the SWM practices for getting the improvement in collection service, the providers of waste collection tend to forget the need of stakeholders *(Lilliana et al., 2013)*. This is a common gap of a municipal SWM system. The loss of revenue is also a substantial problem in financial balance and may cause an economic burden for the municipalities.

4.3. Oriented planning SWM practice for the tourism industry towards sustainability

4.3.1. Analysing the waste flow of SWM practice models

The minimalism of SWM practice at sources in S1 and S2 is shown by the simply flow of TCI's waste in *Figure 4.11*. Notably, the mixed waste flows directly from waste sources to the treatment area by trucks. Whereas, recyclables are sorted at source by the intention rate (S1) and optimal rate (S2), then collected by itinerant buyers or recycling carts. A part of recyclable residue in the mixed waste is picked out by collection crews before loading to the trucks. The recyclables are recovered by formal and informal sectors and sold to the junk shops. Undeniably, being a part of the municipal SWM system, SWM practices in TCI has to be implemented synchronously with that of the municipal.

Although HAC has deployed waste separation at source since 2012, the waste sorting efficiency is still low, which was justified by many barriers *(Pham Phu et al., 2019; Song Toan et al., 2018)*. In the context of facing significant problems and challenges in the SWM system, specifically in tourist areas, hence, the minimalism on SWM practice in S1 and S2 may be considered as timely and consistent solutions for the current situations.

In other aspects, the SWM system of the CTI has advantages and opportunities for improving the performance of SWM practice towards sustainability, an inevitable trend of development. The enhancement of the SWM system for CTI that is simulated in S3 and S4 may create a more complicated waste stream. *Figure 4.12* shows that solid waste out of the sources with three separated directions due to segregation at sources enhancement. The recovery flow of recyclables is a priority in all scenarios of CTI's SWM system in HAC and handled by formal and informal sectors. Besides, one of the light points in S3 and S4 is the stock of waste in the flow by home-composting. The improvement of composting practice at source with the intention rate (S3) and optimal rate (S4) may reduce 3.7 tons and 8.8 tons of waste, respectively. Notably, *Figure 4.12* indicates that a significant daily amount of waste is recycled at sources by composting in the hotels and restaurants with a garden such as HSH, MSH, HOM, VIL, RES-Sub, and RES-Coa. For commercial sectors in the urban area that have favourable conditions for home-composting, bio-waste and non-bio-waste are required to sort for collecting daily by separated trucks. By enhancing SWM practice, solid waste gathers to the treatment area separately by bio-waste for composting and non-bio-waste for incineration.

In general, the more minimal the implementation of SWM practices at source is, the higher the consensus from communities is. This may release barriers of the implementation of SWM practice at source and reduce challenges of the SWM system in the tourism destination. Also, the minimalism in SWM practice at source may bring the neatness to municipal waste flow and simplicity to the collecting system that may increase the collecting rate of tourism waste. Nevertheless, minimalism in SWM system aims to maximise collection rate and minimise the stagnation of solid waste in urban areas are the primary purpose of the SWM system in developing countries in the context of waste generation, health and environmental problems are mounting the urgency. For long term strategy, the gradual improvement of the SWM system in the CTI is the necessary task towards sustainability. Whereby, the enhancement of waste separation at source, minimisation of waste generation and development of recycling practice are said to be the fundamental solutions of sustainable SWM system. Hence, in order to choose the optimal solutions for oriented planning SWM practice in the CTI, the effectiveness and suitability of SWM practice models should be analysed and evaluated.

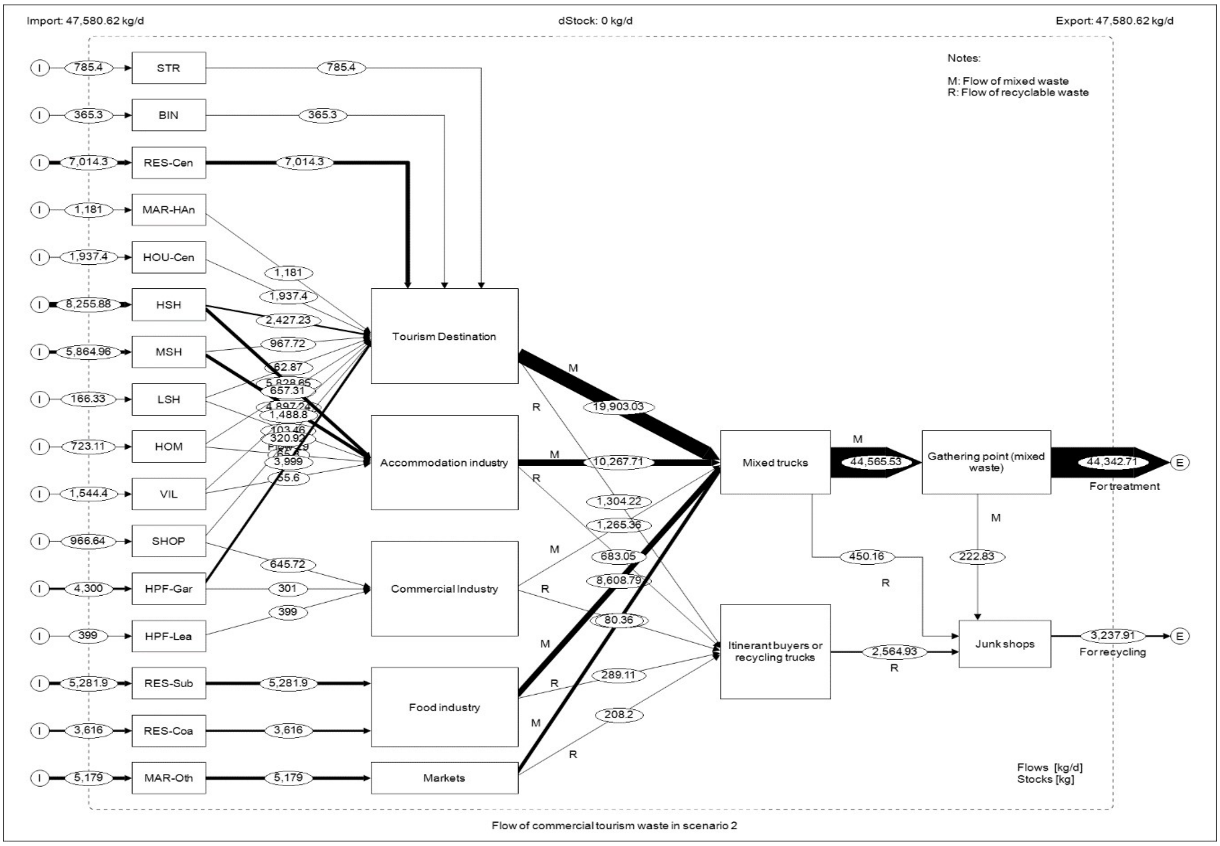


Figure 4.11. The waste flow of SWM practice model in minimalism orientation

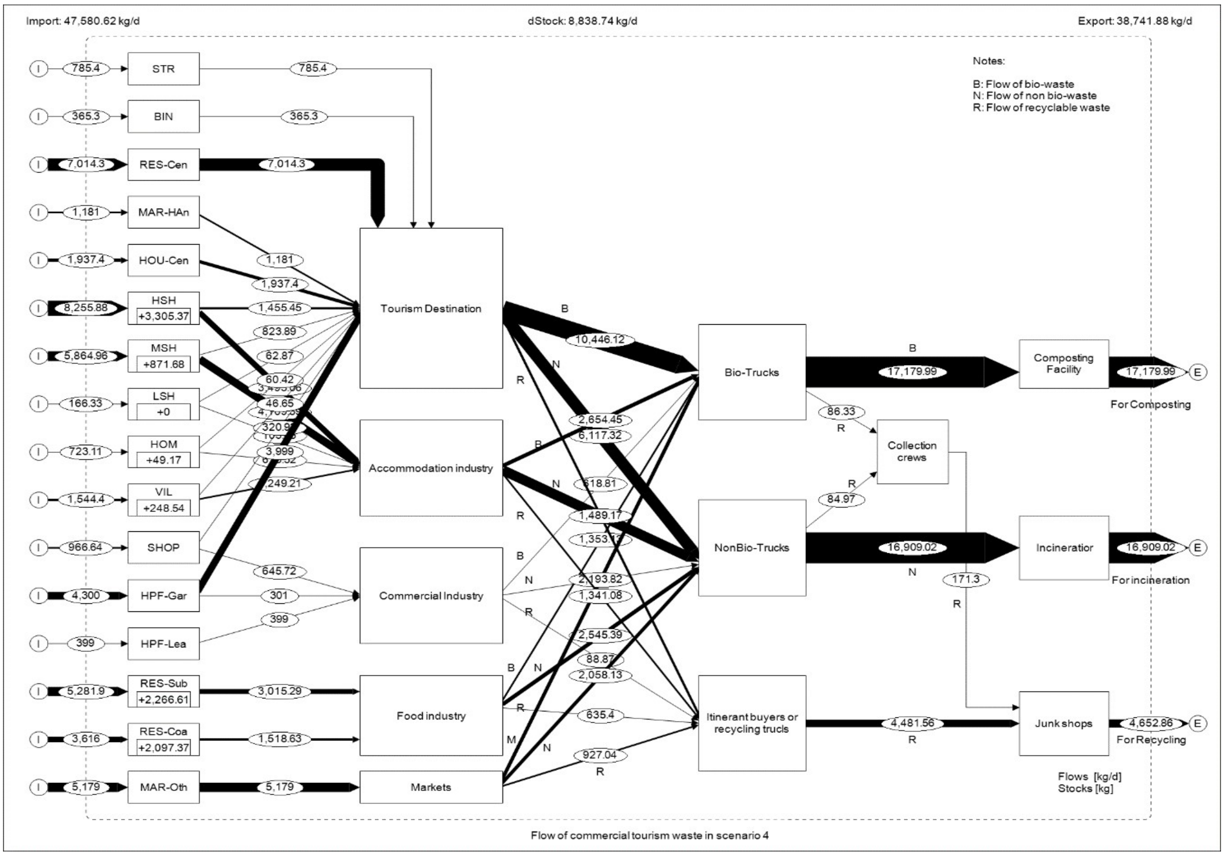


Figure 4.12. The waste flow of SWM practice model in sustainable orientation

4.3.2. Assessing integrated SWM practice models

The integrated SWM is a complex system that requires sufficient organisational capacity, appropriate technical solutions, and co-operation of stakeholders *(Marshall and Farahbakhsh, 2013)*. In which, SWM practice at source is the first step of the operating process and also a key factor of an integrated SWM system. The differences in waste management practice at source may influence the performance of the SWM system of the CTI in HAC.

4.3.2.1.Minimisation of waste to treatment and enhancement of recycling activities

Figure 4.13 presents the reduction efficiency of waste generation (denoted by column) and the recovery amount of recyclables (denoted by line) in different models of SWM practice. Notably, the amount of waste generated daily from the CTI reduces from 46.23 to 34.09 tons due to the enhancement of SWM practices. Also, minimisation efficiency of waste generation at source in S1, S2, S3 and S4 is 1.9%, 4.1%, 12.3% and 26.3%, respectively. Besides, *Table 4.2* shows that the recovery performance of recyclables in S1, S2, S3 and S4 is higher 2.0, 2.8, 6.2 and 11.8 times than that in S0, respectively. Therefore, the performance of waste minimisation at source may be proportional to the efficiency of waste recycling practice. The more recycling, the lower the waste generated.

