Assessment of "Wasteaware" indicator and its application in New York City, Hilo (HI), and Cairo

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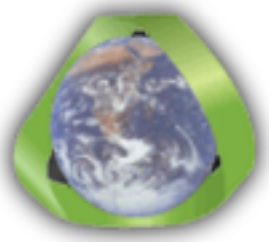

EXECUTIVE SUMMARY

The problem: One of the main challenges of sustainable waste management is the lack of reliable data, and robust indicators able to monitor the progress of cities. A novel methodology was developed by Dr. Wilson that divides several indicators of cities into several sub-indicators. The 'wasteaware' indicator provides an efficient method to compare solid waste management systems of different cities.

The aim of the research: The study uses the 'wasteaware' indicator on New York City, Hilo, and Cairo, which are three cities from the North and the South and are all representative in solid waste management in their own way. The aim of the study is to come up with a score for each sub-indicator.

The methodology used: the methodology to measure solid waste management in general has two aspects, which are the physical and governance. The well-developed methodology has several sub-indicators under the prior indicator, which makes the study more comprehensive and robust. On top of that, the methodology also evaluates the city's income level and population and assesses how those affect the performance of the solid waste management. The last step of the methodology is to put all the information of the three cities in one table and create a comparative radar diagram to visualize the performances of the three cities in each sub indicator.

The key findings: It is found that New York City and Hilo perform better than Cairo from a big picture. However, Cairo does a fairly good job in the physical aspect of solid waste management due to the informal waste collection group Zabbaleen, which does a significant job even better than New York City. However, Cairo scores relatively low in the governance aspect, since the city lacks a top to bottom strategy/policy to implement solid waste management, and is poorly organized in public awareness, financial sustainability, and the like. New York City and Hilo perform well in general, but New York City has a better performance in the governance aspect than in the physical aspect, whereas Hilo performs equally in the physical aspect and the governance aspect.

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First and foremost, I would like to extend a special thank you to Professor Nickolas J. Themelis. It was his support and dedication that made it possibly happen, none of this would have been accomplished if it weren't for his guidance. I would also like to acknowledge the support of Professor Athanasios Bourtsalas, who gave me precious advice and thoughtful opinions along the way. It was his patience and commitment that made this thesis successful. Last but not the least, I would like to thank my fellow classmates for offering me assistance during the process. I genuinely appreciate the cooperation and collaboration.

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1. Introduction

Standing on the frontier of solid waste management, cities play an extremely important role of managing their waste. Everyday, urban wastes are generated from residential and commercial locations, and if they were not dealt promptly and properly, they would damage our cities economically and environmentally. Waste management is usually a function of local government, and is often a city's largest budget item.[1] However, it is not just the government's responsibility to cope with solid waste, every individual and community should be active in promoting solid waste management.

For solid waste management, there is a hierarchy that ranks the most preferable way to address solid waste. Tier one is avoidance, which includes waste reduction and source separation, followed by reuse and recycle. Tier three is energy recovery, which is that waste that cannot be prevented or recycled can be combusted with energy recovery. The last tier is landfilling or incineration without energy recovery.[2]

