Climate benefits of improved organic waste management through the 3Rs approach in developing Asian countries

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Research background

Problems of the waste sector:
- Increasing waste generation
- Increasing social resistance to new landfill and incineration projects.

Problems of the climate sector:
- Increasing anthropogenic GHG emissions
- Rising climate change impact

Matching solutions
- Reducing waste generation
- Decreasing waste to disposal site
- Reducing anthropogenic GHG emissions

3Rs
Key research questions

1) How much the 3Rs can reduce GHG emissions from the waste sector?

2) Do developing Asian countries include the 3Rs in their national climate action plans/strategies?

3) How to enhance the 3Rs implementation successfully in developing Asian countries?

Research activities

1. Reviewing national greenhouse gas (GHG) inventories and national climate action plans/strategies of 10 studied countries.

2. Estimating potential GHG emissions from organic waste in the studied countries.

3. Identifying climate benefits of the 3Rs for organic waste.

4. Reviewing the 3Rs practices for organic waste management.

5. Identifying appropriate organic waste management hierarchies regarding climate change impact and resource efficiency.

6. Developing a decision diagram for associating local governments in selection of organic waste management option.
Overview:
Climate benefits of 3Rs: organic waste

Overview:
GHG emissions and the waste sector

<table>
<thead>
<tr>
<th>Country</th>
<th>National GHG inventories in 1994 (MtCO₂ eq.)*</th>
<th>GHG emissions from the waste sector in 1994 (MtCO₂ eq.)</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>4,081</td>
<td>42.6, 1.04</td>
<td>Chinese Government, 2004</td>
</tr>
<tr>
<td>India</td>
<td>1,252</td>
<td>12.2, 0.97</td>
<td>MoEF, 2004</td>
</tr>
<tr>
<td>Indonesia</td>
<td>883</td>
<td>8.44, 0.96</td>
<td>MENLH, 1999</td>
</tr>
<tr>
<td>Thailand</td>
<td>325</td>
<td>0.411, 0.13</td>
<td>MSTE, 2000</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>154</td>
<td>1.39, 0.90</td>
<td>MNRE, 2003</td>
</tr>
<tr>
<td>Malaysia</td>
<td>144</td>
<td>21.9, 15.2</td>
<td>MOSTE, 2000</td>
</tr>
<tr>
<td>Philippines</td>
<td>169</td>
<td>4.25, 2.51</td>
<td>IACCC, 1999</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>76.3</td>
<td>1.31, 1.72</td>
<td>MoEF, 2002</td>
</tr>
<tr>
<td>Cambodia</td>
<td>59.7</td>
<td>0.124, 0.21</td>
<td>MOE, 2002</td>
</tr>
<tr>
<td>Laos**</td>
<td>24.2</td>
<td>0.240, 0.99</td>
<td>STEA, 2000</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td><strong>7,168</strong></td>
<td><strong>92.9, 1.3</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Sinks are not included. **GHG inventory in 1990.
Current trend of GHG emissions from the waste sector

**GHG emissions estimation**
- Report of methane emissions from landfill of organic waste is required.
- Inclusion of CO₂ emissions from burning of waste containing fossil fuel is currently on voluntary basis.

**Waste management**
- Increase waste generation
- Increase waste collection rate
- Improved waste treatment from open dumping to landfill and incineration

<table>
<thead>
<tr>
<th>Increase accounting of GHG emissions from the waste sector</th>
<th>Increase waste dumped into landfill/incineration</th>
<th>Increase contribution of national GHG inventories from the waste sector</th>
</tr>
</thead>
</table>

Main source of GHG emissions from the waste sector

**Waste compositions** (regional average)

- Degradation of organic waste (152 mil. ton/yr) under anaerobic condition is the largest source of methane emissions.
- Burning of plastic waste (23 mil. ton/yr) is a major source of carbon dioxide emissions.

Note: Compile from various sources
## 3Rs in the national climate action plans/strategies