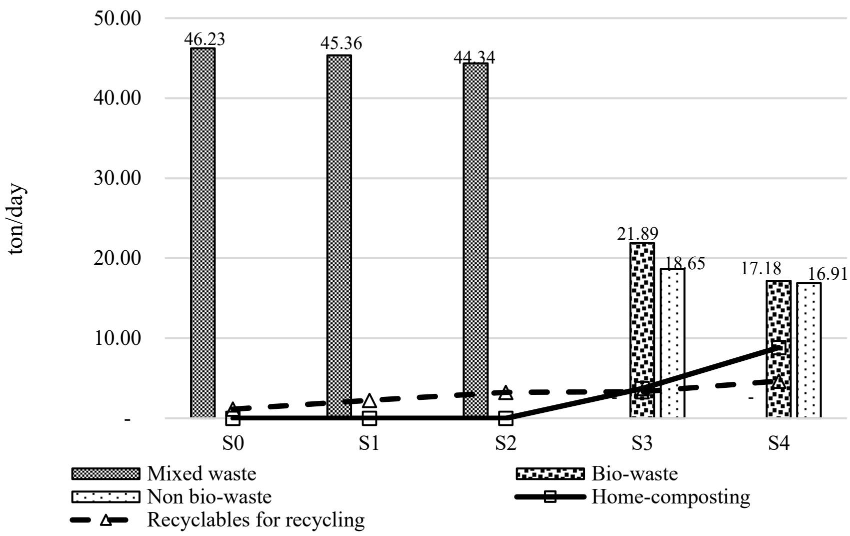


Figure 4.213. The amount of waste to the treatment in scenarios of SWM practice

Furthermore, these results also reveal that the performance of recycling and minimising waste generated at source in S3 and S4 is higher than that of S1 and S2.

Whereby, in S3 and S4, waste reduction performance is higher about 6.5 times, and the amount of recyclables are recovered is higher 3.3 and 4.2 times than that in S1 and S2, respectively. Particularly, *Table 4.2* presents that the amount of marketable recyclables such as papers, cardboard, plastics, PET bottles, and metals are recovered in the direction of gradual increasing from S0 to S4.

Table 4.2. Amount of recyclables recovered in scenarios of SWM practice

Amount of recyclables recovered in scenarios (kg)								
	Bio-waste	Papers	Cardboards	Plastics	PET	Metals	Glass	**Total**
S0	-	261.1	285.6	333	60.1	200.6	-	**1,140.4**
S1	-	446.9	470.5	551.0	88.6	272.3	393.9	**2,223.2**
S2	-	700.8	629.3	729.4	133.2	504.0	541.2	**3,237.9**
S3	3,708.14	640.6	877.0	669.9	99.6	481.4	562.9	**7,039.5**
S4	8,838.74	1,081.8	1,110.7	913.2	182.7	664.0	700.5	**13,491.6**

Although separating these dry recyclables to sell for profit has taken place quite popular in HAC, it seems to be unresponded by commercial sectors because of the consideration of inconvenience and benefits *(Song Toan et al., 2019, 2018)*. The remarkable increase of recycling performance in S3 and S4 may be explained by the improvement of waste separation at source and the promulgation of SWM practice regulation. The role of SWM practice enhancement in SWM system is strengthened again by recycling bio-waste at source. *Table 4.2* shows that a substantial amount of bio-waste in S3 (3.7 tons) and S4 (8.8 tons) may be handled by home-composting which cannot be performed in S0, S1 and S2 with the mixed waste. These results indicate that enhancement of waste separation and management practices at source may significantly bring favourable conditions for recycling and waste reduction.

4.3.2.2.Analysis of waste composition and characterisation for treatment

Figure 4.12 indicates that CTI's waste collected to the treatment area is mixed in S0, S1 and S2 and separated into bio-waste and non-bio-waste in S3 and S4 due to the level of SWM practice at source. The mixture or separation of waste may cause the differences in waste composition and characterisation that are influencing factors of treatment processes. Indeed, the composition of the mixed waste in S0, S1 and S2 seems to be no significant differences. Recycling practice by the intentional and optimal rates may cause a slight decrease in proportions of dry recyclables in S1 and S2. Consequently, the characterisation of the mixed waste in S0, S1 and S2 changes in small ranges of 13.1 to 13.2 kJ/kg for HHV and 47.4 to 48.1% for moisture (*Figure 4.14*). A substantial proportion of non-bio-waste (around 25%) in mixed waste is a significant obstacle for the composting process. Also, the mixed waste with around 60% of bio-waste, low HHV and high moisture are the causes of inefficiency in combustion, currently.

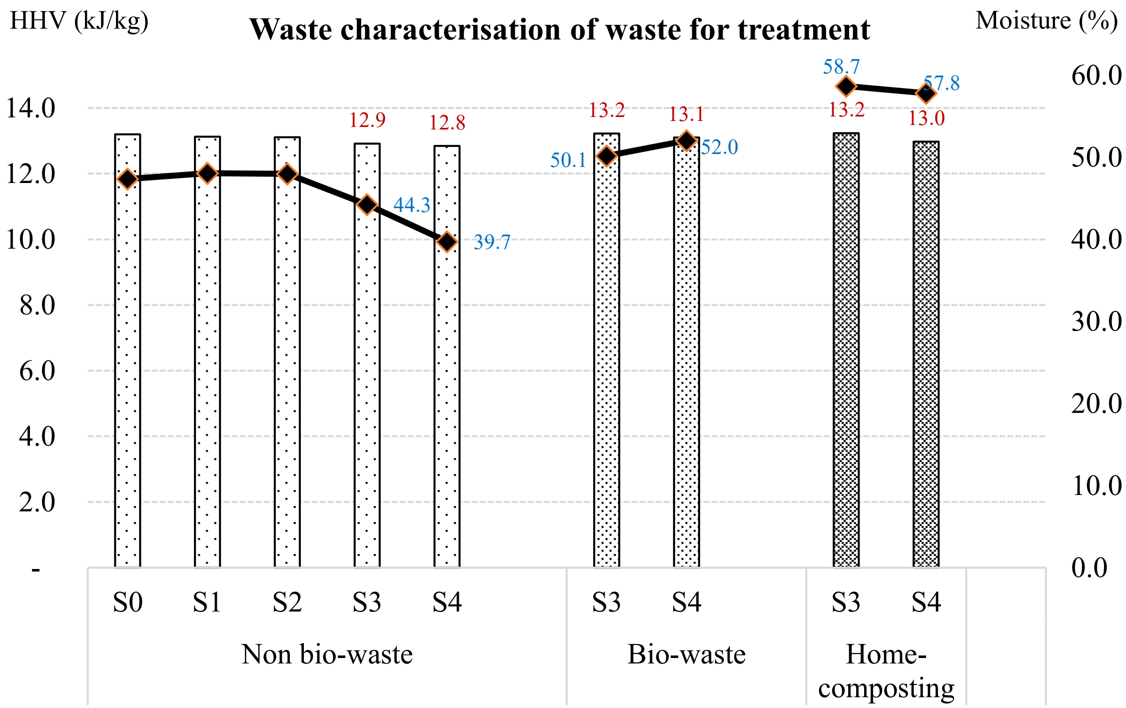


Figure 4.14. The characteristic of solid waste to the treatment of scenarios of SWM practice

Additionally, *Figure 4.21* presents the positive changes in waste composition and characterisation of waste in S3 and S4 for current disposals. Notably, the reduction of the non-biodegradable waste to 18.3% and 14.4% may cause an increase in moisture of bio-waste by 50.1% and 52% in S3 and S4, respectively. Also, the improvement of HHV and the declination of moisture of non-bio-waste may be caused by a significant removal of bio-waste. Consequently, the enhancement of SWM practice in S3 and S4 may contribute to purifying waste, creating favourable conditions for the current treatment processes in HAC.

4.3.2.3.Optimisation of economic benefits

The performance of the scenarios in SWM practice for the tourism industry in HAC was analysed clearly. It can be seen that minimalism in planning SWM practice is quite popular and suitable for urban areas in developing countries. Whereas, developing a sustainable SWMP is a complex process of upgrading SWMP by level in conjunction with an appropriate improvement of facilities and gradual promulgation of regulations and sanctions. Therefore, assessing the economic efficiency of the project is one of the criteria to consider the feasibility of the project with the study area.

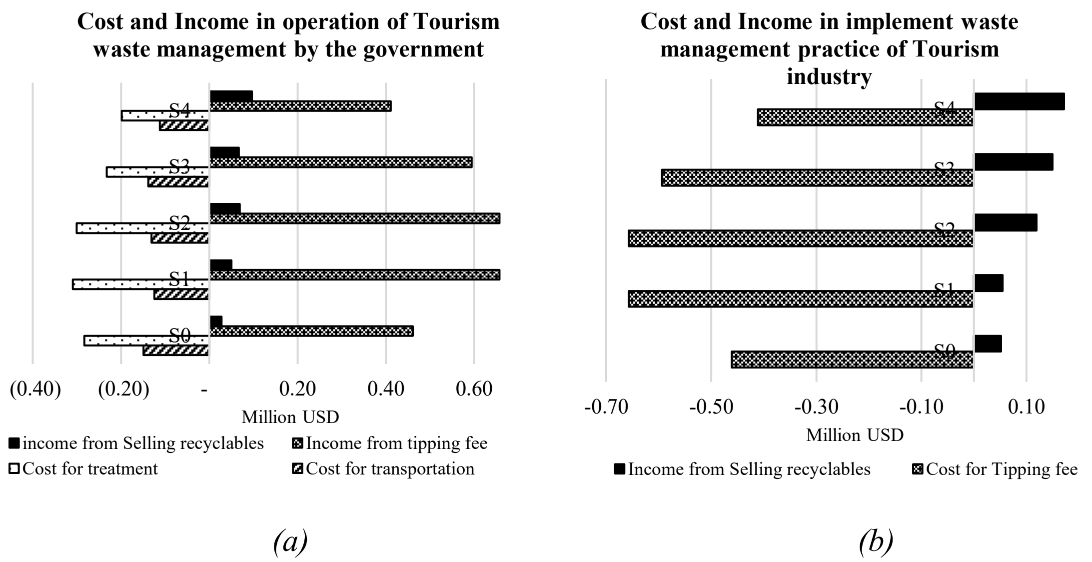


Figure 4.15. Cost and benefit for the government (a) and the TI from implementing SWMP scenarios in the TI

Figure 4.15 (a) & (b) illustrates the cost and income in implementing SWMP by scenarios of the government and the tourism industry. Notably, these figures show that the proceeds of collection fee that commercial sectors pay to the government in S0 are lower than that of to S1, S2, S3 and higher than that of S4. The difference in revenues from collection fee may be explained by the tipping free regulation of "pay as you throw" that means the more you waste, the higher the payment. Moreover, the changes in tipping fee regulation according to the SWMP level – "pay as you do", which is assumpted in scenarios aims to encourage the implementation of SWMP at source by commercial sectors. Whereby, the tipping fee is assumpted to increase 20% more for the minimalism in SWMP at source, and discount 20% for the implementation of SWMP at source comparing to the current tipping fee. The suggestion of "pay as you do" regulation receives the unanimous from the majority of stakeholders. In addition, the changes in the tipping fee corresponding to the quality of collection service in the tourism area may contribute to the difference in the revenues of the SWM system. Notably, the commercial sectors are willing to pay a higher tipping fee corresponding to the improvement of waste collection service quality aims to respond to the waste collection demand of stakeholders.

Furthermore, *Figure 4.15 (a) & (b)* show that the stakeholders and the government are both get benefit from recycling. Whereby, the income from selling dry recyclables by stakeholders and the government increase from S0 to S4 is proportional to the amount of recyclables recovered. It can be seen that the improvement of SWMP at source may help the tourism industry in HAC has a higher net benefit from SWM activities. In term of the city view, *Figure 4.16* reveals that planning in the sustainable strategy of SWMP significantly contributes to reducing the cost of transportation and treatment due to the waste generation minimisation.

