

3-9 Analysis on solid waste generation of Guam influenced by growth of population and tourism

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ABSTRACT

Based on socio-economic data of Guam, the amount of future waste is projected in each scenario that assumes different population increase of residents and tourists. Future population is re-projected to fit actual population in past years. To consider the economic ripple effect, input-output table of Guam is developed and used. Composition of household solid waste is set by referring the result of questionnaire survey which was conducted under the research collaboration with University of Guam. Under the calculation condition that is annual 5% population increase and 1.5 times tourist expenditure of 2007 at 2020, the amount of solid waste in 2020 was 1,158,295ton, that is almost twice of that in 2007. Finally strategy for appropriate future solid waste management was argued.

KEYWORDS

Solid Waste, Guam, Future Projection, IO table, Economic ripple effect, Questionnaire survey

INTRODUCTION

Island countries in Pacific Ocean are emphasizing that the tourism industry makes use of the natural resources. Generally, increase of tourists triggers and increase in food and commodity consumed by tourists during their stay. As a result, it invokes an increase of the import of these goods. The import of attractive products have changed the islander's consumption style from 'economic' to 'wasteful', and have led importing more from oversea. In consequence, the solid waste generated after using goods has been accumulated for long time without treatment, and it became one of the causes of environmental pollution and landscape damage. It is important to establish a sustainable sound material-recycle society in the island having small space, and as the starting point, it is neces-

sary to grasp quality and quantity of solid waste generated from present time until target year in future by considering economic growth and change in resident's lifestyle of the island. In this study, industrial input-output tables are developed based on economic data of Guam. Several future scenarios of population increase and of increase of both number and expenditure of tourists are designed. Using the input-output data, the future final consumptions of the household and the government are calculated under the scenarios. Moreover, using the result of questionnaire survey on household waste, the statistic data of household's consumption expenditure of the island country, and our calculated future household consumption, the future amount of household waste discarded are projected. The future discard of industrial and business waste is projected by multiplying future domestic product with future waste generation factor. Finally, proper solid waste management in Guam is argued.

MATERIALS AND METHODS

1. Preparation of base data

1.1 Input –output table

Since there is no available industrial input-output data, in this study, the input-output table is developed using economic statistic data. Since many economic data has a base of 2007, all economic data used in this study was transformed to a real value of 2005 by using GDP deflator. The characteristic in our input-output table is to have the column of tourism consumption like the final consumptions of household and government. Intermediate input and demand are calculated based on both the money supplied to the industry and the share of sales (local residents, visiting tourists, trade, construction firms, government, and others). The obtained input-output table of Guam is shown on Table 1.

Table 1. Input-Output Table of Guam

2007(2005=100)														(1000 \$)	
	Intermediate demand				Final Demand					Total supply	Import	Domestic Production			
	Trade	Construction	Others	Total	Private	Expenditure	Tourist	Export	Total						
Agriculture,Forestry,Fish	3	0	1,967	1,970	872	0	0	21,649	22,520	24,490	18,641	5,849			
Mining,Electricity,Gas water	3,431	1,144	0	4,575	424,048	198,788	0	0	622,836	627,411	503,102	124,309			
Manufacturing	24,570	59,157	9,703	93,430	22,221	149,615	625	6,857	179,319	272,749	166,596	106,153			
Construction	30,302	168,286	60,605	259,193	56,750	787,785	542	0	845,077	1,104,270	178,583	925,687			
Trade,Hotel,Restaurant	532,978	270,175	266,102	1,069,255	1,287,685	404,029	708,191	57,067	2,456,972	3,526,227	1,125,259	2,400,968			
Transportation and Communication	73,207	53,452	62,143	188,802	170,531	98,076	45,302	483,683	797,592	986,393	347,628	638,766			
Others	101,970	170,611	220,308	492,888	849,020	694,165	180,915	207,293	1,931,392	2,424,281	635,018	1,789,263			
Intermediate input	766,461	722,824	620,827	2,110,112	2,811,127	2,332,458	935,575	776,549	6,855,709	8,965,821	2,974,827	5,990,994			
Value added	1,250,353	202,863	2,425,785	3,879,000											
Domestic Production	2,016,813	925,687	3,046,612	5,989,112											

1.2 Scenarios of population and the number of tourists

The scenarios of population, number of tourists and consumption by tourist are determined considering their future behavior. As for population data, population data in US Bureau of the Census was cited, but the prediction curve was modified to fit the actual population data because the curve did not fit the actual population well at 2000 and 2010.

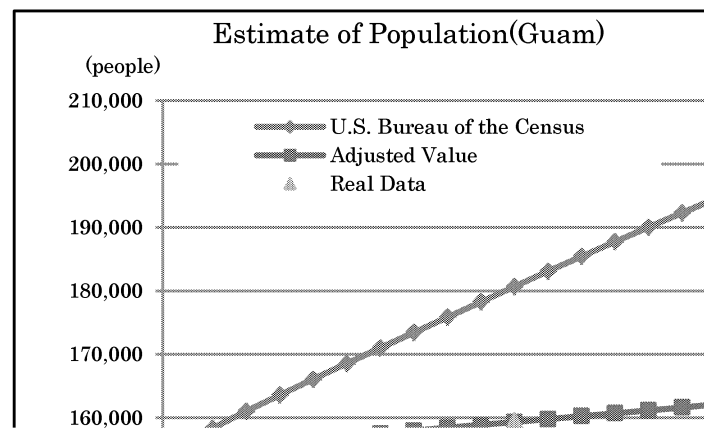


Figure 1. Population Growth Curve of Guam

1.3 Development of feature scenarios

Future private consumption (consumption by household) is calculated by multiplying predicted population by consumption expenditure per capita in 2007, under an assumption of constant consumption expenditure per capita.

