UNESCAP Bangkok Waste Account

2017 – 2020

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1. Introduction

1.1 Purpose

Environmental-Economic Accounting (SEEA) is a framework developed by the United Nations Statistics Division to integrate environment and economic and shows as a data set that could strengthen decision making. SEEA was adopted as an international statistic standard in early 2012. It has been applied in several environmental factors such as water, energy and waste account. UN has initiated the "Greening the Blue" concept to engage and support the UN System in the transition towards greater environmental sustainability in the management of its facilities and operation. SEEA waste accounts framework is applied in UNESCAP main facility in Bangkok as a case study for microscale waste accounting. Waste account using SEEA framework has been tested in several countries such as Nepal and Maldive to conduct and assess opportunities and challenges of waste management in the national scale so as to come up with gap analysis and policy recommendations that align with Sustainable Development Goals (SDGs). Microscale waste account is conducted for the first time at UNESCAP mail facility in Bangkok. This can highlight improvement area of waste management, waste generation at source and waste disposal chain which could be further applied in other UN facilities.

UN has established an environmental management system (EMS) to handle and strengthen improving of overall environmental management for the entire UN System. Waste generation (supply) and disposal (use) was systematically managed and data was collected since 2017 by the EMS team.

This project is to develop waste account of UNESCAP main facility in Bangkok for 2017 to 2020 according to SEEA. The specific objectives are to:

- Provide solid waste accounts for the period 2017 – 2020 in accordance with SEEA concepts and methods for the UNESCAP Bangkok facility;
- Identify gap and key stakeholders for improving waste management;
- Provide cost analysis for waste collection and treatment;
- Provide recommendations for UNESCAP Bangkok facility and for further apply for the entire UN System.

1.2 Scope

Waste account on a microscale was conducted in UNESCAP main facility in Bangkok consisting of three buildings and common areas;

- Secretariat: The building includes 17 floors with total area of 37,750 m^2. It serves as the main office building.
- Service: The building includes 6 floors with total area of 9,400 m^2. It serves as service areas having restaurant and coffee shop.
- UNCC: The building includes 5 floors with total area of 33,150 m^2. It serves as conference center.

Data was collected from the EMS team from year 2017 to 2020 sorted by building and waste type.

1.3 Report layout

This report consists of nine chapters as follow;

- Chapter 1 Introduction: This chapter introduces background of the project as well as overall and specific objectives.
- Chapter 2 Waste management strategy of ESCAP Bangkok: This chapter gives information of history of waste management in UNESCAP Bangkok facility and the establishment of the EMS and current waste management approach.
- Chapter 3 Framework for waste account: This chapter provides information on SEEA framework.
- Chapter 4 Methodology: This chapter highlights data collection methodology according to SEEA framework to fulfill microscale waste account in UNESCAP Bangkok facility.
- Chapter 5 Waste account: This chapter gives insight analysis of waste account of UNESCAP Bangkok facility highlighting opportunities and challenges of waste management.
- Chapter 6 Cost analysis: This chapter shows alternative approaches for waste management together with their cost analysis.
- Chapter 7 Conclusions: This chapter summarizes overall waste management of UNESCAP Bangkok facility resulted from SEEA framework.
- Chapter 8 Recommendations: This chapter gives recommendations for UNESCAP compound to improve their waste management with cost analysis of the alternatives. Entire UN System?
- Chapter 9 References

2. Waste Management strategy of ESCAP Bangkok

2.1 Waste management strategy

ESCAP has established the Environmental Management System (EMS) in 2017. EMS's mandate is to identify environmental management gaps of the entire UN facility in Bangkok as the main purpose to reduce the compound's environmental impacts. Waste management happened to be EMS's top priority as suggested by the Initial Environmental Review (IER). The recommendations brought up from the IER was to reduce generation of mixed waste by reducing amount of avoidable waste. EMS launched waste prevention initiatives to band single-use catering in June 2018 targeting food takeaway containers, drink cups, plastic straws, plastic bags, and single use cutlery by replacing them with reusable items. The initiatives also aimed reducing paper use as well and ESCAP compound was the first pilot project. EMS team also worked together with Seismic Mitigation Project (SMP) to set up waste management facilities such as

recycling bins with the renovation plan as SMP generated significant amount of waste associated with construction, furniture replacement, and archives disposal for relocation and digitalization. The initiative resulted in overall reduction of mixed waste and increasing in portion of recycling waste. It is clear that the initiative could enhance waste segregation efficiency.

EMS waste management strategy showing interaction between key elements, strategy, relevant reference documents and responsible team is summarized in Figure 1.

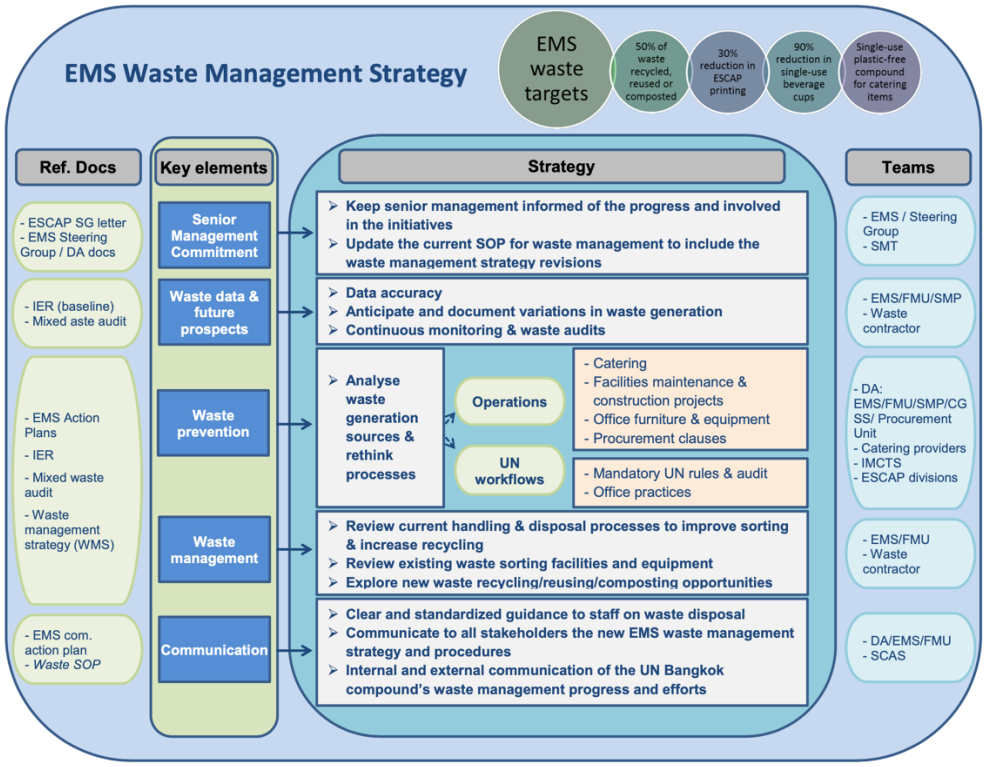

Figure 1 EMS Waste Management Strategy[1]

Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

EMS proposed waste management strategy based on the outcomes of the IER and the Mixed Waste Audit. The proposed strategy focused on increasing portion of recycling waste, reducing waste generation by 3R approach, making mutual understanding on waste management by improving communication and providing clear guidance (labelling, consistency in bin type and signs, etc.) and raising awareness among staff (Figure 2).

[1] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Figure 2 Components of waste management strategy[2]

Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

The proposed waste management strategy has been implemented since June 2018. The outcomes are as Table 1.

[2] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Table 1 Proposed waste management strategy and it's outcomes[3]

Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Key components	Situation	Proposed	Outcomes
Waste management process	- The compound's individual office bins only include two categories of waste: recycling and mixed. Thus, not fully preventing waste contamination. - Recycling bins by type of waste are available next to the elevators only. Very limited use by staff and low visibility/sensitization. - PCS efforts are focused on waste collection, only performing waste sorting for the green individual recycling bins (not for the black mixed waste ones.)	- **Improvement of PCS waste sorting station:** Establishment of a waste recycling station at the compound with large baskets to smoothly and effectively organize waste sorting by PCS staff. - **Standardized recycling stations** composed of 7 different bins (plastic, glass, paper, organic, e-waste, metal, mixed waste) to be installed in **the main office corridors** (next to printing facilities) as well as in **all common areas**. - The**volumeofthebins**shouldvarydependingonthe location and based on PCS feedback (current waste collection). Separate organic waste bins are included in the proposal as the EMS is currently looking for alternatives to dumpsite for its organic waste (e.g. biogas, composting, etc.). - **Removal of personal office bins**. - **Accurate sorting** by PCS of all waste including the mixed waste to ensure 100% recycling of recyclable material. o **Collaboration with the SMP project** to: identify a suitable waste bins solution which can meet the waste recycling and future office space needs and that is timely integrated into the office design o develop an estimated SMP waste inventory to plan for the sale or donation of avoidable waste, and safe disposal	- Increase in average amount of recyclable waste sent to recycling facility - Reduction in food and organic waste disposed by landfill - Slight reduction in overall mixed waste through 2017 – 2019

[3] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Key components	Situation	Proposed	Outcomes
	- Inconsistent types of waste bins throughout the compound (in some cases recycling bins, in others single mixed waste bins only especially in common areas). This directly impacts staff habits in waste disposal and sensitization, and may cause reputational risks with visitors and staff. - PCS waste sorting facilities are basic, lacking some systematic sorting stations which would smoothen the sorting process and increase accurate waste recycling. - The compounds' kitchens lack of systematic waste sorting facilities.	○ establish a separate waste reporting system to account for the SMP associated waste throughout the works. - The **compounds' kitchens** to be equipped with **modern and intuitive waste sorting stations** to simplify kitchen team's work, ensure better waste disposal at source, and prevent waste contamination.	
Prevention	- No specific practices other than signs	- Implementing the ban of single-use catering items offered by the service providers such as straws,	- Reduction in overall waste production of Secretariat Building