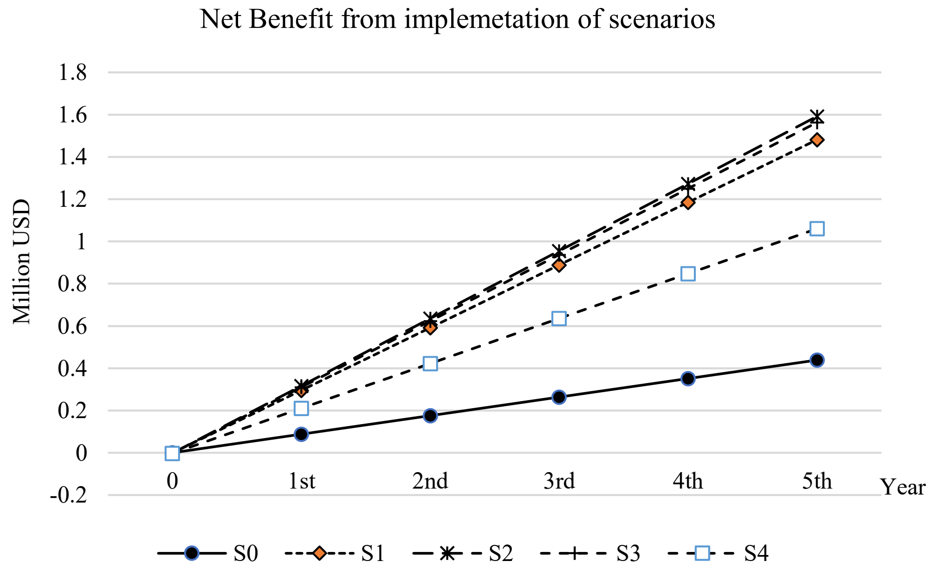
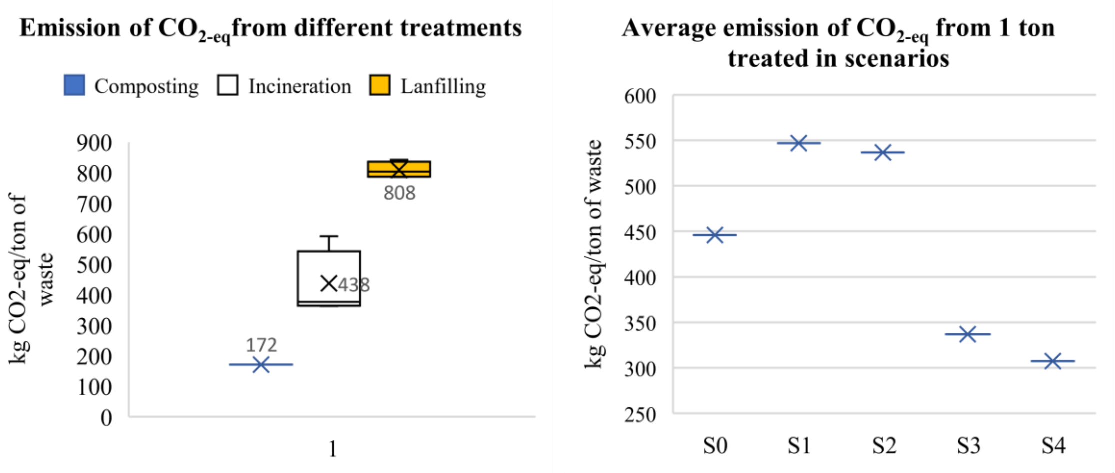


Figure 4.16. The net benefit of municipal SWM system from the implementation of SWMP scenarios

Furthermore, the feasibility of an SWMP development project is also considered by the net benefit which the project brings from the implementation process. *Figure 4.16* shows that the net benefit of the current SWM system for the tourism industry in HAC is the lowest with 0.088 million dollars per year. Whereas, the development of SWMP in the tourism industry may substantially contribute to increasing the economic benefit for municipal SWM system. Notably, the net benefit in S1, S2 and S3 is approximated by 0.3 million USD per year, followed by S4 with 0.21 million USD per year. The cost of investment in the first year of the project in some scenarios is quickly repaid within one year. The growth of net benefit year by year in implementing the project of SWMP is a great advantage to equip the facilities for municipal SWM system.

4.3.2.4.Mitigation of emissions

The level of SWM practice may lead to the reduction of waste to treatment, the changes in waste composition and characterisation. Therefore, the emission from treatment is expected to be mitigated. *Figure 4.17 (a)* presents that landfilling emits the highest amount GHG by 808 kg $CO_{2\text{-}eq}$ per tonne of waste. This is a low-cost and straightforward disposal that is quite common in developing countries. Whereas incineration and composting emit on average 438 and 172 kg $CO_{2\text{-}eq}$/tonne of waste. The low burning technology and inefficiency of exhaust gases treatment may be the reasons for the high emission from incineration in HAC. Composting may be an environmentally friendly solution. Composting is also an appropriate treatment method with solid waste has a high content of organic component that is the feature of solid waste in developing countries.



(a) *(b)*

Figure 4.17. Emission from waste treatment methods (a) and scenarios (b)

Nevertheless, the paradox is that waste separation at source is not considered in these countries, and this is the biggest obstacle in operating composting. The role of composting in emission mitigation from waste treatment is demonstrated in *Figure 4.17* *(b)* with the average carbon-footprint value of the tourism waste in S3 and S4 is 337 and 307 kg $CO_{2\text{-eq}}$ per tonne of solid waste treated, respectively. Whereas, the GHG amount emits from S1 and S2 is higher by 547 and 536 kg $CO_{2\text{-eq}}$/tonne of waste treated, respectively. The differences in the value of carbon-footprint of the tourism waste in scenarios indicate that the improvement of SWMP may contribute to reducing GHG emission from treatment than that of the minimalism.

In conclusion, this study presents the advantages and disadvantages of the minimalist and improved models of SWMP in the tourism industry in HAC. The minimalism model in SWMP seems to be quite popular in developing countries due to its compatibility with the poor SWM system, the low level of SWMP, and the restriction on facilities and lack of support. Besides, this study indicates that the tourism SWM system in HAC has a high potential for upgrading SWMP towards sustainability. Notably, the municipal SWM system in HAC is more complete than that of other areas by the abundant waste treatment plant such as composting facility and incineration plant. Also, waste is required to sort at source and separately collected. These are the favourable condition for developing municipal SWM system. Therefore, the development of SWMP for the tourism industry in HAC can be planned by the project consists of 2 phases with two different strategic directions in 10 years. Notably, the minimalist SWMP project (OP1 - from S0 to S1 and S2) and the sustainable SWMP (OP2 - from S0 to S3 and S4) in ten years of the project.

4.3.3. Oriented planning SWMP for the CTI in HAC towards sustainability

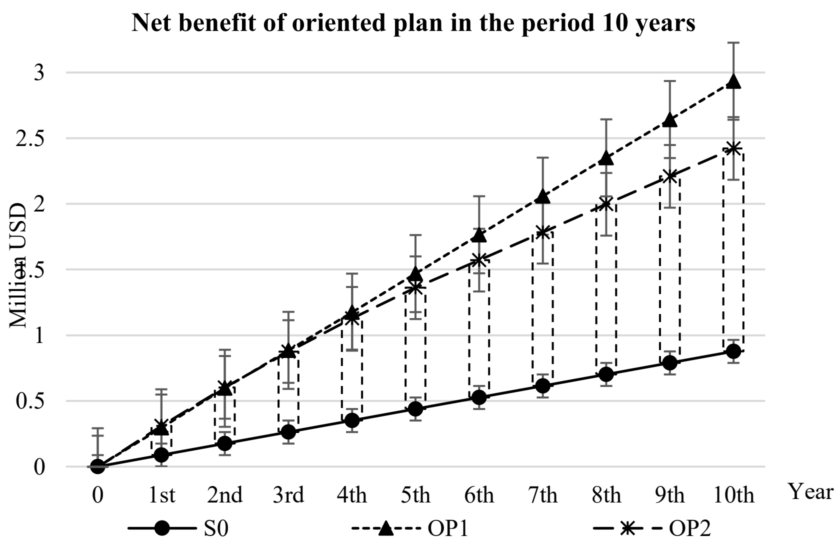


Figure 4.18. The net benefit of implementing SWMP projects

The feasibility of projects of developing SWMP for the TI can be assessed by the net benefit from implicating the projects in the period of ten years. *Figure 4.18* shows that the net benefit of projects OP1 and OP2 is significantly higher than the current project S0. Notably, in the first four years of the projects, there is no difference in the net benefit of two projects. This is explained by the time of returning the investment money and starting-up phase. Thus the changing the habits, improving skills and behaviours of stakeholders in implementing SWMP needs to be adopted gradually. The first phase of the project is to aim to improve the SWMP from the current rate to the intention rate with the support from the government and NGOs. This is a difficult period for the project.

Whereas, the next 5-years of the project is the second phase that is the time to simultaneously conduct SWMP with a higher level from intention rate to the optimal rate. In this phase, the net benefit line of two projects starts showing the difference. Whereby the net benefit of OP2 is lower than that of OP1 during the time of the phase. This difference may be explained by the reduction of income from tipping fee due to the regulation "pay as you throw" and "pay as you do". In term of the economic aspect, the net benefit from OP1 project (about 2 million USD) and OP2 project (1.5 million USD) achieve positive values and is significantly higher than the current project (0.9 million USD). This information reveals that both projects OP1 and OP2 are feasible in implementation.

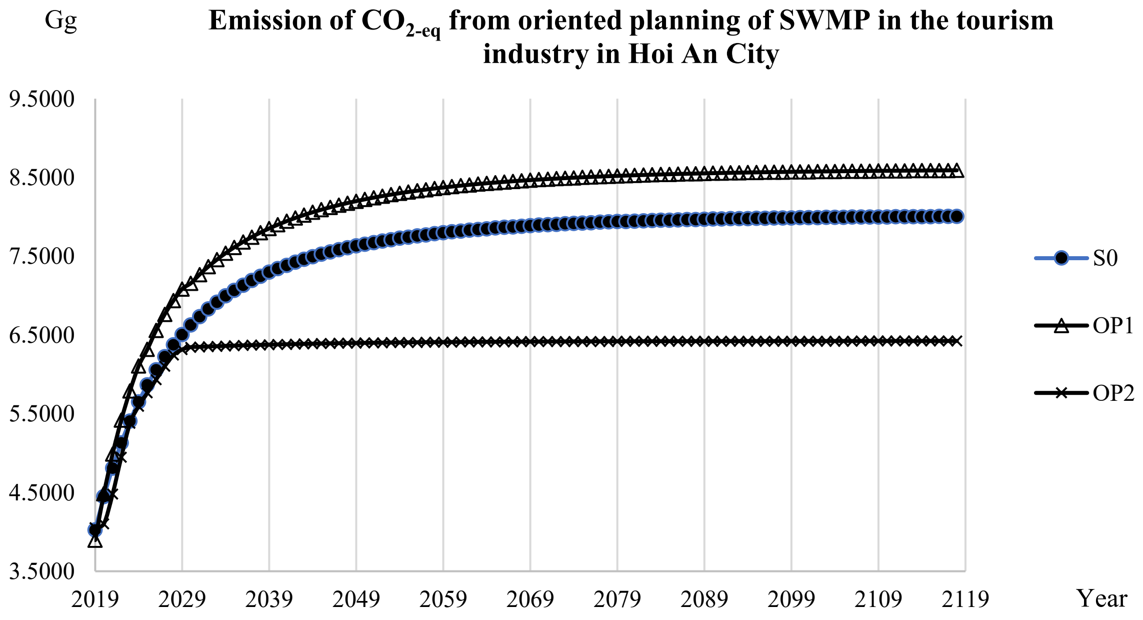


Figure 4.19. GHG emission from projects of SWMP in the TI of HAC

The OP1 has the advantage in the economic aspect; however, in term of environmental aspect, the OP1 emits much GHG than other projects. *Figure 4.19* illustrates the estimation of GHG emission from the treatment of tourism waste in 100 years. The development of SWMP in different orientation may affect the emission. Notably, the minimalism in SWMP at source emits much GHG emission than that of the sustainability. This difference in emission may be explained by the reduction of waste to the landfill, which is the most polluted disposal in along time, and the development of home-composting that is an eco-friendly solution. Thus, in term of environment, OP2 proves that upgrading SWMP plays an important role in emission mitigation.

