



**ISAP 2022**

International Forum for Sustainable Asia and the Pacific




北九州市立大学  
THE UNIVERSITY OF KITAKYUSHU




# A Systematic Review of Open Waste Burning in Southeast Asian Countries for Policy Making

**Bimastyaji Surya Ramadan, Premakumara Jagath  
Dickella Gamaralalage, Toru Matsumoto**

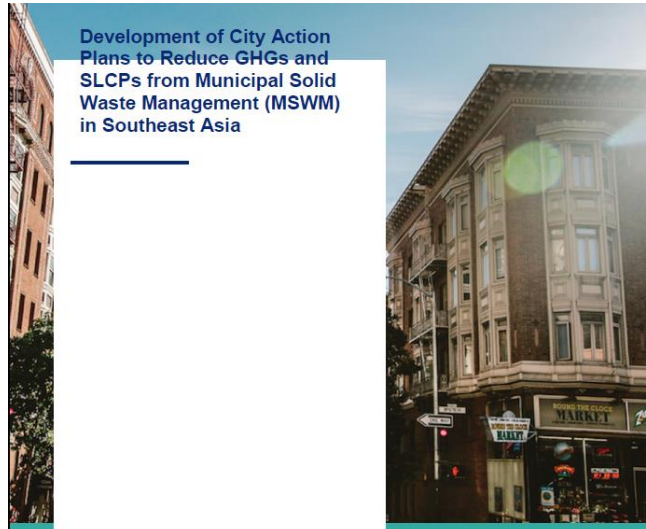
# Scientific and Evidence-based Policy Making to Reduce Open Waste Burning in Asia




Assessment of Climate Impact of Black Carbon Emissions from Open Burning of Solid Waste in Asian Cities



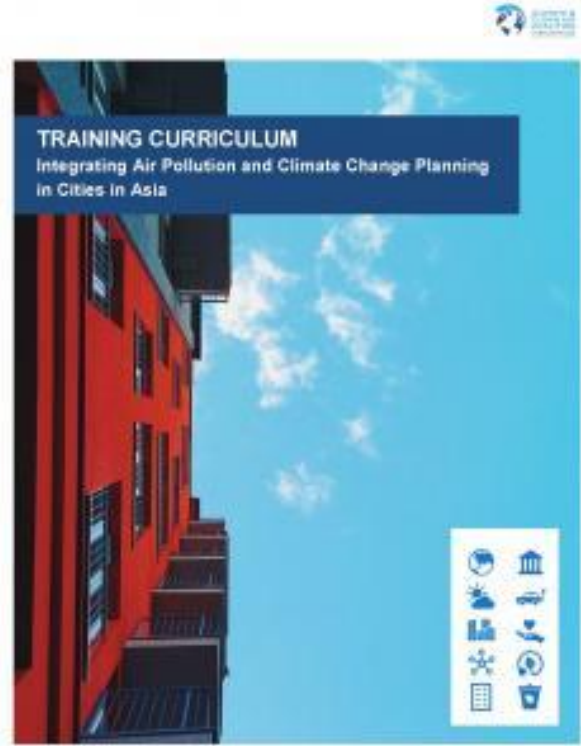
Development of City Action Plans to Reduce GHGs and SLCPs from Municipal Solid Waste Management (MSWM) in Southeast Asia




JUNE 2019



TRAINING CURRICULUM  
Integrating Air Pollution and Climate Change Planning in Cities in Asia



Delivered by



OPEN WASTE BURNING IN ASIAN CITIES: CHALLENGES AND OPPORTUNITIES

SUMMARY OF OPEN WASTE BURNING MONITORING SERIES NO. 1, 22 APRIL 2022

**BACKGROUND**

Open burning of Municipal Solid Waste (MSW) is a common practice, especially in developing countries with inadequate solid waste management systems (Singh et al., 2016; Katsanidou et al., 2011). The main reasons are that it is the cheapest and easiest method of volume reduction and managing MSW, especially for residents in cities with no access to organized waste collection services. Currently, two billion people globally have no official waste collection services, and the waste of over three billion more is either dumped or subject to uncontrolled burning (Circular, 2019).

Open burning of MSW typically occurs under relatively low temperatures, which emits significant amounts of pollutants, especially particulate matter (PM) (PM<sub>10</sub>, PM<sub>2.5</sub>), black carbon, SO<sub>2</sub>, organic carbon (OC), and gaseous pollutants such as nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), methane (CH<sub>4</sub>), and non-methane volatile organic compounds (NMVOC) (INSP, 2021). In addition, open burning of waste results in emissions of wide-ranging potentially hazardous substances such as polycyclic aromatic hydrocarbons, mercury, arsenic, lead, dioxin, sulfur oxides, and hydrochloric acid, most of which are toxic and harmful to the environment and human health (UNEP and UNEP, 2019).

As such, the open burning of MSW represents one of the most significant pollution and climate change problems in developing countries. While various studies on the generation of persistent organic pollutants (POPs) and other hazardous substances exist (UNEP and UNEP, 2019), there is a lack of scientific evidence on how BC emissions from open waste burning impact climate change. This resource scientific study, including the quantitative assessment of such emissions. In this regard, IGES-CCET has been working with its partners to study BC emissions and related climate impacts from open waste burning in selected Asian cities. The first workshop, held on 22 April 2022 and co-organized by three parties, the Institute for Global Environmental Strategy-IGES, IGES-CCET, the Climate and Clean Air Coalition (CCAC), and the United Nations Industrial Development Organization (UNIDO) (INSP, 2021), is aimed to share the results of the research study on open waste burning in Asian Cities, including experiences of case study cities, as well as enable panel discussions involving experts from IGES, CCAC, UNIDO, IGES-CCET, and government officials from Padang City, Indonesia, and Serang City, Comoros.