The scenario conditions for the number of tourists are ①5% increase, ②constant, ③5% decrease, which are compared with the number of tourists in 2007. On the other hand, scenario conditions of the tourist's consumption are ①1.5 times in 2020, ②constant, ③0.5 times in 2020, which are compared with tourist's consumption in 2007. Totally, the combination of those conditions result in 9 scenarios that are shown in Table 3.

Table 2. 9 Scenarios Composed of
3 Tourists Number Conditions and 3 Tourist's Expenditure Conditions

		Expenditure of Tourists per capita		
		1.Increase (1.5time in 2020)	2.Fixed(± 0)	3.Decrease (0.5time in 2020)
Number of Tourists	①Increase (5%each)	①-1	①-2	①-3
	②Fixed	② 1	② 2	② 3
	③Decrease (5%each)	③-1	③-2	③-3

As for the government expenditure, since the government income changes according to both household income and industrial yield, it is assumed that the increment in the tax paid by taxes payers (household and tourists) becomes the increment of government expenditure. The tourist has to pay indirect tax when to buy goods or services. That rate is 12% according to the Guam Visitor Bureau. On the other hand, the tax by household includes both the indirect tax and the direct tax for household income; hence it is difficult to calculate the household tax. Because the difference be-

tween the whole tax and the indirect tax is the direct tax, in this study, household's tax per capita is regarded as the household's direct tax divided by population. The average household tax per capita is estimated as \$8,364/capita/year.

2. Analysis of economic ripple effect

As shown in Fig 2, the analysis of economic ripple effect means calculation of how much a change in demand to an industry affects the demand to each industry. Concretely, the change in consumption expenditure of household, tourists, and government when either population or the number of tourists increases is calculated, after that, change in intermediate input and production in each sector is also calculated.

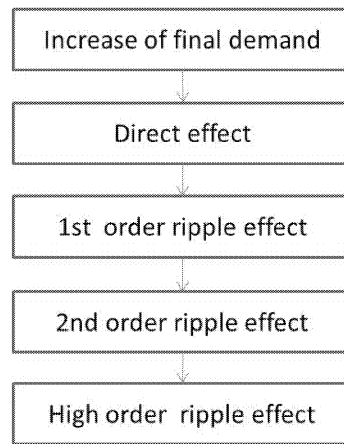


Figure 2 Processes in Calculation of Economic Ripple Effect

As for the future domestic product, the summation of the base production in 2007 and the increment production caused by both the first order ripple effect and the second order ripple effect is estimated as future domestic production. As for the future household expenditure, increment in labor income by the 1st ripple effect and increment in household consumption by the second ripple effect are calculated first, and then they are added to the summation of the base household consumption in 2007.

3. Prediction of future solid waste discards

3.1 Questionnaire survey for household waste in Guam

In relation to this study, we have collected information of solid waste discard in Guam through questionnaire survey with University of Guam. The recovery ratio of the questionnaire was high at 51% (distribution of questionnaire 623, collection of response 320). As a result of analyzing the responses, the share of recyclable waste in household waste in Guam is shown in Figure 3. Per-

centage of food (29.3%) and garden waste (22.1%) is greater followed by the percentage of paper (26%), including cardboard and newspaper.

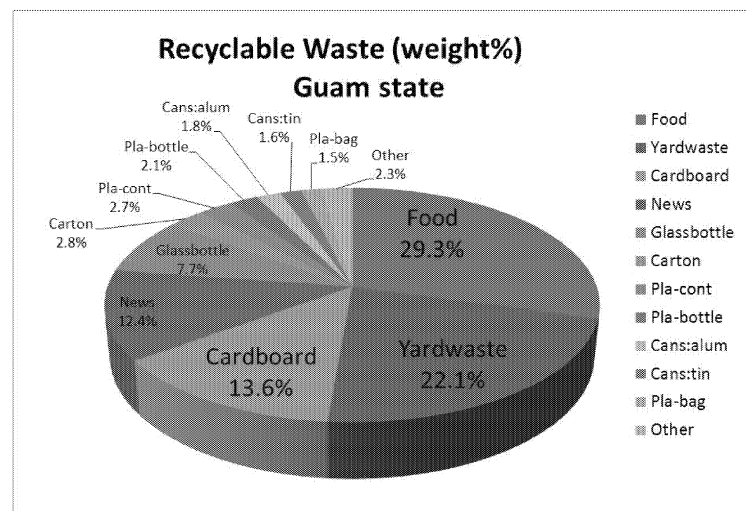


Figure 3. The share of recyclable waste in household waste

3.2 Generation coefficient of household waste

In the next step, the waste amount for each category is calculated from the household consumption expenditure where, for each consumption category, the weights of the waste components (particularly those generated from the consumption item) are reported by Kyoto City local authority. Using this data as well as the surveyed amount of each waste component of Guam and the estimated household expenditure of Guam by each consumption category, waste generation coefficient per \$1 expenditure is calculated. In prediction stage, future waste generation is obtained by multiplying the waste generation coefficient by the projected future household expenditure.

RESULTS AND DISCUSSION

1. Projection result of discharge amount of solid waste in Guam

The amount of discharged solid waste in Guam is 615,143t in 2007. The trend of discarded solid waste of the period from 2007 until 2020 is estimated scenario by scenario and shown in Fig. 4. Moreover, total amount of discarded waste estimated scenario by scenario, is shown in Fig. 5.

The results of the amount of solid waste in 2020 in each scenario show that for scenario ①-1, the solid waste discards in 2020 is 1,158,295ton (twice of that in 2007). For scenarios ②-2 and ③-3, the discarded waste are 814,189t and 657,279t, respectively.

