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Climate Change Mitigation Potential in the Solid Waste Management Sector in Developing countries: Case study in Hanoi city, Vietnam

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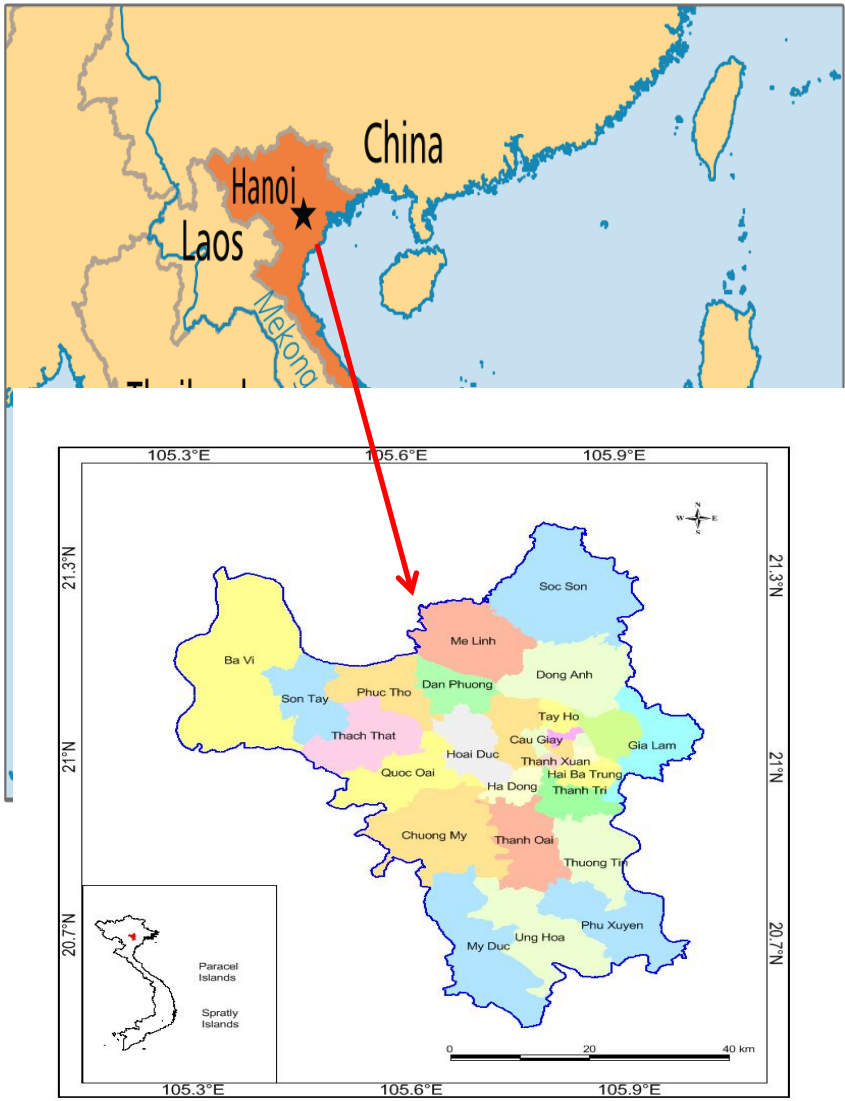
Study area – Hanoi city

- **Area:** 3,325 km2
- **Population:** 6,725,700 (2011)
- **Rank in Population:** 2nd in Vietnam
- **Density:** 2,023 persons/km2
- **Population growth:** 1.1%/year
- **GDP total:** 19.5 billion USD (2013)
- **GDP per capita:** 2,750 USD
- **Economic growth:** 8.25%/year (2013)



MSW management in Hanoi

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MSW management in Hanoi

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- **MSW generation: 6,500** tons/day (**2,372,500** tons/year) in 2011:
- accounted for **11%** of total MSW generation of whole country
- generated rate: 0.96 kg/person/day
- **Waste collection rate:**
- 95% in inner city
- 60% in suburban areas
- overall, collection of MSW: **85%** of total of whole city
- **MSW generation increases 15%/year** (MONRE's report, 2011)

MSW management in Hanoi (cont.)