**KEY TAKEAWAYS**

Open burning is one of the common MSW management practices in many cities in the developing world due to lack of official waste collection system.

Open burning is the cheapest and easiest way of managing MSW in terms of time and cost. Though it is the world and avoid regulatory burden to cities, it is harmful to the environmental and human health.

The open waste burning contributes to the climate impact from open burning, even higher than the emissions from open burning.

Open waste burning is occurring throughout the waste management system, while 95% of national climate impact comes due to burning of MSW at household level in Padang City. Consequently, about 30% of the national climate impact is caused due to burning of MSW at the local disposal site in Serang Municipality Comoros.

There is an urgent action for mitigating open waste burning. This can apply integrated approach including source waste collection service for all residents, including low-income areas, community, voluntary activities of health and recreation to improve the public behavior and local disposal sites, and removal of land use and land cover of densely urban and suburban.



# Objectives and Methodologies

## Objectives

1. Determining the **current status of open burning** (municipal waste, agriculture, forest, and others) in SEA countries and its impact on environment and health of human beings
2. Analysing **factors** of OWB practices and **stakeholder's initiatives** to stop burning practices
3. Assessing the appropriate **policy recommendation** for reducing open waste burning in SEA countries

## Methodologies

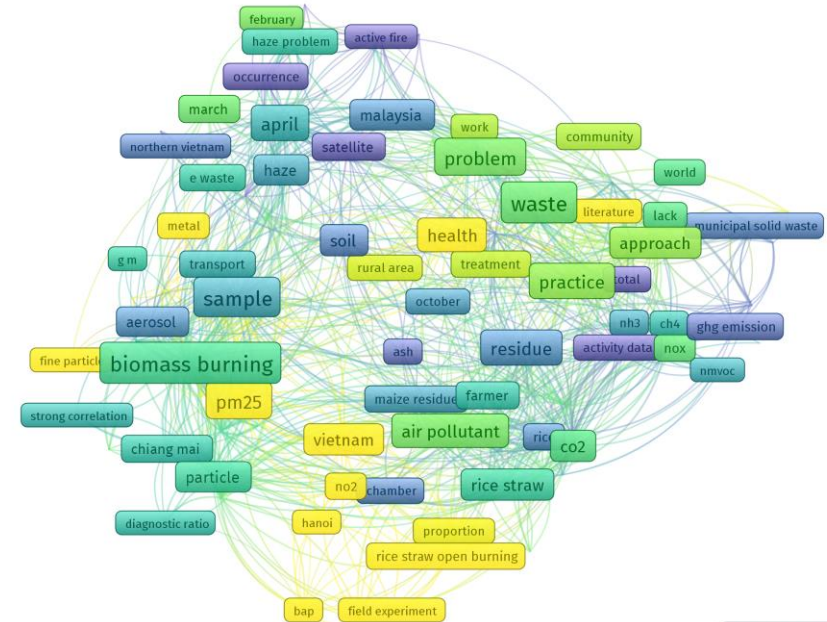
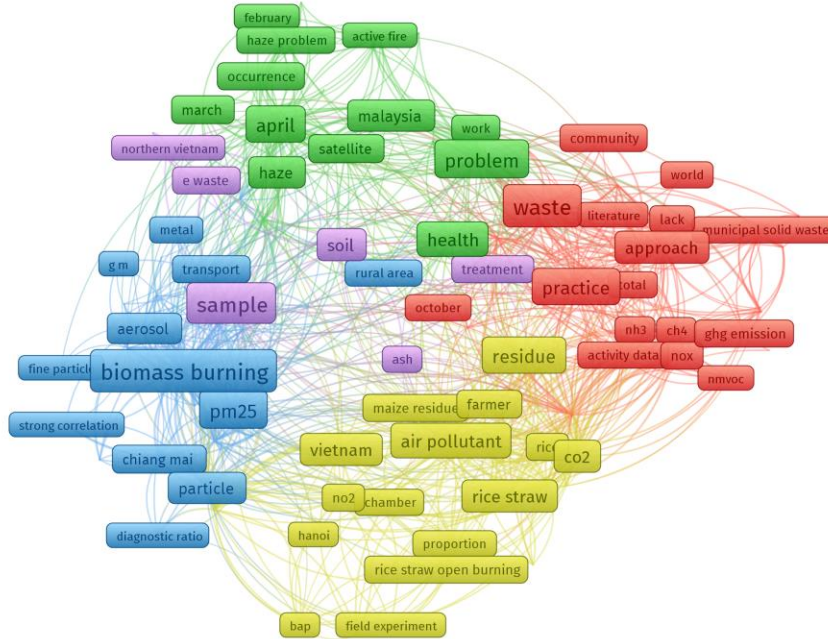
1. Literature review by using PRISMA methodology. Metadata generated from SCOPUS database using keywords of "**Open Burning**".
2. Abstract title, and other metadata were analyzed using VOSviewer software to get the current **research direction** and finding the **gaps**
3. At least **152 documents** were assessed using qualitative analysis to identify the factors, initiatives, and assess policy recommendation at country level



# Occurrence Terms in Title and Abstracts

## Settings

- Binary counting
- Minimum number of occurrences = 5 (236 meet threshold)



Through the maps we can see 5 clusters can be generated from the terms. Higher occurrences of terms are displayed

1. **Red** = waste, practice, reduction, approach, inventory (**waste management approach**)
2. **Green** = problem, health, Malaysia, Northern Thailand, haze (**transboundary haze**)
3. **Yellow** = biomass burning, pm2.5, ratio, particle. size (**biomass burning**)
4. **Blue** = residue, air pollutant, CO<sub>2</sub>, Vietnam, emission factor (**crop residue burning**)
5. **Purple** = sample, soil, treatment, e-waste, ash (**e-waste burning**)

