



# Methodology for MSW Generation Estimation

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2<sup>nd</sup> EXPERT GROUP MEETING ON CHEMICALS AND WASTE SDG INDICATORS

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- **JICA's Standard Methodology for the Waste Amount and Composition Survey (WACS) and the Estimation of MSW Unit Generation Amount (under drafting)**
- **JICA's Pilot Project for 11.6.1 in Nigeria**

**for the Waste Amount and Composition Survey (WACS)  
and the Estimation of MSW Unit Generation Amount**

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#### 4. Estimation of MSW Unit Generation Amount

## 4.1 Data Processing

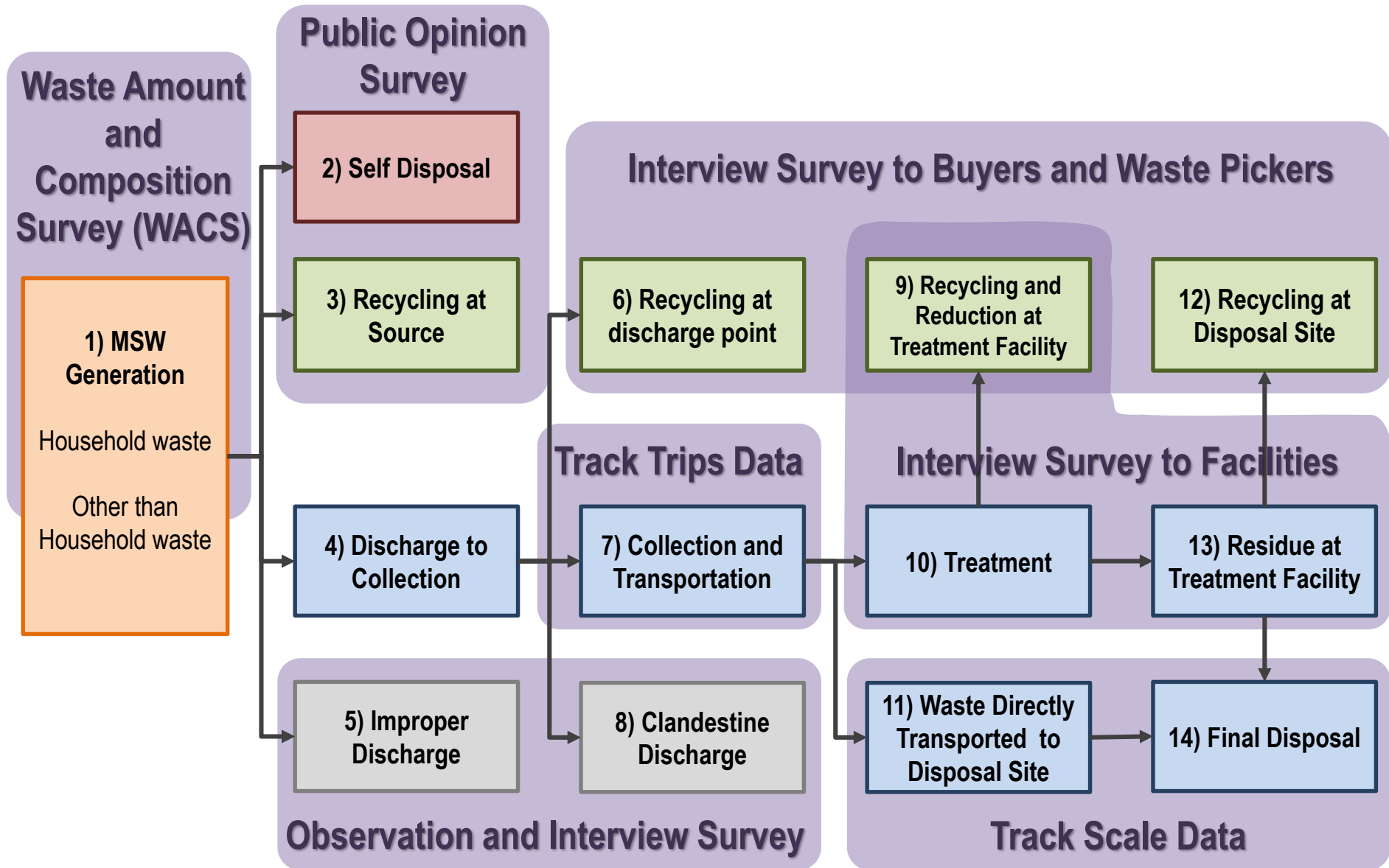
### Attachments *(Excel format)*

- Questionnaire for Households
- Questionnaire for Other sources
- Survey sheet for Household WAS
- Survey sheet for Household WCS
- Survey sheet for Other Source WCS

Survey and Date Sheet for Household Waste Amount Survey

[illegible]

# Waste Flow and Necessary Surveys



# Projects that gathered documents on MSW generation estimation

The Project for the Support of Waste Minimization and 3R Promotion in Republic of Albania (2014-2017)

The Project for Integrated Solid Waste Management System in Federal Capital Territory in the Federal Republic in Nigeria (2015-2018)

The Project for Strengthening the Capacity for Solid Waste Management in Ulaanbaatar City, Mongolia (2009-2012)

The project for promotion of municipal solid waste recycling in China (2011-2014)

The Master Plan on Solid Waste Management for Boracay Island and Municipality of Malay in Republic of the Philippines (2008-2012)

The Project for Capacity Development of Central and Local Government for 3R and Domestic Waste Management System in Indonesia (2013-2017)

Waste minimization and recycling promotion project in the Republic of Fiji (2008-2012)

The Project for Promotion of Sustainable 3R Activities in Maputo, Mozambique (2013-2017)

The Project for Capacity Development for Solid Waste Management in Tiznit Municipality and Neighboring Communes, Morocco (2013-2016)

Yachiyo Engineering  
Co., Ltd.

Kokusai Kogyo  
Co., Ltd.

Nippon Koei  
Co., Ltd.

EX Research  
Institute Ltd.

# Flow of Waste Amount and Composition Survey and the Estimation of MSW Generation Amount

1. Setting categories of generation sources and the number of samples
2. Selecting samples
3. Interview survey
4. One-week consecutive survey
5. Data processing

# Setting Categories of Generation Sources

## Categories of Generation Sources

- **Households**
  1. **Income level:** High, Middle, Low
  2. **Area characteristic:** Business, Residential, Peri-urban
  3. **Residential type:** Ger, Apartment
- **Commercial**

Restaurants, Hotels, etc.
- **Institutions**

Public and Private offices, Schools, Hospitals, etc.
- **Markets**
- **Public area**

Roads, Parks, Drains, Green waste, etc.



# Waste Generation Sources and Numbers of Samples in Lautoka, Fiji

| Generation Source       |                  | No. of source    | Waste Amount |      |              | Waste Composition |      |                      |                  |