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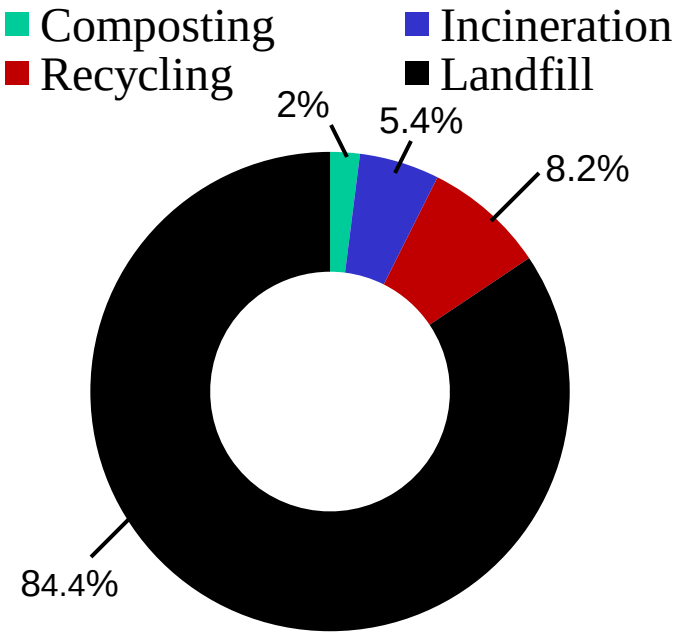
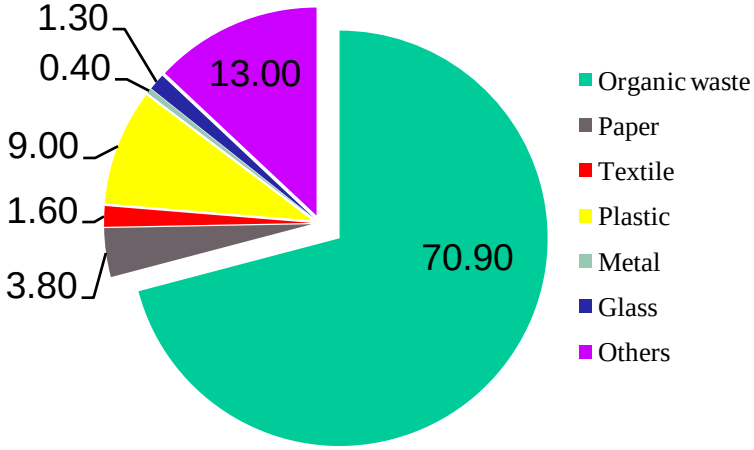
MSW treatment in Hanoi



(Source: URENCO, 2011)

Physical composition (%)



(Source: JICA, 2011)

MSW management in Hanoi (cont.)

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★ : Landfill

★ : Composting

★ : Incinerator

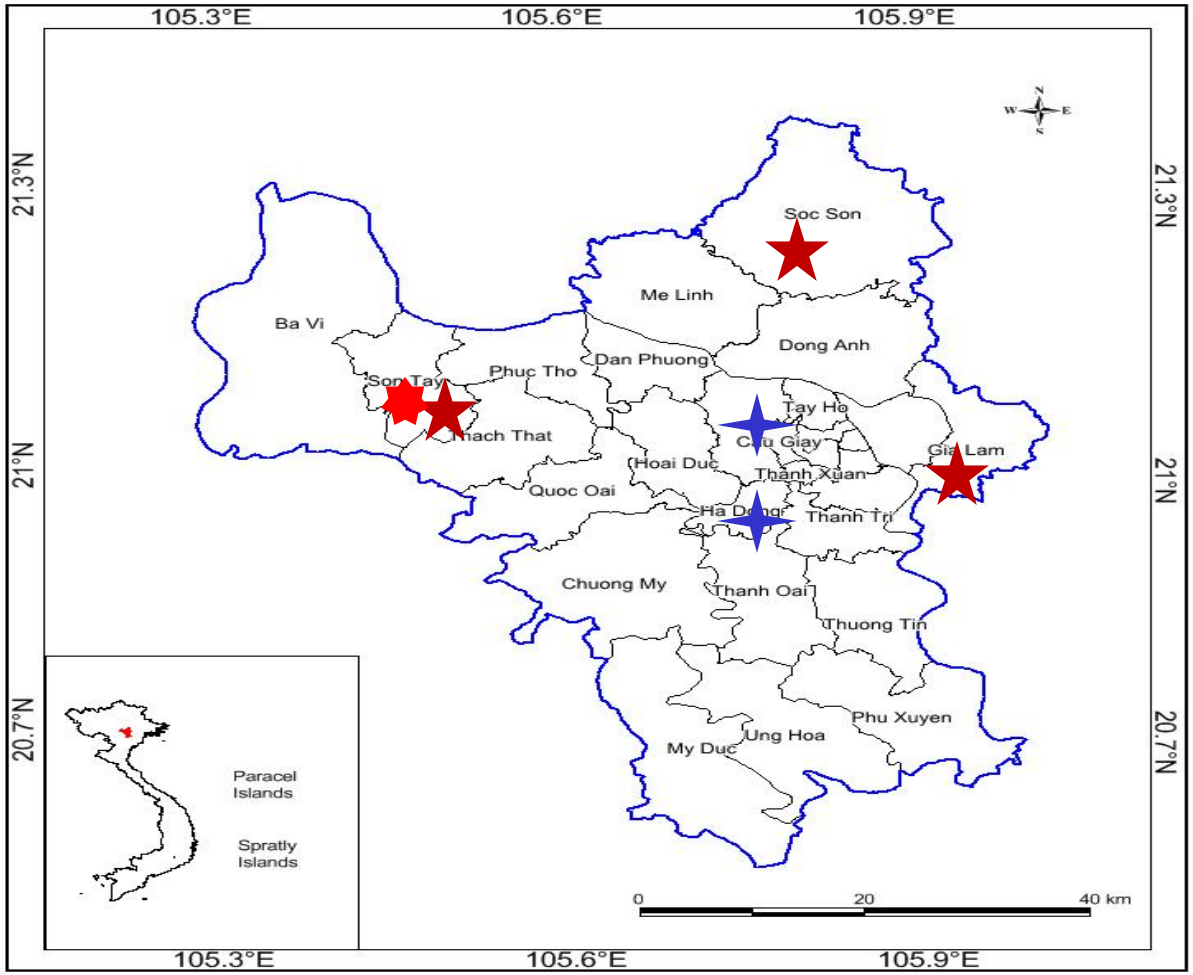

Fig.1. Location of solid waste treatment facilities in Hanoi

Solid waste management and climate change

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Why GHG emission from MSW in developing countries?