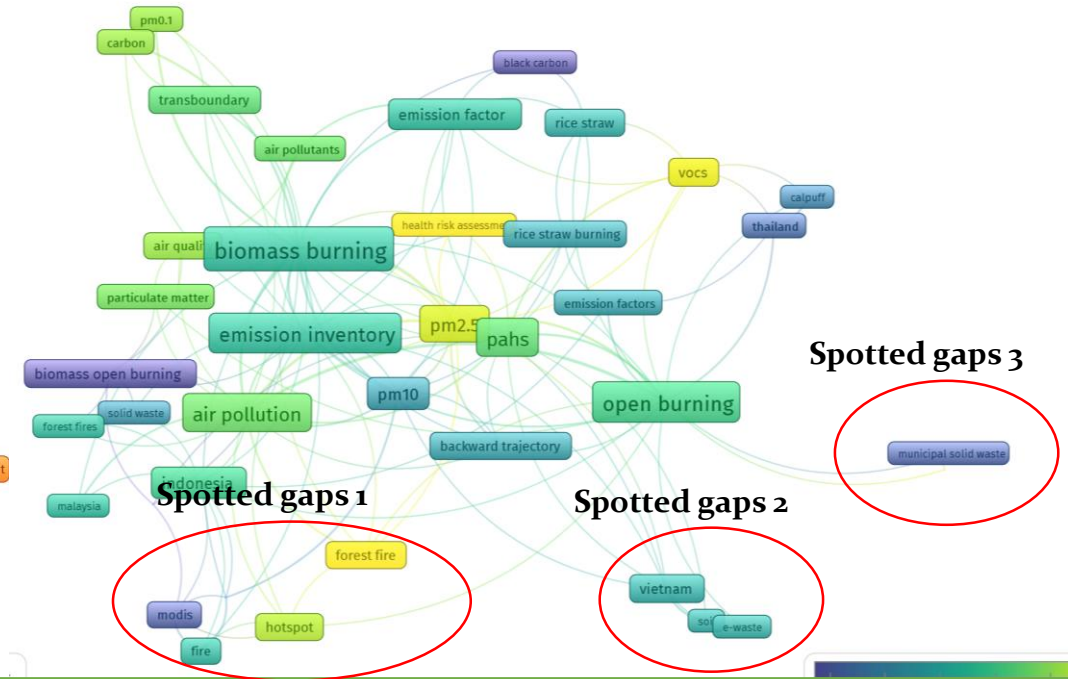
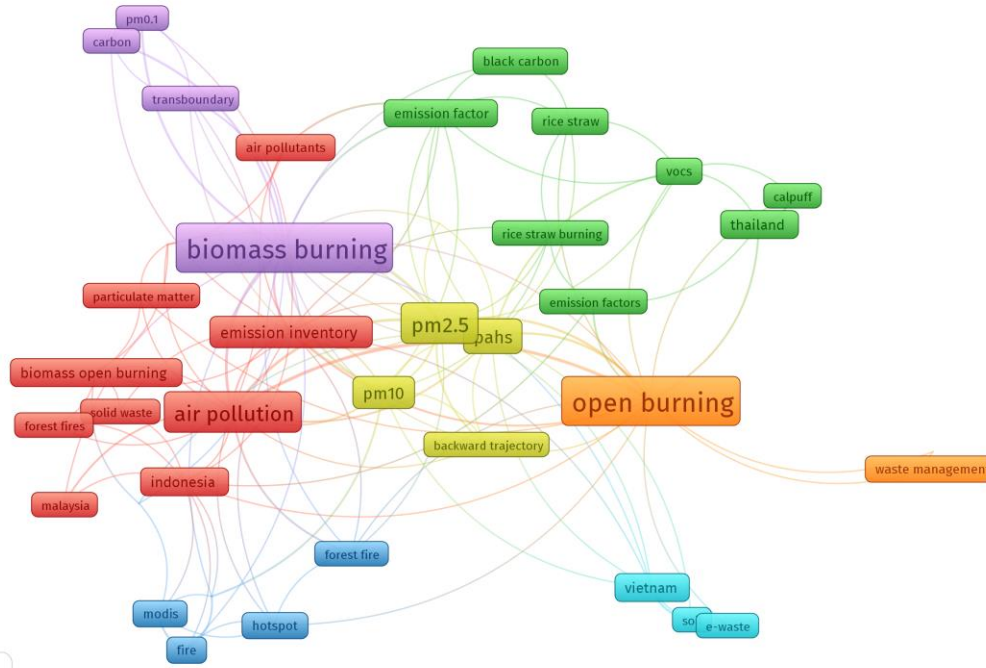
Related to the publication year, there are also some findings:

1. The older terms is found in the municipal solid waste, haze and satellite burning. Indicating the concern of researchers on the **transboundary air pollutant** caused by open burning.
2. In the middle publication year (2017-2019), some terms such as biomass burning, community, and approach are found. Indicating the researchers were shifting to **biomass burning activity and its solution**.
3. Current research are found to be focused on **health impact** on crop residue burning especially in Vietnam area.

# Occurrence Keywords

## Settings

- Full counting
- Minimum number of occurrences = 3 (39 meet term threshold)



Through the maps we can see 7 clusters can be generated from the keywords provided by scientific papers.