<table>
<thead>
<tr>
<th>Countries</th>
<th>Mention of solid waste</th>
<th>Mention of 3Rs approach</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Yes</td>
<td>Reduce, Recovery, Utilization</td>
<td>NCCCC, 2007</td>
</tr>
<tr>
<td>India</td>
<td>Yes</td>
<td>Reduction, Recycling</td>
<td>PMCCC, 2008</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Yes</td>
<td>5Rs for industry &amp; 3Rs for MSW</td>
<td>MENLH, 2007</td>
</tr>
<tr>
<td>Thailand</td>
<td>Yes</td>
<td>3Rs</td>
<td>ONEP, 2008</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Yes</td>
<td>No</td>
<td>MoEF, 2008</td>
</tr>
<tr>
<td>Philippines</td>
<td>Limited</td>
<td>No</td>
<td>IACCC, 1999</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>No</td>
<td>No</td>
<td>MNRE, 1999</td>
</tr>
<tr>
<td>Malaysia</td>
<td>No</td>
<td>No</td>
<td>MOSTE, 2000</td>
</tr>
<tr>
<td>Cambodia</td>
<td>No</td>
<td>No</td>
<td>MOE, 2002</td>
</tr>
<tr>
<td>Laos**</td>
<td>No</td>
<td>No</td>
<td>STEA, 2000</td>
</tr>
</tbody>
</table>

### Climate benefits of the 3Rs

- **Reduce,** **Recovery,** **Utilization**
- **Reduction,** **Recycling**
- **5Rs for industry & 3Rs for MSW**
- **3Rs**
Climate benefits of 3Rs: organic waste

**Life-cycle approach**

- Reduce emissions from energy, agriculture, industry, land use change & forestry, and waste sectors
- Maintain forest sequestration
- Increase soil carbon storage
- Avoid fossil consumption
- Provide renewable energy sources

**Potential GHG emissions reduction through the 3Rs**

**Direct emissions reduction from organic waste**

- 20-98% reduction by composting and 60-100% by anaerobic digestion of food waste (compared to landfill).

<table>
<thead>
<tr>
<th>Organic waste</th>
<th>Potential net GHG emissions reduction compared to landfill (KgCO2eq / kg of organic waste)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waste reduction</td>
</tr>
<tr>
<td>Food waste</td>
<td>0.42 - 1.05</td>
</tr>
<tr>
<td>Paper</td>
<td>1.12 - 2.80</td>
</tr>
<tr>
<td>Grass</td>
<td>0.48 - 1.19</td>
</tr>
</tbody>
</table>

**Indirect GHG emissions reduction**

- 94% by recycling of plastic.
- 80% by recycling of steel.
- 56-64% by using 50% recycled aluminum.
- 22% by increasing use of recycled glass from 25% to 59%. 
Potential GHG emissions reduction through the 3Rs

<table>
<thead>
<tr>
<th>Country</th>
<th>Total MSW (Mt/yr)</th>
<th>Potential GHG emissions reduction from 30% reduction of organic waste dumped into landfills (MtCO₂eq/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Food</td>
</tr>
<tr>
<td>China</td>
<td>120</td>
<td>17.6 - 44.1</td>
</tr>
<tr>
<td>India</td>
<td>42</td>
<td>4.9 - 12.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>22.5</td>
<td>4.9 - 12.2</td>
</tr>
<tr>
<td>Thailand</td>
<td>14.7</td>
<td>2.8 - 6.9</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>12.8</td>
<td>2.3 - 5.6</td>
</tr>
<tr>
<td>Philippines</td>
<td>11</td>
<td>1.5 - 3.6</td>
</tr>
<tr>
<td>Malaysia</td>
<td>8.7</td>
<td>1.3 - 3.2</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>4.9</td>
<td>1.0 - 2.4</td>
</tr>
<tr>
<td>Regional</td>
<td>236.6</td>
<td>36.3-90.3</td>
</tr>
</tbody>
</table>

Recommendations:

I. Waste separation at source
II. Selection of waste management option
I. Waste separation at source

- Waste separation at sources is a key of success.
- Development of guideline for waste separation at source: category, bin, collection schedule, etc.
- Food waste separation at source should be prioritized.
- Paper, wood, and grass wastes separation should be promoted.

II. Selection of organic waste management option

<table>
<thead>
<tr>
<th>Municipality need</th>
<th>Social need</th>
<th>Preferable technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce waste flows to final disposal site</td>
<td>Food security</td>
<td>Efficient resource recovery</td>
</tr>
<tr>
<td>Improve collection and treatment of waste</td>
<td>Energy security</td>
<td>Low GHG emissions</td>
</tr>
<tr>
<td>Reduce cost for waste collection and disposal</td>
<td>Poverty reduction/job creation</td>
<td>Low energy input</td>
</tr>
<tr>
<td>Reduce environmental impact from waste treatment</td>
<td>Income distribution</td>
<td>Low monetary investment</td>
</tr>
<tr>
<td>Implement simple and easy to handle management system</td>
<td></td>
<td>Low environmental impact</td>
</tr>
</tbody>
</table>
Food waste management hierarchy