4.4. Conclusion

This chapter finds the appropriate solutions to resolve the current problems that the SWM system in the TI is facing.

For the accommodation, this study focused on assessing the efficiency of separation at source of the hotels' waste and evaluating the recycling potential of the hotel industry in HAC. Separation and recycling practice scenarios were designed based on the status and intention of WMP, and the importance of factors related to RPE. This study revealed that the SWM system of the hotel industry in HAC has a high potential for developing recycling practices and will get significant benefits from recycling.

(1) The recyclable materials accounted for a significant proportion (84.3%) of the hotel waste, in which compostable waste constituted 58.5%. Furthermore, 88.65% of the hotel waste was produced from the HSH and MSH, which have favourable conditions for home composting.

(2) Although the efficiency of waste segregation at source was restricted, the high intentions of WMP of the hoteliers were a positive sign for enhancing recycling practices. Besides, WMP, PP and EBO were identified as the most important factors should be developed toward sustainable recycling practice.

(3) Waste generation from the hotel industry was estimated to significantly reduce in the range of 30% to 70% of total hotel waste depending on the performance of recycling practices. The higher the rate of recycling practice, the higher the proportion of waste reduction.

(4) Separation and recycling practice might positively change the characteristics of waste in favour of waste treatments. Whereby, the decrease in the moisture content and the increase in the HHV of the mixed waste might contribute to improving the efficiency of incineration. Also, the characteristics of the mixture of kitchen waste, garden waste, and tissue paper were suitable for composting at the hotel, as it had a moisture content of 57%– 60% and a C/N of 23.4–27.6.

(5) Recycling practice was estimated to provide substantial economic benefits to the hotels. The higher the efficiency of recycling practice, the higher the economic benefit. Even as the recycling practice approaches the optimum value, the profits from the sustainability of the SWM system would be positive.

This study also indicated that to enhance recycling practices, WMP should be improved, waste regulation and encouragement should be promulgated and intensified, and benefits to the hotels from recycling should be further studied to improve the SWM motivation of the hoteliers. Besides the role of government, stakeholders' roles should be strengthened to support the hoteliers in the implementation of SWM.

For the tourism area, the results reveal that the non-separation at source scenarios (S1, S2, and S3) get a more positive response from stakeholders (especially commercial sectors) by the high consensus and willing to pay the higher tipping fee due to the minimalism in waste management practice at source. However, the models of the SWM system with waste segregation at source requirement (S4, S5, and S6) are more effective. Whereby, the SWM system in S6 is the optimal and feasible model for the TA in HAC. In order to approach this optimal model, the gradual upgrade process of the SWM system is suggested to deploy step-by-step from S0 to S4, and S5 under the monitoring of the government and the support from social organisations. Thereby, some solutions are suggested to implement as follows:

(6) Solid waste separation at source should be continuously encouraged and supported to improve with three types such as bio-waste (kitchen waste, garden waste, and tissue paper), recyclable waste (metals, plastics, PET bottles, cardboard, papers, and glass), and the residues.

(7) Investment of waste collection infrastructure should be considered as the priority solution. Whereby, the number of street trash and cart is added more 20 and eight, respectively. Three trash with the international symbol corresponding to three types of waste should be set up at a collection point.

(8) Waste collection service should be enhanced. Notably, bio-waste and residues are collected daily by trucks in the morning and carts in the afternoon, respectively, while recyclables are recovered one per day by carts. Furthermore, the collection schedule of trucks should be considered to be in the night time to avoid traffic and disrupting tourist.

(9) The tipping fee should be identified based on the actual waste generation from commercial sectors. Then, it should be considered for increasing by 10% more due to the improvement of collection service and agreement of business sectors. The environmental fee for tourist entering the TA should be considered for charging 1% of the ticket.

(10) Waste management regulation should be considered for promulgation. Notably, refusing collection and financial punishment for un-classification at source. Also, regulation on the recovery of recyclable materials should be widely promulgated in the TA. The illegal collection activities should be severely punished both of the suppliers and users service.

(11) The policy of support and reward from the government should be enhanced to encourage the efforts of business sectors in the implementation of waste management policy.

For the tourism industry, this study indicates that the development of SWM practice for the tourism industry in HAC in sustainable direction has many advantages and may contribute to resolving the current problems of municipal SWM system.

(12) Reducing 26.5% waste generation at source and enhancing recycling efficiency (8.84 tons by composting, and 4.65 tons of dry recyclable is recovered for recycling)

(13) Positively improving waste composition and characterisation for incineration (HHV increase to 13.0 MJ/kg) and composting (moisture increase to 52%).

(14) Significantly increasing the net benefit value of tourism SWM system and contribute to improving the net benefit of municipal SWM system.

(15) Substantially mitigating emission from waste treatment (from 446 t0 307 kg CO_{2-eq} per kg of waste treated)

Overall, the TI in HAC has potential to upgrade SWMP from the current status to optimal practice rate under the oriented planning projects in ten years. The core value of the sustainable model of SWMP in the TI is reflected in the compatibility with the region, the effectiveness in SWM techniques, contributing positively to solving the current problems of municipal SWM system. Furthermore, the core value of sustainable SWM system in the TI is also balanced in the integrated enhancement of economy, environment and society.

4.5. References

Atalia, K.R., Buha, D.M., Bhavsar, K.A., Shah, N.K., 2015. A Review on Composting of Municipal Solid Waste. IOSR Journal of Environmental Science, Toxicology and Food Technology 9, 20–29. https://doi.org/10.9790/2402-09512029

Cencic, O., 2016. Nonlinear data reconciliation in material flow analysis with software STAN. Sustainable Environment Research 26, 291–298.

Dinh, P.., Giang, H.M., Song Toan, P.., Takeshi, F., 2018a. Kinetics of carbon dioxide, methane and hydrolysis in co-digestion of food and vegetable waste. Global J. Environ. Sci. Manage 4, 401–412. https://doi.org/10.22034/gjesm.2018.04.00

Dinh, P.., Takeshi, F., Bach, L.., Song Toan, P.., Giang, H.M., 2020. A review of anaerobic digestion systems for biodegradable waste: Configurations, operating parameters, and current trends. Environmental Engineering Research 25, 1–17.

Dinh, P.., Takeshi, F., Song Toan, P.., Giang, H.M., 2018b. Kinetic of Biogas Production in Co-Digestion of Vegetable Waste, Horse Dung, and Sludge by Batch Reactors. IOP Conference Series: Earth and Environmental Science 159, 304–311.

Ezeah, C., Fazakerley, J., Byrne, T., 2015. Tourism Waste Management in the European Union: Lessons Learned from Four Popular EU Tourist Destinations. American Journal of Climate Change 04, 431–445. https://doi.org/10.4236/ajcc.2015.45035

Giang, H.M., Song Toan, P.., Takeshi, F., 2016. An investigation of househouse waste generation and composition in Hoi An, Vietnam. Presented at the 3RINCs International Conference, Ha Noi City,Vietnam, pp. 123–126.

Giang, H.M., Takeshi, F., Song Toan, P.P., 2017. Municipal Waste Generation and Composition In A Tourist City - Hoi An, Vietnam. Journal of JSCE 5, 123–132.

Hoi An Public Work Company, 2017. Data collection.

Kim, M., Jang, Y.-C., Lee, S., 2013. Application of Delphi-AHP methods to select the priorities of WEEE for recycling in a waste management decision-making tool. Journal of Environmental Management 128, 941–948. https://doi.org/10.1016/j.jenvman.2013.06.049

Lilliana, A.G., Ger, M., William, H., 2013. Solid waste management challenges for cities in developing countries. Waste Management 33, 220–232. https://doi.org/10.1016/j.wasman.2012.09.008

Marshall, R.E., Farahbakhsh, K., 2013. Systems approaches to integrated solid waste management in developing countries. Waste Management 33, 988–1003. https://doi.org/10.1016/j.wasman.2012.12.023

Nguyen, T., Nguyen, H., Lobo, A., Dao, T., 2017. Encouraging Vietnamese Household Recycling Behavior: Insights and Implications. Sustainability 9, 179–194. https://doi.org/10.3390/su9020179

Pham Phu, S.T., Fujiwara, T., Hoang, M.G., Pham, V.D., Tran, M.T., 2019. Waste separation at source and recycling potential of the hotel industry in Hoi An city, Vietnam. Journal of Material Cycles and Waste Management 21, 23–34. https://doi.org/10.1007/s10163-018-0807-5

Pham Van, D., Hoang, M.G., Pham Phu, S.T., Fujiwara, T., 2018. A new kinetic model for biogas production from co-digestion by batch mode. Global Journal of Environmental Science and Management 4, 251–262. https://doi.org/10.22034/gjesm.2018.03.001

Pirani, S.I., Arafat, H.A., 2014. Solid waste management in the hospitality industry: A review. Journal of Environmental Management 146, 320–336. https://doi.org/10.1016/j.jenvman.2014.07.038

Quang Nam Province, 2016. Regulation of waste collection fee in Quang Nam province.

Shamshiry, E., Mokhtar, M.B., Abdulai, A.M., Komoo, I., 2015. Using the Analytic Hierarchy Process to Enhance Sustainable Solid Waste Management: Case Study of Langkawi Island, Malaysia: Sustainable Solid Waste Management. Environmental Quality Management 24, 51–64. https://doi.org/10.1002/tqem.21404

Shamshiry, E., Nadi, B., Bin Mokhtar, M., Komoo, I., Saadiah Hashim, H., Yahaya, N., 2011. Integrated Models for Solid Waste Management in Tourism Regions: Langkawi Island, Malaysia. Journal of Environmental and Public Health 2011, 1–5. https://doi.org/10.1155/2011/709549

Song Toan, P.., Takeshi, F., Hoa, K.T., 2017. An Analysis Of Waste Characteristics And Counting Of Greenhouse Gas Emissions From Cam Ha Composting Facility In Hoi An City, Vietnam. Presented at the The 5th Vietnam-Japan Workshop on Estuaries, Coasts and Rivers, Construction Publisher, Hoi An, Vietnam, pp. 221–227.

Song Toan, P.P., Fujiwara, T., Dinh, P.V., Hoa, K.T., 2018a. Waste Recycling System for a Tourism City in Vietnam: Situation and Sustainable Strategy Approach – Case Study in Hoi An City, Vietnam. IOP Conference Series: Earth and Environmental Science 159, 342–349. https://doi.org/10.1088/1755-1315/159/1/012046

Song Toan, P.P., Minh Giang, H., Takeshi, F., 2018b. Analyzing solid waste management practices for the hotel industry. Global Journal of Environmental Science and

Management 4, 19–30. https://doi.org/10.22034/gjesm.2018.04.01.003

Song Toan, P.P., Takeshi, F., Giang, H.M., Dinh, P.V., 2019. An analysis of the commercial waste characterisation in a tourism city in Vietnam. Int. J. Environment and Waste Management 23, 319–335. https://doi.org/10.1504/IJEWM.2019.099015

Toan, P.P.S., Takeshi, F., M. Giang, H., 2017. A Comparison of solid waste generation rate between types of hotel in Hoi An ancient City, Vietnam, in: Waste Management. Presented at the The 28th Annual Conference of JSMSWM, Tokyo, pp. 507–508.