1. **Red** = Forest fire
2. **Green** = Rice straw burning
3. **Dark Blue** = Fire hotspot in ASEAN
4. **Yellow** = Health risk of open burning
5. **Purple** = Transboundary pollution of biomass burning
6. **Blue** = e-waste burning
7. **Orange** = Municipal solid waste burning

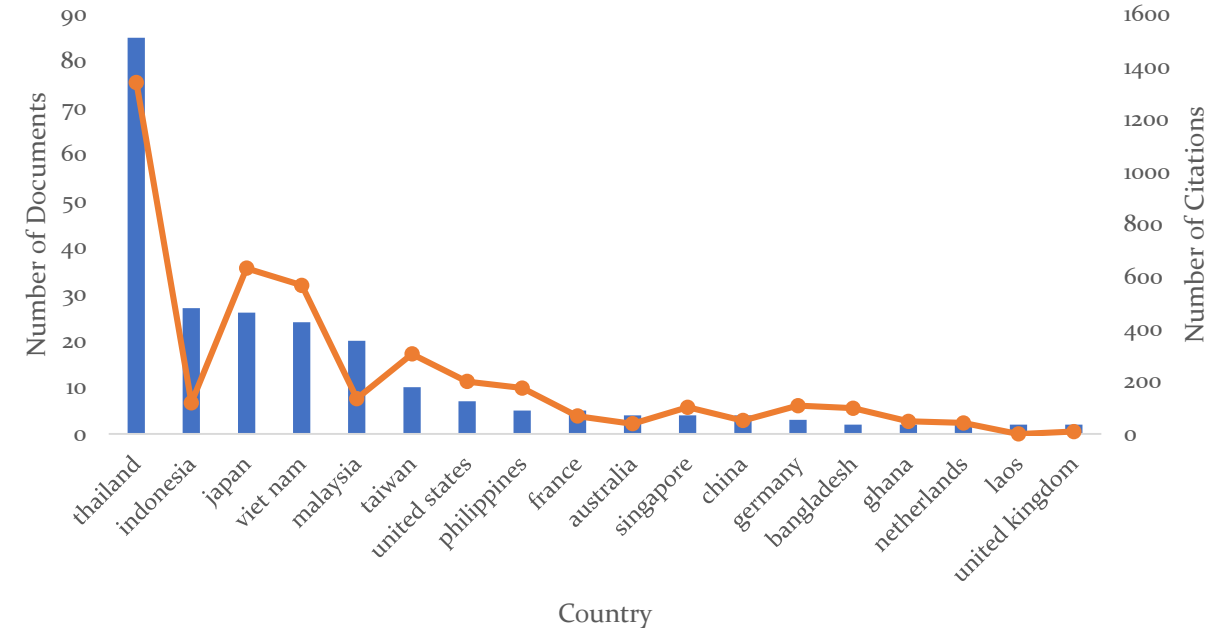
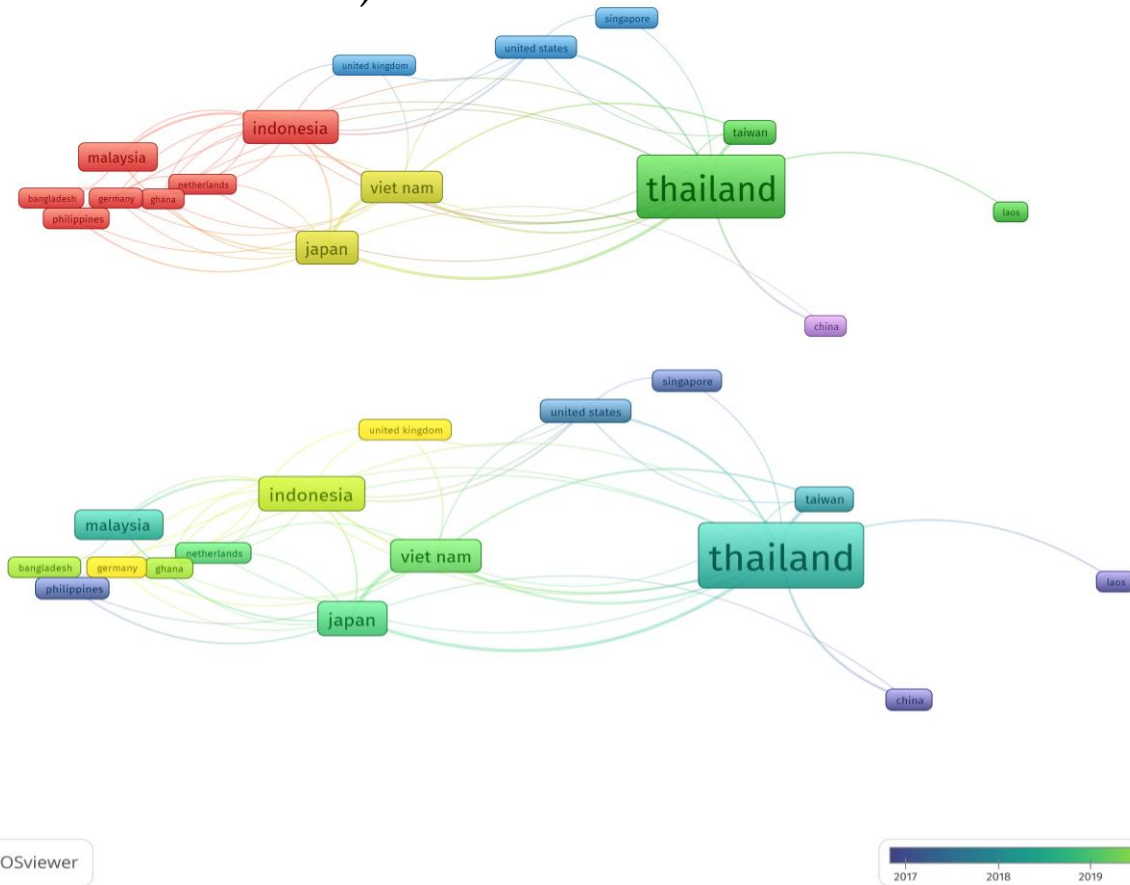
Related to the publication year, there are also some findings:

1. The older terms found such as municipal solid waste, biomass open burning, Thailand, and modis (remote sensing method). Indicating the concern of researchers on the **biomass burning**.
2. In the middle publication year (2017-2019), some terms such as biomass burning, pm10, and e-waste are found. Indicating the researchers were shifting to **crop residue burning**.
3. Current research are found to be focused on **health risk assessment** caused by forest burning.