|-------------------------|------------------|------------------|--------------|------|--------------|-------------------|------|----------------------|------------------|
|                         |                  |                  | Sample       | days | Total Sample | Sample            | Days | Physical Composition | Three Components |
|                         |                  |                  | –            | –    | BxC          | –                 | –    | ExF                  | –                |
|                         |                  | A                | B            | C    | D            | E                 | F    | G                    | H                |
| Household               | Business area    | 5                | 5            | 7    | 35           | 1                 | 7    | 7                    | 0                |
|                         | Residential area | 12* <sup>1</sup> | 12           | 7    | 84           | 1                 | 7    | 7                    | 5x3              |
|                         | Peri-urban area  | 3                | 3            | 7    | 21           | 1                 | 7    | 7                    | 0                |
| Commercial              | Restaurant       | 5                | 5            | 7    | 35           | 1                 | 7    | 7                    | 0                |
|                         | Others           | 5                | 5            | 7    | 35           | 1                 | 7    | 7                    | 0                |
| Hotel                   |                  | 3                | 3            | 7    | 21           | 1                 | 7    | 7                    | 0                |
| Public & private office |                  | 3                | 3            | 7    | 21           | 1                 | 7    | 7                    | 0                |
| School                  |                  | 3                | 3            | 7    | 21           | 1                 | 7    | 7                    | 0                |
| Market                  |                  | 1                | 1            | 5    | 5            | 1                 | 5    | 5                    | 5x3              |
| Public area             | Road             | 1                | 1            | 5    | 5            | 1                 | 5    | 5                    | 0                |
|                         | Park             | 1                | 1            | 5    | 5            | 1                 | 5    | 5                    | 1x3              |
|                         | Drain            | 1                | 1            | 5    | 5            | 1                 | 5    | 5                    | 0                |
| Green waste             |                  | 1                | –            | –    | –            | 1                 | 2    | 2                    | 0                |
| Total                   |                  | –                | 43           | –    | 293          | –                 | –    | 78                   | 33               |