Key components	Situation	Proposed	Outcomes
	informing staff to ask for smaller food portions to avoid waste, and the sale of goods still in good condition.	food containers, cups, etc. to both tackle waste reduction and plastic pollution. Special focus on plastic items to be replaced with reusable ones or more sustainable single-use ones. Surcharge mechanisms to be adopted where necessary. - Collaboration with the SMP project as mentioned above	but not effectively prevent waste generation of Service and UNCC building
Labeling	- Signs on individual bins: "Waste" and "recycling symbol". These are located on the sides of the bins, not easily visible to staff who thus dispose of their waste often randomly.	- Clear guidelines and pictures on all bins should be provided and located where visible to support staff awareness and guide proper disposal - All stations where only a single mixed-waste bin is available should be fully replaced with the standardized recycling bins set.	- Increase in average amount of recyclable waste sent to recycling facility
Awareness	- Posters in the elevators and banners are provided to invite staff to bring their own mugs and food containers. - No waste information is sent to staff concerning their floor / block performance	- **Awareness campaigns** through posters, videos and events to be organized especially in occasion of the World Environment Day celebrations. - **Communication to staff** to inform them of the management changes and the reasons for the transition. - **Kitchen and PCS staff awareness** should be raised on the new waste bins and system, training in collaboration with the EMS team. - **Waste audits** by floor to monitor waste disposal practices and inform staff of their (comparative) performance	- Increase in average amount of recyclable waste sent to recycling facility

2.2 Waste management situation

Waste management was mostly handled by PCS company. Waste was segregated to recyclable non-hazardous waste, recyclable hazardous waste, and mixed waste. Recyclable non-hazardous waste was categorized into food waste, other biodegradable waste, paper, cardboard, plastic, glass, can, metal and other non-specified non-hazardous waste. Recyclable hazard waste includes electronic waste devices, battery, light bulbs, lamps, hazardous construction waste, medical waste (infectious waste) and other non-specified hazardous waste. Detail of each waste type collection and management is as follow (Table 2 and 3);

Recyclable non-hazardous waste

- Food waste managed by PCS sending to private contractors for composting and providing for animal food.
- Other biodegradable waste managed by PCS transferring to landfill by Bangkok Municipal Authority (BMA).
- Paper, cardboard plastic, glass, can, metal managed by PCS sending to recycling facility at Wongpanit Company.
- Other non-specified non-hazardous waste (Furniture) managed by ESCAP Asset Management Unit (ASMU).

Recyclable hazardous waste

- E-waste (Computer and other devices) handled by ESCAP Asset Management Unit (ASMU) for sale and reuse purpose.
- Battery, light bulbs and lamps managed by PCS sending to One More Link for recycle.
- Hazardous construction waste handled by construction contractor sending to secured landfill.
- Medical waste or infectious waste managed by PCS sending to CANON Hygiene for incineration.
- Other non-specified hazardous waste managed by PCS sending to secured landfill.

Mixed waste

- Mixed waste is waste that was not separated at sources. It is collected by BMA and send to sanitary landfill.

Table 2 Recyclable non-hazardous waste management[4]

Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Waste Type	Waste Collection (Percentage)			End Disposal / Use (Percentage)						Name of Entity Handling Waste
	Municipal Government	Private Contractor	Sale	Re-use	Recycling	Composting/ Animal Feed	Energy Recovery	Incineration (Closed)	Landfill	
Paper/ Cardboard		100%			100%					PCS/Wongpanit
Plastic		100%			100%					PCS/ Wongpanit
Biodegradable (Food, Garden waste, etc.)		100%				100%				SOS / Onsite for garden waste
Wood		100%		90%					10%	Construction contractor
Glass		100%			100%					PCS/ Wongpanit
Metal		100%			100%					PCS/ Wongpanit
Non-hazardous construction waste		100%			100%					Construction contractor
Other non-hazardous waste type 1 (specify in notes) - Furniture			100%	100%						ESCAP Asset Management Unit (ASMU) and construction contractor
Other non-hazardous waste type 2 (specify in notes)		100%					100%			PCS/Sci-ECO
Other non-hazardous waste type 3 (specify in notes)		100%			100%					SOS
Mixed non-hazardous waste not accounted for above	100%								100%	Bangkok Municipal Authority (BMA)

[4] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Table 3 Recyclable hazardous waste management[5]
Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Waste Type	Waste Collection (Percentage)			End Disposal / Use (Percentage)						Name of Entity Handling Waste
	Municipal Government	Private Contractor	Sale	Re-use	Recycling	Composting	Energy Recovery	Incineration (Closed)	Landfill	
E-waste: Electronics			100%	100%						ESCAP Asset Management Unit (AMSU)
E-waste: Batteries		100%							100%	PCS/One More Link
E-waste: Light bulbs and lamps									100%	PCS/One More Link
Hazardous construction waste		100%							100%	Construction contractor
Medical waste		100%						100%		PCS / CANON Hygiene
Other hazardous waste (specify in notes)									100%	PCS

[5] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

3. Framework for waste account

3.1 Definition of waste

SEEA framework[6] has defied solid waste as discarded material that are no longer required by the owner or user. This solid waste is considered as flow of materials. It includes three definitions of flows as residual flow, actual residual flow and product flow. *Residual flow* is defied based on discarded residual receiving no payment for the materials. In the case of ESCAP Bangkok, this could be the type of wastes disposed by landfill and incinerator such as organic waste, mixed waste, construction waste and medical waste. *Actual residual flow* is residual receiving payment but small amount. *Product flow* considered from having large amount and receive a payment as a recycling material or sold as second-hand products. That is furniture, recyclable and compostable wastes.

3.2 Sources of waste

Table 4 Source of waste and its characteristics

Sources/buildings	Utility space (m^2)	Activities	Type of waste
Secretariat	37,750	Office building Restaurant	Office waste Food waste Recycle waste Hazardous waste
Service	9,400	Restaurant Coffee shop	Food waste Recycle waste Hazardous waste
UNCC	33,150	Conference center	Food waste Recycle waste Hazardous waste
Others	-	Public space Parks	Garden waste Recycle waste Hazardous waste

3.3 Waste categories

EMS team has categorized waste into mainly three type which are recyclable non-hazardous waste, recyclable hazardous waste and mixed waste. Detail is as Table 5.

[6] https://unstats.un.org/unsd/envaccounting/seearev/seea_cf_final_en.pdf

Table 5 Definition of waste defied by ESCAP EMS team[7]
Source: EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Waste Type	Information
Recyclable non-hazardous waste	
Paper/ Cardboard	Paper is the most common waste type in offices. Cardboard is a form of paper typically used for packaging. Cardboard and other types of paper (e.g. printing paper, magazines, newspapers) are often sorted together. Please enter the total quantity of paper and cardboard. If paper and cardboard are sorted separately at your compound, please enter the total combined amount under Paper/ Cardboard and mention the separate amounts for each in the "Comments and Assumptions" column.
Plastic	Please enter the amount of separated plastic waste. Keep in mind that only certain types of plastic can be recycled and these types can vary by location. As plastic waste has become a large environmental issue, some UN sites have banned single-use plastics.
Biodegradable (Food, Garden waste, etc.)	Some sites separate biodegradable waste for composting. The most common types of biodegradable waste is food waste and garden waste. Other types of biodegradable waste may include paper if it has reached the end of its recyclability cycle and possibly dust from vacuum cleaners if it comes from woollen carpet. Please indicate the amount of biodegradable waste. If this waste is further separated by type, for instance into food or garden waste, please indicate the individual amounts in the "Comments and Assumptions" column.
Wood	Please enter the amount of separated wood waste.
Glass	Please enter the amount of separated glass waste.
Metal	Please enter the amount of separated metal waste. Aluminium and steel are the most common metal waste types found in UN offices. They are typically used for drink and food containers but can be found in other products such as radiators, vehicles, electronic devices and appliances.
Non-hazardous construction waste	This category covers a wide range of materials used for construction or generated as a result of demolition including concrete, bricks, tiles, ceramics, wood, glass, plastic, non-hazardous bituminous mixtures, metals, non-hazardous soil and stones, insulation materials and gypsum based materials. Please report the quantity of construction waste and indicate whether it is a result of a one-off major refurbishment in the "Comments and Assumptions" column.
Other non-hazardous waste type 1-3 (specify in notes)	These entries can be used to describe any other type of separated non-hazardous waste not mentioned above. This may include items such as textiles, tyres and furniture. Please describe the category in the "Comments and Assumptions" column.

[7] EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

Waste Type	Information
Mixed non-hazardous waste not accounted for above	Use this category for general waste that has not been separated for re-use or recycling.
Recyclable hazardous waste	
E-waste: Electronics	E-waste (Electronic waste): Electronics refers to end-of-life or discarded appliances using electricity. The most common types are personal computers, printers, monitors, television sets, domestic appliances and mobile phones. Please indicate the waste quantity of these items. Electronic products contain several types of hazardous materials, such as mercury, arsenic, lead, cadmium, and should be discarded properly, **not** through general municipal solid waste.
E-waste: Batteries	Please indicate the quantity of batteries disposed. The majority of household and industrial batteries contain hazardous substances and therefore must be separated from general waste and disposed of properly.
E-waste: Light bulbs	Please indicate the quantity of separated light bulbs. All fluorescent tube lighting is hazardous as it contains mercury. Halogen and incandescent lighting is not hazardous and can be disposed with general non-hazardous waste. The classification of LED lighting may vary depending on location and traits of the specific lighting used.
Motor oil and related fluids	The majority of fluids from vehicles and machinery are hazardous and must be collected and disposed with care using a specialist facility. Typical fluids include motor oil, brake oil, antifreeze (if a hazardous type is used), petrol, diesel and lubricating oils. Please indicate the waste quantity of these items.
Vehicles/ Machinery/ Scrap metal	Discarded vehicle and machinery parts and scrap metal are considered hazardous when they are contaminated with harmful substances that they come into contact with during typical operation such as motor oil, asbestos within break pads, explosive charge in air bags, car batteries and equipment containing mercury and PCBs (polychlorinated biphenyls). Please indicate the quantity of vehicle, machinery and scrap metal waste that have not been decontaminated (free of hazardous substances).
Refrigerants	Please indicate the quantity of disposed refrigerants. Refrigerants should not be vented or improperly released. Refrigerants contained in appliances (for example refrigerators) that are properly disposed of do not need to be accounted for separately here.
Paints	Please indicate the quantity of disposed paint. Paint contains chemicals such as solvents and metals and should never be disposed with general waste in a liquid form.
Chemicals	Please indicate the quantity of any chemical waste that is not already covered such as cleaning products or pesticides and provide a description in the "Comments and Assumptions" column.
Hazardous construction waste	Please indicate the quantity of hazardous construction waste (not to be confused with non-hazardous construction waste). This category covers any construction or demolition waste material containing a hazardous substance such as asbestos, treating agents or adhesives.