# Number of Country Affiliations

## Settings

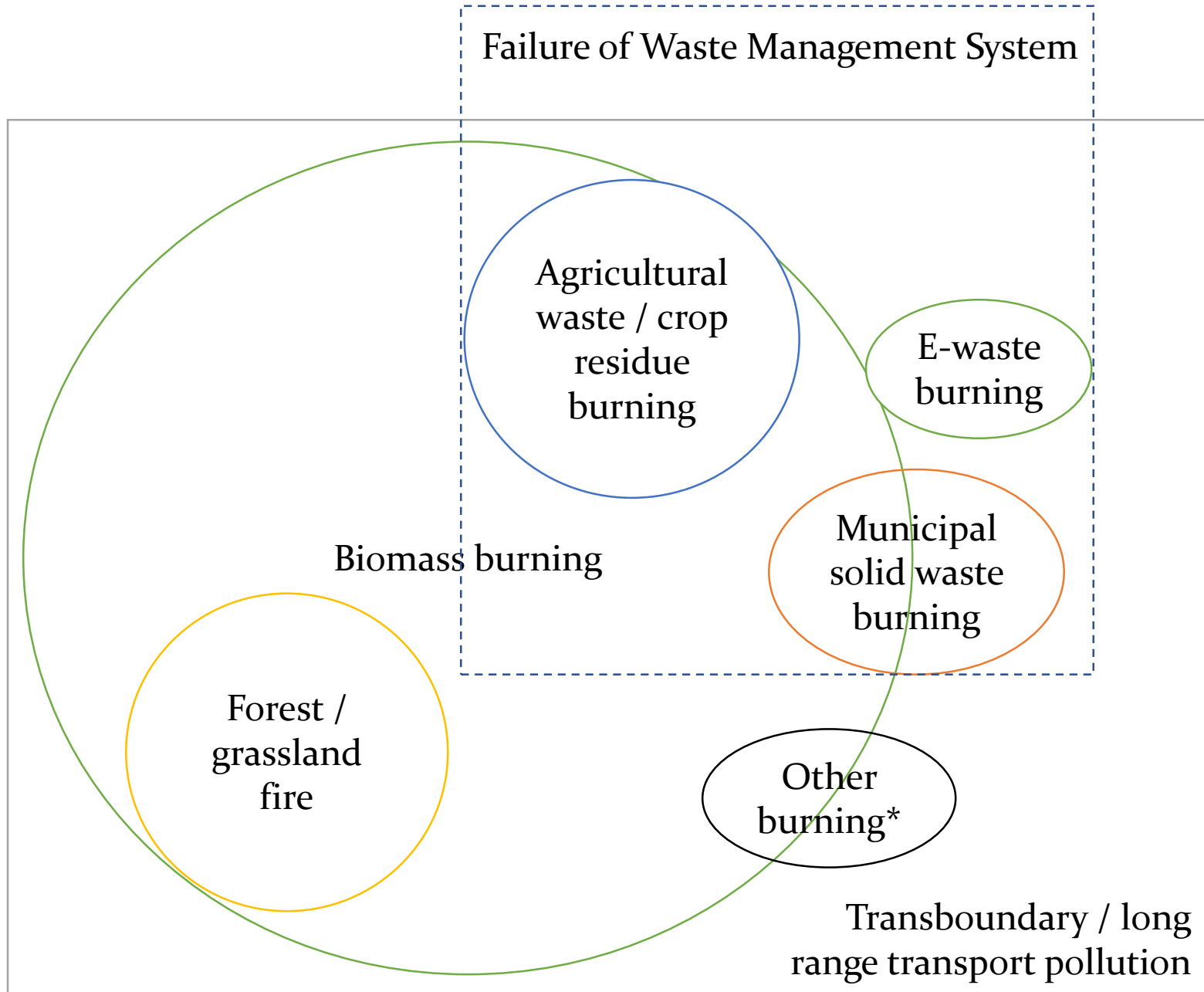
- Full counting
- Minimum number of documents of a country = 2 (18 meet threshold)