Finally, Fig. 6 shows the component of the waste where the percentages of kitchen waste and paper waste are 35% and 37%, respectively.

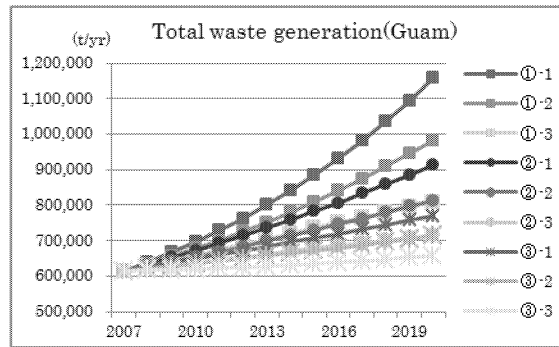


Figure 4. Projection of solid waste discharge in Guam by scenario.

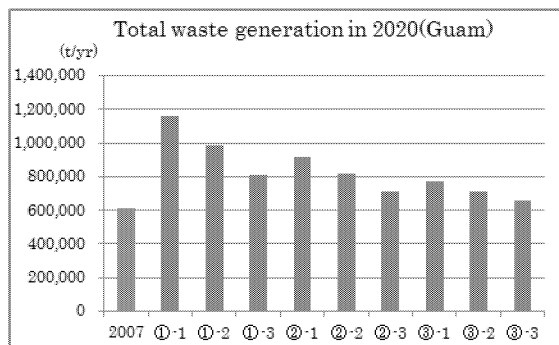


Figure 5. Solid waste discharge in Guam at 2020, by scenario

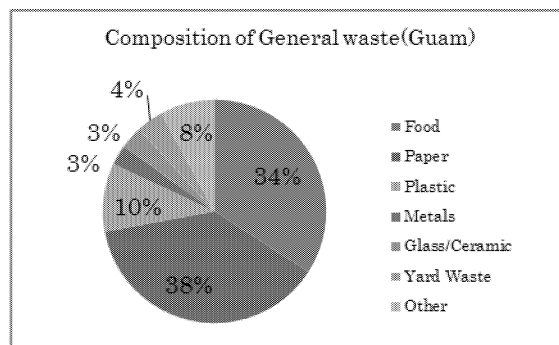


Figure 6. Composition of general waste in Guam

2. Discussion

From the characteristics of waste discards in Guam, waste reduction countermeasures are discussed (in Fig. 7)

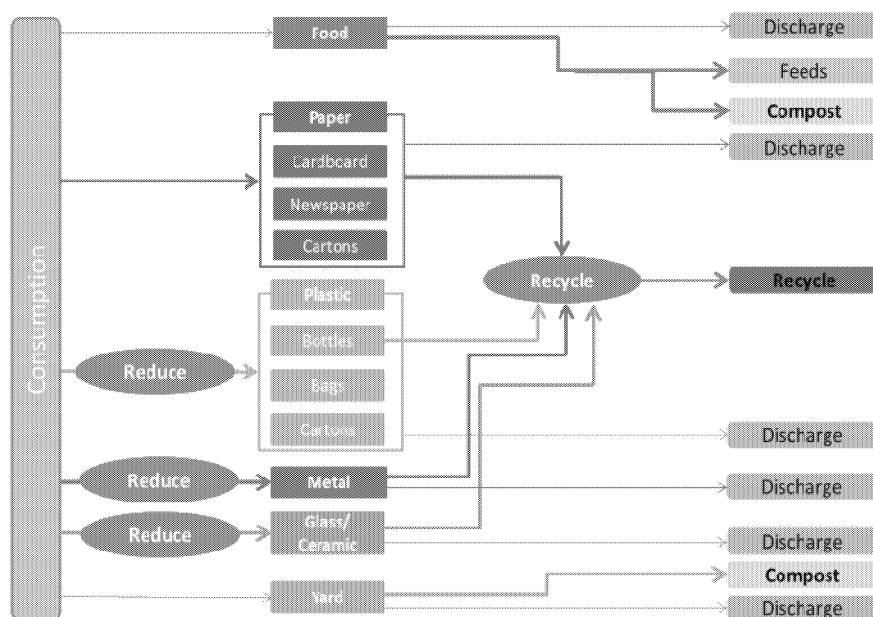


Figure 7. Strategy of solid waste management for Guam

The following 4 countermeasures could generate about 15% reduction of waste generation in 2020.

1) Reduction of organic waste by 15%

Most of kitchen waste is generated from households or from hotel and restaurant of tourism sector. One of the effective reduction methods in Guam having no incinerator is composting. Since many households in Guam grow plants in large gardens, and the island has large green areas, the produced compost could be use for growing the garden plants and maintaining the green area.

2) Reduction of paper waste by 15%

Due to many office works and retail works in Guam, large amount of paper waste is discarded, in addition, it is supposed that paper packaging and wrapping for imported goods occupies a large part of paper waste. Paper separation at source, segregated collection and selling to overseas places is a good reduction way. In Guam, except cardboard, papers are not separated and recycled. Even recycling only newspaper and magazines is effective to reduce the waste.

3) Reduction of plastic waste by 20%

The major plastic waste discarded in Guam are PET bottles and plastic bags. Though the weight-base percentage of plastic component is not so high, many plastic products were found in landfill site. Hence, it is thought that the separate recollection of PET bottles and prevention of plastic bag discards by taking my bag to the shop are inevitable.

4) Reduction of cans and glass bottles by 20%

The waste of metal and glass corresponds to a small portion of the whole waste, similar to the case of plastic waste. However, in order to prevent accumulation of the waste in the landfill, waste reduction, recycling, and selling to the oversea should be promoted.