Waste Type	Information
Medical waste	Please indicate the quantity of medical waste. This includes expired pharmaceuticals, sharp medical instruments and any waste contaminated with bodily fluids or other potentially infectious materials.
Explosive ordnance	Please indicate the quantity of explosive ordnance. This includes munitions and ammunition containing explosives, radioactive materials, and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket, and small arms ammunition; all mines, torpedoes, and depth charges; demolition charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components that are explosive in nature.
Other hazardous waste (specify in notes)	Please use this entry to include the quantity of any other hazardous waste type not listed above. Please indicate the type in the "Comments and Assumptions" column.

3.4 Physical Supply and Use Tables

According to SEEA, there are two types of data required which are Physical Supply Table and Use Table. Supply Table represents waste generation statistic by waste types and sources. The Use Table capture the disposal methods of waste generated from different sources.

The two tables prepared for the SUT of the Waste Account Framework were as follows:

1. **Physical Supply Table** – Supply Waste consists of waste type categorized by waste generation sources. Waste types are mixed waste (which is waste that is not segregated at source), recycling waste (which is divided into paper, wood, food, garden waste, other biodegradable, textile, plastic, glass, metal, furniture, tyres, non-hazardous waste, toners and other non-hazardous waste) and hazardous waste (e-waste, machinery, chemicals, medical waste, explosive ordinance. Other hazardous waste). Waste was collected from trash bins located at each floor of Secretariat, Service and UNCC Building and at public area by PCS (Private contractor). The collected waste was then weighted by type of waste of each building daily. Food waste is stored in a cool room controlled temperature at 4°C to avoid organic biodegradation causing unpleasant smell. Recyclable materials are stored in recycling warehouse for later transported to recycling facilities by private contractors. Mixed waste and food waste is disposed by landfill daily by Bangkok Metropolitan Authority (BMA). Large portion of food waste is dispose by compost and feeding animal.

2. **Use Table** – Use Table presents waste disposal methods by type of waste mentioned in the Supply Table and by waste generation sources which are secretariat building, service building, UNCC building and other public areas. Different type of waste is

treated differently. Following detail shows waste disposal methods applied for ESCAP waste

- *Landfill*: Any kind of waste disposed to landfill is stored and collected daily by BMA. Food waste generated in 2017 – 2019 was sent to sanitary landfill managed BMA. Food waste is no longer sent to landfill. It is currently utilized as compost and animal food. Mixed waste is collected and send to landfill daily by BMA. Some hazardous construction material is sent to secured landfill by construction contractor.
- *Recycle*: Recyclable waste is collected on occasionally by PCS and store at recycle store room before collection by private contractors. Both non-hazardous and hazardous recyclable waste is handled by PCS from the point of waste generation to the store room.
- *Composting*: Compostable waste such as garden waste, food waste and other organic waste is sent to private contractor for composting and a small amount of garden waste (3-5%) is handle by gardeners for composting at ESCAP.
- *Animal feed*: Food waste is provided as animal food since the beginning of 2020.
- *Incineration*: Some type of hazardous waste and medical waste is collected by PCS and sent to incineration facility by private contractor.
- *Reuse*: Reusable materials such as furniture and e-waste is handled by ESCAP Asset Management Unit (ASMU) annually. These materials are stored in a store room and sold through auction event.

3.5 Availability of data

Information available for performing waste account on a micro scale of ESCAP Bangkok is accurate and sufficient. EMS team records waste generation and waste disposal sorted by type and by source daily. Information is available from 2017 – 2020. Not every type of waste generated by non-ESCAP agency is included. Waste for sale (furniture and e-waste) from non-ESCAP agency is not included in the waste account as they take care of the waste by themselves. Waste generation and treatment in 2020 is not consistent due to COVID19 situation causing fewer staff utilized the building and some private contractors cancelled their contract.

4. Waste account

4.1 Waste account for 2017 – 2020

Data on waste generation was collected from EMS team. Data shown in the Physical Supply Table is from primary data recorded by PCS monthly. There is the only amount of garden waste disposed by composting that are estimation value from percentage of organic waste utilized by compost together with information from interviewing PCS team. This Physical and Use Table allows simple interpretation and analysis of the data bank through systematical accounting system. The information from the waste account would greatly support decision making and developing policies relevant to waste management.

4.1.1 Physical Supply Table

Total waste generation of ESCAP Bangkok compound is 2017 – 2020 was 183.5, 207.9, 225.3 and 135.4 ton/year, respectively. Secretariat and UNCC Building produced around 60-80% of total waste followed by Service building (10-20%) and other public area (less than 10%) (Table 6-9). Total amount of waste tended to slightly increase each year especially for UNCC Building. Mixed waste drastically decreased from almost 80% of total waste generated to in 2017 to 41.97% in 2018 due to discarding of food waste from mixed waste and treated by compost. Consequently, amount of recyclable waste increase gradually throughout the new waste management strategy managed by EMS team from mid of 2018.

Table 6 Supply of waste in 2017 categorized by building

Categories of Waste	Amount of waste by building (kg/year)					Percent to total
	Secretariat Bldg.	Service Bldg.	UNCC Bldg.	Others	Total	
General waste						
Mixed waste	44,478.90	26,025.50	74,974.60		**145,479.00**	**79.28**
Recycling						
Non-hazardous						
Paper	26,519.50	2,553.00	713.00		**29,785.50**	**16.23**
Plastic (PET/HDPE)	263.50	101.50	237.50	744.90	**1,347.40**	**0.73**
Glass	338.50	166.50	366.50		**871.50**	**0.47**
Metal (Can/vehicles/electronic devices/appliances)	51.80	44.50	74.50		**170.80**	**0.09**
Toner	21.00	-	1.00		**22.00**	**0.01**
Steel				2,707.40	**2,707.40**	**1.48**
Hazardous						
E-waste: batteries	11.00	1.00	-		**12.00**	**0.01**
E-waste: light bulbs and lamps				3,110.00	**3,110.00**	**1.69**
TOTAL	**71,684.20**	**28,892.00**	**76,367.10**	**6,562.30**	**183,505.60**	**100.00**
Percent to total	**39.06**	**15.74**	**41.62**	**3.58**	**100.00**	

Table 7 Supply of waste in 2018 categorized by building

Categories of Waste	Amount of waste by building (kg/year)					Percent to total
	Secretariat Bldg.	Service Bldg.	UNCC Bldg.	Others	Total	
General waste						
Mixed waste	38021.10	12312.00	28737.10	8,187.10	87,257.30	**41.97**
Recycling						
Non-hazardous						
Paper	28,470.38	8,887.35	1,141.10		38,499.01	**18.52**
Food	8,540.84	16,960.00	45,409.70		70,910.54	**34.10**
Garden waste				3,270.80	3,270.80	**1.57**
Plastic (PET/HDPE)	205.87	242.08	144.65		592.60	**0.29**
Glass	407.40	439.30	645.90		1,492.60	**0.72**
Metal (Can/vehicles/electronic devices/appliances)	68.10	102.10	100.40		270.60	**0.13**
Furniture	2,725.00	45.00	1,095.00		3,865.00	**1.86**
Toner	0.00	108.00	0.00		108.00	**0.05**
Hazardous						
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods	468.70	769.25	373.00		1,610.95	**0.77**
E-waste: batteries	0.00	48.80	0.00		48.80	**0.02**
TOTAL	**78,907.39**	**39,914.06**	**77,646.85**	**11,457.90**	**207,926.20**	**100.00**
Percent to total	**37.95**	**19.20**	**37.34**	**5.51**	**100.00**	

Table 8 Supply of waste in 2019 categorized by building

Categories of Waste	Amount of waste by building (kg/year)					Percent to total
	Secretariat Bldg.	Service Bldg.	UNCC Bldg.	Others	Total	
General waste						
Mixed waste	28,255.30	7,183.90	26,470.01	1,703.30	63,612.51	**28.24**
Recycling						
Non-hazardous						
Paper	24,607.40	4,756.49	6,839.50		36,203.39	**16.07**
Food	4,401.90	17,892.48	66,168.84		88,463.22	**39.27**
Garden waste				4,754.40	4,754.40	**2.11**
Plastic (PET/HDPE)	252.99	249.30	416.31		918.60	**0.41**
Glass	603.21	869.05	1,422.24		2,894.50	**1.28**
Metal (Can/vehicles/electronic devices/appliances)	93.50	9,861.90	7,481.30		17,436.70	**7.74**
Furniture	4,813.00	2,117.00	2,056.00		8,986.00	**3.99**
Toner	-	-	3.70		3.70	**0.00**
Hazardous						
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods	437.00	1,085.50	402.50		1,925.00	**0.85**
E-waste: batteries	0.80	5.00	25.00		30.80	**0.01**
E-waste: light bulbs and lamps	-	28.60	-		28.60	**0.01**
TOTAL	**63,465.10**	**44,049.22**	**111,285.40**	**6,457.70**	**225,257.42**	**100.00**
Percent to total	**28.17**	**19.56**	**49.40**	**2.87**	**100.00**	