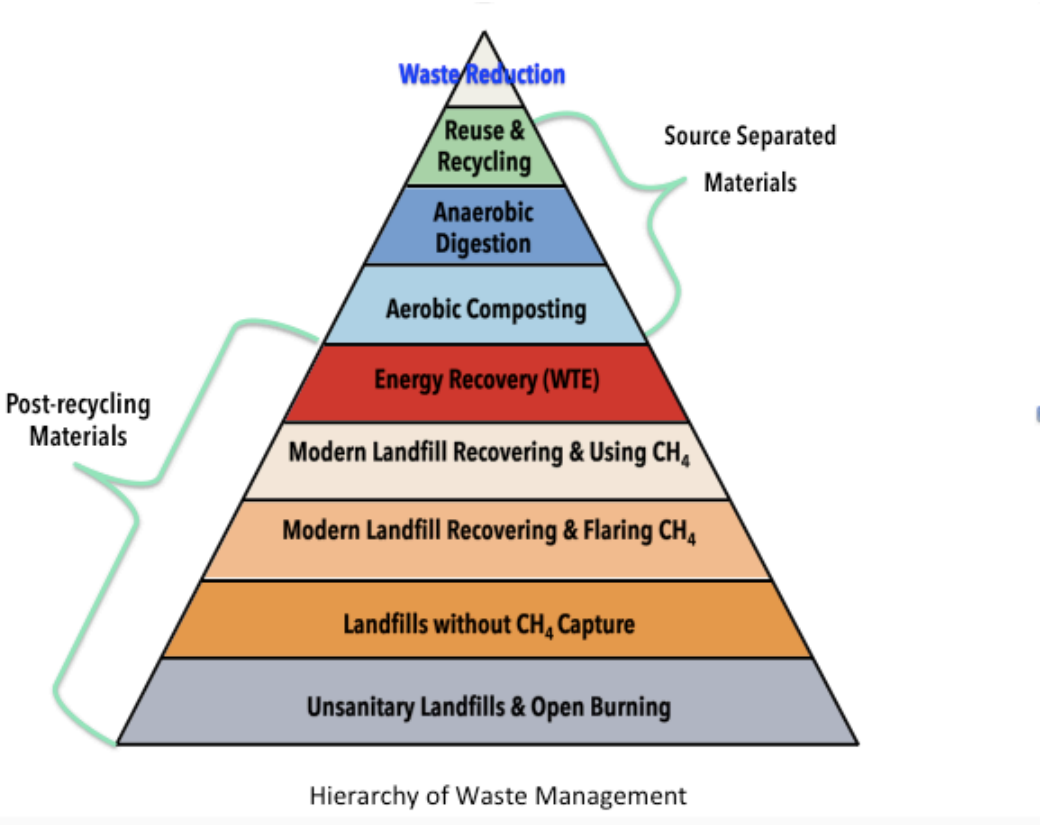

Fig. 1. The hierarchy of solid waste management

2. An overview of the Wasteaware indicators metrics

[1] http://www.columbia.edu/~sc32/documents/ALEP%20Waste%20Managent%20FINAL.pdf
[2]https://waste.zendesk.com/hc/en-us/articles/211674068-What-is-the-solid-waste-management-hierarchy-

2.1 Integrated Sustainable Waste Management (ISWM) framework - qualitative and quantitative

While solid waste management is a big issue, there is a major problem in international solid waste management, which is the lack of data and the lack of consistent data to allow comparison between cities. Based on the pioneering work for UN-Habitat's solid waste management in the World's cities, Professor David Wilson from Imperial College London introduced the Integrated Sustainable Waste Management (ISWM) framework to benchmark a city's performance in solid waste management.[3] The framework can be applied both in North and South cities, enabling observation of comparison among cities with tremendous difference.

The framework comprises two components, physical and governance, which can also be stated as quantitative indicators and qualitative indicators. The first component includes collection, recycling and disposal; the second component includes inclusivity; financial sustainability; and sound institutions and proactive policies. The indicators are easy to apply, and by looking into each criterion of waste management in each city, Professor David Wilson aimed to study the ISWM performance of cities with different economies and policies.

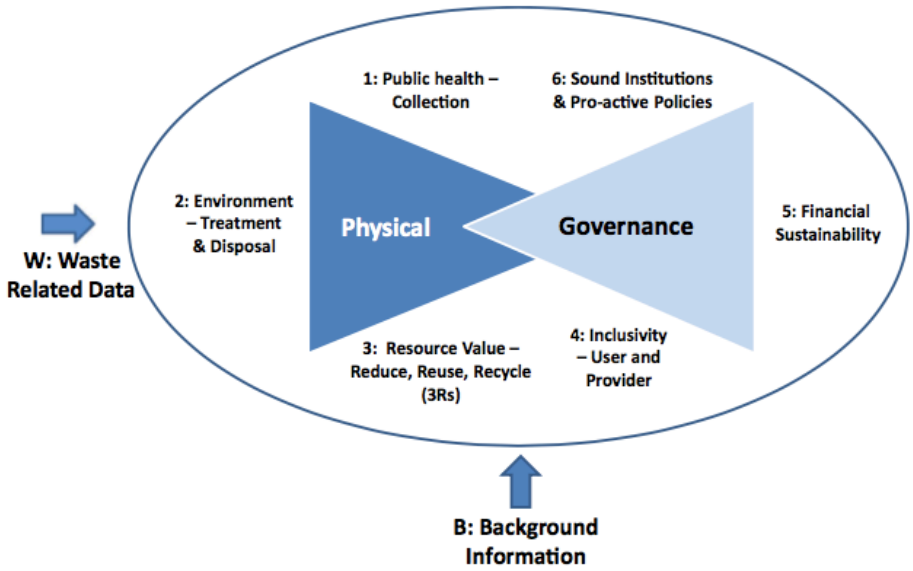

Fig. 2. The Integrated Sustainable Waste Management (ISWM) framework

[3] 'Wasteaware' benchmark indicators for integrated sustainable waste management in cities

2.2 The importance of the development of the metrics

The goal of the Wasteaware ISWM benchmark indicators is to use existing data to provide an overview of cities' solid waste management performance. Therefore, in order to be more comprehensive, the metrics has been revised, in which each component should be as detailed as possible to cover the basic criteria in solid waste management. For example, component 3 includes materials recycling but not energy recovery.

In addition, it is more visualized for the information user if the indicators are quantified; as a result, resulting performances have been score with a range, and each range has been coded with a different color just to give information users a rapid visual assessment. For the low range 0–20%, it is coded as red; low/medium range 21–40% is coded red-orange; medium range 41–60% is coded orange; medium/high range 61–80% is coded amber-green; and high range 81–100% is coded green.

After being revised, the Wasteaware ISWM benchmark indicators have been applied to five cities across the world, which are Monrovia, Liberia, Maputo, Mozambique, Lahore, Pakistan, Guadalajara, Mexico, and Belfast, and Northern Island. It covers different levels in income, population, waste generation, etc. In this application, the color orange is also shaded, to make the color more easily readable even when printed in black and white.[4]

[4] Ibid.