CONCLUSIONS AND PERSPECTIVES

In this research, first of all, input and output table of Guam state was developed so that to grasp economic situation. By calculating economic ripple effect in future by using the IO table, generation of household waste, industrial waste and business waste are projected from the present until 2020. As for a future study, collecting actual industrial and business waste and evaluating the accuracy of the model should be conducted, and solid waste management should be established by considering the results of estimation and evaluation of waste transport and the cost.

Analysis on Solid Waste Generation Effected by Tourism and Population Growth of Guam by Using Input and Output Table

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Background and Purpose

Background

- In Pacific islands, change in waste composition and increase of waste generation has become serious problems, not only caused by the tourist industry, but also by the import of large amounts of consumer goods from abroad due to the little manufacturing.
- Therefore, it is important to make comprehensive analysis of economic development and lifestyle changes and to understand the types of waste and the amount of waste generated currently and future to promote waste management.

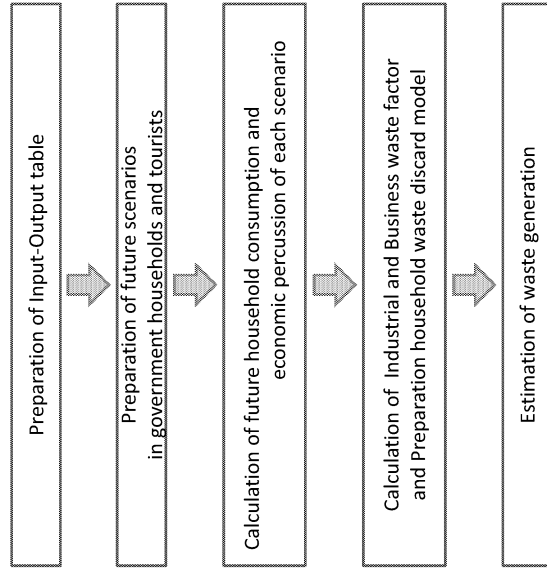
Purpose

- Using developed input-output table based on Guam’s economic data, estimate the future economic percussion, final demand, and the changes of number and expenditure of population and tourists.
- Estimate the amount of Household waste and Industrial waste generation affected by future economic percussion, final demand, and

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Study flow



Input Output table

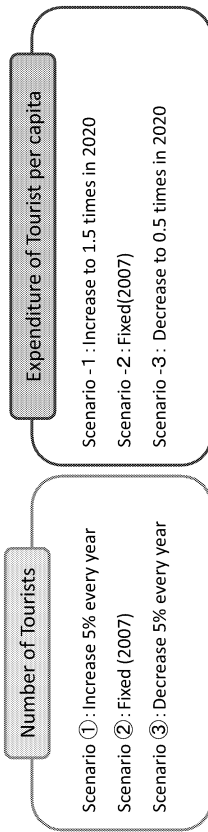
Scenario

Input Output table

● Guam

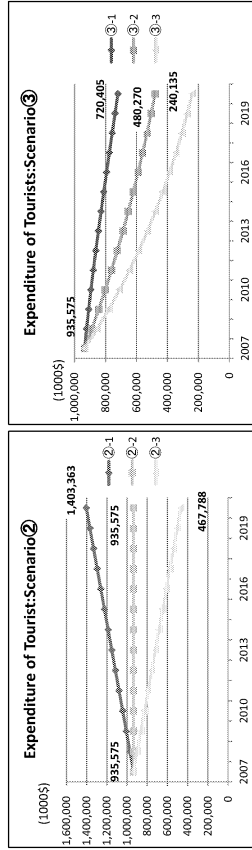
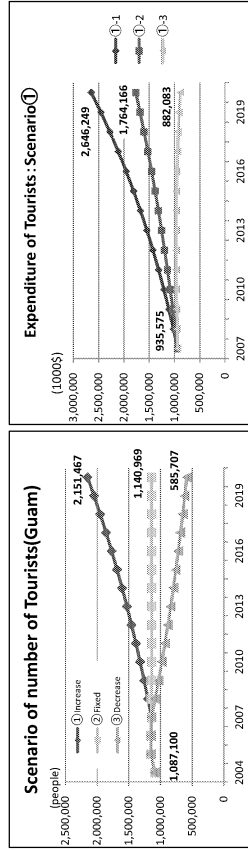
2007/2005=100														(1000 \$)	

Scenario(Tourists)

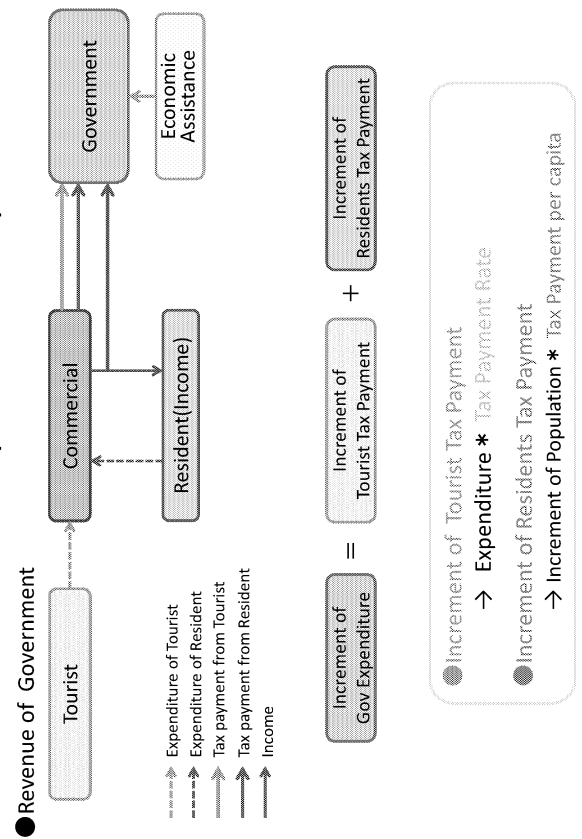


Number of Tourists	Expenditure of Tourists per capita		
	1. Increase (1.5time in 2020)	2. Fixed(±0)	3. Decrease (0.5time in 2020)
① Increase (5%each)	①-1	①-2	①-3
② Fixed	②-1	②-2	②-3
③ Decrease (5%each)	③-1	③-2	③-3