Table 9 Supply of waste in 2020 categorized by building

Categories of Waste	Amount of waste by building (kg/year)					Percent to total
	Secretariat Bldg.	Service Bldg.	UNCC Bldg.	Others	Total	
General waste						
Mixed waste	12,137.81	3,863.00	12,597.05	1,653.90	30,251.76	**22.34**
Recycling						
Non-hazardous						
Paper (Paper+cardboard)	45,769.37	1,950.90	9,807.04	-	57,527.31	**42.49**
Can	96.90	80.80	609.90	15.00	802.60	**0.59**
Food	1,601.94	3,826.69	16,270.01		21,698.64	**16.03**
Garden waste				4,144.98	4,144.98	**3.06**
Plastic (PET/HDPE)	94.16	119.94	792.40	127.00	1,133.50	**0.84**
Glass	259.45	185.00	810.00	-	1,254.45	**0.93**
Furniture	1,988.50	-	1,773.00		3,761.50	**2.78**
Non-hazardous construction waste (concrete/bricks/tiles/ceramics/wood/glass/bituminous/ metals/soil/ etc)				6,670.00	6,670.00	**4.93**
Toner	-	-	-	380.00	380.00	**0.28**
Air filter				1,760.00	1,760.00	**1.30**
Others (Office waste)	106.90	99.40	52.00	-	258.30	**0.19**
Other non-hazardous waste type 1 (specify in notes) (Cooking oil)	5.00	30.00	61.50	-	96.50	**0.07**
Hazardous						
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods	1,740.50	843.50	2,597.00		5,181.00	**3.83**
E-waste: batteries	2.70	0.30	-	-	3.00	**0.00**
E-waste: light bulbs and lamps	-	-	10.20	460.00	470.20	**0.35**
Medical waste			10.30		10.30	**0.01**
TOTAL	**63,803.23**	**10,999.53**	**45,390.40**	**15,210.88**	**135,404.04**	**100.00**
Percent to total	**47.12**	**8.12**	**33.52**	**11.23**	**100.00**	

4.1.2 Use Table

Table 10, 12, 14 and 16 shows use of waste generated in 2017 – 2020 categorized by building and Table 11, 13, 15 and 17 shows total amount of waste treated by different approaches. In 2017, waste was treated by landfill and recycle with almost 80% of waste disposed to landfill and around 20% was sent to recycling system. Almost all the waste produced from UNCC Building was sent to landfill due to high portion of food waste. Portion of waste to landfill slightly decreased in 2018 as compost system was introduced. UNCC Building contributed 33.41% of total waste discarded to landfill. Table 14 – 17 clearly show the positive shift in waste management to lesser environmental impact as decreasing in waste transported to landfill and increasing in recycling portion in 2019 and 2020. From 2020, ESCAP is no longer dispose food waste to landfill.

Table 10 Use of waste in 2017 categorized by building

Source	Amount of waste (kg/year)								
	Secretarait Bldg.		*Service Bldg.*		*UNCC Bldg.*		*Others*		
Categories of Waste	*Landfill*	*Recycle*	*Landfill*	*Recycle*	*Landfill*	*Recycle*	*Landfill*	*Recycle*	*Total*
General waste									
Mixed waste	44,478.90		26,025.50		74,974.60		-		*145.48*
Recycling									
Non-hazardous									
Paper		13,893.50		1,496.00		428.00			***15,817.50***
Cardboard		12,626.00		1,057.00		285.00			***13,968.00***
Can		51.80		44.50		74.50		-	***170.80***
Plastic		263.50		101.50		237.50		744.90	***1,347.40***
Glass		338.50		166.50		366.50		-	***871.50***
Metal (Steel)		-		-		-		2,707.40	***2,707.40***
Toner		21.00		-		1.00		-	***22.00***
Hazardous									
E-waste: batteries		11.00		1.00		-		-	***12.00***
E-waste: light bulbs and lamps		-		-		-		3,110.00	***3,110.00***
TOTAL	**44,478.90**	**27,205.30**	**26,025.50**	**2,866.50**	**74,974.60**	**1,392.50**	**-**	**6,562.30**	**183,505.60**
Percent to total	**24.24**	**14.83**	**14.18**	**1.56**	**40.86**	**0.76**	**-**	**3.58**	**100.00**

Table 11 Total use of waste in 2017

Categories of Waste	Amount of waste (kg/year)		
	Landfill	*Recycle*	*Total*
General waste			
Mixed waste	*145,479.00*		*145,479.00*
Recycling			
Non-hazardous			
Paper		15,817.50	***15,817.50***
Cardboard		13,968.00	***13,968.00***
Can		170.80	***170.80***
Plastic		1,347.40	***1,347.40***
Glass		871.50	***871.50***
Metal		2,707.40	***2,707.40***
Toner		22.00	***22.00***
Hazardous			
E-waste: batteries		12.00	***12.00***
E-waste: light bulbs and lamps		3,110.00	***3,110.00***
TOTAL	**145,479.00**	**38,026.60**	**183,505.60**
Percent to total	**79.28**	**20.72**	**100.00**

Table 12 Use of waste in 2018 categorized by building

Source	Amount of waste (kg/year)											
	Secretarait Bldg.			*Service Bldg.*			*UNCC Bldg.*			*Others*		
Categories of Waste	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Compost*	*Total*
General waste												
Mixed waste	*38,021.10*			*12,312.00*			*28,737.10*			*8,187.10*		87,257.30
Recycling												
Non-hazardous												
Paper		10,393.05			2,439.43			652.40				**13,484.88**
Cardboard		18,077.33			6,448.10			488.70				**25,014.13**
Can		68.10			102.10			100.40				**270.60**
Food	8,540.84			16,960.00			45,409.70					**70,910.54**
Garden waste										1,045.36	2,225.44	**3,270.80**
Plastic		205.87			242.08			144.65				**592.60**
Glass		407.40			439.30			645.90				**1,492.60**
Furniture			2,725.00			45.00			1,095.00			**3,865.00**
Toner		0.00			108.00			0.00				**108.00**
Hazardous												
E-waste: monitors, TVs, laptops, etc.		-	468.70			769.25		-	373.00			**1,610.95**
E-waste: batteries		-			48.80			-				**48.80**
TOTAL	**46,561.94**	**29,151.75**	**3,193.70**	**29,272.00**	**9,827.81**	**814.25**	**74,146.80**	**2,032.05**	**1,468.00**	**9,232.46**	**2,225.44**	**207,926.20**
Percent to total	**22.39**	**14.02**	**1.54**	**14.08**	**4.73**	**0.39**	**35.66**	**0.98**	**0.71**	**4.44**	**1.07**	**100.00**

Table 13 Total use of waste in 2018

Categories of Waste	Amount of waste (kg/year)				
	Landfill	*Recycle*	*Compost*	*Sold/ Donated*	*Total*
General waste					
Mixed waste	*87,257.30*				*87,257.30*
Recycling					
Non-hazardous					
Paper		13,484.88			**13,484.88**
Cardboard		25,014.13			**25,014.13**
Can		270.60			**270.60**
Food	70,910.54				**70,910.54**
Garden waste	1,045.36		2,225.44		**3,270.80**
Plastic		592.60			**592.60**
Glass		1,492.60			**1,492.60**
Furniture				3,865.00	**3,865.00**
Toner		108.00			**108.00**
Hazardous					
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods				1,610.95	**1,610.95**
E-waste: batteries		48.80			**48.80**
TOTAL	**159,213.20**	**41,011.61**	**2,225.44**	**5,475.95**	**207,926.20**
Percent to total	**76.57**	**19.72**	**1.07**	**2.63**	**100.00**

Table 14 Use of waste in 2019 categorized by building

Source	Amount of waste (kg/year)											
	Secretarait Bldg.			*Service Bldg.*			*UNCC Bldg.*			*Others*		
Categories of Waste	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Recycle*	*Sold/Donated*	*Landfill*	*Compost*	*Total*
General waste												
Mixed waste	28,255.30			7,183.90			26,470.01			1,703.30		**63,612.51**
Recycling												
Non-hazardous												
Paper		6,454.48			1,943.20			1,463.70				**9,861.38**
Cardboard		18,152.92			2,813.29			5,375.80				**26,342.01**
Can		93.50			9,861.90			7,481.30				**17,436.70**
Food	3,576.40		825.50	14,201.88		3,690.60	48,798.79		17,370.05			**88,463.22**
Garden waste										93.52	4,660.88	**4,754.40**
Plastic		252.99			249.30			416.31				**918.60**
Glass		603.21			869.05			1,422.24				**2,894.50**
Furniture			4,813.00			2,117.00			2,056.00			**8,986.00**
Toner		0.00			0.00			3.70				**3.70**
Hazardous												
E-waste: monitors, TVs, laptops, tablets, etc.			437.00			1,085.50			402.50			**1,925.00**
E-waste: batteries		0.80			5.00			25.00				**30.80**
E-waste: light bulbs and lamps		0.00			28.60			0.00				**28.60**
TOTAL	**31,831.70**	**25,557.90**	**6,075.50**	**21,385.78**	**15,770.34**	**6,893.10**	**75,268.80**	**16,188.05**	**19,828.55**	**1,796.82**	**4,660.88**	**225,257.42**
Percent to total	**14.13**	**11.35**	**2.70**	**9.49**	**7.00**	**3.06**	**33.41**	**7.19**	**8.80**	**0.80**	**2.07**	**100.00**