Troschinetz, A.M., Mihelcic, J.R., 2009. Sustainable recycling of municipal solid waste in developing countries. Waste Management 29, 915–923. https://doi.org/10.1016/j.wasman.2008.04.016

Chapter 5

Conclusion and Recommendation

5.1. Summary of key findings

This study indicated that solid waste generated from the TI in HAC accounted for 65% of the municipal waste. Whereby the generation rate from each source of tourism waste is 33% from tourism area, 27% from accommodation business, 19% from restaurants, 10% from markets, and 11% from other commercial activities. Furthermore, identification of the SWG rate, waste composition, and characterisation of the TI in HAC are the primary findings of this study.

(1) The average SWG rate of the hotel industry in HAC is 2.28 kg.guest^{-1}.day^{-1}. Besides, the difference in SWG rate between types of hotels is statistically significant. Whereby, the higher the scale of the hotels, the higher the SWG rate. This study also proves that internal objective factors as the capacity of the hotels, cost of the room, garden, and restaurant were highly correlated with SWG rate. Besides, the average SWG rate of commercial sectors is identified by 1.27 kg.bill^{-1} for restaurants, 0.86 kg.shop^{-1}.day^{-1} for shops business, 1.15 kg.stall^{-1}.day^{-1} for markets, 0.28 kg.product^{-1} for garment production, and 0.26 kg.product^{-1} for leather production. In each commercial business, the differences in SWG rate is proved and explained. Also, the restaurants in the centre daily generated more waste than that in the sub-centre and coastal areas.

(2) About 84.3% of hotel waste is organic and recyclable waste. Also, SWC of the hotels in the wet season compared with the dry seasons is slightly different. Mainly, in the wet season the percentages of kitchen waste (35.5%), glass (2%) and plastic (13.8%) are lower, and the rate of garden waste (15.5%), combustible waste (13.8%) and incombustible waste (1.5%) are higher than that of the dry season. Furthermore, this study also reveals that the waste composition of various hotels is a little different. Whereby, the higher scale hotels, the higher percentage of biodegradable waste, the less proportion of recyclable waste. Additionally, the composition of commercial waste in Hoi An tourism city are analysed by 66.8% for biodegradable, 20.1% for recycling, 11.3% for combustible, 1.8% for

incombustible, and 1.4% for hazardous waste. The waste composition features of each type of business are identified and compared. Notably, the biodegradable and recycling waste are the primary components of the restaurant industry (76.9% and 18%), markets (41% and 38%), and shop business (58% and 26.8%). Whereas, waste from manufacturing is the features of waste composition in handicraft production facilities.

(3) The characterisation of commercial waste is measured, compared and analysed in detail. Whereby, the density and moisture of waste of the restaurants are higher than that of markets, shops, and HPF, while the heating value of waste is variable in the opposite direction. Furthermore, this study also indicates that home-composting model is feasible to applicate for restaurant waste due to the favourable concentration of carbon and nitrogen of biodegradable waste.

(4) The SWM practice of the hotels in HAC initially reaps quite positive achievements with the rate of hotels that deployed SWM practices are 76% for sorting, 39% for recycling, 29% for reduction and 0.8% for composting. Whereby, the higher the scale of hotels, the more attention in SWM practices. Moreover, the performance of sorting practice of the hotel is pretty high for chemical residue (93%) followed by glass (77.5%), textile (77.0%), metal (74.8%), PET bottle and garden waste (72.2%) except for some misclassifications for paper and combustible waste. The situation of SWM practices of the hotels is explained by many subjective and objective causes by hoteliers such as unfavorite waste storing, lack of SWM information and skills, occupying the significant area, taking more time and labours, and being unsanitary. In the TA, the SWM practices are not well responded to, except for the households, restaurants, and hotels. Low rates and inefficiency in waste separation practices are justified by a small downtown, odour, and lack of necessity due to a small waste amount. Low recycling efficiency is explained by inconvenience in storing recyclable materials and lack a recycling collection service.

(5) The overload of waste in street bins and disruption of waste collection in the TA of HAC are the urgent problems of the SWM system and may be caused by the illegal throw of waste into street bins by shops owners and illegal collection of restaurant waste by carts. The tacit deal in this illegal collection brings small income for

collection crews but causes a significant financial loss to the SWM system ($17,007 year^{-1}) and restaurants ($75.08 restaurant^{-1}.year^{-1}). This gap in the SWM system in HAC also signifies a significant challenge for the government to reach a sustainability goal in the SWM. Furthermore, the mixing of waste after separation causes the denial of waste segregation effort at source and leads to the distrust of residents and tourists to a waste management program in the TA of HAC. The inappropriate collection time and manner, and dissatisfaction in waste collection demands from a business sector cause non-cooperation of stakeholders and disruption in the waste collection system. Thus, a balance in waste collection demands from a business sector and timely response of the collection system should be found. It is also a substantial challenge that the waste collection system currently faces.

(6) The inefficiency of waste treatment plants and the overload of open dumping sites in HAC due to the unsuitable technology of treatment facilities and the unfavorability of waste characterisation are the substantial problems for the SWM system. Improvement in these restrictions may cause a significant challenge for the government.

This study finds the appropriate solutions to resolve the current problems that the SWM system in the TI is facing.

(7) For the accommodation, this study revealed that the SWM system of the hotel industry in HAC has a high potential for developing recycling practices and will get significant benefits from recycling. The recyclable materials accounted for a significant proportion (84.3%) of the hotel waste, in which compostable waste constituted 58.5%. Furthermore, 88.65% of the hotel waste is generated from the HSH and MSH, which have favourable conditions for home composting. Although the efficiency of waste segregation at source is restricted, the high intention of WMP of the hoteliers is a positive sign for enhancing recycling practices. Besides, WMP, PP and EBO are identified as the most important factors should be developed toward sustainable recycling practice. Waste generation from the hotel industry is estimated to significantly reduce in the range of 30% to 70% of total hotel waste depending on the performance of recycling practices. The higher the rate of

recycling practice, the higher the proportion of waste reduction. Separation and recycling practice might positively change the characteristics of waste in favour of waste treatments. Whereby, the decrease in the moisture content and the increase in the HHV of the mixed waste might contribute to improving the efficiency of incineration. Also, the characteristics of the mixture of kitchen waste, garden waste, and tissue paper are suitable for composting at the hotel, as it had a moisture content of 57%– 60% and a C/N of 23.4–27.6. Recycling practice is estimated to provide substantial economic benefits to the hotels. The higher the efficiency of recycling practice, the higher the economic benefit. Even as the recycling practice approaches the optimum value, the profits from the sustainability of the SWM system would be positive.

(8) For the tourism area, the results reveal that the non-separation at source scenarios (S1, S2, and S3) get a more positive response from stakeholders (especially from commercial sectors) by the high consensus and willing to pay the higher tipping fee due to the minimalism in waste management practice at source. However, the models of the SWM system with waste segregation at source requirement (S4, S5, and S6) are more effective. Whereby, the SWM system in S6 is the optimal and feasible model for the TA in HAC.

(9) For the tourism industry, this study indicates that the development of SWM practice for the tourism industry in HAC in sustainable direction has many advantages and may contribute to resolving the current problems of municipal SWM system, such as reducing 26.5% waste generation at source and enhancing recycling efficiency (8.84 tons by composting, and 4.65 tons of dry recyclable is recovered for recycling). Positively improving waste composition and characterisation for incineration (HHV increase to 13.0 $MJ.kg^{-1}$) and composting (moisture increase to 52%). Significantly increasing the net benefit value of tourism SWM system and contribute to improving the net benefit of municipal SWM system. Substantially mitigating emission from waste treatment (from 446 t0 307 kg CO_{2-eq} per kg of waste treated)

Overall, this study concludes that the tourism industry in HAC has potential to upgrade SWMP from the current status to optimal practice rate under the oriented planning projects in ten years. The core value of the sustainable model of SWMP in the tourism industry is reflected in the compatibility with the region, the effectiveness in SWM techniques, contributing positively to solving the current problems of municipal SWM system. Furthermore, the core value of sustainable SWM system in the tourism industry is also balanced in the integrated enhancement of economy, environment and society.

5.2. Limitations of the study and recommendations for future studies

The dissertation aims to oriented planning on the SWM practice of the tourism industry in Hoi An City towards sustainability. However, there are some limitations.

(1) There are some itinerant commercial sectors such as travel company, street vendors or floating restaurant (on the boat) that are the non-permanent operation of time and space are not mentioned in this study. The solid waste generated from these sectors was not identified and also difficultly controlled by the government.

(2) The primary survey in this study is in the wet season. Although there was a sampling survey in the dry season in 2016 by previous PhD student, municipal waste was the main objective. Therefore, the lack of analysis of tourism solid waste characterisation by season is one of the limitations of this study.

(3) In waste management practice at source, reduce and reuse are the priority activities in the waste management hierarchy. However, these practices, that were not analysed more in this study due to the concept of the study should be considered to study as a long-term strategy in waste minimisation at source.

(4) The estimation of the number of collection route by the reduction of waste generation at source in scenarios is a limitation in the analysis of optimal collection system and the benefit from the collection. A clear analysis of economic for HAC should be developed before implementing the project.

This study is the pre-feasibility researching step for a planning project of developing a SWM system in Hoi An City, in which, the tourism waste is the first priority. From planning project to the implementation to reality will be facing many gaps and challenges. Thus, several issues should be studied more to gradually implement the project.

(1) Study on an appropriate guideline of SWM practice for the commercial tourism sectors. In which in each period, the main task and the detail activities should be

presented. Also, the support and monitoring from the NGOs should be provided to optimise the efficiency of waste management practice at source.

(2) Waste management regulation should be studied based on the results of this study. The decision-making process should be promoted to become a legal framework of waste management that is a useful tool to effectively support the implementation process.

(3) Waste recycling system should be studied and upgraded to meet the enhancement of recycling practice at source. Also, home-composting should be studied more to optimise the efficiency of the composting system and improve the composting practice rate.

(4) The performance of treatment plants (composting and incineration plants) that is the current problems of the city should be studied to improve.

(5) An integrated model of the municipal SWM system that consists of tourism waste, household waste and other waste sources should be developed.