# Selecting Samples in Lautoka, Fiji

| Generation Source       |                  | No. of source    |
|-------------------------|------------------|------------------|
|                         |                  | A                |
| Household               | Business area    | 5                |
|                         | Residential area | 12* <sup>1</sup> |
|                         | Peri-urban area  | 3                |
| Commercial              | Restaurant       | 5                |
|                         | Others           | 5                |
| Hotel                   |                  | 3                |
| Public & private office |                  | 3                |
| School                  |                  | 3                |
| Market                  |                  | 1                |
| Public area             | Road             | 1                |
|                         | Park             | 1                |
|                         | Drain            | 1                |
| Green waste             |                  | 1                |
| Total                   |                  | —                |



# Interview survey

## Questionnaire to Households (example)

### 1) General information of household:

- How many family members are living in your household?
- How many persons are usually living or working in your house, such as maid and driver?
- How much is the total income of your household?

### 2) Waste collection service:

- Do you have the collection service?
- How many times a week?
- Who collects your waste?

### 3) Self disposal

- Do you burn your waste?
- Do you bury your waste?
- Do you dump your waste to vacant area, rivers, etc.?

### 4) Recycling

- Do you separate recyclable materials?
- Do you use organic waste for making compost?

**Questionnaire for Households**  
**Waste Amount and Composition Survey**

**1. General Information**

Date \_\_\_\_\_

Name of Interviewer \_\_\_\_\_

Name of Interviewee \_\_\_\_\_

District & Address of the Interviewee : District \_\_\_\_\_

: Address \_\_\_\_\_

**2. General Information of Interviewee**

(Ask an appropriate question depending on the type of generation category.)

(Notes! The Contractor shall change the questions in accordance to the "waste generation source unit" to be applied.)

Q.1. How many persons live in your home? : [ ] persons

Q.2. How many tables are there in your restaurant? : [ ] tables

Q.3. How many persons work in your shop? : [ ] persons

Q.4. How large is the floor area of your shop (hypermarket)? : [ ] square meters

Q.5. How many rooms are there in your hotel? : [ ] rooms

Q.6. How many persons work in your institution/office? : [ ] persons

Q.7. How many are the students in your school? : [ ] persons

Q.8. How many stalls are there in the market? : [ ] stalls

Q.9. How long is the road where the waste is sampled (to be asked to the sweeper)? : [ ] kilometers

Q.10. How wide is the park where the sweeping waste is sampled (to be asked to the sweeper/park maintenance staff)? : [ ] square meters

# One-week consecutive survey in Nigeria

① Selection and collection of Sample



② Measurement for Weight of Sample



③ Measurement for Volume of Sample



④ Extraction of Sample of Each Source for Analysis of Waste Composition



⑤ Measurement of Weight and Volume of Sample for Analysis of Waste Composition



⑥ Measurement of Weight of Each Sample Classified into 10 Types for Analysis of Waste Composition