Table 15 Total use of waste in 2019

Categories of Waste	Amount of waste (kg/year)				
	Landfill	*Recycle*	*Compost*	*Sold/ Donated*	*Total*
General waste					
Mixed waste	63,612.51				**63,612.51**
Recycling					
Non-hazardous					
Paper		9,861.38			**9,861.38**
Cardboard		26,342.01			**26,342.01**
Can		17,436.70			**17,436.70**
Wood					
Food	66,577.07			21,886.15	**88,463.22**
Garden waste	93.52		4,660.88		**4,754.40**
Other biodegradable					
Textiles/fabric					
Plastic		918.60			**918.60**
Glass		2,894.50			**2,894.50**
Metal					
Furniture				8,986.00	**8,986.00**
Tyres					
Non-hazardous construction waste					
Toner		3.70			**3.70**
Hazardous					
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods				1,925.00	**1,925.00**
E-waste: batteries		30.80			**30.80**
E-waste: light bulbs and lamps		28.60			**28.60**
TOTAL	**130,283.10**	**57,516.29**	**4,660.88**	**32,797.15**	**225,257.42**
Percent to total	**57.84**	**25.53**	**2.07**	**14.56**	**100.00**

Table 16 Use of waste in 2020 categorized by building

Source	Amount of waste (kg/year)																			
	Secretarait Bldg.					*Service Bldg.*					*UNCC Bldg.*						*Others*			*Total*
Categories of Waste	*Landfill*	*Recycle*	*Animal Feed*	*Compost*	*Sold/Donated*	*Landfill*	*Recycle*	*Animal Feed*	*Compost*	*Sold/Donated*	*Landfill*	*Recycle*	*Animal Feed*	*Compos*	*Incineration*	*Sold/Donated*	*Landfill*	*Recycle*	*compost*	
General waste																				
Mixed waste	12,137.81					3,863.00					12,597.05						1,653.90			**30,251.76**
Recycling																				
Non-hazardous																				
Paper and cardboard		45,769.37					1,950.90					9,807.04								**57,527.31**
Can		96.90					80.80					609.90						15.00		**802.60**
Food			855.52	746.42				2,003.44	1,823.24				8,525.73	7,744.28						**21,698.64**
Garden waste																			4,144.98	**4,144.98**
Plastic		94.16					119.94					792.40						127.00		**1,133.50**
Glass		259.45					185.00					810.00								**1,254.45**
Furniture					1,988.50					0.00						1,773.00				**3,761.50**
Non-hazardous construction waste																	6,670.00			**6,670.00**
Toner																		380.00		**380.00**
Air filter																	1,760.00			**1,760.00**
Others (Office waste)		106.90					99.40					52.00								**258.30**
Other non-hazardous waste type 1 (specify in notes) (Cooking oil)		5.00					30.00					61.50								**96.50**
Hazardous																				

Source	Amount of waste (kg/year)																			
	Secretarait Bldg.					*Service Bldg.*					*UNCC Bldg.*						*Others*			*Total*
Categories of Waste	*Landfill*	*Recycle*	*Animal Feed*	*Compost*	*Sold/Donated*	*Landfill*	*Recycle*	*Animal Feed*	*Compost*	*Sold/Donated*	*Landfill*	*Recycle*	*Animal Feed*	*Compos*	*Incineration*	*Sold/Donated*	*Landfill*	*Recycle*	*compost*	
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods					1,740.50					843.50						2,597.00				**5,181.00**
E-waste: batteries		2.70					0.30													**3.00**
E-waste: light bulbs and lamps												10.20						460.00		**470.20**
Medical waste															10.30					**10.30**
TOTAL	**12,137.81**	**46,334.48**	**855.52**	**746.42**	**3,729.00**	**3,863.00**	**2,466.34**	**2,003.44**	**1,823.24**	**843.50**	**12,597.05**	**12,143.04**	**8,525.73**	**7,744.28**	**10.30**	**4,370.00**	**10,083.90**	**982.00**	**4,144.98**	**135,404.04**
Percent to total	**8.96**	**34.22**	**0.63**	**0.55**	**2.75**	**2.85**	**1.82**	**1.48**	**1.35**	**0.62**	**9.30**	**8.97**	**6.30**	**5.72**	**0.01**	**3.23**	**7.45**	**0.73**	**3.06**	**100.00**

Table 17 Total use of waste in 2020

Categories of Waste	Amount of waste (kg/year)						
	Landfill	*Recycle*	*Animal Feed*	*Compost*	*Sold/ Donated*	*Incinerated*	*Total*
General waste							
Mixed waste	30,251.76						**30,251.76**
Recycling							
Non-hazardous							
Paper and cardboard		57,527.31					**57,527.31**
Can		802.60					**802.60**
Wood							
Food			11,384.70	10,313.94			**21,698.64**
Garden waste				4,144.98			**4,144.98**
Other biodegradable							
Textiles/fabric							
Plastic		1,133.50					**1,133.50**
Glass		1,254.45					**1,254.45**
Metal							
Furniture					3,761.50		**3,761.50**
Tyres							
Non-hazardous construction waste	6,670.00						**6,670.00**
Toner		380.00					**380.00**
Steel							
Air filter	1,760.00						**1,760.00**
Others (Office waste)		258.30					**258.30**
Other non-hazardous waste type 1 (specify in notes) (Cooking oil)		96.50					**96.50**
Hazardous							
E-waste: monitors, TVs, laptops, tablets & mobile phones, white goods					5,181.00		**5,181.00**
E-waste: batteries		3.00					**3.00**
E-waste: light bulbs and lamps		470.20					**470.20**
Medical waste						10.30	**10.30**
TOTAL	**38,681.76**	**61,925.86**	**11,384.70**	**14,458.92**	**8,942.50**	**10.30**	**135,404.04**
Percent to total	**28.57**	**45.73**	**8.41**	**10.68**	**6.60**	**0.01**	**100.00**

4.2 Analysis

4.2.1 Material Flow Analysis

Material Flow Analysis (MFA) illustrates physical flow of waste from sources to collection systems and exporting to disposal facilities. Comparing mass of waste from year 2017 – 2020, amount of waste input of 2017 is similar to 2018 as the consumption behavior was no significant different despite the new waste management strategy was implemented in mid-2018. The differences fall into portion of mixed waste was largely reduce in 2018. It is assumed to be due to the awareness raising campaign and trash bins labeling. However, separated mixed waste and other organic waste was still sent to landfill (Figure 3 and 4). Recyclable waste was able to segregated more efficiently in 2019 and 2020 (Figure 5 and 6). All food waste and other organic waste was utilized as compost and animal food in 2020 which reduced environmental impact caused by biodegradation of organic matter in landfill causing GHG emission (US EPA, 2020)[8] and also leachate contamination to ecosystem if the landfill utilized is not well managed. Significantly low amount of waste in 2020 was caused by COVID19 situation. The Work-From-Home measure made reducing in number of staff working physically at the compound. Considering portion of recycling waste in Figure 6, it is significantly larger than the other waste types. It is probably because people tended to buy food packed in single-used plastic container to avoid the contamination with the virus. Looking at the amount of plastic waste alone, it shows clear evidence that plastic was increasingly consumed since the beginning of the COVID19 episode.

MFA charts clearly show effectiveness of utilizing waste as valuable materials feeding back to economic system. ESCAP Bangkok Compound waste management has greatly improved from 2017 – 2020. MFA charts show close connection between the environment and the economy. Greenish lines exhibit utilizing waste as valuable material such as transforming to raw material for industrial production through recycle facility, sold as second-hand to allow reuse practice, converting organic waste to useful mineral by composting and directly use as animal food. Yellowish lines reflex sink of material as the form of waste and its emissions. It shows residual flow of waste which was not utilized as valuable material by sending them to landfill or incinerator.

[8] https://www.epa.gov/ghgreporting/ghgrp-waste

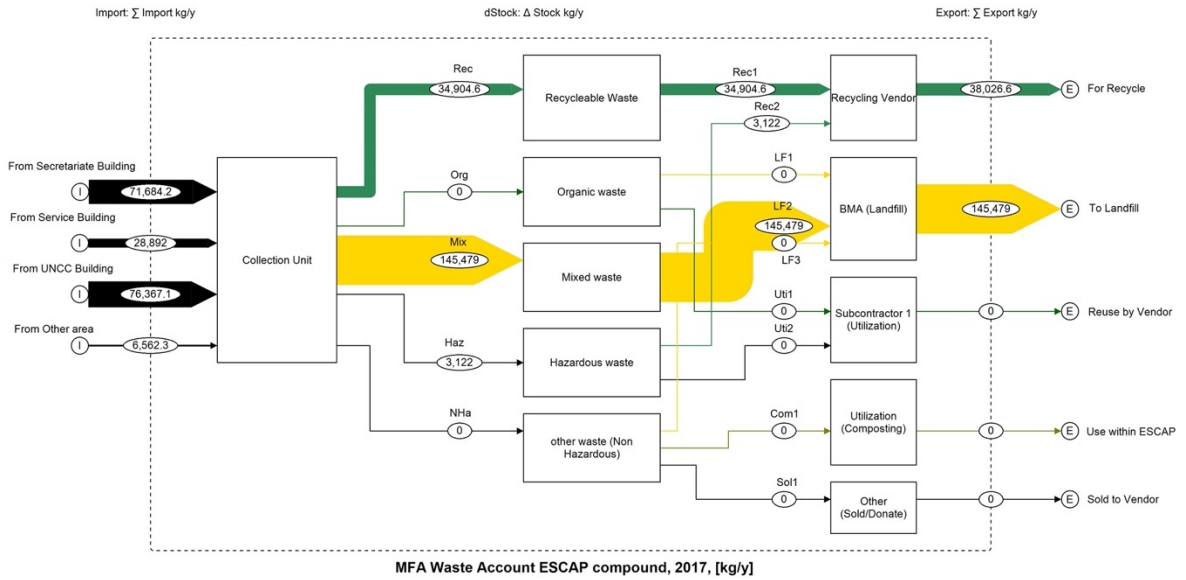

Figure 3 Material Flow Analysis of waste generated from ESCAP Bangkok Compound in 2017