Appendix

A. Waste sampling survey

A.1-2. Solid Waste collected from high-scale hotels to sampling site (for a big amount of waste)

A.3-4. Solid waste collected from street bins and markets

A.5-6. Solid waste collected from street and Villa (small amount of waste)

B. Waste composition analysis

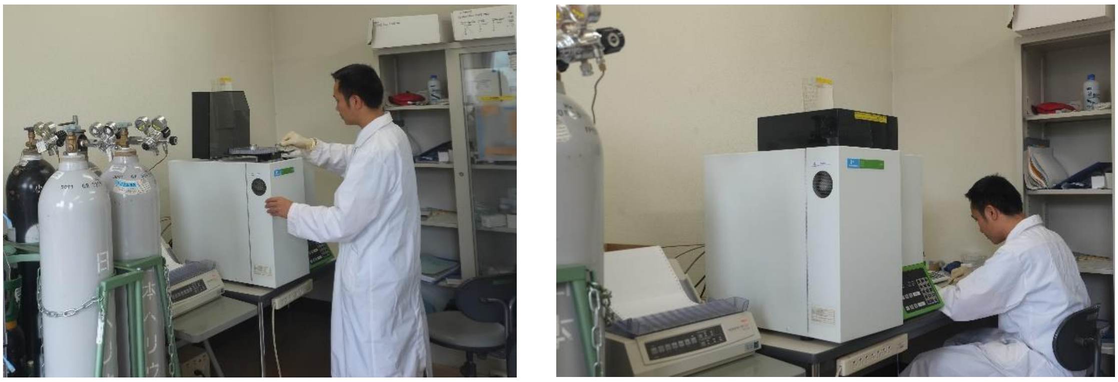
B.1-2. Corning and quatering method

B.3-4. Sorting solid waste at the sampling site

C. Waste characterisation analysis

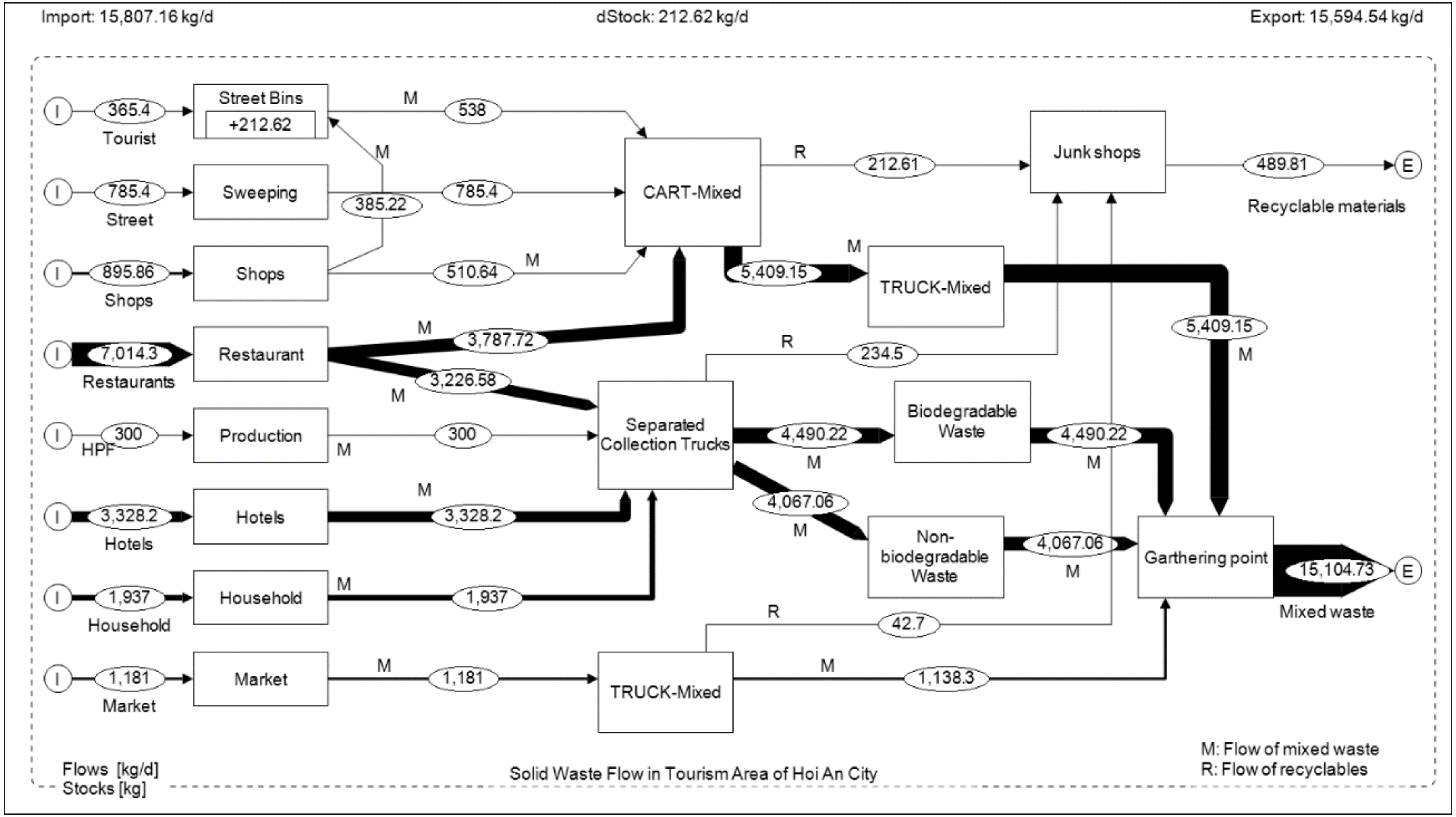
C.1-2. Waste analysis at the sampling site