# Waste Composition Survey in Nigeria

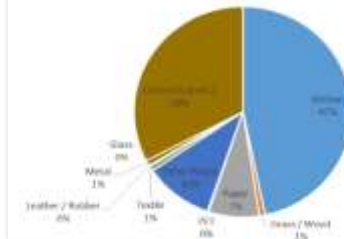
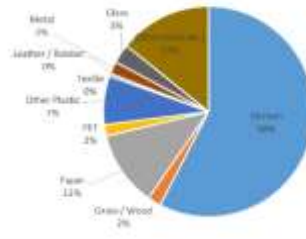
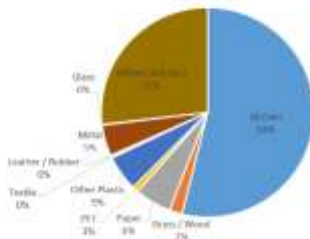
**Categories: (1) Kitchen, (2) Grass/Wood, (3) Paper, (4) PET, (5) Other Plastic, (6) Textile, (7) Leather/Robber, (8) Metal, (9) Glass, (10) Other (Soil etc.)**



Sampling Waste of High Income

Sampling Waste of Middle Income

Sampling Waste of Low Income



# Data Processing

How to handle outliers?

| Low Income                                    |    |                    |      |      |      |      |      |      |
|---|----|--------------------|------|------|------|------|------|------|
| 1   | 7  | 0.20               | 1.17 | 0.83 | 0.83 | 0.91 | 0.23 | 0.71 |
| 2   | 5  | 0.12               | 1.00 | 1.80 | 0.34 | 0.00 | 0.00 | 0.12 |
| 3   | 4  | 2.00               | 1.95 | 2.60 | 1.45 | 4.80 | 0.60 | 2.10 |
| 4   | 5  | 0.04               | 1.04 | 0.36 | 1.16 | 0.84 | 0.24 | 0.08 |
| 5   | 5  | 2.16               | 1.52 | 1.16 | 0.92 | 0.56 | 0.16 | 0.44 |
| 6   | 6  | 0.20               | 1.20 | 0.90 | 0.40 | 0.37 | 0.90 | 1.00 |
| 7   | 8  | 0.50               | 0.83 | 0.38 | 0.55 | 0.00 | 0.50 | 0.95 |
| 8   | 4  | 2.50               | 0.50 | 1.75 | 1.20 | 1.20 | 0.60 | 1.00 |
| 9   | 6  | 0.60               | 0.07 | 1.20 | 1.67 | 1.20 | 0.73 | 0.40 |
| 10  | 4  | 0.40               | 1.70 | 1.75 | 0.65 | 0.15 | 0.40 | 0.90 |
| 11  | 3  | 1.67               | 1.07 | 1.27 | 2.27 | 0.47 | 0.13 | 0.33 |
| 12  | 5  | 0.32               | 0.10 | 0.36 | 0.72 | 0.28 | 0.32 | 0.96 |
| 13  | 7  | 0.06               | 0.51 | 1.60 | 0.82 | 0.40 | 0.26 | 0.89 |
| 14  | 3  | 0.73               | 0.40 | 0.80 | 1.33 | 0.67 | 0.27 | 1.67 |
| 15  | 4  | 1.50               | 0.30 | 0.65 | 1.15 | 1.40 | 1.15 | 0.20 |
| 16  | 6  | 0.90               | 0.00 | 0.17 | 1.07 | 0.50 | 0.63 | 0.43 |
| 17  | 3  | 2.73               | 1.40 | 0.93 | 0.33 | 3.67 | 0.33 | 2.33 |
| 18  | 5  | 0.80               | 1.04 | 0.60 | 0.92 | 1.04 | 0.68 | 0.72 |
| 19  | 3  | 0.07               | 1.37 | 0.67 | 1.47 | 1.80 | 0.73 | 0.13 |
| 20  | 20 | 0.11               | 0.21 | 0.61 | 0.10 | 0.08 | 0.22 | 0.18 |
| 21  | 7  | 1.26               | 1.17 | 2.87 | 0.66 | 2.17 | 0.34 | 1.54 |
| 22  | 2  | 0.60               | 0.20 | 0.92 | 1.08 | 0.48 | 1.40 | 0.44 |
| 23  | 7  | 1.20               | 0.23 | 0.43 | 1.20 | 0.34 | 0.34 | 0.69 |
| 24  | 25 | 0.06               | 0.19 | 0.55 | 0.00 | 0.32 | 0.11 | 0.37 |
| 25  | 4  | 0.50               | 0.30 | 1.75 | 0.55 | 1.18 | 0.80 | 2.55 |
| 26  | 40 | 0.10               | 0.07 | 0.40 | 0.01 | 0.12 | 0.13 | 0.01 |
| 27  | 3  | 2.93               | 1.67 | 0.33 | 5.67 | 0.40 | 3.60 | 0.20 |
| 28  | 10 | 0.10               | 0.42 | 0.30 | 0.04 | 0.00 | 0.34 | 0.54 |
| 29  | 5  | 0.00               | 0.64 | 0.48 | 0.24 | 1.12 | 1.32 | 0.16 |
| 30  | 4  | 0.50               | 1.13 | 1.25 | 0.50 | 0.38 | 0.75 | 0.25 |
| Average (incl. abnormal value)                |    | 0.86               | 0.81 | 0.99 | 1.01 | 0.99 | 0.63 | 0.74 |
| Average (exc. abnormal value)                 |    | 0.52               | 0.81 | 0.92 | 0.79 | 0.67 | 0.52 | 0.56 |
| Unit generation amount (incl. abnormal value) |    | 0.86 kg/capita/day |      |      |      |      |      |      |
| Unit generation amount (exc. abnormal value)  |    | 0.69 kg/capita/day |      |      |      |      |      |      |