Table 1: Summary results for the Wasteaware ISWM benchmark indicators in five case study cities[5]

No	Category	Indicator	Results				
City			Monrovia	Maputo	Lahore	Guadalajara	Belfast
Country			Liberia	Mozambique	Pakistan	Mexico	UK - Northern Ireland
Background information on the city							
B1	Country income level	World Bank income category	Low	Low	Lower-middle	Upper-Middle	High
		GNI per capita	$370	$450	$1,140	$9,640	$38,250
B2	Population	Total population of the city	1,021,768	1,131,149	8,160,000	4,664,924	218,000 City only
B3	Waste generation	MSW generation (tonnes/year)	287,000	508,000	1,916,000	2,000,000	149,000
Key Waste-related data							
W1	Waste per capita	MSW per capita (kg per year)	*230*	*316*	*219*	*440*	*683*
W2	Waste composition:		*4 key fractions - as % of total waste generated*				
W2.1	Organic	Organics (food and green wastes)	*50%*	*65%*	*65%*	*53%*	*35.1%*
W2.2	Paper	Paper and card	*5%*	*8.5%*	*2%*	*9%*	*21%*
W2.3	Plastics	Plastics	*13%*	*8%*	*12%*	*10%*	*6%*
W2.4	Metals	Metals	*2%*	*2.5%*	*0.1%*	*1.4%*	*3.3%*
Physical Components							
1.1	Public health – waste collection	Waste collection coverage	*33% (L)*	*82% (M)*	*77% (M)*	*95% (M/H)*	*100% (H)*
1.2		Waste captured by the system	*30% (L)*	*75% (M)*	*80% (M)*	*95% (M/H)*	*98% (M/H)*
1C		Quality of waste collection service	*M (58%)*	*M/H (63%)*	*M (58%)*	*M (50%)*	*H (100%)*
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	*70% (L/M)*	*0% (L)*	*8% (L)*	*95% (H)*	*98% (H)*
2E		Degree of environmental protection in waste treatment and disposal	*M (45%)*	*L/M (21%)*	*L/M (37%)*	*M (60%)*	*H (100%)*
3	Resource management – reduce, reuse and recycle	Recycling rate	*8% (L)*	*<5% (L)*	*35% (M)*	*12% (L/M)*	*35% (M)*
3R		Quality of 3Rs – Reduce, reuse, recycle – provision	*L/M (33%)*	*L/M (29%)*	*L (17%)*	*L (13%)*	*H (83%)*
Governance Factors							
4U	Inclusivity	User inclusivity	*M/H (67%)*	*M (46%)*	*L/M (37%)*	*M (46%)*	*M/H (79%)*
4P		Provider inclusivity	*M (60%)*	*M (60%)*	*M (50%)*	*L/M (40%)*	*M/H (80%)*
5F	Financial sustainability	Financial sustainability	*M (46%)*	*M/H (67%)*	*M (54%)*	*L/M (40%)*	*H (100%)*
6N	Sound institutions, proactive policies	Adequacy of national SWM framework	*L (17%)*	*L/M (29%)*	*L/M (29%)*	*M/H (67%)*	*M/H (66%)*
6L		Local institutional coherence	*M (46%)*	*M (58%)*	*M/H (62%)*	*M (46%)*	*H (100%)*

Besides, the revised metrics adds a radar diagram for each city at the end, to show a city's performance in solid waste management in a more visualized way. Each

[5] Ibid.

diagram has 6 indicators, corresponding to the 6 indicators in the revised metrics. One indicator takes one point, 6 indicators have 6 points, and eventually forms an area. In the end, whichever city has the largest area has the best performance in solid waste management comprehensively.