C.3-4. Analysing solid waste moisture and storing samples to bring to Okayama

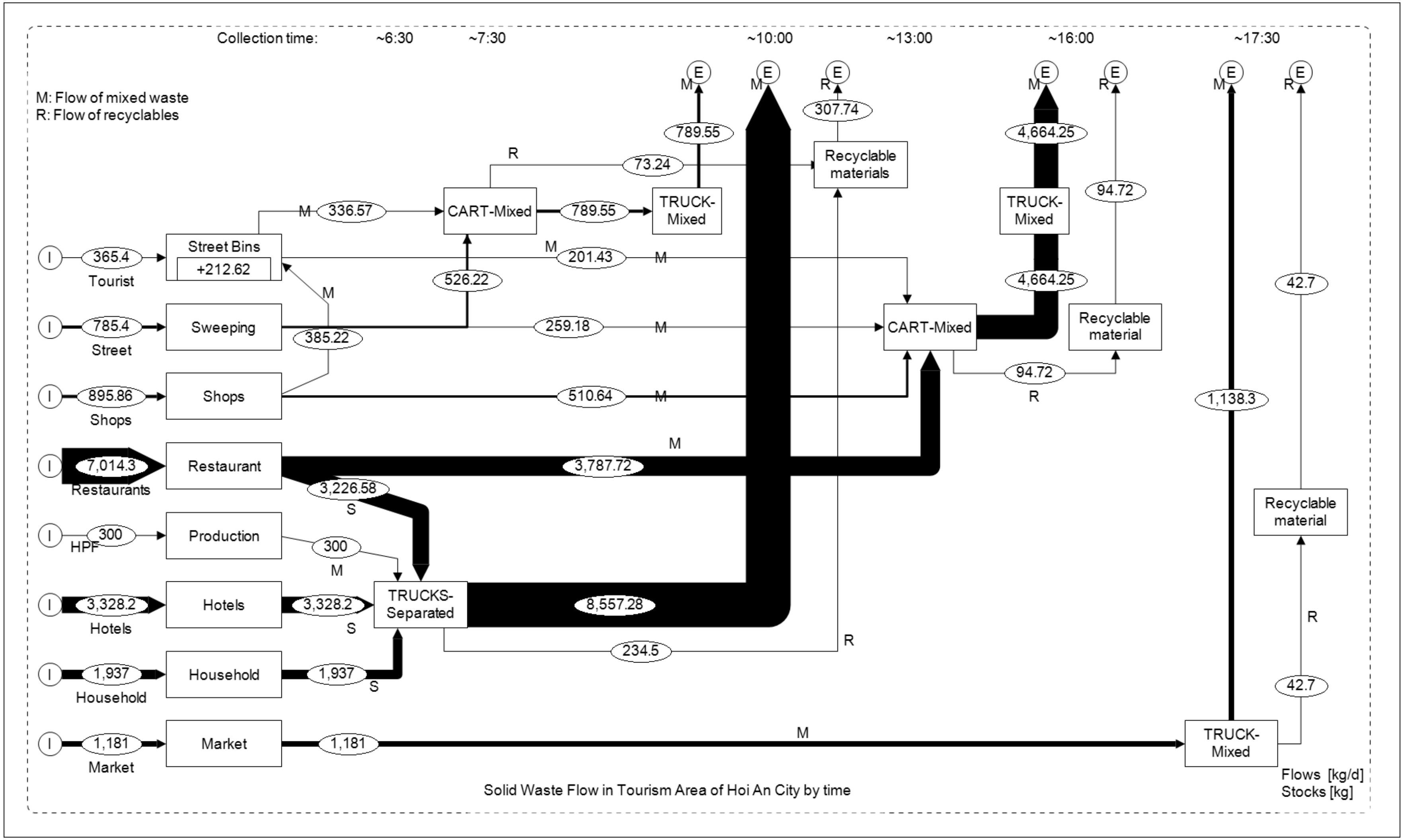


D. 5-6. Analysing chemical waste characterisation in Okayama University

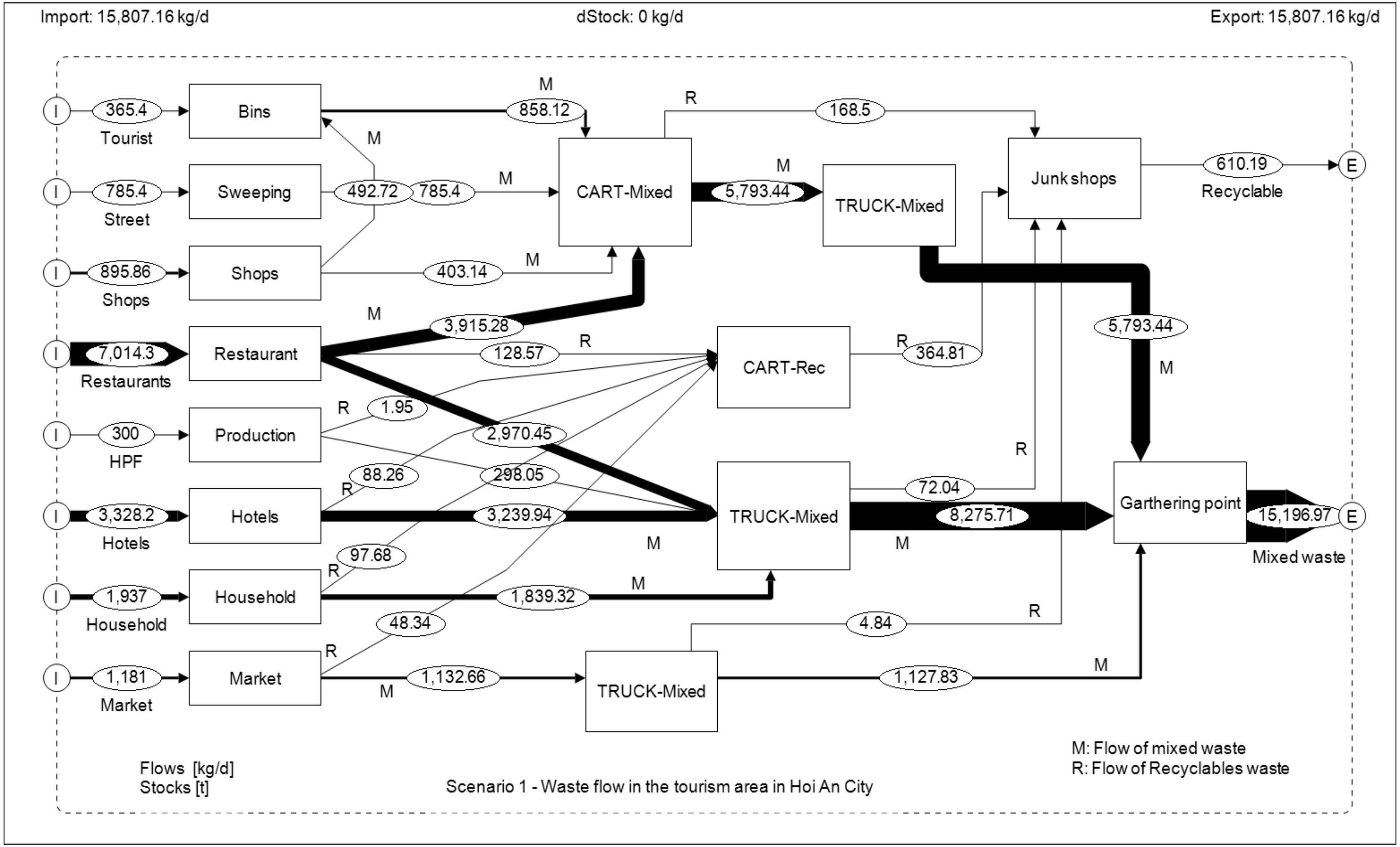
E. Waste flow analysis



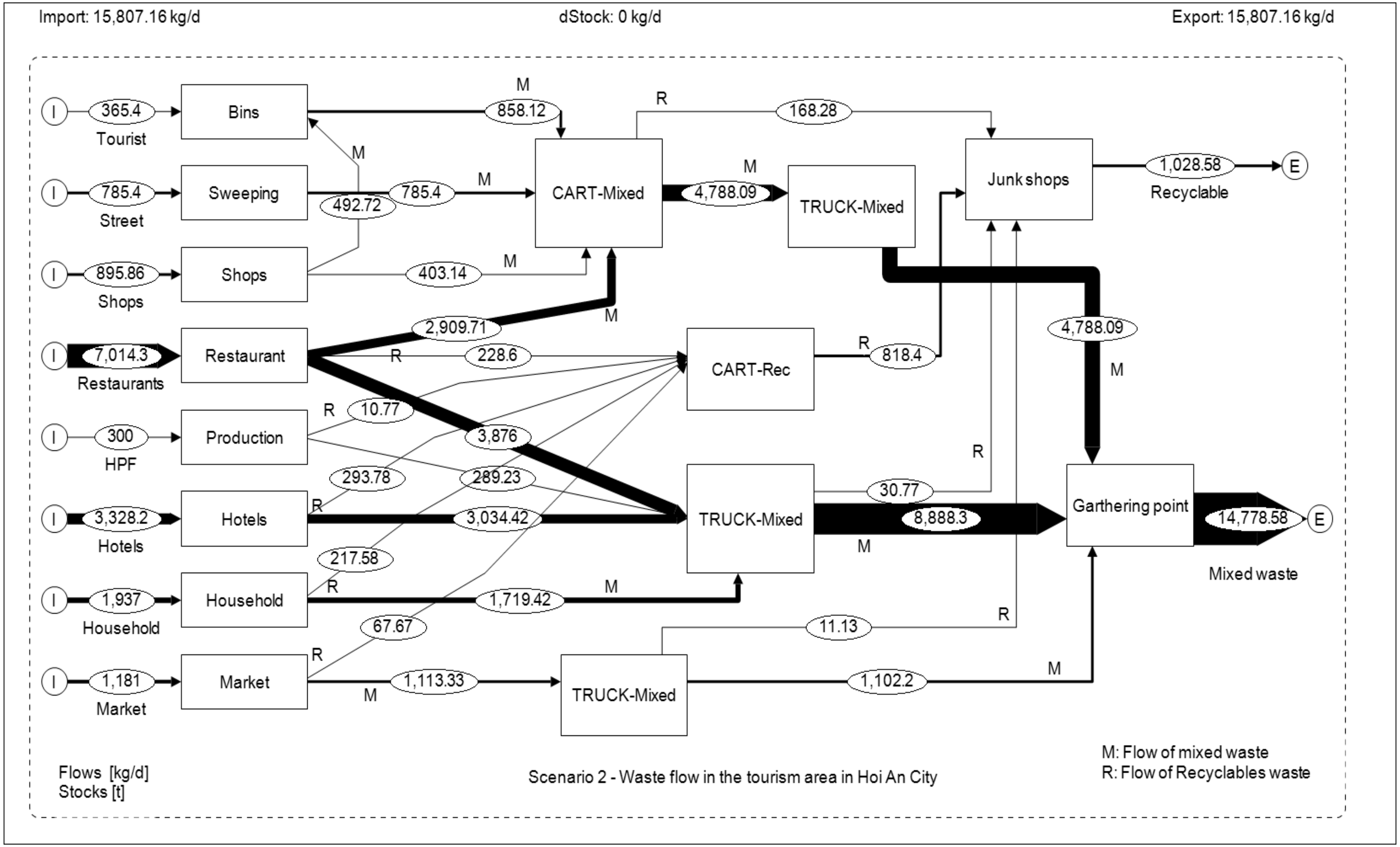
D.1. The current solid waste flow in tourism area ($S0_{TA}$)



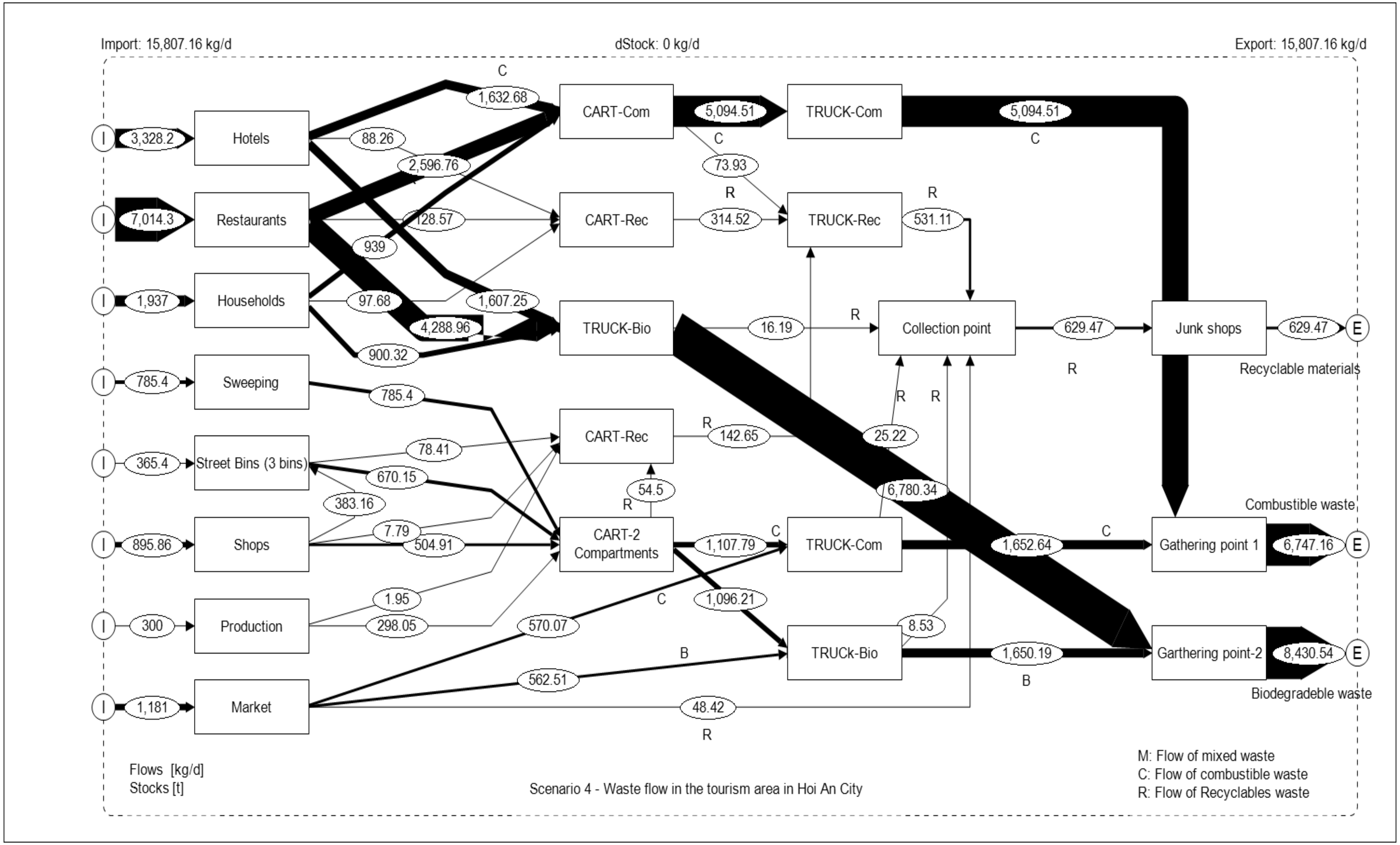
D.2. The current solid waste flow by time in the tourism area



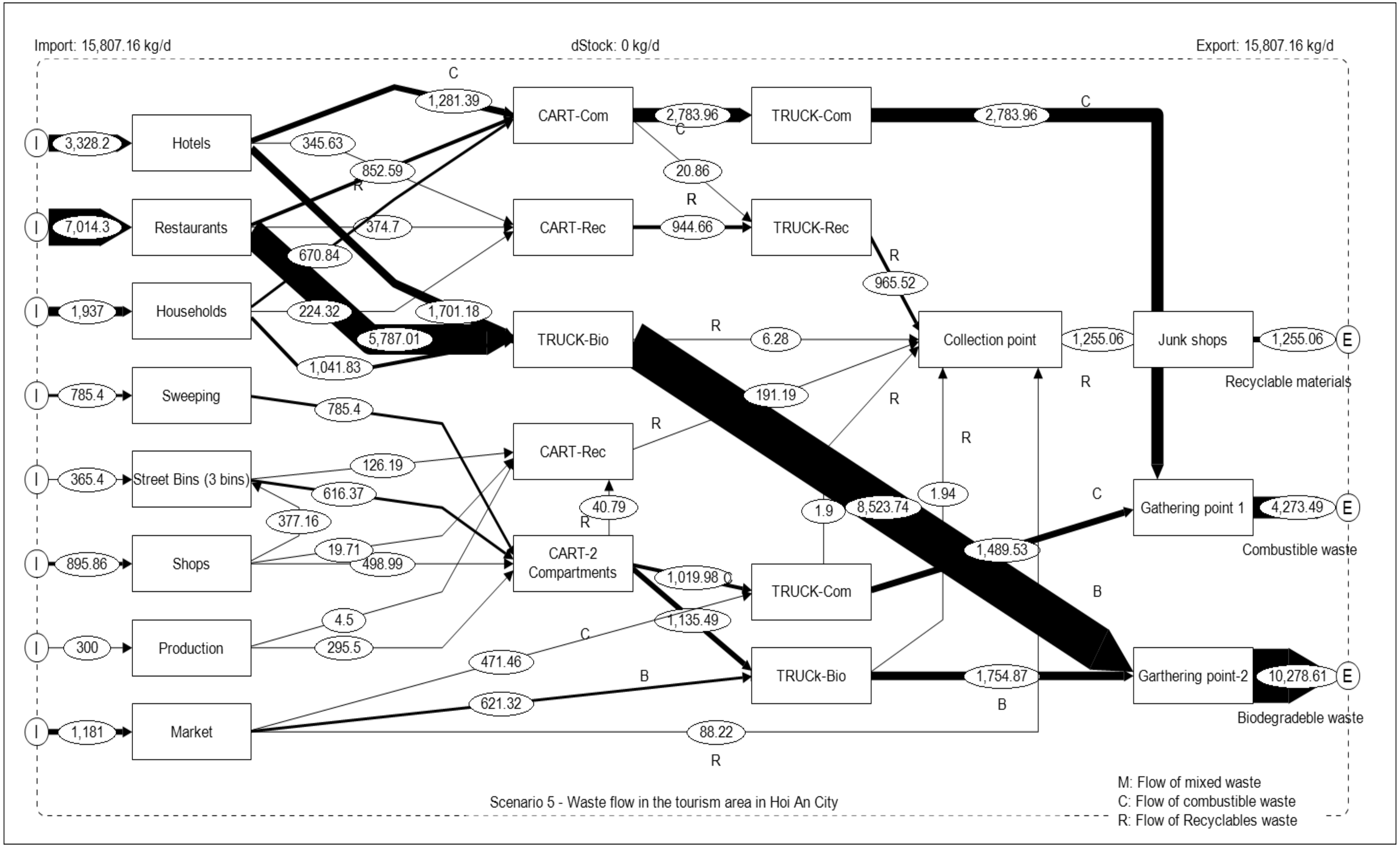
D.3. The flow of solid waste in the tourism area in Scenario 1 ($S1_{TA}$)