- MSW generation is increasing due to urbanization and population growth
- MSW containing high organic waste is often mainly dumped in landfills in developing countries
- Have few information to estimate GHG mitigation effects of alternative waste management activities
- Most recent researches consider only direct emission from landfills
- Limited landfill gas recovery system

→ **high potential for GHG mitigation (methane)**

Objectives

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- to **estimate** GHG emissions associated with the current MSW management in fast growing city, Hanoi, by using the life cycle assessment approach
- to **create scenarios** that project the MSW management situation and GHG emissions in the future
- to **evaluate potentials** for mitigation of GHG emissions from the waste management sector in Hanoi
- to help policymakers establish GHG reduction target, especially for **Nationally Appropriate Mitigation Actions** (NAMAs) program in the waste management sector in Vietnam

Method

❖ **MSW generation forecast:** system dynamic modeling (Stella package software)

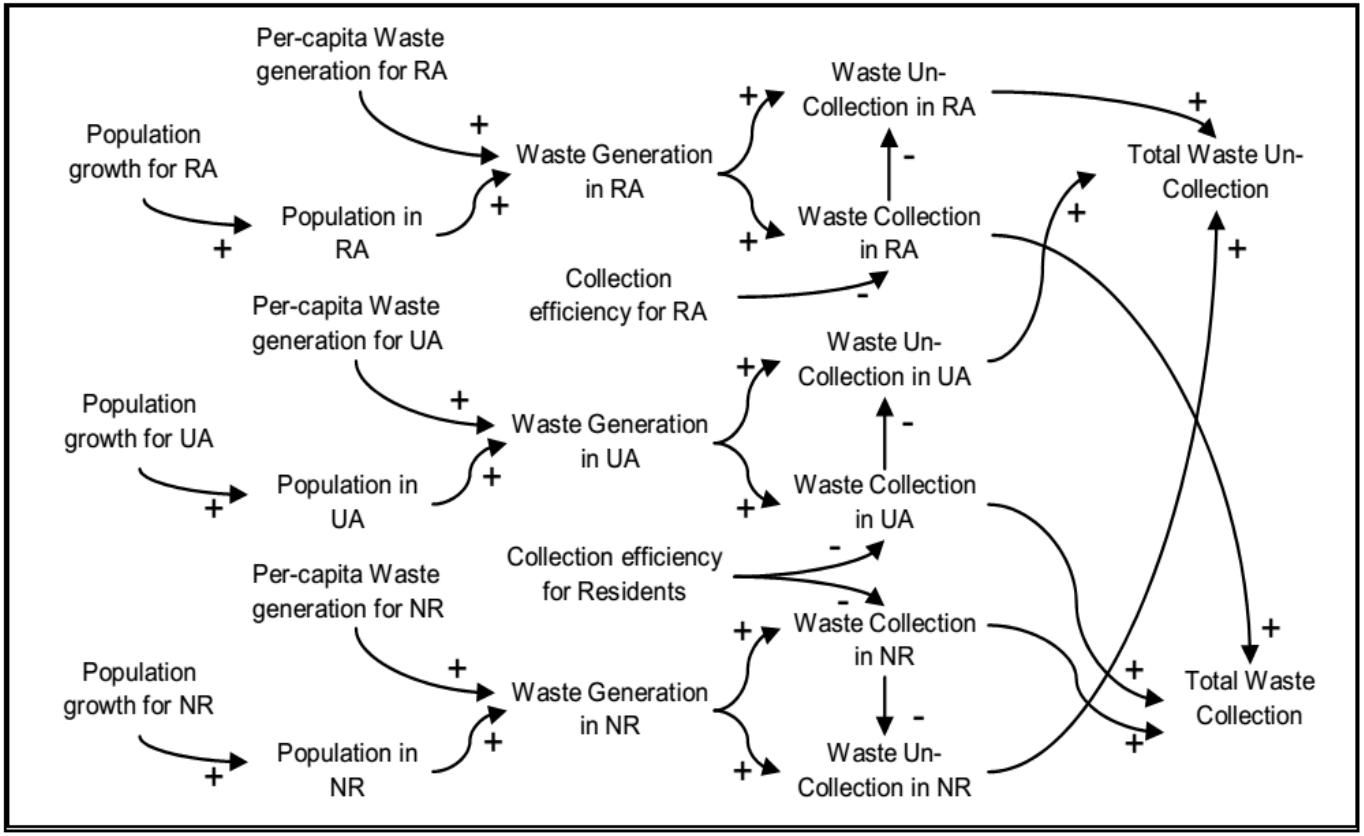


Fig.1. Causal loop diagram of MSW management

Method

❖ **MSW generation forecast:** system dynamic modeling

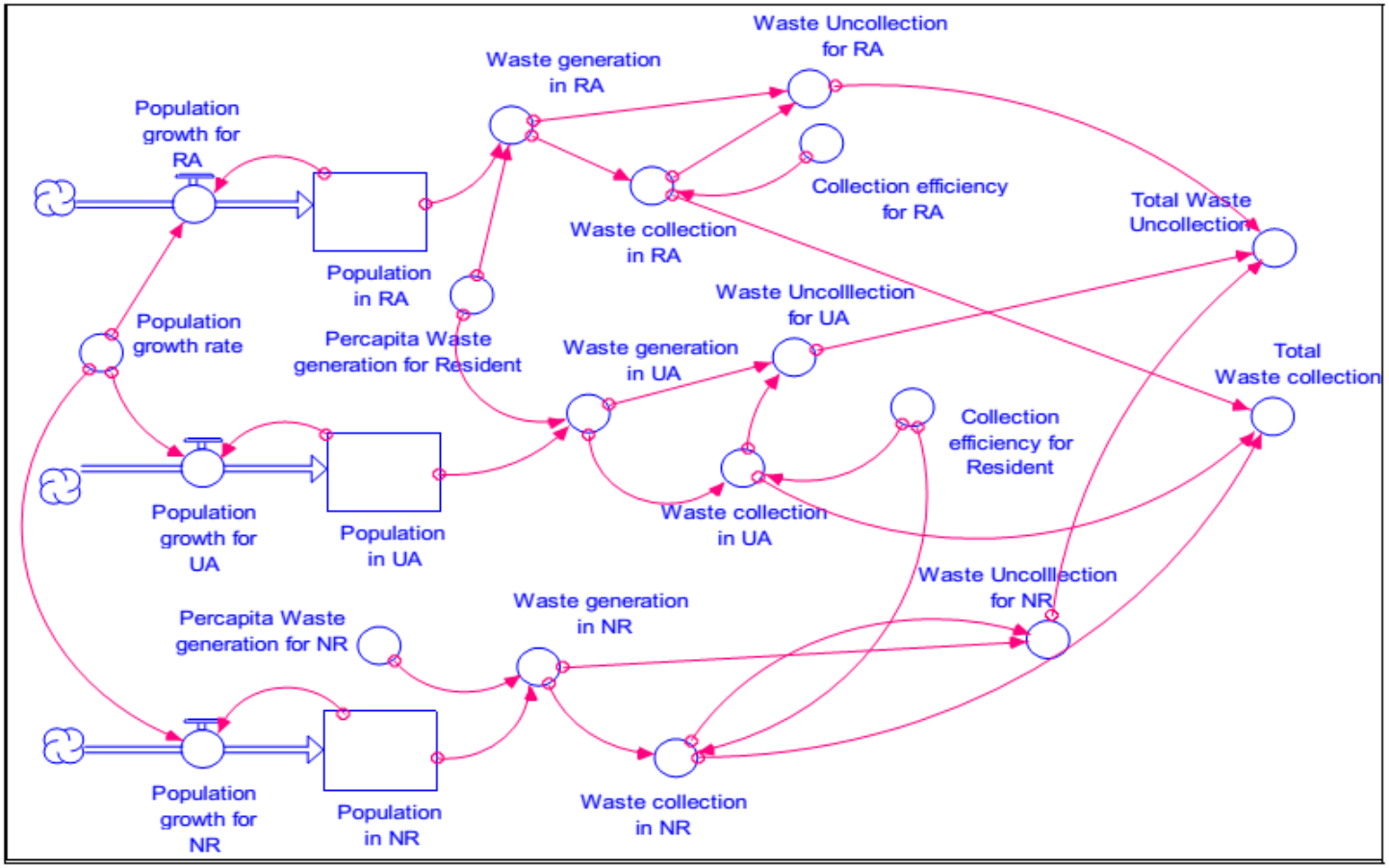
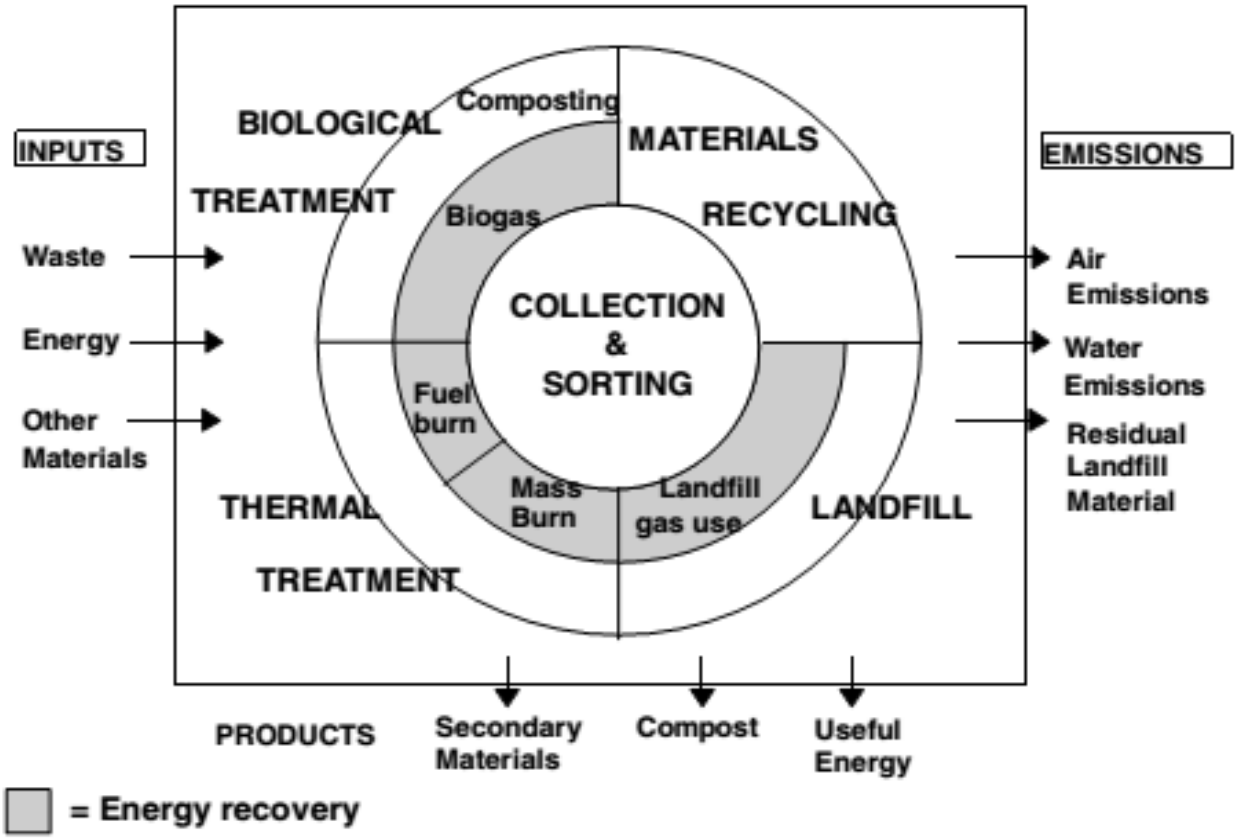