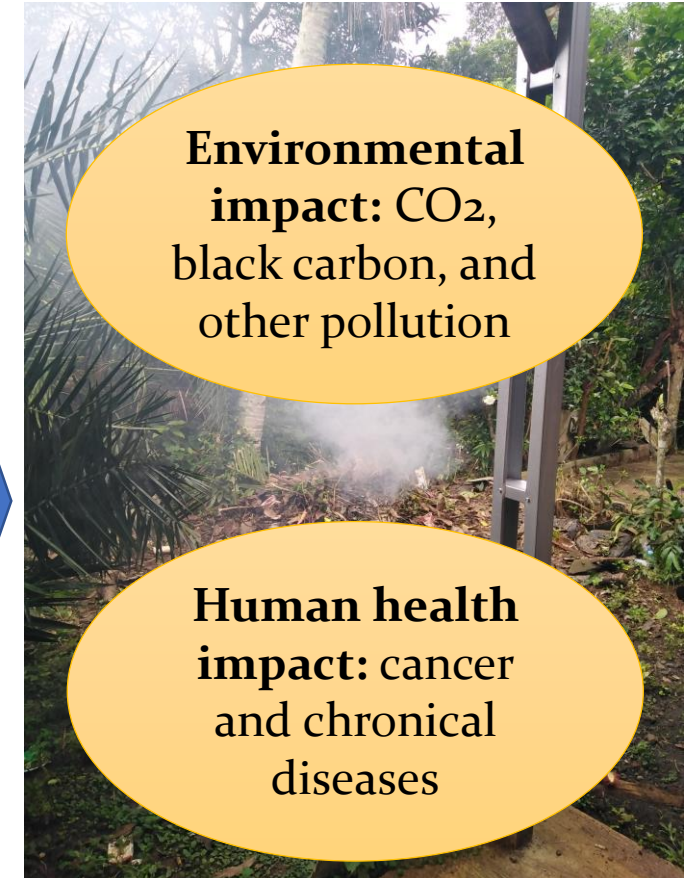
Some **conclusions** from the graph can be drawn

1. Thailand is the leading countries for research in open burning in ASEAN, while Indonesia is the second and Japan is the third.
2. There is an anomaly in the citations of documents from Indonesia and Malaysia, probably the documents are not published in high impact journal or just a conference proceeding or there is another reasons(?)
3. European researchers are found to be interested to studies about open burning in ASEAN.
4. Some clusters are found (showing in different colors) which showing collaboration between the affiliation country.

\*Incense burning, Hungry Ghost festival, etc.



# Summary



# Health Impact

\*Sorted from the highest to lowest contributor


Waste burned*	Specific sources / chemical characteristics	Pathway	Health impact	Study location	References
Biomass (forest and crop residue)	PM <sub>10</sub> -bound PAHs	Inhalation	Cancer risk from PAHs exposure	Thailand	Wiriya et al., 2013
Crop residue (maize)	PM <sub>10</sub> -bound PAHs	Inhalation	Cancer risk from PAHs exposure	Thailand	Morknoy et al., 2017
1. Forest fire 2. Crop residue	Black carbon	Inhalation	The same risk with passively smoked cigarette	Thailand	Pani et al., 2019
Forest fire	PM <sub>2.5</sub>	Inhalation	Cancer risk from PAHs exposure	Thailand	Chantara et al., 2020
Crop residue	PM <sub>2.5</sub>	Inhalation	Lower respiratory infections, ischemic heart diseases (IHD) = Long-term mortality / non-accidental deaths	Thailand	Chi and Oanh, 2020
Biomass (forest, crop residue, and grassland)	PM <sub>2.5</sub>	Inhalation	<b>Stroke burden</b> , ischemic heart disease (IHD), lung cancer (LC), and chronic obstructive pulmonary disease (COPD) = premature death	Thailand	Punsompong et al., 2021
1. Forest fire 2. Crop residue	n.d.	Inhalation	Respiratory disease, such as COPD and lung cancer	Thailand	Kaewrat et al., 2022
1. Forest fire 2. Crop residue	PM-bound PAHs during haze events	Inhalation	Respiratory health risks	Thailand	Insian et al., 2022



# Health Impact (Cont.)

\*Sorted from the highest to lowest contributor

Waste burned*	Specific sources / chemical characteristics	Pathway	Health impact	Study location	References
Crop (rice straw) residue	PM2.5-bound PAHs	Inhalation	Cancer risk from PAHs exposure	Vietnam	Pham et al., 2019
Open biomass burning (forest and crop residue)	PM2.5	Inhalation	Respiratory morbidity, ischemic heart disease (IHD), lung cancer (LC), chronic obstructive pulmonary disease (COPD), cardiovascular disease	Laos, Myanmar, Cambodia, Thailand, Vietnam	Thao et al., 2022
1. Municipal waste 2. Biomass (as fuel)	PM2.5-bound PCDD/Fs (dioxin)	Ingestion, diet	Cancer risk from dioxin exposure	Thailand, Vietnam, Taiwan	Chi et al., 2022
1. E-waste 2. Municipal waste	Flame retardant additives (for plastic or electronic additives)	Ingestion, inhalation, dermal	Autism, affect brain development, promote the growth of cancer cells, protein denaturation, membrane cells malfunction	n.d.	Chean-Yiing et al., 2022
E-waste (cables and wires for metal recovery)	Dioxin (PAHs), flame retardant, and metals	Inhalation, ingestion, diet	Non-cancer risk (bioaccumulation) caused by metals contamination. Other adverse effect related to the emitted pollutant.	Vietnam	Hoang et al., 2022

 Spotted gaps

# Environmental Impact

Study location	Fuel Type	Emission Factor (dry biomass)		Total Annual Emission Estimation (Mt)		References
		CO <sub>2</sub> (g kg <sup>-1</sup> )	BC (g kg <sup>-1</sup> )	CO <sub>2</sub> (Mt)	BC (kt)	
Thailand	Sugarcane biomass (pre- and post-harvesting)	1,515	-	Pre-harvest 9.80 Post-harvest 12.7	-	Sompoon et al., 2014
Indonesia	Rice straw	-	0.939 ± 0.417	-	-	Hafidawati et al., 2017
Thailand	Rice straw	1,177 ± 140	0.53	5.34	2.1 ± 1	Junpen et al., 2018
Vietnam	Rice straw	1,177	0.51	3.82	1.6	Le et al., 2020
Thailand	Rice straw	1,247 ± 190	-	8.23	-	Hong Phuong et al., 2022
Indonesia	Savanna / shrub land	1,613	0.48	<i>Total emission =</i> 57.28	<i>Total emission =</i> 0.24	Permadi et al., 2013 (2007 data)
	Peat land / mangrove forest	1,703	0.57			
	MSW	1,453	0.65			
	Tropical forest	1,580	0.66			
Thailand	Cropland	1,585	0.75	<i>Total emission =</i> Myanmar 64 ± 12 Cambodia 45 ± 8 Laos 13 ± 2 Thailand 27 ± 9 Vietnam 30 ± 12	<i>Total emission =</i> Myanmar 20 ± 12 Cambodia 13 ± 7 Laos 4 ± 3 Thailand 10 ± 5 Vietnam 13 ± 6	Junpen et al., 2020 (2015 data)
	Forestland	1,643	0.52			
	Shrubland / savanna	1,686	0.37			