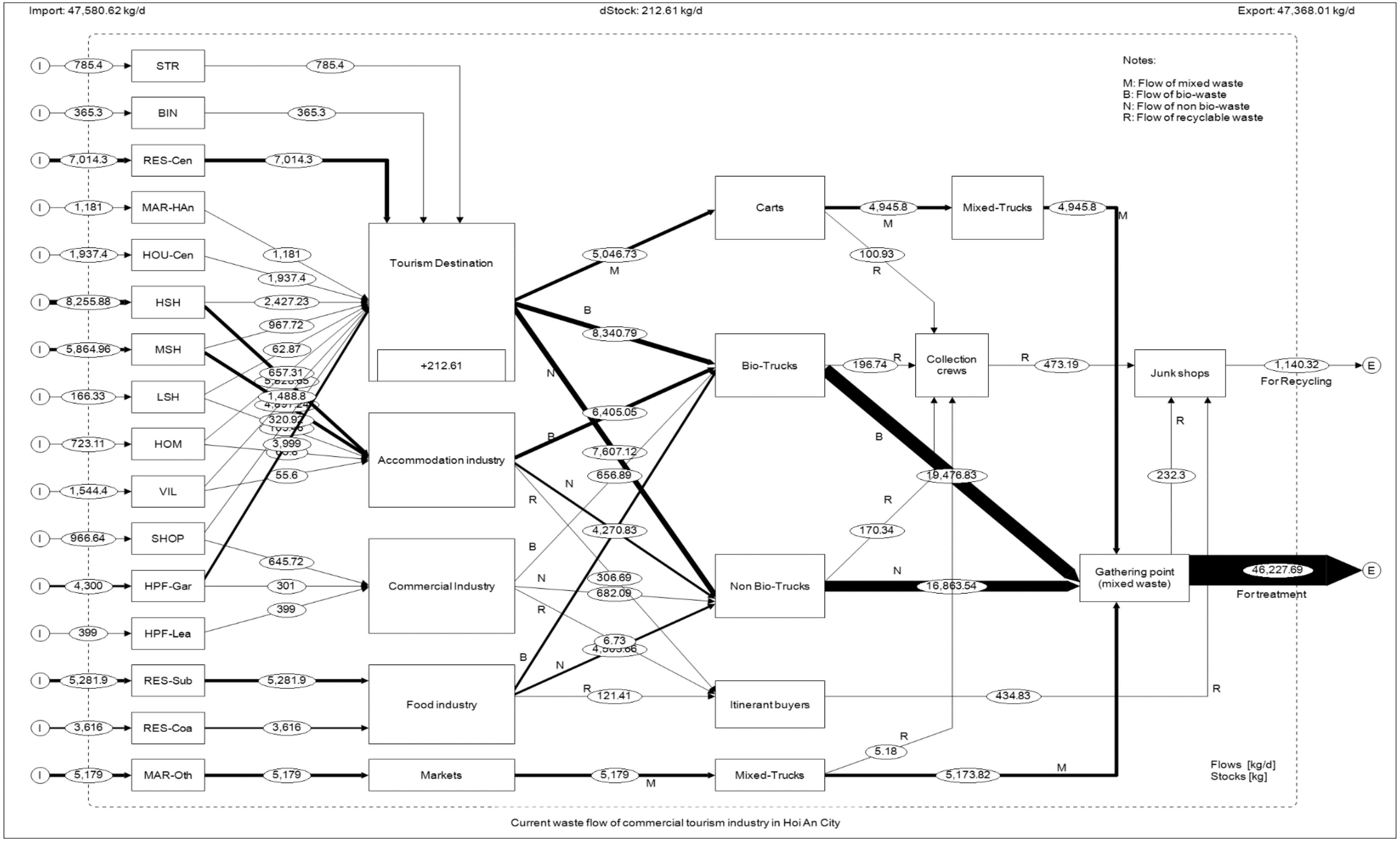
D.4. The flow of solid waste in the tourism area in Scenario 2 ($S2_{TA}$)



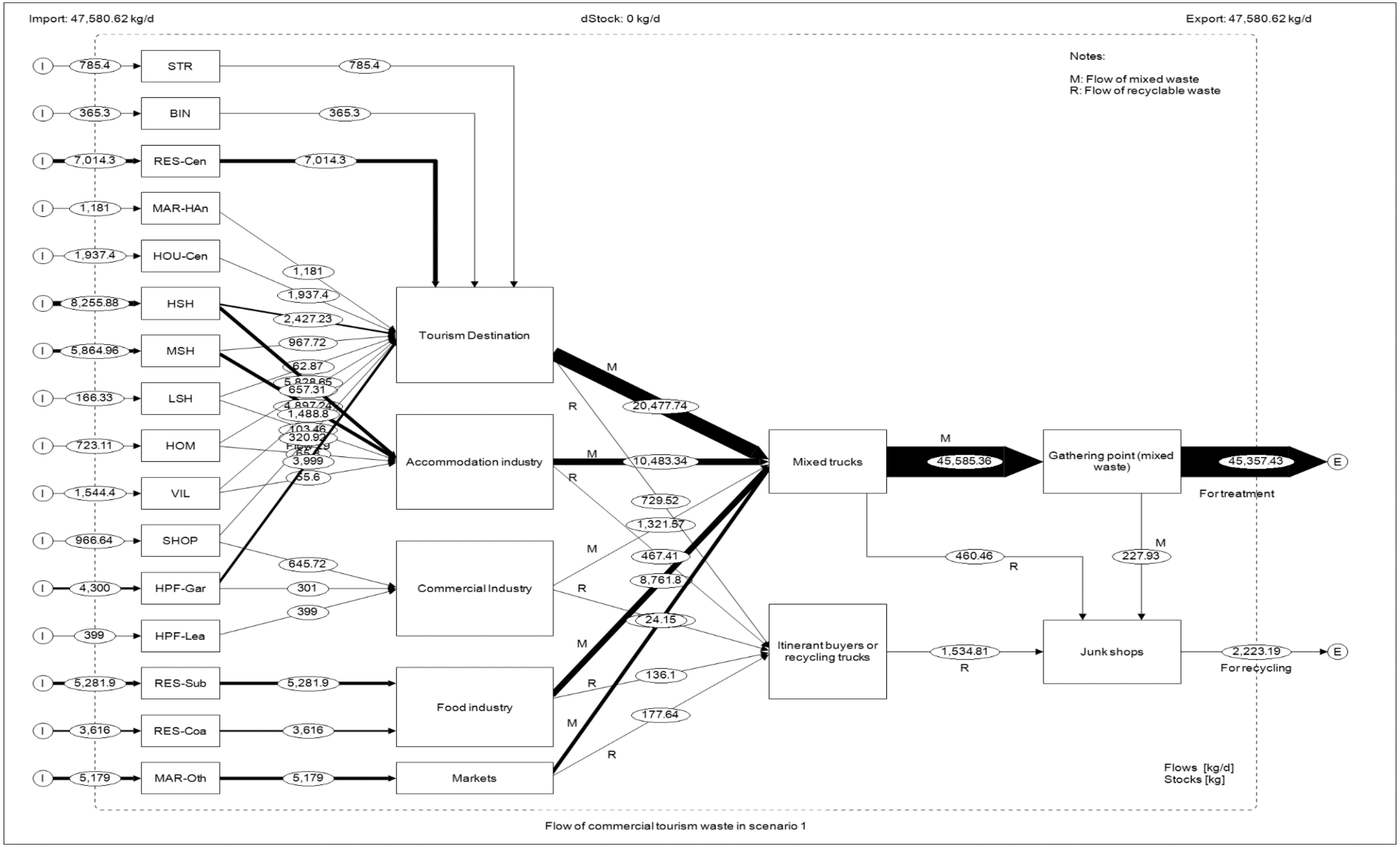
D.5. The flow of solid waste in the tourism area in Scenario 4 ($S4_{TA}$)



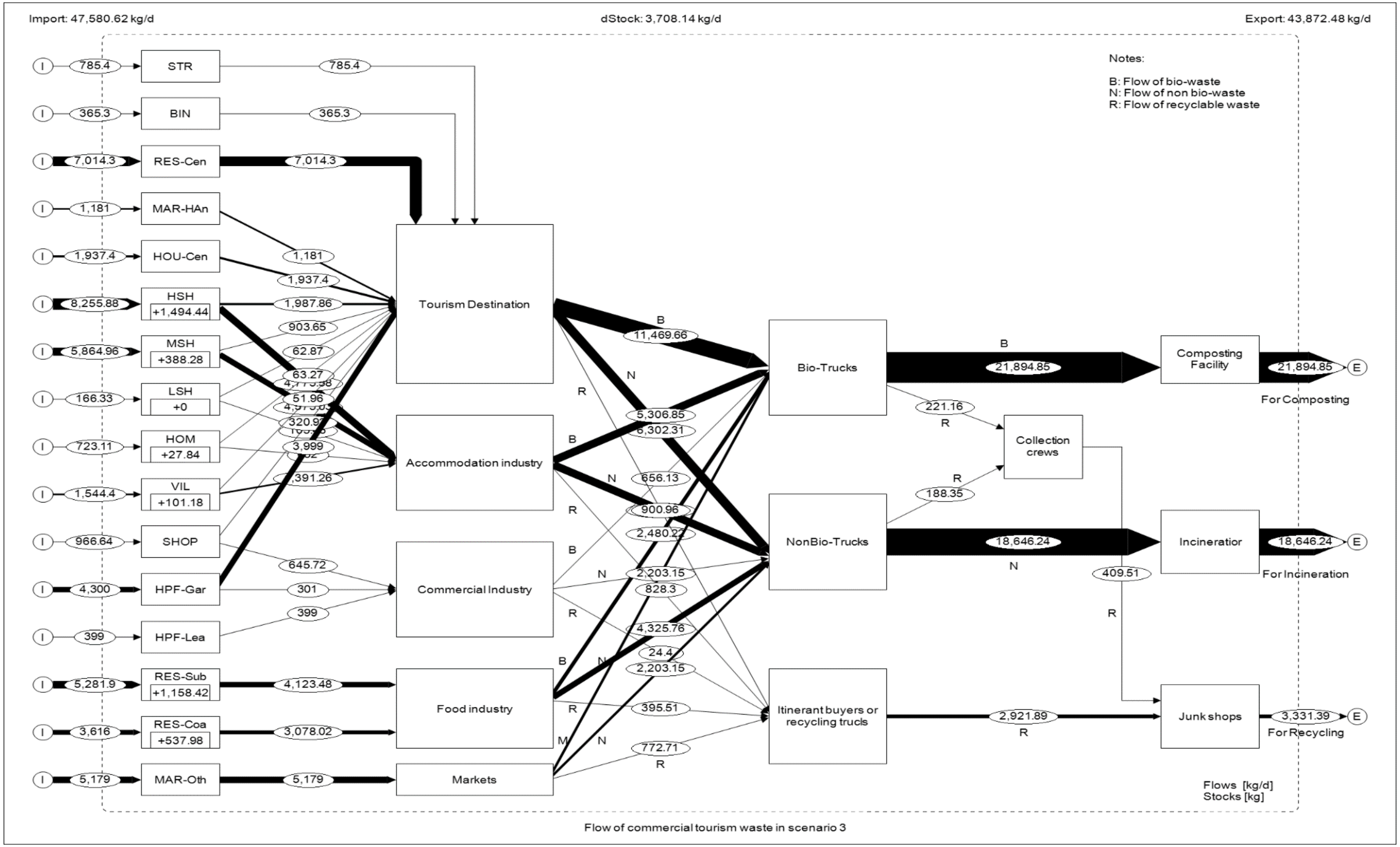
D.6. The flow of solid waste in the tourism area in Scenario 5 ($S4_{TA}$)



D.7. The current flow of solid waste in the tourism industry ($S0_{TI}$)



D.8. The flow of solid waste in the tourism industry in Scenario 1 ($S1_{TI}$)



D.9. The flow of solid waste in the tourism industry in Scenario 3 ($S3_{TI}$)

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