Fig.1. Flow stock diagram of MSW model

Methodology

❖ **GHG emission estimates: LCA approach**

A process based-LCA in waste management**:**



(Forbes *et al., 2001)*

Method

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❖ **Scenario proposals:**

- *Considering the national strategies, policies on solid waste management; and feasible scenarios*
- **Scenario group 1** (7 scenarios)**:** to compare and evaluate GHG emissions and reduction between treatment options with the same amount of waste of 2011
- **Scenario group 2:** to compare and investigate GHG emissions and reduction potentials for future waste management: 2011, 2015, 2020 and 2025

FS1: 2011 management path applied

FS2: Government oriented path

Scenario group 1

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Scenario	Com-posting (%)	Anaerobic Digestion (%)	Recy-cling (%)	Incine-ration (%)	Landfill (%)	Assumptions
S0 - Baseline	2	0	8.2	5.4	84.4	- no energy recovery - no LFG recovery
S1-Governmental Plan	**30**	**10**	**10**	**10**	**40**	- no energy recovery - no LFG recovery
S2 - LFG recovery	2	0	8.2	5.4	84.4	- no energy recovery - **LFG recovery (efficiency: 90%)** - **captured methane is flared**
S3 - Composting upgrade	**30**	0	8.2	5.4	56.4	- **source separation** - no energy and LFG recovery - **compost used as fertilizer**
S4 - AD upgrade	2	**30**	8.2	5.4	54.4	- **source separation** - no energy and LFG recovery - **biogas is to produce electricity**
S5 - Material recycling upgrade	2	0	**10**	5.4	79.8	- no energy recovery - **LFG recovery** (efficiency: 90%) - captured methane is flared
S6 - Integrated management	**20**	**10**	**10**	**10**	**50**	- **energy recovery, source separation** - **LFG recovery** (efficiency: 50%) - captured methane is flared

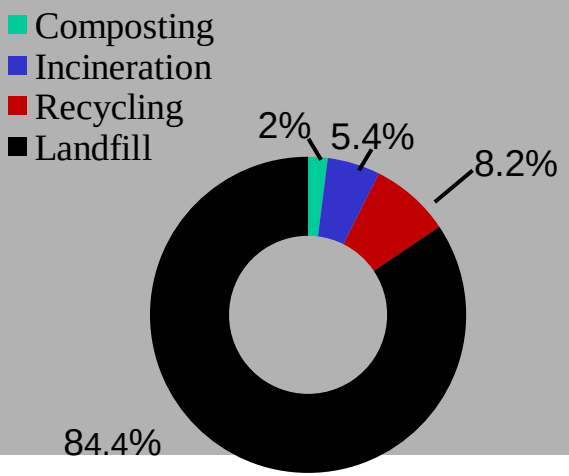
Scenario group 2

FS1

2011 management path applied

Assumptions:

- 2011 solid waste management still remains for future years (2015, 2020 and 2025)
- Changes in compositions and generation of waste



FS2

Government oriented path

Assumptions:

- **2015:** 85% waste collected, sorting partly, 60% of collected waste recycled (composting,
- **Targets will be adjusted in this research**
- collected waste recycled;
- **2025:** 100% waste collected, 90% of collected waste recycled;