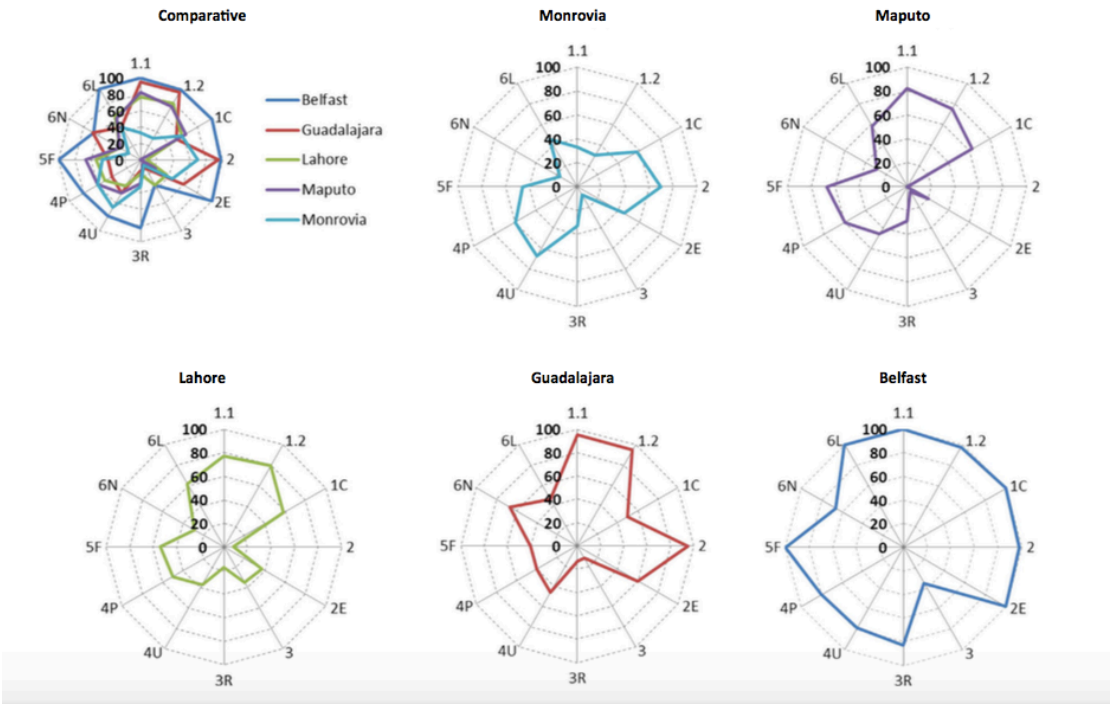

Fig. 3. Radar diagrams summarizing the 12 Wasteaware ISWM benchmark indicators for the five cities[6]

According to the radar diagrams, Monrovia, Liberia, Maputo, Mozambique, and Lahore, Pakistan are performing relatively poorly in solid waste management, while Guadalajara, Mexico, and Belfast, and Northern Island cover a larger area in the radar diagrams, indicating a better performance in solid waste management.

2.3 Thesis overview

Having been inspired by the Wasteaware ISWM benchmark metrics, this thesis dedicates to apply the well-developed metrics on three international cities. The goal of thesis is to apply the metrics on three international cities around the world, for different cities have different population, income level, waste generation, etc. Based on that, the metrics can be applied on each of them even there are differences. This

[6] Ibid.

can, on the other hand, prove how generic the metrics is and can be used for different scenarios, yet the quantitative results can still be drawn under the same criteria.

The thesis chose New York City, NY, Hilo, Hawaii, and Cairo, Egypt as the three case studies because each case is unique in its own way. It is representative as these three cities have a different background in population, resident income, etc. Among these, the case of Hilo, Hawaii is particularly symbolic. The income level of the residents in Hawaii ranks top5 across the country, yet since it has limited resources since the landscape of islands. However, Hawaii is progressive in advocating renewable energy. Not to mention the ubiquitous windmills, Hilo alone has waste to energy plants, which is not common in the country. Cairo is also an interesting case, since it produces less waste than a mega-city is supposed to generate, and it is mostly because of the informal waste collection services called the Zabbaleen.[7] Cairo has 11 million more population than New York City, yet it produces 9 millions tons of waste.[8]

Following the Wasteaware ISWM benchmark metrics, the thesis will introduce the general information of each city, including major parameters such as the population, the income level, the amount of waste generation, etc., together with figures and tables needed to illustrate the information. Subsequently, the performance in each indicator will be compared among these three cities. At the point, the quantified performance will only be showed in low, medium, and high three rough levels, and each level will be shown with color black, green, and red respectively. Ultimately, all the indicators and factors will be put in a final table, and the assessment will be given, coupled with the visualized radar diagram. Expectantly, information users can gain the information they need at a glance by reading the tables and diagrams, which is the objective of the thesis.

3. Application - comparing cities

3.1 New York City

New York City has about an eight million population and generates 14 million tons of waste and recyclables per year (2014). New York city has seven waste collection zones, which are Manhattan, Bronx, Brooklyn North, Brooklyn South,

[7] https://www.ecomena.org/garbage-cairo/
[8] https://www.ecomena.org/tag/waste-management-in-cairo/

Queens West, Queens East, Staten Island. These seven collection zones can also be divided into 59 community district zones.

Before the trash goes out to the curb for pickup, the law of New York City requires it to be separated into three categories: paper, metal/glass/plastic, or mixed solid waste (non-recyclable garbage). Each type of waste is typically collected separately and follows a different path to its ultimate destination, often with several intermediate stops along the way.

Each day, New York's public garbage trucks collect nearly 7,000[9] tons of residential mixed solid waste. After finishing their routes, most of these trucks will deposit the garbage in one of New York's waste transfer stations located throughout the city. From there, the garbage will eventually be loaded on to a barge or train and carried as far as 600 miles to its final stop. For most of New York's mixed solid waste (about 80% of it by tonnage), this last stop will be a landfill. The remaining 20% will end up at a waste-to-energy plant, where it will be incinerated and converted into energy.[10]

Paper and metal/glass/plastic waste is brought to one of the City's recyclables handling and recovery facilities, specialized plants, which separate and sort the recyclable materials. From this point, the journey of New York's recyclable waste splits apart into many possible directions. Some of it will be sold to local raw material processors (paper mills, smelters etc.), some will be exported overseas, most often 6,000 or 7,000 miles to China or India, some will be sold through intermediary waste brokers, and some specific items will be separated and sold directly to their end-users (for example, crates to a Coca-Cola bottling plant, or beer kegs to Anheuser-Busch).

[9] https://dsny.cityofnewyork.us/wp-content/uploads/2018/04/2017-Waste-Characterization-Study.pdf
[10] Ibid.