# Environmental Impact (Cont.)

Study location	Fuel Type	Emission Factor (dry biomass)		Total Annual Emission Estimation (Mt)		References
		CO <sub>2</sub> (g kg <sup>-1</sup> )	BC (g kg <sup>-1</sup> )	CO <sub>2</sub> (Mt)	BC (kt)	
ASEAN	Crop residue (RS = rice straw, M = maize, S = sugarcane, OCR = other crop residue)	RS 1,177 M 1,350 S 1,130 OCR 1,130	RS 3.1 M 2.2 S 3.3 OCR 0.7	172	74	Oanh et al., 2018
	Forest	-	-	655	220	
Vientianne, Laos	MSW	1,453 (wet basis)	-	0.027	-	Babel and Vilaysouk, 2016
Luangprabang, Laos	MSW	1,453 (wet basis)	5.5	0.005	0.007	Vilaysouk and Babel, 2017
Depok City, Indonesia	MSW	801.2	-	0.26	-	Kristanto and Koven, 2019
Thailand	MSW	n/a (IPCC calculation)	-	0.499	-	Pansuk et al., 2018
Philippines	MSW	n/a (IPCC calculation)	0.65	944.69 (uncollected waste)	1.63	Premakumara et al., 2018

Emission from MSW in ASEAN countries is not fully understood  
The number of **waste burned has not estimated yet**

Emission from MSW burning has the same potential of BC emitted from **rice straw residue burning in Vietnam**

# Regional Outlook

In avg, 57% of waste are not collected in ASEAN countries which subjected to improper waste disposal



Country	Population <sup>a</sup>	GDP <sup>a</sup> (billion USD)	GDP per Capita <sup>a</sup> (USD)	CO <sub>2</sub> Emissions <sup>a</sup> (t per capita)	Total GHG Emissions <sup>a</sup> (kt CO <sub>2</sub> -eq)	Avg Waste Generation (kg/cap/day)	Waste Collection Efficiency (%)
Singapore	5,453,566	360.90	66,176.4	8.3	67,230	1.10 <sup>b</sup> ; 0.94 <sup>c</sup>	100 <sup>g</sup>
Brunei Darussalam	441,532	13.21	29,927	16.1	9,300	0.66 <sup>b</sup> ; 1.40 <sup>c</sup>	50-70 <sup>h</sup>
Malaysia	32,776,195	354.88	10,827.3	7.9	313,020	0.81 <sup>b</sup> ; 0.90 <sup>c</sup>	66-90 <sup>h</sup>
Thailand	69,950,844	438.62	6,270.4	3.8	422,090	0.64 <sup>b,c</sup>	59 <sup>n</sup>
Indonesia	276,361,788	1,070.00	3,855.8	2.3	1,002,370	0.76 <sup>b</sup> ; 0.49 <sup>c</sup>	65 <sup>i</sup>
Vietnam	98,168,829	331.13	3,373.1	3.5	450,150	0.61 <sup>b</sup> ; 0.41 <sup>c</sup>	60 <sup>e</sup>
Philippines	111,046,910	378.96	3,412.6	1.3	234,280	0.52 <sup>b</sup> ; 0.40 <sup>f</sup>	65 <sup>f</sup>
Papua New Guinea*	9,119,005	24.21	2,655.2	0.9	22,410	0.41 <sup>d</sup>	n/a
Laos	7,379,358	19.05	2,582.2	2.6	29,280	0.55 <sup>b</sup> ; 0.64 <sup>c</sup>	40-50 <sup>j</sup>
East Timor*	1,343,875	2.19	1,626.4	0.5	5,910	0.45 <sup>e</sup>	55 <sup>k</sup>
Cambodia	16,946,446	23.72	1,399.8	1.0	40,060	0.52 <sup>b</sup>	72 <sup>l</sup>
Myanmar	54,806,014	70.81	1,292.1	0.7	133,250	0.45 <sup>b</sup> ; 0.44 <sup>m</sup>	53-84 <sup>m</sup>

<sup>a</sup>data.worldbank.org accessed Nov 26, 2022; GDP is calculated using constant USD from 2015; <sup>b</sup>Nguyen Ngoc et al. (2009); <sup>c</sup>Kawai and Tasaki (2016); <sup>d</sup>Karak et al. (2012); <sup>e</sup>Woodruff (2014); <sup>f</sup>Premakumara et al. (2018); <sup>g</sup>Jerin et al. (2022); <sup>h</sup>Faulstich et al. (2011); <sup>i</sup><https://sipsn.menlhk.go.id/sipsn/> accessed Nov 27, 2022; <sup>j</sup>Global Green Growth Institute (2022); <sup>k</sup>Ximenes and Maryono (2021); <sup>l</sup>Pheakdey et al. (2022); <sup>m</sup>The World Bank Infographic (2019); <sup>n</sup>Pansuk et al. (2018); \*Observer countries