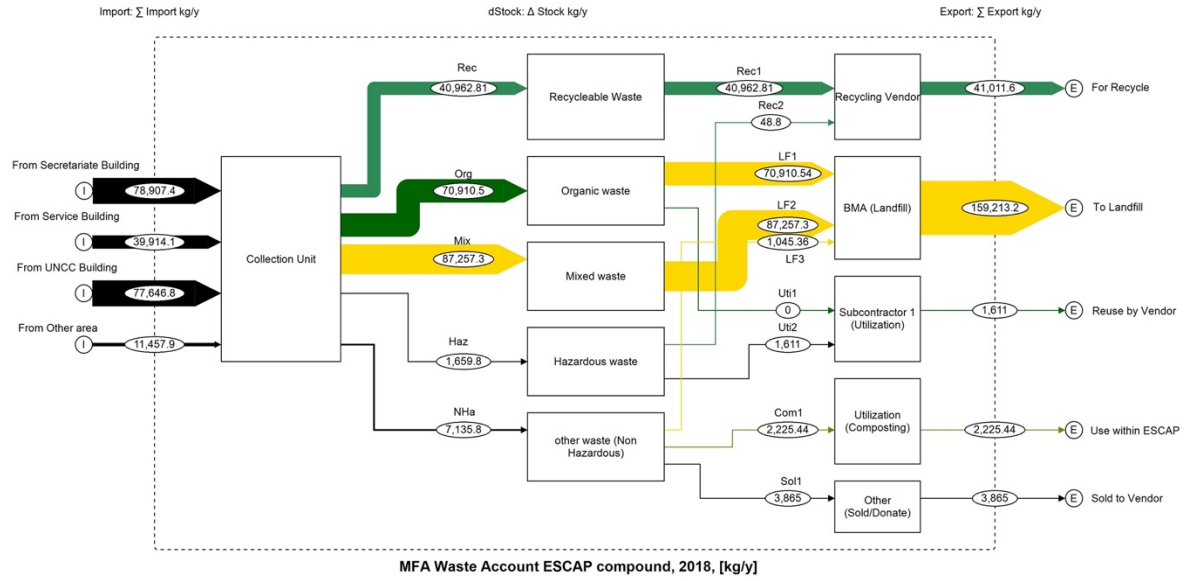

Figure 4 Material Flow Analysis of waste generated from ESCAP Bangkok Compound in 2018

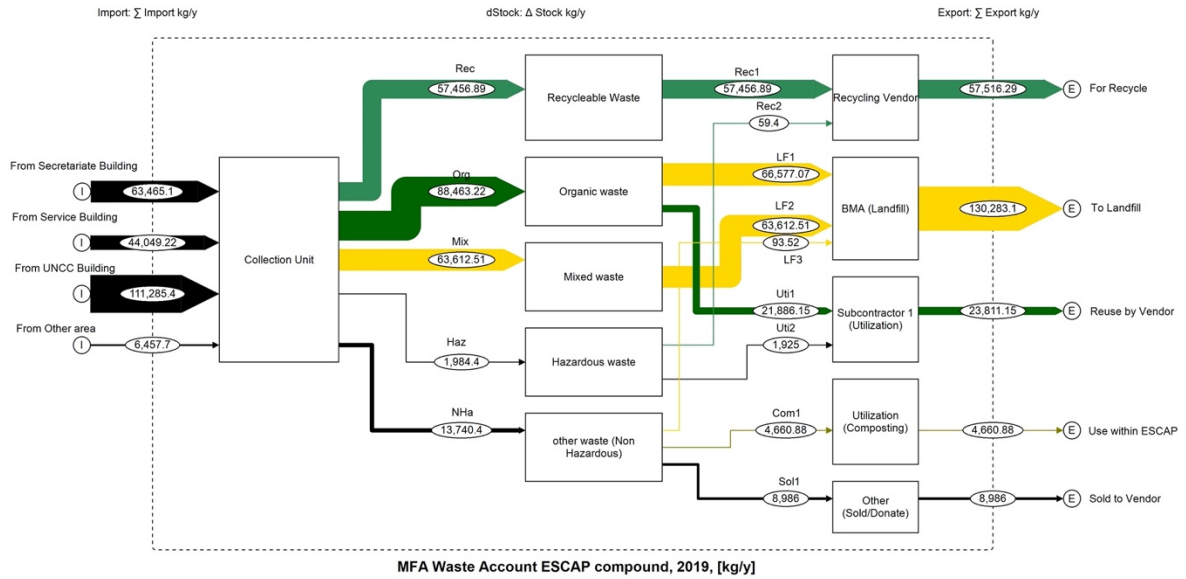

Figure 5 Material Flow Analysis of waste generated from ESCAP Bangkok Compound in 2019

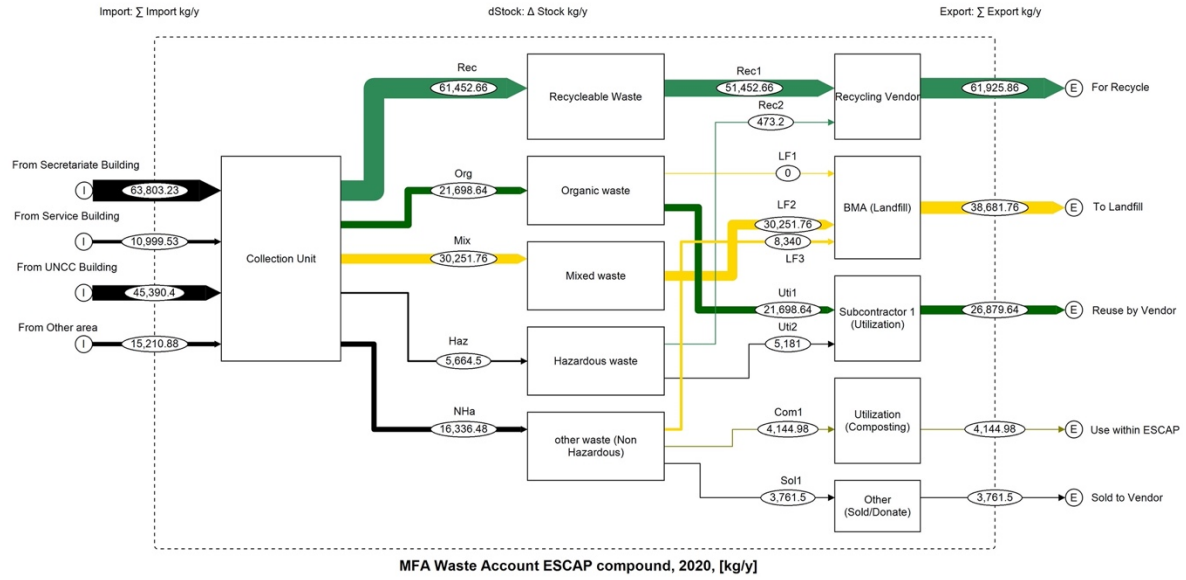

Figure 6 Material Flow Analysis of waste generated from ESCAP Bangkok Compound in 2020

4.2.2 Waste generation at source (Supply)

Figure 7 shows variation of waste generation by type of waste (recycling, mixed and infectious waste). Overall amount of waste was gradually increased from 2017 – 2019 and reduced significantly in 2020. Whilst, the portion of waste as percentage of total tended to decline for mixed waste and increase for recyclable waste (Figure 8).