## Grubbs's test

Mean:  $\bar{X} = \frac{1}{n} \sum_{i=0}^n x_i$

Standard deviation

$$S = +\sqrt{S^2} \quad S^2 = \frac{n}{n-1} \sum_{i=0}^n (x_i - \bar{x})^2$$

95% confidence interval

$$R_{95} = \bar{X} \pm 1.96 \left( \frac{s}{\sqrt{n}} \right)$$

Statistic index value for Grubbs's test

$$T = \frac{|x_{\max \text{ or } \min} - \bar{x}|}{s}$$

# Data Processing

## Estimation of Waste Generation Amount of Household Waste

| Household     | Unit Generation Amount | Population        | Estimation of Waste Generation |
|---------------|------------------------|-------------------|--------------------------------|
| High Income   | 0.36kg/capita/person   | 831,834 persons   | 299.5t/d                       |
| Middle Income | 0.44kg/capita/person   | 879,368 persons   | 386.9t/d                       |
| Low Income    | 0.69kg/capita/person   | 665,467 persons   | 459.2t/d                       |
| <b>Total</b>  |                        | 2,376,669 persons | 1,145.6t/d                     |

## Estimation of Waste Generation Amount of Commercial and Institution Waste

| Commercial    | Unit Generation Amount | Adjusted Value      | Number | Estimation of Waste Generation |
|---------------|------------------------|---------------------|--------|--------------------------------|
| Restaurant    | 0.88kg/table/day       | 10 table/restaurant | 395    | 3.5t/d                         |
| Hotel         | 0.27kg/room/day        | 50 room/hotel       | 406    | 5.5t/d                         |
| Market / Shop | 2.01kg/shop/day        | —                   | 9,663  | 19.4t/d                        |
| Office        | 0.05kg/capita/day      | 80 persons/office   | 2,624  | 10.5t/d                        |
| School        | 0.01kg/capita/day      | 375 persons/school  | 217    | 0.8t/d                         |
| <b>Total</b>  |                        |                     |        | 39.7t/d                        |