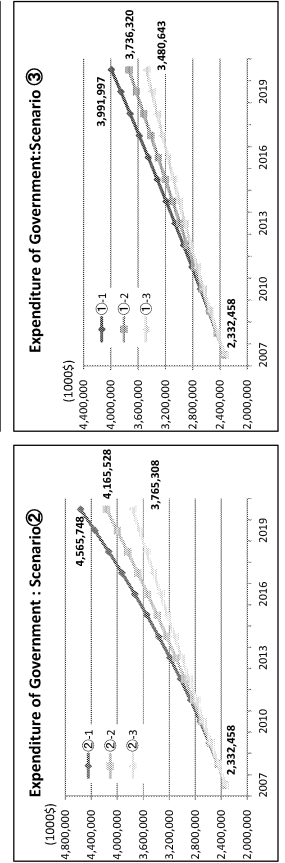
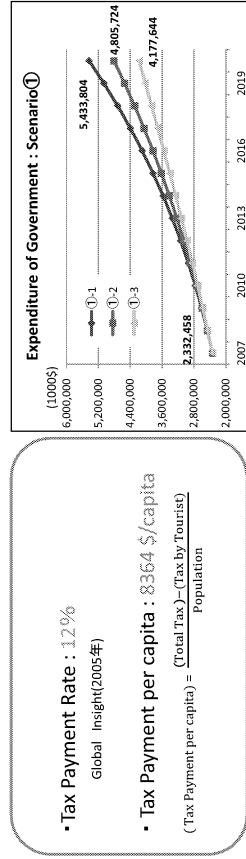
Scenario(Tourists)



Scenario(Government)

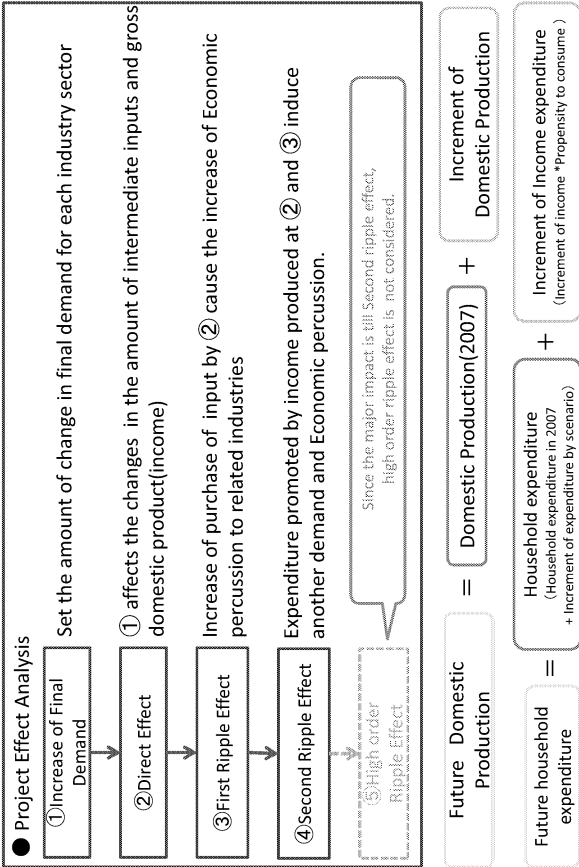


Scenario(Government)

