DECISION SUPPORT MODEL FOR SUSTAINABLE WASTE MANAGEMENT TOWARD LOW CARBON ECO REGIONS

case study of Jakarta, Indonesia and Hamburg, Germany

Ova Candra Dewi, MSc.

PhD. Supervisors:

PD. Dr.-Ing. habil. Ina Koerner, AWW, Bioconversion and Emission Control Group, TUHH
Prof. Miranda Schreurs, Institute of Environmental Policy Research, FU
Prof. Triatno Yudo Harjoko, Department of Architecture, UI
technologies

managements

routing, facility siting, tools, etc.

Society agreement/ Acceptance!!
Low Carbon Eco Region ???

“in particular the contribution of waste management sector, is a living in a low rate of carbon generation, using fewer natural resources, encouraging energy recovery and waste reduction at generation source by improving the quality of any material used (up-cycling)”

Goal

Assist the stakeholders, using key of society’s involvement to set up alternatives of most appropriate management and technology for sustainable waste management by considering geographic, environmental impact, social capital and economics aspect; towards low carbon eco regions

‘waste reduction at source as the most rational and cleanest means of waste management’ (Boyle 1989)
Decision Support Model (DSM): The Generalization

Input: Models’ background and purpose, data inventory, condition setting

Process / Dialogues and Simulations: Performance criteria, assessment/evaluation instrument

Output: “Comparative Results”

General Models’ System Boundary (here: generation amount to treatment technology)

Intended User(s) with key assumptions for important decisions (External Conditions)

Generalization of a Decision Support Model (DSM), Adapted from Sprague and Watson (1996)

Dedicated to dense settlements urban village in Jakarta City ~ Kampung Area (complex environmental, social and political issue)
### DSM Type based on Analysis Method, some samples and Review

<table>
<thead>
<tr>
<th>Model Based</th>
<th>Cost Based Model</th>
<th>Environmental Impact Based Model</th>
<th>Multi-criteria Decision Based Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Familiar as</strong></td>
<td>First and most customary model</td>
<td>The most common model among researcher</td>
<td>The most comprehensive/widest scope model</td>
</tr>
<tr>
<td><strong>Standard Measurement</strong></td>
<td>Monetary Value</td>
<td>Potential impact to the environment</td>
<td>3 dimensional sustainability</td>
</tr>
<tr>
<td><strong>Sample of approach</strong></td>
<td>Individual contribution/fee</td>
<td>Environmental performance</td>
<td>Weighting/scoring/valuing parameters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Developed Country's</th>
<th>Developing Country's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bigger scope</td>
<td>Smaller scope</td>
</tr>
<tr>
<td>Models before 90s mainly focus on <strong>cost</strong>, but later on wider</td>
<td>Models on 00s are still mainly focus on <strong>cost</strong></td>
</tr>
<tr>
<td>Dominant focus is on <strong>environmental impacts</strong></td>
<td>Dominant focus is on <strong>cost</strong></td>
</tr>
<tr>
<td>Developed/supported by <strong>environmental agency</strong> and for long term research</td>
<td>Developed/supported by <strong>researcher initiative</strong> and for short term research</td>
</tr>
</tbody>
</table>

- Chang and Wang, Taiwan (1996)
- Barlishen and Baetz, Canada (1996)
- Kikerby et al., Denmark (1996)
- Ghewala and Liamsanguan, 2007
- Den Boer et al., (2007)
Assessment Processes

Output

Comparative Results

Box GEO

Site map, number of inhabitants per house, list of house and non-house function, number of employee for non house function, inventory tools, road specifications, vacant land, waste generation per house.

Possibilities of routings, sitting temporary collection point, suitable tools, frequency of collections.

Tools: GIS and Excel.

Box ENVIM

Number of houses, number of inhabitants per house, waste generation per capita, waste composition, sorting efficiencies.

Scenario:
A. 100% Dumpsite
B. 100% Incineration
C. XX% landfill, YY% Composting, ZZ% Recycling
D. XX% landfill, YY% Anaerobic Digestion, ZZ% Recycling
E. XX% landfill, YY% Anaerobic Digestion and then Composting, ZZ% Recycling
F. 100% Landfill

Tools: EASEWASTE, STAN, Excel

Box SOCECO

List of collective actions and the participators.

Cadres investigation from existing social capital, continue with Motivation and Monetary power assessment by society internal discussion:
Waste separation and financial sources.

List of agreeable acts on waste management.