## Estimation of Waste Generation of Road Waste

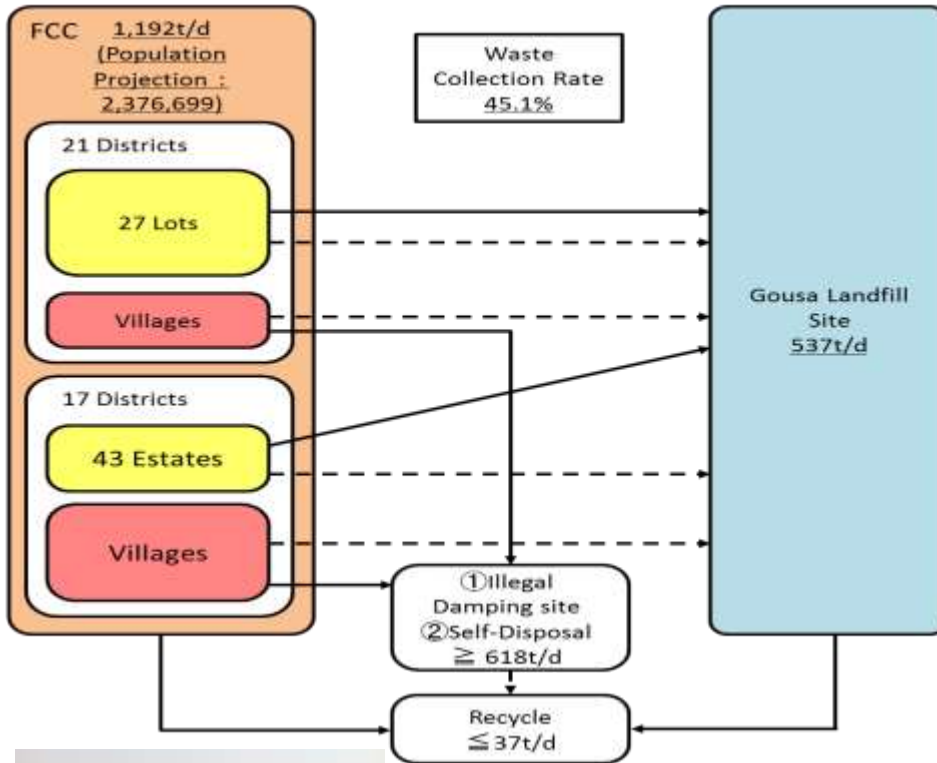
|            | Population | Road Extension      | Total Distance | Unit Generation Amount | Estimation of Waste Generation |
|------------|------------|---------------------|----------------|------------------------|--------------------------------|
|            | (1)        | (2)                 | (1) × (2)      | (3)                    | (1) × (3)                      |
| Road Waste | 2,376,669  | 0.4km/1,000 persons | 950.7km        | 6.94kg/km/d            | 6.60t/d                        |

**Total Waste Generation Amount in Abuja = 1,192t/day**



# Pilot Project for 11.6.1 in Nigeria

Waste Flow (2018)



| Landfill Site Name  | Landfill Type       | Operation Start Year            | Degree of Control Score |         | Amount of MSW Received | Amount of Sewage Sludge Received |
|---------------------|---------------------|---------------------------------|-------------------------|---------|------------------------|----------------------------------|
|                     |                     |                                 | JPT                     | C/P     |                        |                                  |
| Gousa Landfill site | Controlled dumpsite | Phase (1) 1982 & Phase (2) 2005 | (1) 7.1                 | (1) 8.6 | 537.6 t/d              | N/A                              |
|                     |                     |                                 | (2) 10                  | (2) 10  |                        |                                  |
|                     |                     |                                 | (3) 2.5                 | (3) 3.0 |                        |                                  |

- (1) Degree of control over waste reception and handling at each site
- (2) Degree of control over both the waste treatment and disposal process in use at each site and over any potential emissions.
- (3) Degree of monitoring and verification of environmental controls

|    | Level of Control                  | Score |
|----|-----------------------------------|-------|
| a. | None                              | 0     |
| b. | Low (Semi-controlled facility)    | 5     |
| c. | Medium (Controlled facility)      | 10    |
| d. | Medium/high (Engineered facility) | 15    |
| e. | High (State-of-the-art facility)  | 20    |

$$x = \frac{\text{Municipal solid waste collected and managed in a controlled facility}}{\text{Total municipal solid waste generated by the city}} \times 100 (\%)$$