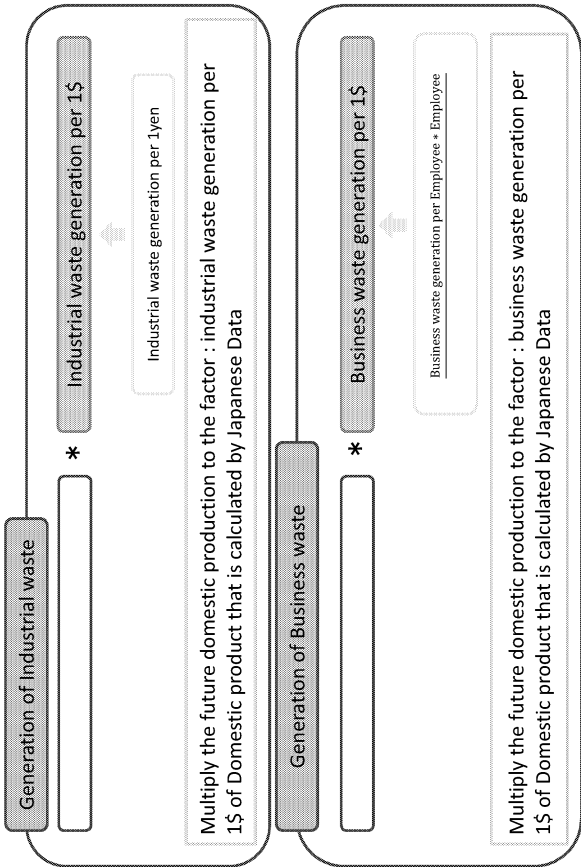


Economic percussion

Economic percussion

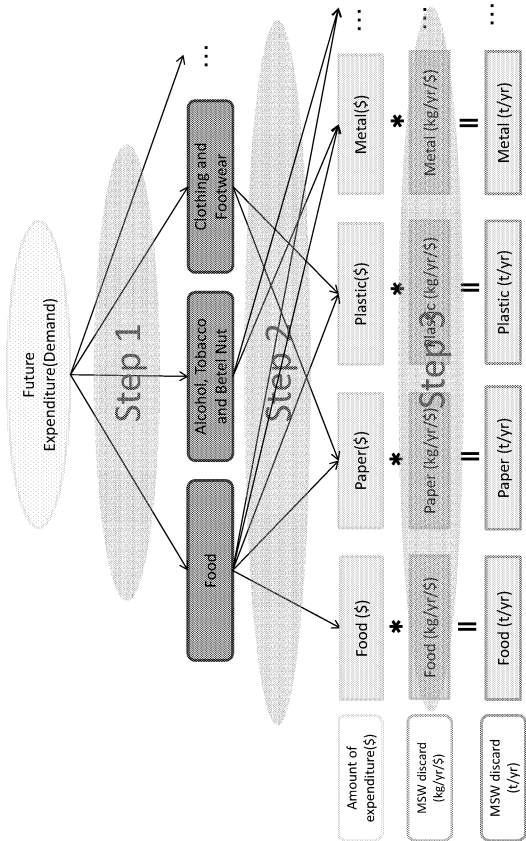


Industrial waste and Business waste

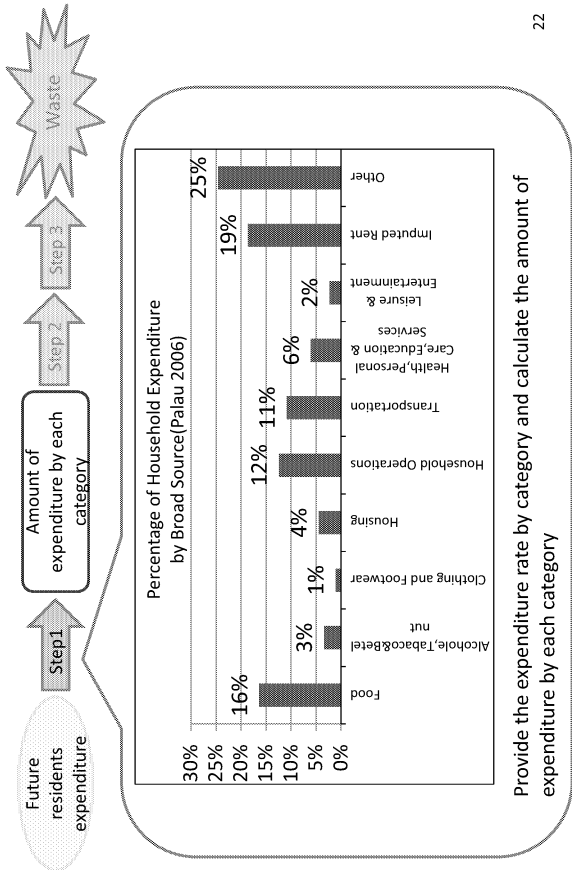


Method for waste Estimation

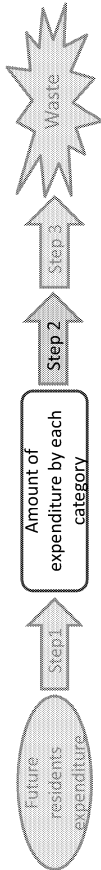
Household Waste Discard Model



Household Waste Discard Model



Household Waste Discard Model

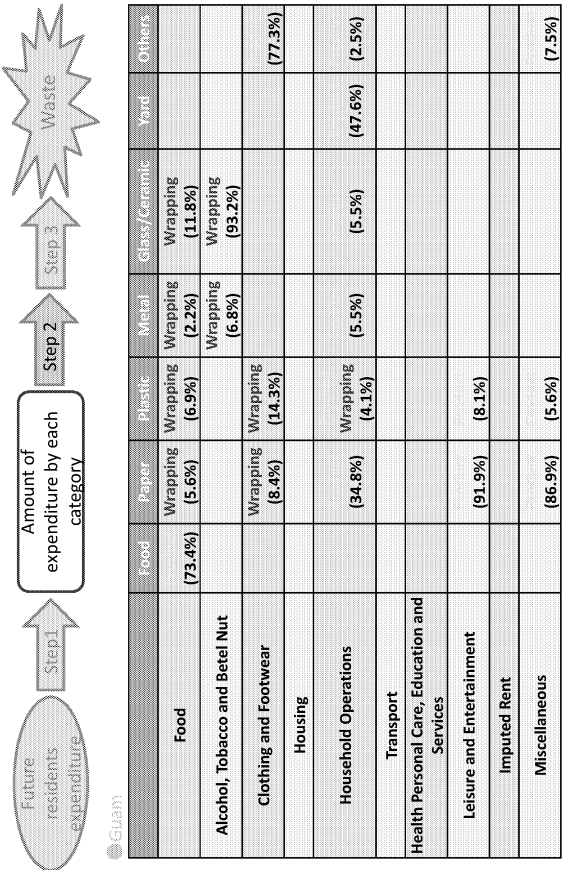


● Data from Kyoto City (Composition of household waste)