List of combinations of box 1, 2, 3 with the consequences.
Team Preparation with trained facilitator --- students

Field Survey: mainly to get society awareness and interact with the society members directly

**Purpose:** To develop a proxy members’ motivation to participate in community participatory planning and/or social work, investigate the local cadres (society members) and ZONE

**Collective action/Community based activity + frequency list**

Grade and Rank them based on frequency and intensity (Quantitatively and Quantitatively) – Intersection (Set Theory)

**Social Cluster based/Alley based division area**

<table>
<thead>
<tr>
<th>No.</th>
<th>Collective Actions</th>
<th>Frequency</th>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Street Cleansing (jumat bersih)</td>
<td>once per week</td>
<td>52</td>
</tr>
<tr>
<td>02</td>
<td>Gymnastics (senam)</td>
<td>Once every 2 weeks</td>
<td>26</td>
</tr>
<tr>
<td>03</td>
<td>Social Gathering (arisan)</td>
<td>Once per month</td>
<td>12</td>
</tr>
<tr>
<td>04</td>
<td>Quran Study (pengajian)</td>
<td>Once per week</td>
<td>52</td>
</tr>
<tr>
<td>05</td>
<td>Community health awareness (posyandu)</td>
<td>Once every 3 months</td>
<td>4</td>
</tr>
</tbody>
</table>

*Table 1. List of Collective Actions*

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Joined Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Aaaaaa</td>
<td>01</td>
</tr>
<tr>
<td>02</td>
<td>Bbbbbb</td>
<td>02, 03</td>
</tr>
<tr>
<td>03</td>
<td>Cccccc</td>
<td>02, 03, 05</td>
</tr>
<tr>
<td>04</td>
<td>Dddddd</td>
<td>02, 04</td>
</tr>
</tbody>
</table>

*Table 2. List of Participant*

Note: number cadres needed based on society agreement in this sample is assumed 50%
Team Preparation with trained facilitator --- students
Field Survey: mainly to get mapping the infrastructures, marking meeting points, public and social facilities
With ArcGIS (Geographic Information System)

**Purpose**: To develop a most effective routing, suitable collection points and tools

Location Map, with Inventory of houses, (community/social points) and Infrastructures (bridge, road, access)

Quantify the most effective routing, potential collection points and tools

Alternative routings and list of suitable collection tools

<table>
<thead>
<tr>
<th>No.</th>
<th>function</th>
<th>Number of employee</th>
<th>Type of waste</th>
<th>If specific waste, please define</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mix waste</td>
<td>Specific waste</td>
</tr>
</tbody>
</table>

**Table 4. Houses**

<table>
<thead>
<tr>
<th>No.</th>
<th>function</th>
<th>Number of employee</th>
<th>Type of waste</th>
<th>If specific waste, please define</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td></td>
<td></td>
<td>Mix waste</td>
<td>Specific waste</td>
</tr>
<tr>
<td>B.</td>
<td></td>
<td></td>
<td>Mix waste</td>
<td>Specific waste</td>
</tr>
</tbody>
</table>

**Table 5. Non-Houses**

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Wide</th>
<th>Suggested tools</th>
<th>Temporary collection here? (yes or no)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge(br), Road(rd), Street(st), Alley(al), vacant land(vl)</td>
<td>2 cars or more(a), 2 cars(b), 1 car(c), no car(d)</td>
<td>&gt;see inventories</td>
<td>(yes or no)</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6. Infrastructure**

- Collection tools inventory
- Waste Generation inventory
Team Preparation with trained facilitator --- students
Field Survey: conduct waste inventory research
Based on ASTM D5231 – Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste

**Purpose:** To investigate waste characteristics and potential environmental impacts and communicate them with society

- **Data Inventory:** waste characteristics (generation amount and composition by weight)
- **Mass Balance and Impact Categories:** based on Life Cycle Assessments (LCA), with the use of EASEWASTE Model (v.2008) and STAN2 to communicate the system/flow
- **Normalization to person equivalent (PE) of Each Impact Categories with main substances - EASEWASTE and Alternative of Waste Flows/Streams (STAN2)**

**Input:**
- Data Inventory: waste characteristics

**Assessment Processes:**
- Mass Balance and Impact Categories based on Life Cycle Assessments (LCA), with the use of EASEWASTE Model (v.2008) and STAN2 to communicate the system/flow

**Output:**
- Normalization to person equivalent (PE) of Each Impact Categories with main substances - EASEWASTE and Alternative of Waste Flows/Streams (STAN2)

---

ASTM = American Society for Testing Materials

STAN software, TU Wien and EASEWASTE model, TU Denmark
Low Carbon Ecocity Development
Sustainable regional decision support
Model on Waste Management.