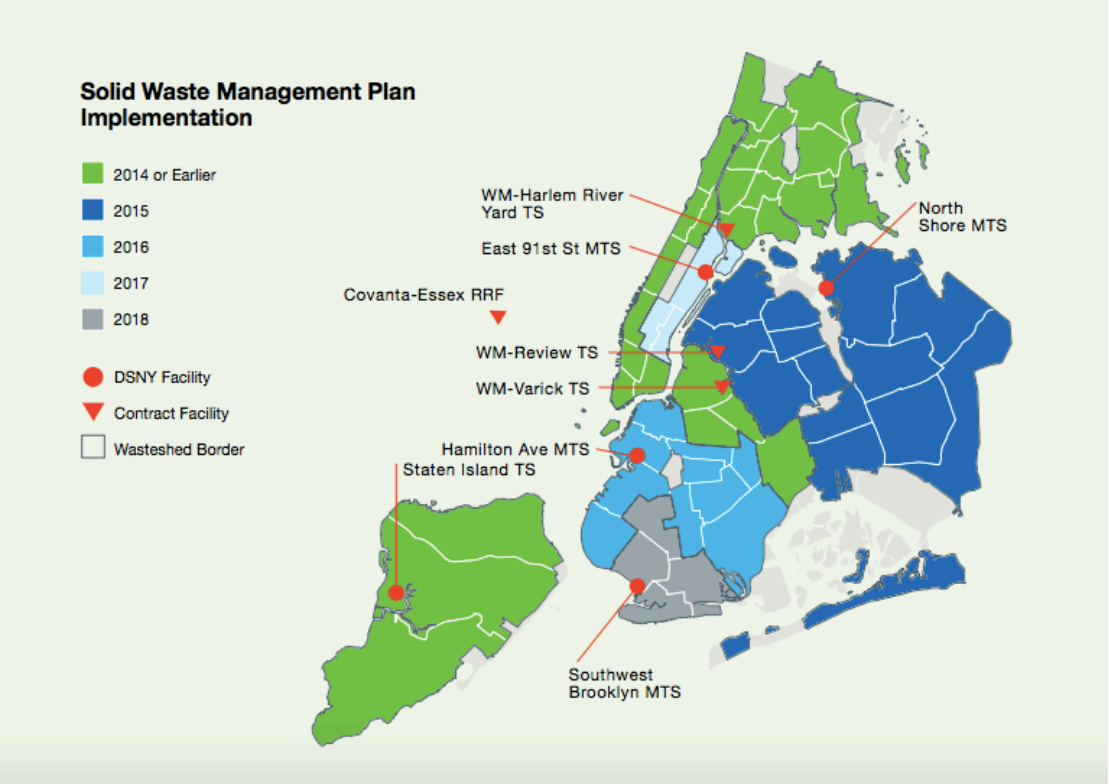

Fig. 4. The Solid Waste Management Plan Implementation of New York City by 2018

Over time, the City improved waste management operations, closing its incinerators and landfills and creating the nation's largest mandatory recycling program.

In 2006, the City Council ratified a Comprehensive Solid Waste Management Plan (SWMP), which aimed to establish a cost-effective, sustainable and environmentally sound system for managing the city's waste. The foundation of the City's recycling attempt is to collect paper, metal, glass and plastic.

During Mayor Michael Bloomberg's term, he implemented the first sustainability plan of New York City: PlaNYC 2030, which dedicates to achieve the environmental goals of the city. The policy was not just seeking for sustainability, but the growth of the city, resiliency, and equity, etc.[11] Apparently, solid waste management was a crucial part of the plan.

Below are some highlights of PlaNYC 2030 plan:

- Expand the New York City Organics program to serve all New Yorkers by the end of 2018

[11] http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf

- Expand the New York City Organics program by increasing curbside organics collection and convenient local drop-off sites.
- Develop additional organics sorting and processing capacity in New York City and the region
- Process 250 tons of food waste per day at the waste water treatment plants and assess long-term feasibility of scaling up processing of organic food waste[12]
- Expand community composting opportunities in all five boroughs
- Enhance the city's curbside recycling program by offering single-stream recycling by 2020
- Create and expand markets for recycled materials
- Reduce the use of plastic bags and other non-compostable waste
- Expand opportunities to reuse and recycle textiles and electronic waste
- Encourage periodic waste audits for large commercial buildings

Because of the great emphasis on organics, the plan was able to set up curbside collection, drop off sites, and the like. The figure below shows how much the organic programs have covered New York City.

