学位論文の要旨

Abstract of Thesis

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学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

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

学位論文の要旨 Abstract of Thesis

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 ten years, 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 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 TI in HAC aims to reduce the current waste problems and contribute to improving municipal SWM system toward sustainability.

Methodology

The studying process is summarised in Figure 1 by fours main steps such as planning, sampling, analysis and modelling. Notably, all waste sources 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 tourism area (TA) was collected in seven consecutive days in December 2016. The amount of waste was measured by weighting by handi-scales. Also the composition was identified with 18 categories. The characterisation of samples was analysed at the laboratory of Okayama University after drying. Data from the survey was statistically processed to assess the status and analyse the problems of the SWM system in the TI. Then, SWM practice models were built, simulated and optimised aims to resolve the problems,

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reduce the challenges and bring the sustainable values to SWM system for the TI.

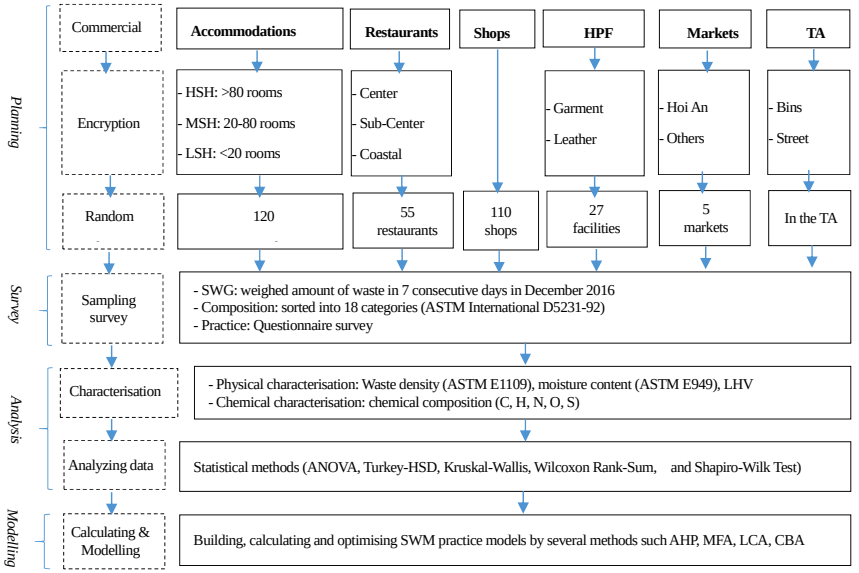

Figure 1. The process of the study

Results and Findings

This study indicates some findings:

Firstly, the status of the SWM system in the TI is presented. Notably, the daily SWGR of each commercial sector is identified by 2.28 kg/guest for the hotels, 1.27 kg/bill for restaurants, 0.86 kg/shop, 0.28 kg/product for HPF, 1.15kg/stall for markets, 0.066 kg/tourist, 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 (LHV: 15 – 16 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 TI 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 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 TI. Notably, the accommodation business (AB) that is one of the essential business activities of the TI daily generates about 16.5 tons of solid waste (accounted for 35% of the total waste of the TI). 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,

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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 TI 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 $CO_{2\text{-eq}}$ per ton of treated waste) than that of MOM model (from 547 to 536 kg $CO_{2\text{-eq}}$ 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 TI is the optimal development model in accordance with the current situation of the SWM system in HAC towards sustainability.