Site 1. Cipedak, South Jakarta
292 houses, 1168 persons–53,500 m2
Waste generation 44.3 t/a

Site 2. Cikini, Central Jakarta
86 houses, 430 persons–2,800 m2
Waste generation 13.5 t/a
Site 1. Characteristics

- House with garden/open space
- Urban Farming
- Street and waste bin

CIPEDAK MAP

= two or more stories house

Collection tool: pick up car

Collection tool: handcart
Site 2. Characteristics

Located in the middle of urban infrastructures, (Legally)

Public facilities for washing, “mobile” collection points, Public toilets

View between houses from up to down
SERENSENG SAWAH - CIPEDAK (167 h)

High organic waste and plastics producer
Unmanaged waste collection management
Open n green space available
Community based organization available
Absence of waste separation at source
No experience in any kind of 3R
Limited access for some houses
No further treatment except open dumping

CIKINI - AMPIUN (88 h)

High organic waste and plastic producer
Managed Waste management collection
Open n green space not available
Community based organization available
Absence of waste separation at source
Experience to participate in 3R
Limited access in all area
No further treatment except open dumping
Output Sample
Site 1. Collection System

MAP LAYERS: houses, streets, trees, and public facilities

ALTERNATIVE COLLECTION SYSTEM

- Collection points
- Collection points alternative with access to the road

Collection route alternative
**BOX SOCECO**

**Output Sample: Zoning**

**Site 1. Cluster based Social Zone**

**Site 2. Alley based Social Zone**

Discussions  
workshops  
decision taking
**INTRODUCTION**

**Background Information**

**METHODOLOGY**

**Result and Discussion**

**CONCLUSION**

---

**BOX ENVIM**

**Waste Composition: Site 1 and Site 2 (% in weight based)**

- **73%**
- **68%**

**Treatment Technologies Classification**

I. **Landfill Group**: Open Dumping, Sanitary Landfill, Controlled Landfill

II. **Thermal Treatment**

III. **Biological Treatment Group**: Composting, Anaerobic Digestion, Mechanical Biological Treatment (MBT)

IV. **Recycling Utility Landfill (RUL)** – Society Based Activities: Recycle Bank, Composting on Land

---

**Existing Material Recovery**

**Location Categories**

A. (i) Centralized and/or (ii) Decentralized

B. (i) Regional/Settlement or (ii) City Level
Result 1. Material Flow Analysis, Landfill Group 1. Open Dumping, STAN2

<table>
<thead>
<tr>
<th>IMPACT CATEGORIES</th>
<th>Total (PE)</th>
<th>Name of the 2 main substances (Values (PE))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photochemical Ozone Formation, low NOx (EDIP97)</td>
<td>1.121</td>
<td>CH4 (1.047)</td>
</tr>
<tr>
<td>Photochemical Ozone, high NOx (EDIP97)</td>
<td>1.13</td>
<td>CH4 (1.047)</td>
</tr>
<tr>
<td>Global Warming (EDIP97)</td>
<td>8.329</td>
<td>CH4 (9.887) Carbon Sequestered (-1.957)</td>
</tr>
<tr>
<td>Stratospheric Ozone (EDIP97)</td>
<td>2.716</td>
<td>CFC12 (1.592), CFC11 (0.971)</td>
</tr>
<tr>
<td>Nutrient Enrichment (EDIP97)</td>
<td>0.039</td>
<td>NOx (0.03896)</td>
</tr>
<tr>
<td>Acidification (EDIP97)</td>
<td>0.04</td>
<td>NOx (0.03248)</td>
</tr>
</tbody>
</table>

Result 2 LCA – Non Toxic Categories, EASEWASTE 2008

Result 3 LCA– Toxic Categories, EASEWASTE 2008
HOW? TOWARD LOW CARBON ECO REGIONS from the contribution of waste sector

1. Waste Reduction from Generation Source
   ‘the cleanest means of waste management’

2. Waste Separation from Generation Source
   saving virgin material and waste as resources material

Condition:
- Good Cooperation
- Trained Facilitators
- Time Consuming
- Maximize Localities

Condition:
- Independent Society
- Open Entrepreneurship
- additional income

SUSTAINABILITY

Some of emission factors:
- Transportation
- Industrialization
- Deforestation
- Animals (manure)
- Waste disposal

Condition:
- Society agreement
- Acceptance!!
APPLICABILITY

University's Regular Community Service Program

Student intake - practical research course
Load: course, training, fieldwork (credits)
Funding possibility: university and society

Research Activities
Working Groups on BOX GEO, ENVI and SOCECO

Registered Municipalities, or Local public authorities (asking for assistance)

Society members

Iterative Process:
Decision Making

Waste Management OPTIONS

Team Preparation
Registration
Team Ready
Research
Result
Thank you for your attention....
Email: ova.candra@tuhh.de