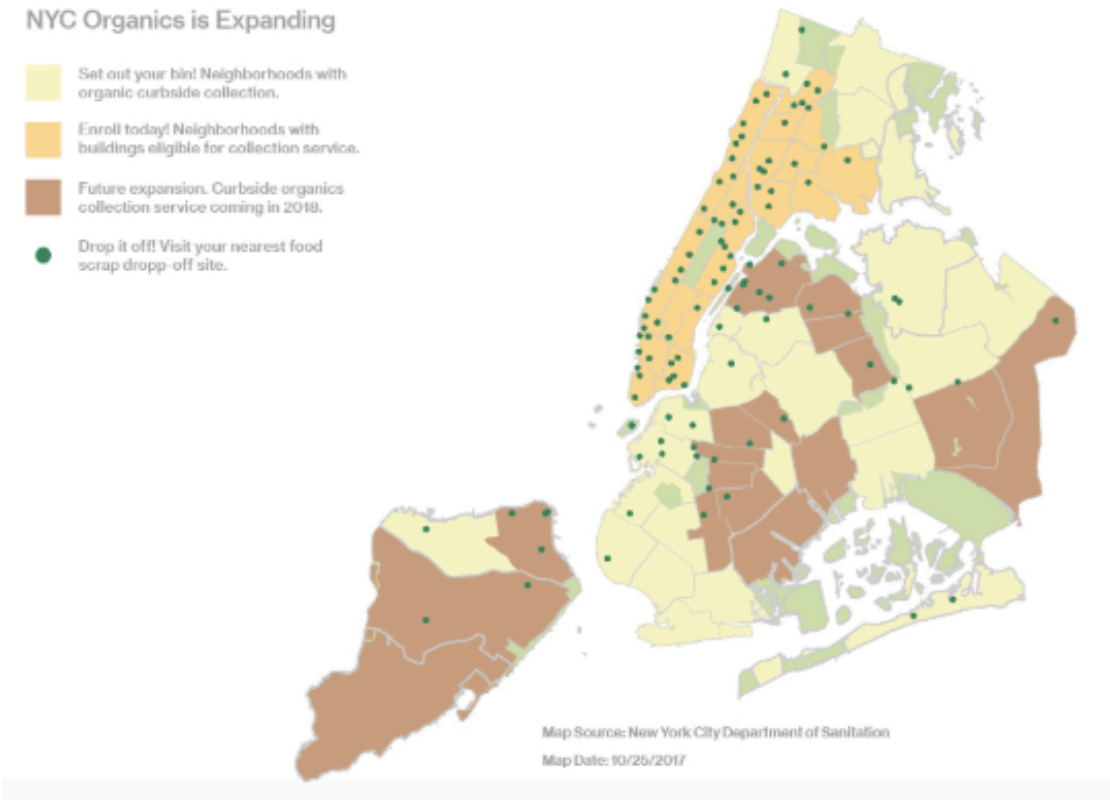

Fig. 5. Organics Programs in New York City by 2017

[12] Ibid.

In April 2015, New York City Mayor Bill de Blasio declared the rebranding of PlaNYC to One NYC. The rebranded plan retained the ambitious goal of zero waste by 2030, meaning no waste is sent to landfills. The volume of New York City Department of Sanitation collected refuse (excluding material collected for reuse/recycling) reduced from approximately 3.6M tons in 2005 to 3,213,400 tons in 2017. Besides, The city always has the curbside program, which collects paper, metal, glass and plastic, the curbside and containerized diversion rate went from 15.4 % in 2014 to 17.4% in 2017. Diversion rate is tonnage diverted divided by the sum of tonnage diverted and disposed. Disposed materials are sent via transfer stations to landfills or waste-to-energy facilities outside of New York City. Diverted materials are sent to reuse or recycling facilities inside or outside of New York City.

In order to meet the PlaNYC 2030 goal, the city set up multiple programs and received correspondingly positive feedback. The e-cycle New York City program, which features in reducing electronic waste, has made the progress of collecting 3,800 tons of electronic waste from 11,555 buildings.[13] What is more staggering is more than 15 million pounds of electronic waste is diverted for recycling since 2015.[14] By the end of 2019, the program will extend to Bronx and cover the whole New York City area by then.

3.2 Hilo, Hawaii

Waste disposal has always been a challenge for islands, and Hilo is no exception. Hilo is the largest city in Hawaii County, which encompasses the Island of Hawaii in the State of Hawaii. Hilo has a rubbish problem, and it becomes more of an issue. With more and more rubbish going into landfill, Hilo has to come up with a solution. With a population of about 43,000, Hilo generates 246,000 tons (year of 2016) every year.

[13] http://www.waste.exposed/
[14] https://onenyc.cityofnewyork.us/goals/zero-waste/