=0

# Findings of Pilot Project for 11.6.1 in Nigeria

|                           | Challenges  | Proposal  |
|---------------------------|---|---|
| 1. Definition of MSW      | <ul style="list-style-type: none"> <li>- The definition of MSW is different according to countries</li> <li>- Even in Nigeria, there are three definitions in different official documents</li> </ul>   | <ul style="list-style-type: none"> <li>- Proposed definition of MSW:                         <ol style="list-style-type: none"> <li>1) SW to be managed by municipal government</li> <li>2) MSW = domestic waste + commercial waste</li> </ol> </li> </ul>  |
| 2. Population             | <ul style="list-style-type: none"> <li>- Population relies on the projection based on 2006 census, which does not reflect the reality</li> <li>- Especially population in low income layer is difficult to estimate due to the lack of data</li> </ul>                          | <ul style="list-style-type: none"> <li>- Adjustment of population increase rate based on the economic development status. However this is not certified data</li> <li>- Low income population = estimated total population – high and low middle income population</li> </ul>   |
| 3. Number of household    | <ul style="list-style-type: none"> <li>- Extremely difficult to estimate since there are many informal housing</li> <li>- The number of household with access to regular collection services is difficult to obtain</li> </ul>  | <ul style="list-style-type: none"> <li>- It is possible to count number of housing based on satellite image in pilot area</li> <li>- Customer list from collection companies? (the reliability is low.)</li> </ul>  |
| 4. WACS                   | <ul style="list-style-type: none"> <li>- High technical skill and experience is required to conduct the survey appropriately</li> <li>- Certain budget is needed to conduct the survey (human resources and vehicles)</li> </ul>  | <ul style="list-style-type: none"> <li>- Capacity development on the survey for local government officials is a MUST</li> <li>- Budget allocation for local government to conduct survey is necessary</li> </ul>  |
| 5. Total waste generation | <ul style="list-style-type: none"> <li>- Sampling methodology to determine the number of household should be standardized</li> <li>- Necessary data (e.g. inventory of hotels, restaurants, offices, supermarkets, etc.) is unavailable to estimate commercial waste</li> </ul> | <ul style="list-style-type: none"> <li>- Standardize sampling methodology for household waste survey</li> <li>- Establish methodology for comparison between 1) estimation based on waste generation rate and 2) estimation based on collection coverage and amount of waste received by dumpsite, especially for commercial waste</li> </ul> |

# Findings of Pilot Project for 11.6.1 in Nigeria

|                                       | Challenges  | Proposal   |
|---------------------------------------|---|--|
| 6.Recycle Amount                      | <ul style="list-style-type: none"> <li>- Difficult to clarify the amount of recycle, because recycling activities are mainly carried out by the informal private sector.</li> </ul>   | <ul style="list-style-type: none"> <li>- Conduct interview surveys to recyclers and intermediaries with relatively large scale and grasp the amount of recycling.</li> <li>- Introduce registration systems and formalize recycling activities. Impose duties on reporting dealing volume.</li> </ul>  |
| 7.Five-Grade Evaluation by Wasteaware | <ul style="list-style-type: none"> <li>- The evaluation result in Abuja was between “(Semi-controlled” and “controlled” facility.</li> <li>- The evaluation results adopting Wasteaware, by C/P and JPT were different because of the difference of experiences, knowledge, etc. Unified evaluation by each party/ estimator was impossible.</li> <li>- Some evaluation items cannot be applied. Therefore, it is necessary to re-arrange the evaluation items to meet the characteristics of each SWM facility to be evaluated.</li> </ul> | <ul style="list-style-type: none"> <li>- Show the facility examples corresponding to each of the 5 grades by photographs and facility specifications.</li> <li>- Develop evaluation indices (scores allocation) for developing countries, so that we can indicate the direction of improvement.</li> <li>- Classify the facilities to be evaluated into two categories: (1) final disposal site, (2) intermediate treatment facility (incineration treatment facility, recycling facility, relay transport facility, etc.), organize and set the evaluation items to be applied to each</li> </ul> |



# Thank you for your attention!

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