Results

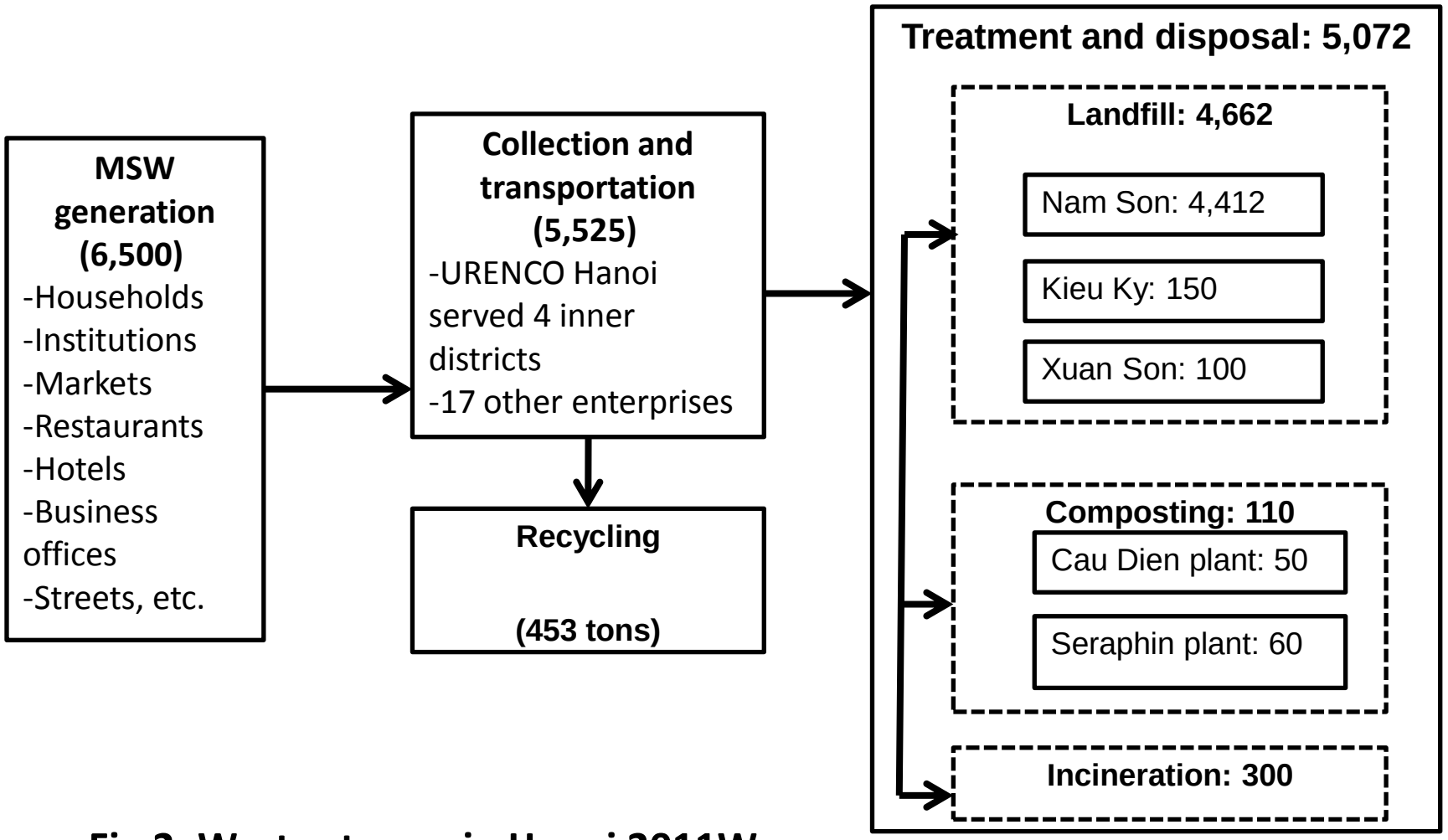


Fig.2. Waste stream in Hanoi 2011W

(Unit: tons/day)

GHG emissions by gas (group 1)

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- **CH_4**: main contributor of S0, S1, S3, S4 and S6 at 2.7; 1.06; 1.58; 1.55 and 0.61 M tons of CO_2e, respectively.
- **CO_2**: the largest contributor of S2 and S5 because CH_4 captured and flared
- **N_2O:** the smallest amount emitted from scenarios studied