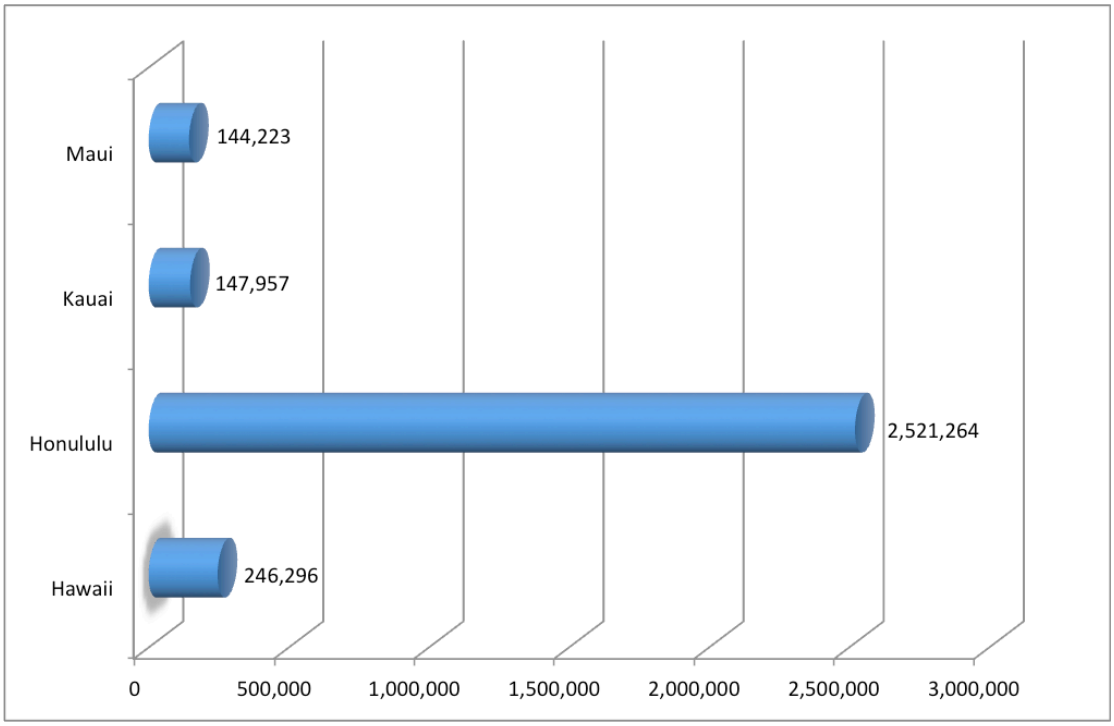

Fig. 6. Solid waste generation in main islands in Hawaii (unit: tons)

In the 246,000 tons of waste generation, organics accounts for 32.9 %, making the best part of the waste generation, followed by paper, metal, and construction & demolition waste. In the aspect of waste composition, Hawaii is a lot like New York City. According to the statistics in 2017, organics accounts for the largest part of solid waste in New York City, which is 34%, also followed by paper and metal, which both makes up for 17% of the solid waste.

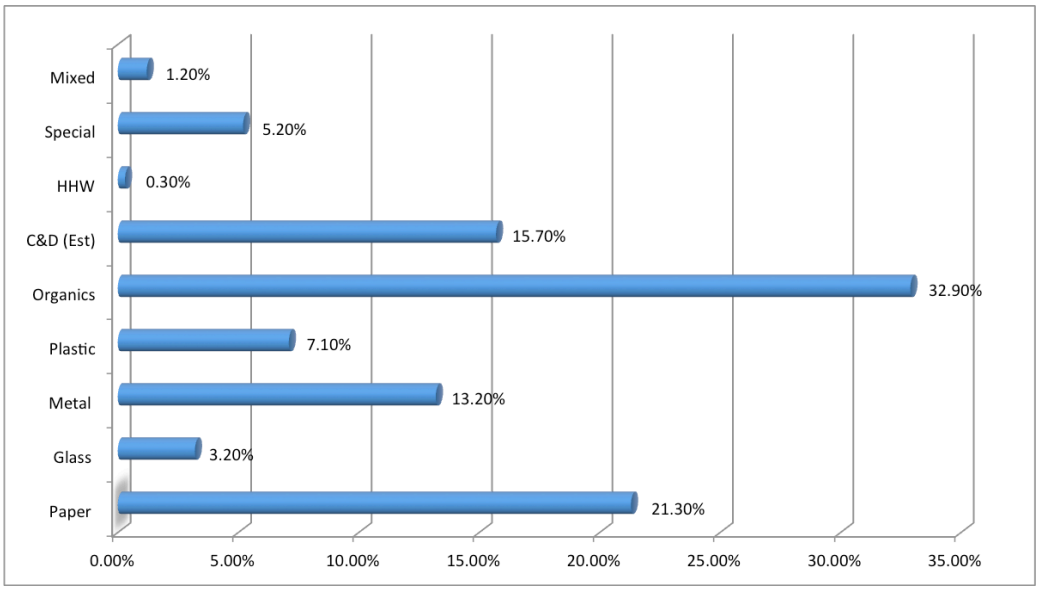

Fig. 7. Hilo Waste Stream Composition Estimates (2001)

However, metal, organics, and household hazardous waste make up the largest percentage in being recycled. Plastic has the least percentage for being recycled, the biggest reason is that locating in the Pacific Ocean, Hawaii has a lot of plastics coming from the ocean to the shore that cannot be dealt with promptly.[15]