# OWB Profiles



Around 40% of waste is burned worldwide (Wiedinmyer et al., 2014)

Location	Average waste generation (Mt/year)	Total waste burning (kt/year)	Fraction of open burning (%)	Composition (%)							References
				Food waste	Garden waste	Plastic	Paper	Metal and Glass	Textile and Rubber	Others/ Inert	
Vientiane City, Laos	0.23	35.18	15	34.0	30.0	12.0	7.0	8.0	8.0	1.0	Babel and Vilaysouk, 2016
Luangprabang City, Laos	0.03	2.64	9	39.0	31.0	8.0	6.0	2.0	5.0	9.0	Vilaysouk and Babel, 2017
Depok City, Indonesia	0.41	25.55	6.3	73.0	3.7	3.6	7.1	2.6	3.6	6.4	Kristanto and Koven, 2019
Semarang City, Indonesia	0.61	58.80	9.7	53.9 <i>0.2</i>	- <i>73.4</i>	21.5 <i>17.5</i>	10.9 <i>4.3</i>	8.7 <i>0.3</i>	- <i>3.3</i>	5.0 <i>1.0</i>	Hadiwididodo et al., 2022 Ramadan et al., 2022*
Thailand	26.20	3,430	13	- <i>10.3</i>	48.0 <i>17.4</i>	15.0 <i>36.3</i>	15.0 <i>0.9</i>	10.0 <i>4.7</i>	- <i>18.1</i>	14.0 <i>12.2</i>	Pansuk et al., 2018*
Philippines	14.86	2,602	17.5	52		28.0			20.0 (include special waste like e-waste, healthcare, and bulky waste)		Premakumara et al., 2018

\*The italic number represents the composition of burned waste pile (below) which is different with the municipal waste composition (above)

Please noted that **plastic burning** especially **PET and Polystyrene** emit the higher black carbon than other type of waste (Reyna-bensusan et al., 2019). See the **emission factors** based on lab-scale measurement ( $\text{g kg}^{-1}$ )



Paper and Cardboard	Garden waste	Textiles	LDPE	HDPE	PET	Polystyrene	Mixed waste*
0.02	0.5	9	0.1	0.2	46	53	4.7

\*Mexico case study

# E-waste Burning



E-waste generation\*  
**3.7 kg/capita/year**

\*Vietnam case study  
Noted that municipal waste generation is **0.41 kg/capita/day** (Kawai and Tasaki, 2016)

Producers,  
importers and sale  
agents; Formal  
waste treatment

Traditional  
recycling of e-waste  
by informal sector

Open burning, manual dismantling,  
plastic recycling

Concerned on emerging pollutants from  
flame retardants burning, dioxin-related  
compound

Metals and organic  
compound  
pollution to the  
environment

Metal recovery and  
burning fewer  
valuable materials

Recovery process: (1) primary  
dismantling, (2) crushing and  
enrichment, (3) smelting and precious  
metal recovery

# Key factors of OWB Practices

## Technical factors

- Lack of proper domestic waste disposal (Kong et al., 2020)
- Lack of regulatory / law enforcement (Kong et al., 2020)
- Inadequate waste transportation infrastructure (Ramadan et al., 2022b)
- Bigger space for waste dumping in the backyard (Ramadan et al., 2022b)
- Distance between landfill to the service area (Ramadan et al., 2022b)

## Non-technical factors

- Lack of environmental health awareness, attitude, and practices (Kong et al., 2020)
- The need of heat from burning activities (Ramadan et al., 2022a)
- Lack of motivation to sort waste (Ramadan et al., 2022b)
- Exceeding volume of waste due to some specific event (Ramadan et al., 2022b)
- Local people's rejection of the establishment of waste collection facility (Ramadan et al., 2022b)
- Impatience habits in waiting collection services (Ramadan et al., 2022b)

# Initiatives

Decentralized waste management system, case of Phillipines (Premakumara et al. 2018)

- Localized approach for implementing MSWM policy is useful to reduce open burning. Law/policy enforcement and commitment from the national to local level could reduce the burning activity.

Community empowerment (Brotosusilo and Naldi, 2021 and Budihardjo et al. 2022)

- In many places in Indonesia and Thailand, waste management which is empowering local actors to manage their own waste was introduced and strengthened in the national policy. This initiatives are useful to boost recycling thus reducing waste burning practices

Zero burning policy in Upper Northern Thailand (Yabueng et al. 2020)

- To reduce the biomass burning event in Thailand, the government enforced the policy during February to April (dry season) since 2016. The biomass burning hotspot reduced in the implementation of the policy, while this situation could also be done for open burning of waste.





# Summary and Policy Recommendations

## Summary

- Many researchers are focusing on biomass and crop residue burning. While the information of other burning practices such as MSW and e-waste burning are lacking.
- MSW burning is potentially emitted significant number of pollutant with the similar or even higher impact than biomass burning.
- More work in the MSW and e-waste burning field are needed to fill the scientific gaps and baseline study for appropriate policy recommendation.

## Recommendation

- Improvement of collection and transportation service
- Regular inspection reinforcement
- Establishment of policies both local and national to reduce burning practice
- Establishment of community waste management unit to do recycling activities
- Establishment of community education and awareness campaign
- Promoting recycling activities of informal actors at household levels
- Improving working condition of informal recycling actors

**ご清聴ありがとうございました。**  
Thank you very much for your attention.

**Bimastyaji Surya Ramadan, [bimastyaji@live.undip.ac.id](mailto:bimastyaji@live.undip.ac.id)**  
**Premakumara Jagath Dickella Gamaralalage, [premakumara@iges.or.jp](mailto:premakumara@iges.or.jp)**