	Food	Paper	Plastic	Metal	Glass/Ceramic	Yard	Others
Food	(100.0%)	Wrapping (7.8%)	Wrapping (43.5%)	Wrapping (25.6%)	Wrapping (61.0%)		
Alcohol, Tobacco and Betel Nut				Wrapping (1.0%)	Wrapping (6.2%)		
Clothing and Footwear		Wrapping (2.1%)	Wrapping (16.3%)				(75.0%)
Housing							
Household Operations		(56.0%)	Wrapping (25.7%)	(73.4%)	(32.8%)	(100.0%)	(15.5%)
Transport							
Health Personal Care, Education and Services							
Leisure and Entertainment		(5.5%)	(2.2%)				
Imputed Rent							
Miscellaneous		(28.6%)	(8.3%)				(9.5%)

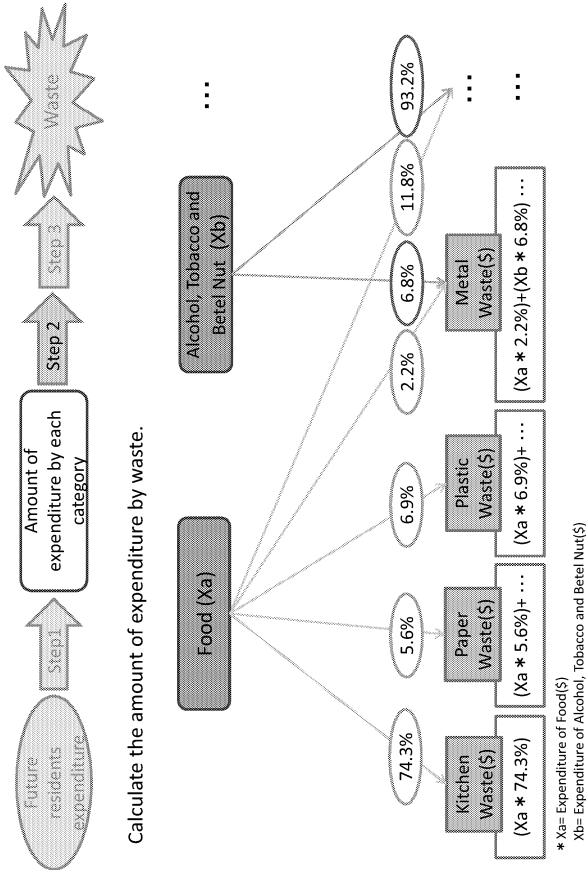
Provide the weight rate of origin(expenditure category) of each waste.

Household Waste Discard Model

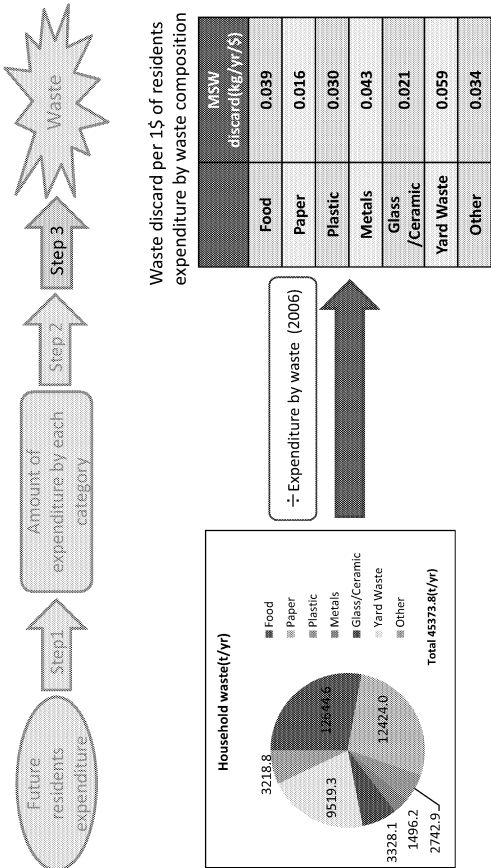


Provide the weight rate of each waste discard by each expenditure category.