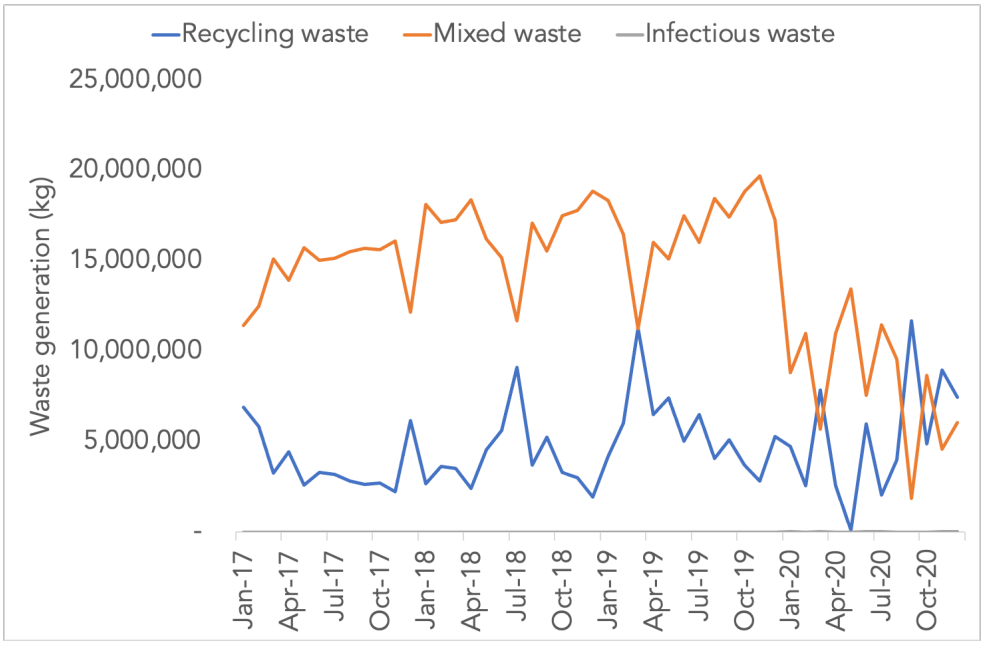

Figure 7 Over all waste production of ESCAP Bangkok Compound from 2017 – 2020

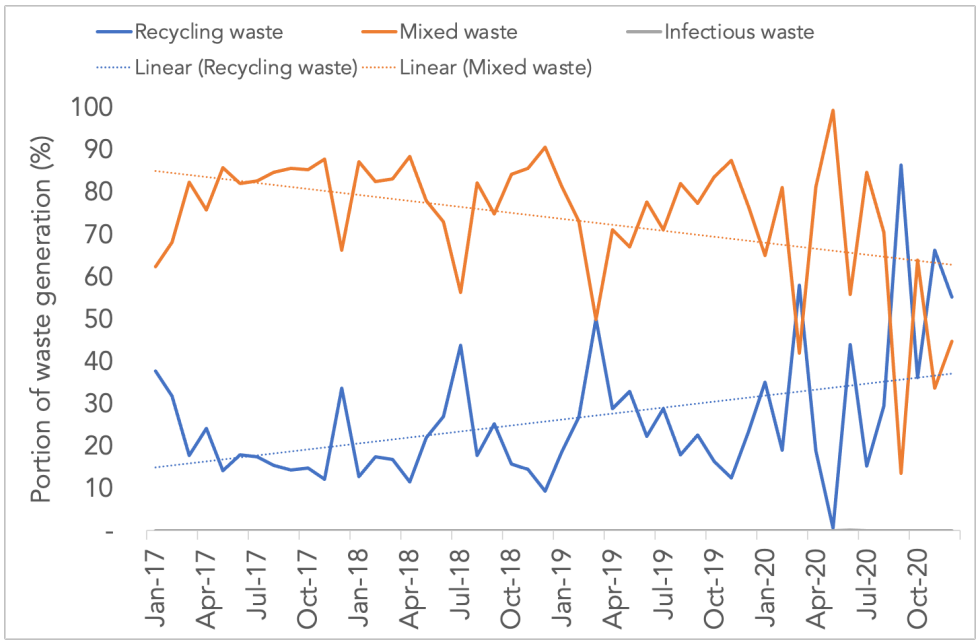

Figure 8 Portion of waste generation of ESCAP Bangkok Compound from 2017 – 2020

UNCC produced highest amount of waste each year (Figure 9) but Service Building contributed the most in terms of waste generation rate per unit area (kg/m^2) (Figure 10). It means that activities occurred in Service Building produce large amount of waste such restaurants while waste generation rate of Secretariat Building is the lowest. Most efficient approach to reduce waste production is to prioritize Service Building as it has high potential to improve its waste production.

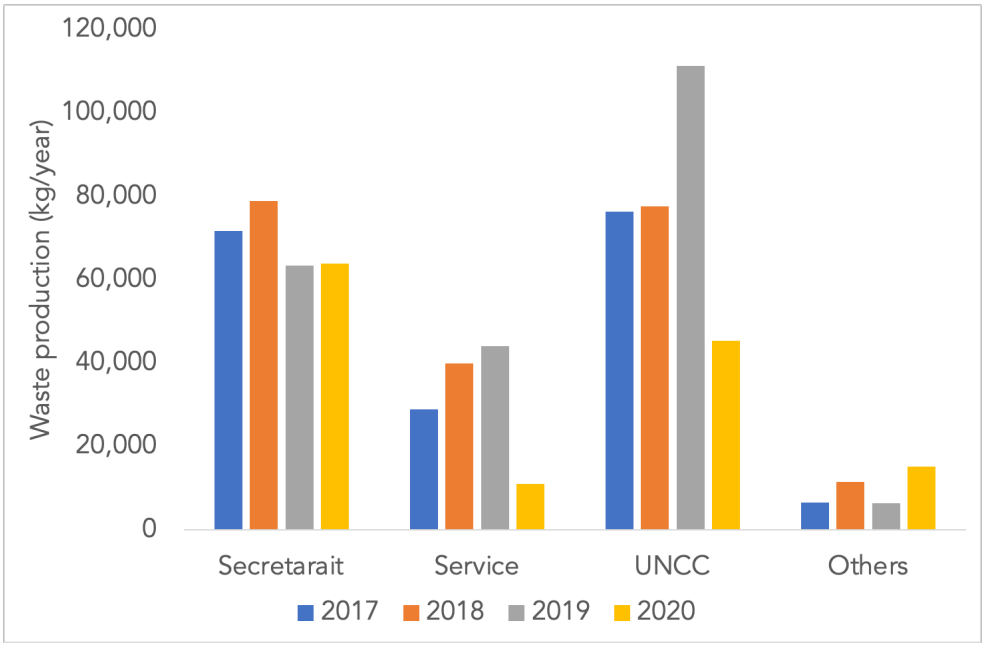

Figure 9 Waste production of ESCAP Bangkok Compound by sources from 2017 - 2020

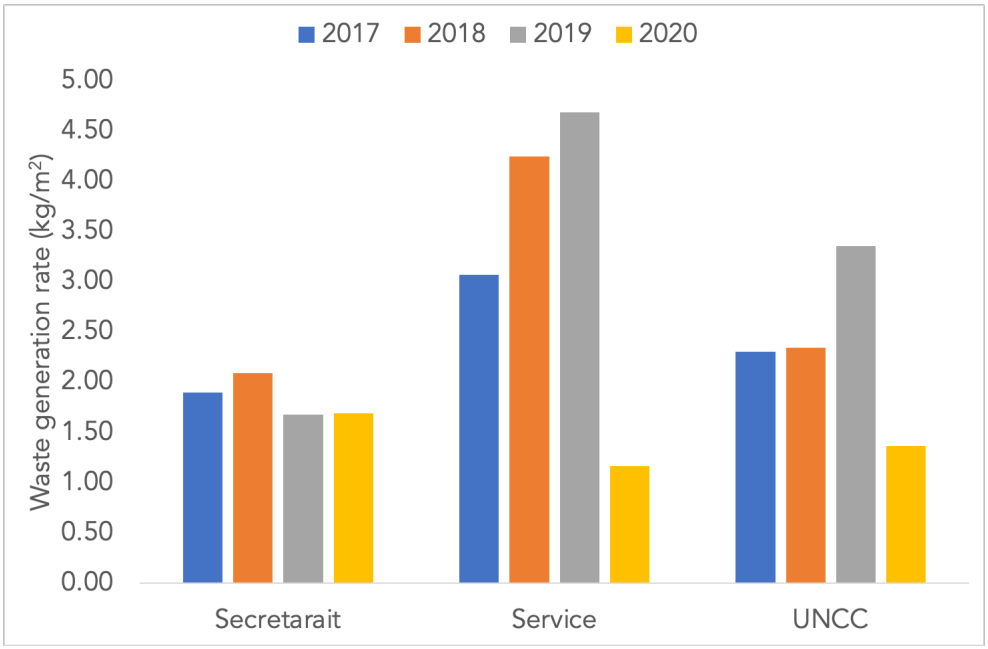

Figure 10 Waste generation rate of ESCAP Bangkok's buildings from 2017 – 2020

4.1.3 Waste disposal (Use)

Large portion of waste was disposed by two main approaches which are landfilling and recycling. Waste disposal was shifted over time from landfilling to recycling (Figure 11) which contributing more value to the waste as materials for productivity rather than sinking for its waste and emission.

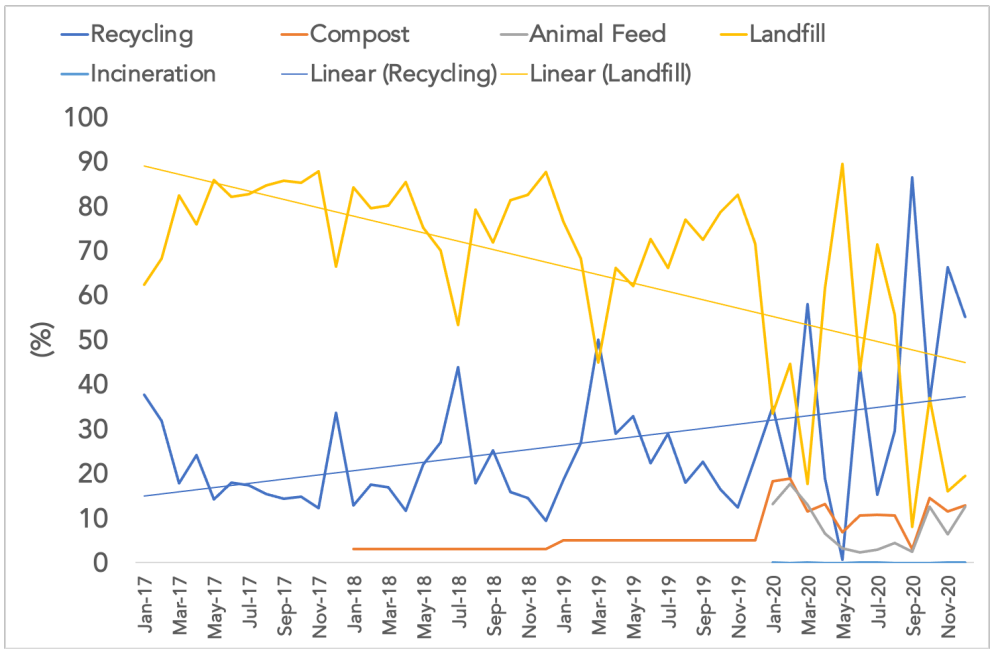

Figure 11 Over all use of waste produced at ESCAP Bangkok Compound from 2017 – 2020

From the Use Table, Figure 12 and 13 was plotted to illustrate proportion of waste utilized as material supplied to the economy (Greenish color) and in the other hand discarded as sink of environmental problems (Yellowish color). During 2017-2019, more than half of waste was discarded to landfill while it was used as valuable materials for almost 70% of total waste production in 2020. UNCC Building contributed the most to material sink as waste and its emission and large portion of waste generated at Secretariat Building was treated as valuable material by sending to recycling facilities.