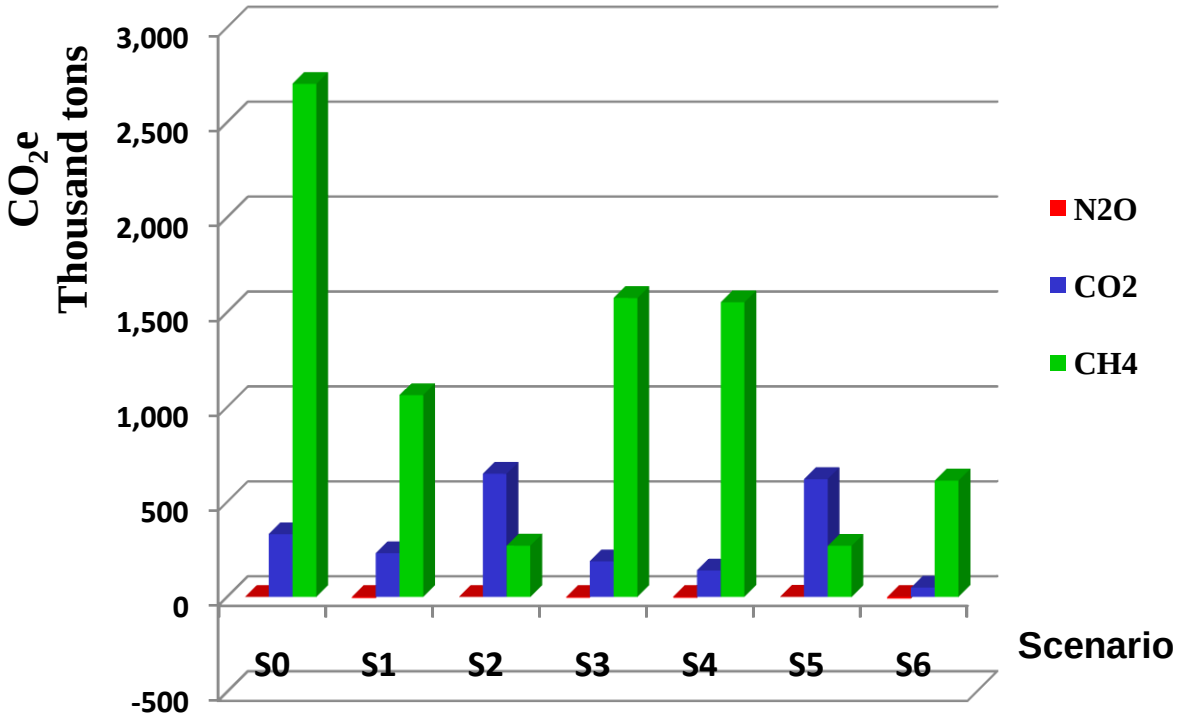

Fig.4. GHG emissions from scenarios studied by greenhouse gas

GHG emissions by source (group 1)

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- **Landfill:** > 90% of total emission), followed by incineration and collection;

- **Biological treatment** and **recycling: avoid** emission through replacing raw material extraction and processing

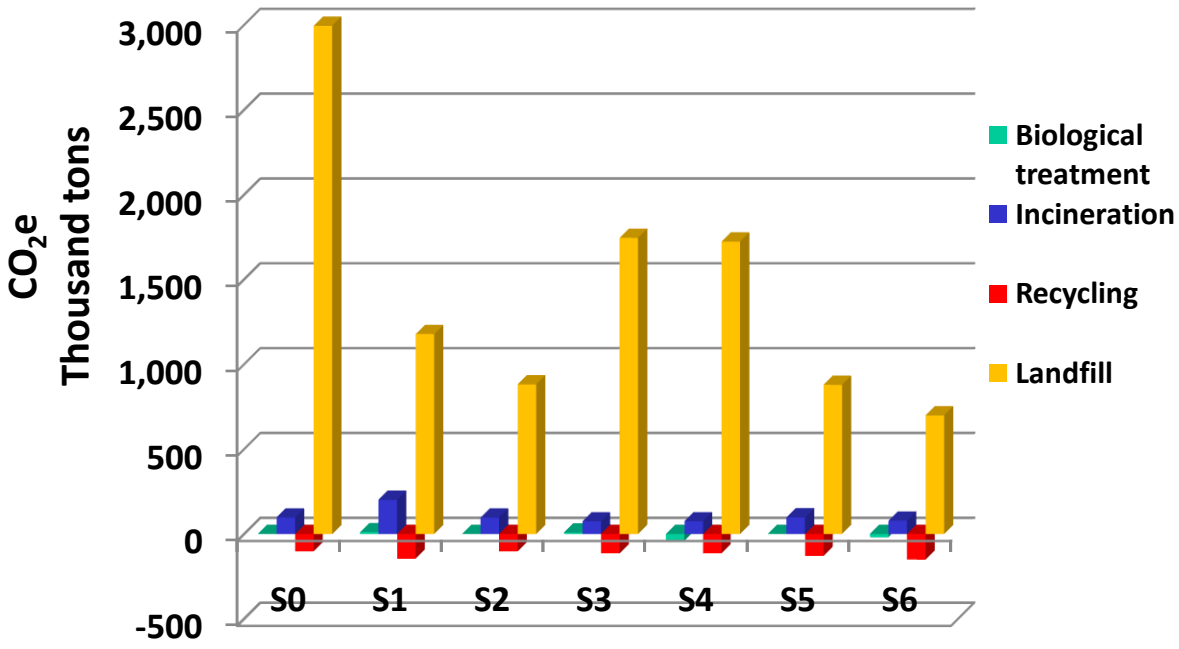

Fig.5. GHG emissions from scenarios studied by source

Net GHG emissions (group 1)