Household Waste Discard Model

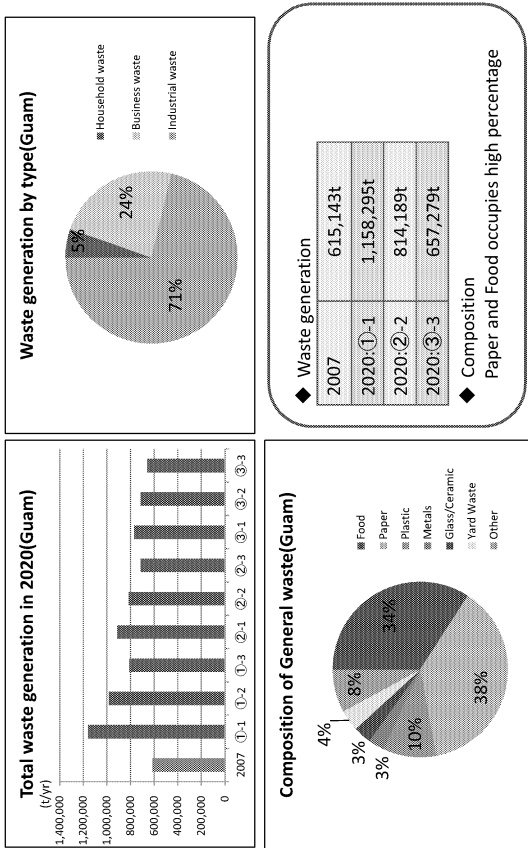


Household Waste Discard Model



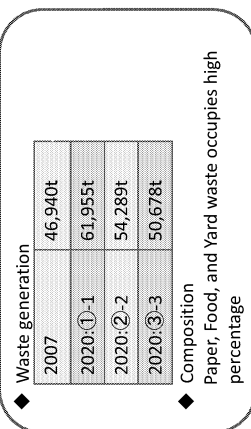
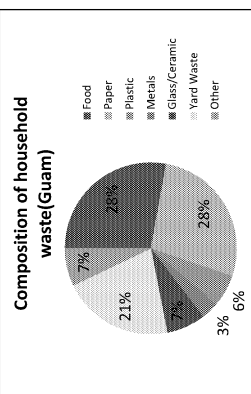
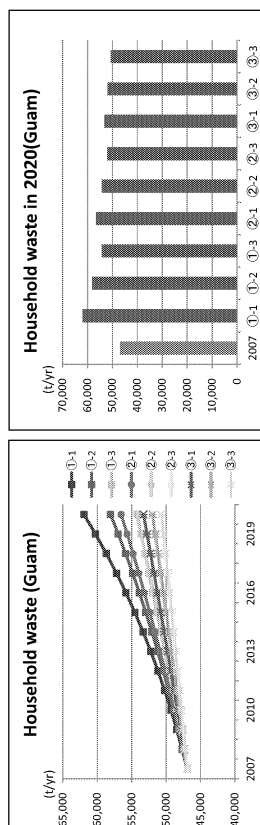
Calculate the total waste generation by Questionnaire survey data and calculate the waste discard per 1\$ of residents expenditure by waste.

Total Waste



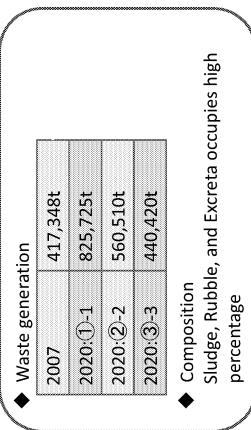
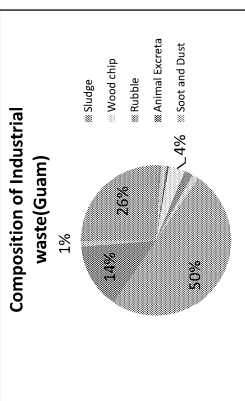
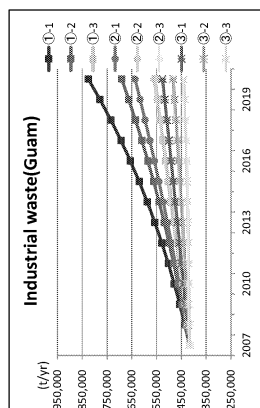
Result

Household Waste



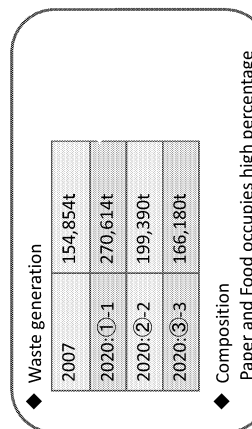
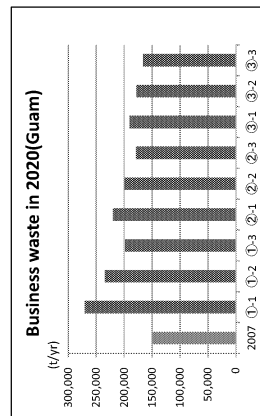
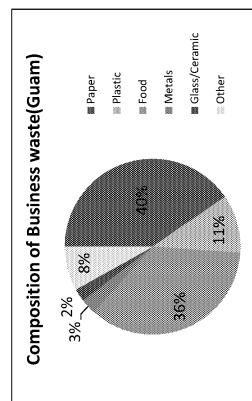
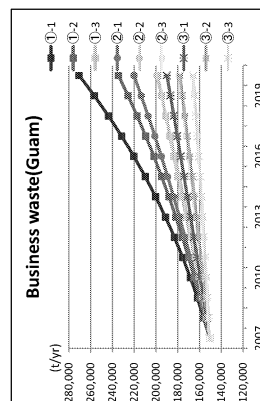
Composition
Paper, Food, and Yard waste occupies high percentage

Industrial waste



Composition
Sludge, Rubble, and Excreta occupies high percentage

Business waste



Composition
Paper and Food occupies high percentage

Discussion

- ✓ As a result of total waste generation, 615,143 ton of waste is generated in 2007, and in 2020 it will increase to 657,279 ton – 4,158,295 ton.
- ✓ As a result of type of the waste, industrial waste occupy high percentage (71%).
- ✓ As a result of general waste,
 - Generation of food waste is very high.
 - It is considered to be discharged from the home, and also from the hotels and restaurants, such as contained in the tourism industry.
 - Generation of Paper waste is very high.
 - It is considered to have been many paper waste because there are a lot of office work and retail trade in Guam. In addition, Guam is importing many goods, and that is causing the generation of paper packaging materials, such as excessive packaging of products by imports.
 - Plastic materials are disposed.
 - A large number of plastic such as plastic bags, bottles, and cartons are found in landfill. Also, many plastic bags are found without tearing. It delays biological degradation of organic material inside.
 - Cans and bins are mixed with other waste.
 - Currently, most of glass and metals, instead of being separated, has been reclaimed along with the other trash. However the emissions is few, it cause to shorten the use of the landfill.

Conclusion and Research Plan

Conclusion

- I-O table of Guam was created, and the economic situation was understood.
- From the questionnaire, the quantity of household waste by category was figured out.
- The future economic percussion by each scenarios were calculated.
- The amount of household waste, industrial waste, and business waste from 2007 to 2020 were estimated.

Research Plan

- Due to insufficient data on household consumption, it is necessary to collect the data and to apply it.
- It is necessary to collect the data about the business waste and industrial waste in the island countries, to examine the accuracy of the estimation results.