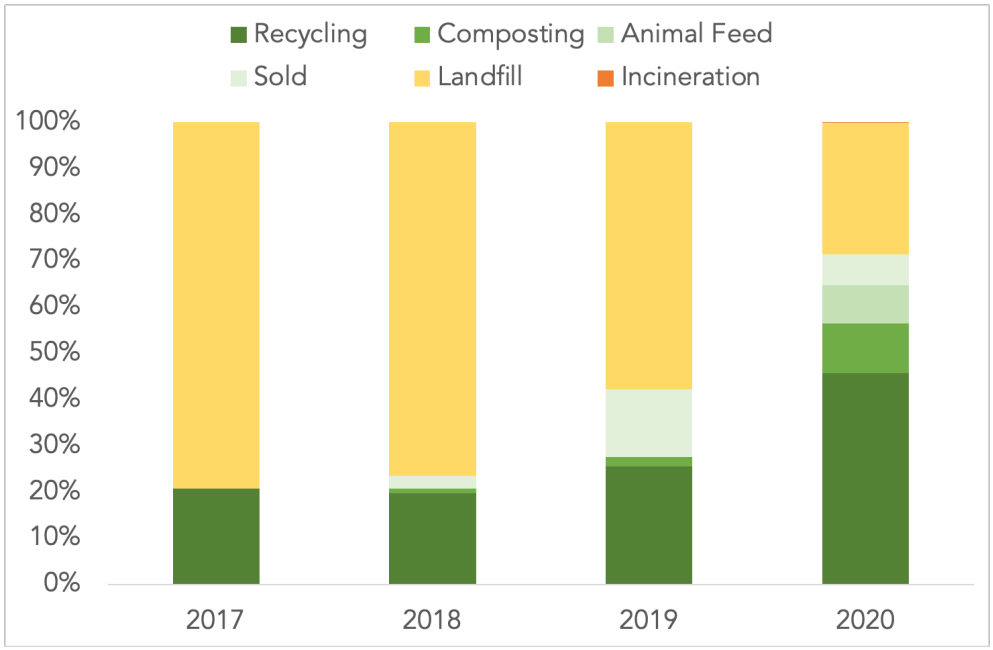

Figure 12 Portion of waste managed by various approaches from 2017 – 2020

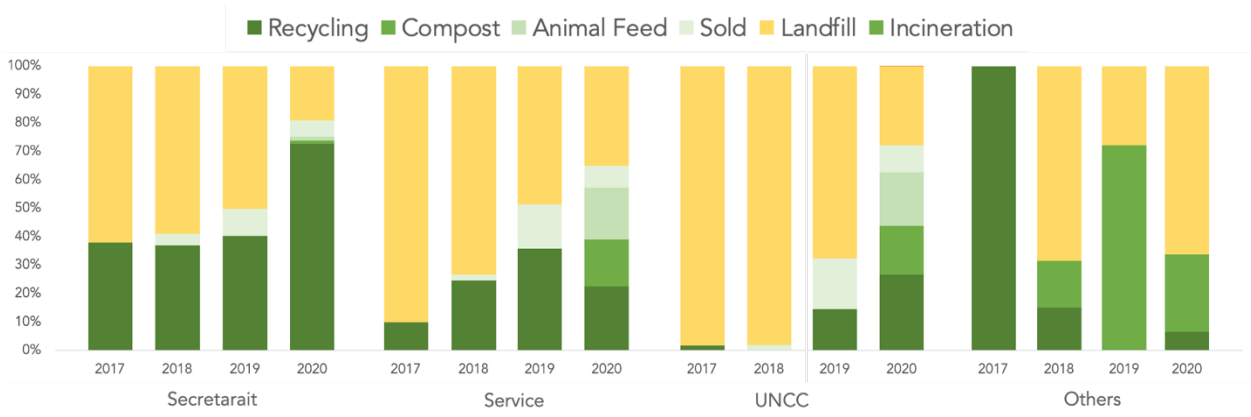

Figure 13 Portion of waste from different sources managed by various approached from 2017 – 2020

5 Cost analysis

5.1 Current waste management expenditure

In monetary terms, ESCAP has expenses for managing of waste especially in 2018 and 2020 where capital cost was for weight scale and refrigerated garbage storage and new recycling facility, respectively (Table 18). However, this cost was paid in order to lesser impact of waste to the environment by feeding them as materials flowing to the economic system. For sustainable waste management, life-cycle cost benefit should be analyzed to consider economic,

environment and social impacts of current waste management strategies and for considering alternative methods[9].

Table 18 waste management expenditure of ESCAP Bangkok Compound from 2017 - 2020

Items	Amount paid (THB)			
	2017	2018	2019	2020
Food waste				
Capital cost for the cool room (Weight scale and refrigerated garbage store		-1,134,665		
Operation cost; service fee for BMA	-72,000	-72,000	-72,000	-72,000
Maintenance cost; weight scale and refrigerated garbage store		-65,000	-65,000	-65,000
Recycle waste and other waste handling by PCS				
Capital cost; new recycling facilities construction				-1,062,441
Operation cost; service fee for PCS	-180,000	-180,000	-180,000	-350,472
Furniture and e-waste				
Expense; advertisement for auction		-53,100	-101,000	-42,000
Revenue; total proceeds from sale		662,977	463,000	534,000
Net cost	-252,000	-841,788	-45,000	-1,057.913

5.2 Managing food waste and utilize in ESCAP Bangkok Compound

Due to large amount of food waste, EMS team used to have ideas to manage food waste and utilize within the compound. Biogas plant used to be considered to convert food and organic waste to biogas providing directly to cooking stove in the restaurants. However, it requires technician and biogas estimated to produce was expected to be insufficient for consistency supply to the cooking facilities. Another concern was bad odor that could be unpleasant due to anaerobic digestion of the biogas tank. Alternative technology that could be possible for ESCAP is aerobic digestion tank. Recently, there is a simple innovative technology for aerobically digestion of food waste and garden waste developed by Mahidol University (Figure 14). It has less odor comparing with anaerobic digestion but the composting time is usually longer than anaerobic system. The digestion time is 2-3 months depending on size of waste fed in the tank. This simple technology could be possible to upscale for ESCAP. The cost of a small unit for 10 kg of waste daily is around 1,000 – 2,000 THB. It does not require skilled technician to operate. The product from digestion system could be utilized as soil improvement material and could possibly replace usage of chemical fertilizers.

[9] Lam et a., 2018. Life-cycle cost-benefit analysis on sustainable food waste management: The case of Hong Kong International Airport. Journal of Clean Production. 187: 751-762.

Figure 14 Aerobic digestion system for organic waste (Food waste and garden waste) digestion developed by Mahidol University[10]

6 Conclusions

Microscale waste account experiment at ESCAP Bangkok Compound was performed to consider whether it is a good tool for enhancing decision making in waste management system in a micro scale. Waste account through Physical Supply and Use Table could reveal certain areas of problem in waste management and highlight improvement of waste management efficiency due to the waste management strategy introduced in 2018. The physical supply and use data could obviously show integration of environment and economic of waste as valuable material. The waste generated has two different distinct destinations to become material for economic or to be sink of its environmental impacts. These two destinations is up to decision made for waste management strategy. Microscale waste account could be a powerful tools for managing waste of a small unit like buildings.

7. Recommendations

Information from the Physical Supply Table and the Use Table clearly shows that amount of waste generated by ESCAP Bangkok Compound was not effectively reduced by the waste management strategy implemented in mid-2018. Considering waste generation information of 2017 -2019, overall waste production tended to rise. Whilst, EMS was able to improve waste separation at sources as can be seen from decreasing in mixed waste amount and increasing in recyclable waste. Food waste remains in high portion comparing with other kind of waste which need to be prioritized because food waste could bring significant impact on the environment through its life time from production to disposal[11]. This is still need to be considered even though all of the food waste was sent back to the economy system through compost and animal feeding.

[10] https://www.channel.mahidol.ac.th/?page=view&id=1960

[11] Corrado et al, 2019. Food waste accounting methodologies: Challenges, opportunities and further advancements, Global Food Security 20: 93-100.

From the site survey, it was found that mixed waste could be reduced as mixed of waste in recycling trash bins was found which means source separation is needed to be strengthen. List of improvements that could strengthen efficient waste management are as follow;

- Strengthen food waste reduction throughout the process from food production to consumption by setting up regulations for food stores in the compound to reduce food waste production.
- Awareness raising campaign among staff for reducing their food waste production especially at Service and UNCC Building.
- Stronger and clearer communication of waste separation among staff and also provide brief information on waste practices in the ESCAP Compound to guests at their first arrival.
- Single-use plastic waste is still found in the ESCAP Compound even though it was banded from restaurants and coffee shop in the compound due to takeaway packaging from outside the compound. In this case, waste should be cleaned and separated by type of plastic before dumped into trash bins.
- Life-cycle cost benefit should be analyzed to consider economic, environment and social impacts of current waste management strategies and for considering alternative methods that could be possible to lesser impact to the environment.

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9. References

EMS Waste Management Strategy for the UN Bangkok Compound Report, ESCAP

https://unstats.un.org/unsd/envaccounting/seearev/seea_cf_final_en.pdf accessed on 27 April 2021

https://www.epa.gov/ghgreporting/ghgrp-waste accessed on 27 April 2021

Lam, C. M., Iris, K. M., Medel, F., Tsang, D. C., Hsu, S. C., & Poon, C. S. (2018). Life-cycle cost-benefit analysis on sustainable food waste management: The case of Hong Kong International Airport. *Journal of Cleaner Production*, *187*, 751-762.

https://www.channel.mahidol.ac.th/?page=view&id=1960 accessed on 27 April 2021

Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O. J., Hauser, H. E., van Holsteijn, F., ... & Sala, S. (2019). Food waste accounting methodologies: Challenges, opportunities, and further advancements. *Global food security*, *20*, 93-100.