- **Reduce overall environmental impact**
  - Reduce over consumption
  - Human consumption
  - Animal feed
  - Anaerobic digestion
  - Composting
  - Mechanical biological treatment (combined with landfill/incineration)
  - Sanitary landfill equipped with methane collection

- **Direct nutrient recovery**
  - Direct nutrient recovery

- **Energy and indirect nutrient recovery**
  - Indirect nutrient recovery

- **Reduce impact from landfill/incineration**
  - Reduce methane emission

- **Main Benefits**
  - Direct nutrient recovery
  - Energy and indirect nutrient recovery
  - Reduce impact from landfill/incineration
  - Reduce methane emission

- **Notes**
  - Direct nutrient recovery
  - Energy and indirect nutrient recovery
  - Reduce impact from landfill/incineration
  - Reduce methane emission

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Paper waste management hierarchy

- **Reduce overall environmental impact**
  - Reduce Paper use
  - Reduce Paper use

- **Reduce waste generation**
  - New products (e.g. construction bricks, pots)
  - New paper production
  - Alternative fuel source
  - Avoided methane emission & produced soil amendment materials
  - Reduce impact from landfill/incineration
  - Reduce methane emission

- **Reuse**
  - New product development
  - Recycle (paper to paper)
  - Fuel briquette
  - Pyrolysis/controlled combustion/incineration
  - Mechanical biological treatment (combined with incineration/landfill)

- **Recycle**
  - New products (e.g. construction bricks, pots)
  - Paper used both sides
  - Alternative fuel source
  - Avoided methane emission & produced soil amendment materials
  - Reduce impact from landfill/incineration
  - Reduce methane emission

- **Recovery**
  - Sanitary landfill equipped with methane collection

- **Notes**
  - Good quality paper
  - Paper used both sides
  - Energy use purpose
  - Low quality paper wastes
  - Unsorted waste
**Wood waste management hierarchy**

- **Main benefits**
  - Reduce deforestation & waste generation
  - Reduce deforestation & waste generation
  - Alternative fuel source
  - New products (e.g., mushroom media, bricks)
  - Alternative fuel source
  - Energy & nutrient recovery
  - Nutrient recovery
  - Enhance resource recovery
  - Reduce methane emission

- **Most preferable**
  - Reuse
  - Repair (Reduction)
  - Fire wood
  - New product development
  - Fuel briquette

- **Notes**
  - By other user or by other purpose
  - By the same user
  - Piece wood
  - Medium-high investment capacity
  - High investment capacity

- **Less preferable**
  - Sanitary landfill equipped with methane collection

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**Grass and garden waste management hierarchy**

- **Main benefits**
  - Soil amendment
  - Direct nutrient recovery for animals
  - Soil amendment
  - New products (e.g., bricks, plates)
  - Alternative energy source
  - Energy recovery, soil amendment
  - Energy recovery, soil amendment
  - Energy recovery

- **Most preferable**
  - Soil mulching
  - Animal feed
  - Composting
  - New product development
  - Fuel briquette
  - Pyrolysis/Controlled combustion/Incineration
  - Anaerobic digestion
  - Sanitary landfill equipped with methane collection

- **Notes**
  - Fresh and dry matters
  - Fresh and dry matters
  - Fresh and dry matters
  - Dry matters
  - Dry matters, branches
  - Medium-high investment capacity
  - High investment capacity
**Decision diagram for selection of appropriate organic waste management option**

**Divided into 8 lines:**

A: Unsorted waste and mixed organic waste → no/less organic waste separation

B: Food waste

C: Mixed non-food waste

D: Paper

E: Mixed wood and grass wastes

F: Wood waste

G: Grass waste

**Institute for Global Environmental Strategies**

Climate benefits of 3Rs: organic waste

**Inaugural Workshop of Asia Resource Circulation Policy Research, 9-10 November 2009, Tokyo**
Conclusion

- The 3Rs are a national concern and should be promoted widely in order to reduce resource consumption, decrease GHG emissions, reduce the need for landfill, and avoid land-use conflicts.
- More research on the various benefits of the 3Rs in the studied region → Lifecycle assessment of GHG emissions and environmental impact, and cost-benefits analysis.
- Improved interaction between researchers and policy-makers are needed to enhance implementation.
- Pilot project demonstrating the 3Rs and waste separation at source should be granted.
- Strengthened international research cooperation and improved information sharing among countries in Asia are likely to be conducive towards that end.

Further activity

- Revising the report
  - Please send any comment to sang-arun@iges.or.jp by 10 December 2009.
- Publishing a policy report by mid 2010.