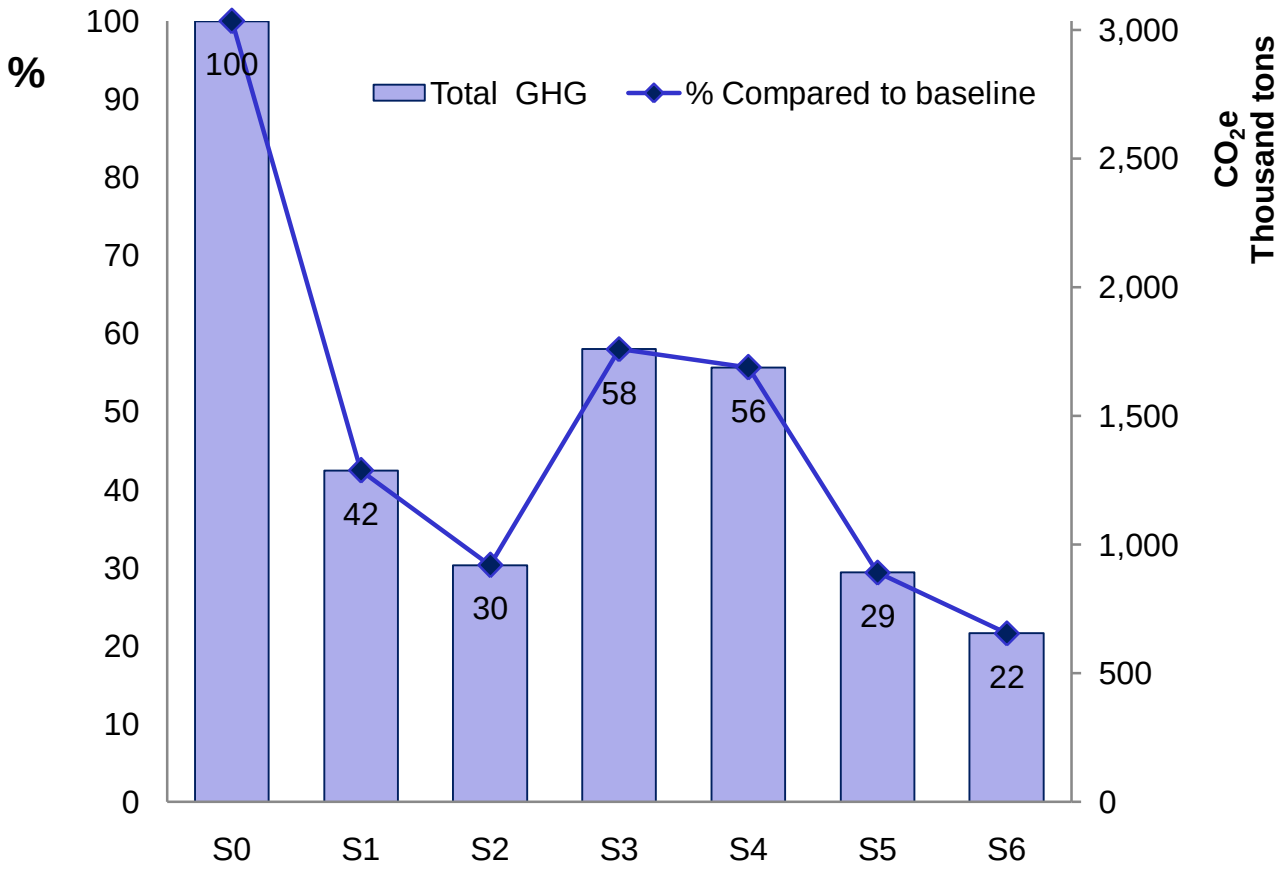

Fig.3. Net GHG emissions from scenarios studied

Sensitivity of GHG emission to LFG capture

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- The sensitivity of emission to different LFG capture efficiency from 0% to 90%;
- **CO_2e** : dependent variable
- **LFG capture efficiency:** independent variable
- The amount of total **CO_2e** has strong **inverse relation** with LFG capture efficiency with coefficient of the determination, $R^2 = 0.960$

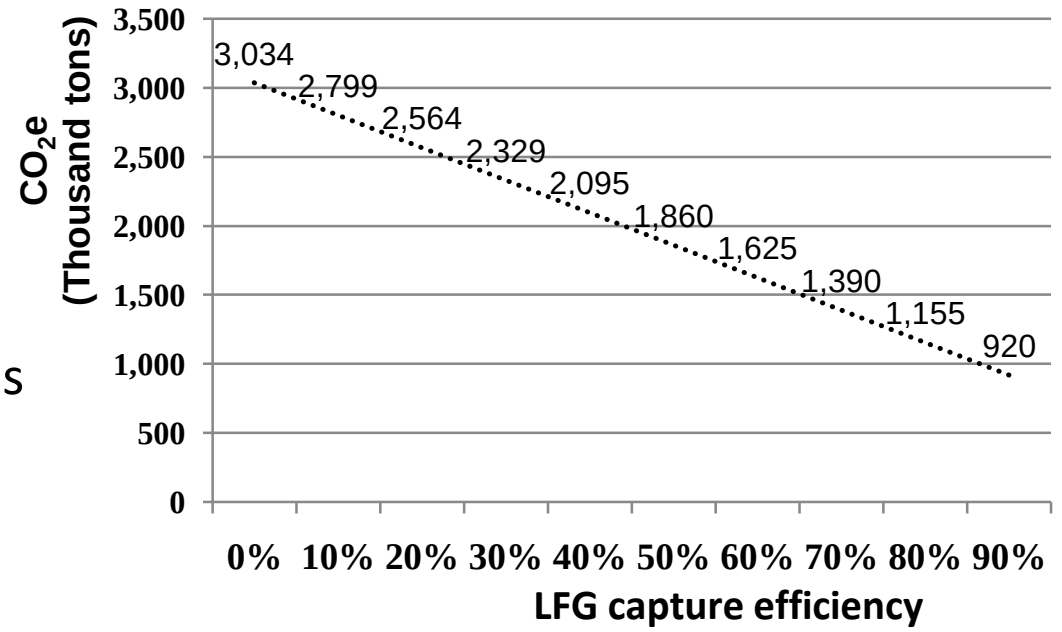

Fig.6. Sensitivity of LFG capture efficiency

Conclusions

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- The **current MSW management** practice has released **a large amount of greenhouse gas emission** (GHG) into the atmosphere
- **Different treatment options** have varied impacts on greenhouse gas mitigation, in which **diversion of organic waste from landfill** and **LFG recovery application** could reduce the most GHG emissions in the solid waste management.
- **Integrated solid waste management** should be adopted by country because it has a high potential for climate change mitigation (i.e. reduce current GHG emissions by 78%)

Future work

- Calculating the GHG emissions from scenarios group 2
- Considering other environmental impacts associated with scenarios studied
- Estimating costs-benefits associated with scenarios studied
- Making an overall evaluation of GHG mitigation potentials in the solid waste management sector

Many thanks for your listening!

Have a nice Merry Christmas and New Year!