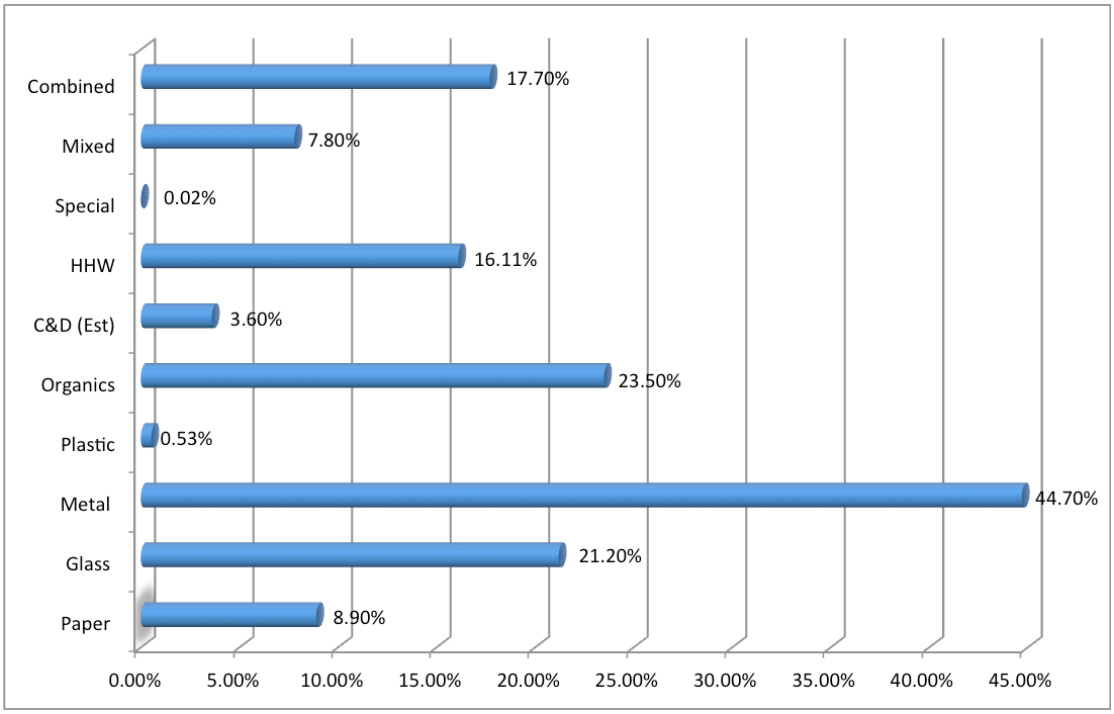

Fig. 8. Percentage of Discards Recycled (2004)

The amount of waste going to disposal in Hilo is very small compared to that of going to make waste-to-energy incineration plants. There may be a greater demand for the incineration of recyclable materials (such as plastics, wood and paper) than in other areas that have chosen incineration as a sustainable and affordable disposal option. Because as it is shown in the above figure, there are not many plastics, paper, glass being recycled compared to metal.

In addition, recycling makes materials available as inexpensive feedstock for new and often innovative local industries. For example, recycled plastic lumber can be produced in relatively small-scale facilities from discarded plastic already on the island. Since Hilo has a great amount of rainfall year round and recycled plastic lumber does not rot, it is ideal for the wood lumber to have a longer lifespan.[16]

[15] http://www.hawaiizerowaste.org/site-content/uploads/3-14-09-Hawaii_Zero_Waste_Plan.doc.pdf
[16] http://www.kohalacenter.org/pdf/waste_mgmt.pdf

The Hawai‘i County Council proposed to develop a plan based on the concepts of Zero Waste in October 2007. The goal of Zero Waste is to find better uses for the materials that residents usually take to the landfill and reduce the as close to zero as possible. Besides, the proposal dedicates to keep green waste and compostable items out of the landfill, creating more reuse opportunities for clothing, household goods, and building supplies, reducing packaging and transport costs by purchasing food from local farmers, and making it more convenient for island residents to properly dispose of hazardous and electronic waste.[17] Another goal of the proposal is to bring the key stakeholders together - such as recyclers, haulers, farmers, and associated businesses - to express their opinion for how to better manage the solid waste generation in Hilo. Zero Waste is a forward-thinking proposal, not only because it creates advanced way to cope with solid waste, but also offers a platform for key stakeholders to contribute their ideas.

3.3 Cairo, Egypt

Cairo is the capital of Egypt. The city has a population of 19,500,000. Like many other megacities, Cairo suffers from high levels of pollution and traffic. At the same time, solid waste management is also a huge challenge for Cairo. The city produces over 15,000 tons of solid waste every day, which is about 5,475,000 tons a year.[18] Waste collection services in Cairo are provided by both formal and informal sectors. Formal public sector, such as the Cairo Cleanliness and Beautification Authority (CCBA), comes from local authorities,[19] whereas the main informal waste collection services is made of traditional garbage collectors (the Zabbaleen), since informally the waste collection services are subcontracted to those garbage collectors, local private companies, multinational companies or NGOs.[20]

About 60% (2,880 tons/day) of the solid waste is managed by formal as well as informal waste collection, and the Zabbaleen contributes for the most of it.[21] Over years, the Zabbaleen have improved their methods of classifying garbage and advanced the waste management system. 60% is some figure that is not common

[17] http://www.hawaiizerowaste.org/site-content/uploads/3-14-09-Hawaii_Zero_Waste_Plan.doc.pdf
[18] https://www.ecomena.org/garbage-cairo/
[19] http://cairoclimatetalks.net/sites/default/files/EN%20Annual%20Report%20on%20Waste%20in%20Egypt_2013.pdf
[20] https://planbleu.org/sites/default/files/publications/gestion_dechets_egypte_en.pdf
[21] Ibid.

achieved just by sorting waste, even in the western world. Therefore, Cairo performs better in this regard compared to New York City; even Cairo has a bigger population. Only about 3% of the total waste, currently transported to the composting plants, is sorted out as recyclable (this amounts to about 4,320 tons/year).

Waste collected in Cairo respectively:

- waste collected by the CCBA 3600 tons/ year,
- waste collected by private collectors 3600 tons/ year,
- waste remaining for casual collection 1800 tons/ year.

Fig. 9. A group of Zabbaleen boys at Muqattam Village

Organics makes up over half of the solid waste composition in Cairo. With an average individual income of $19324 per year, Cairo is considered as low-income city. It is almost a normalcy that low-income countries have the highest proportion of organic waste, while paper, plastics, and other dry materials make up the highest proportion of solid waste in high-income countries.

Composting Plants		No. of Fina Disposal Sites		
No. of Plants/Location	Efficiency (%)	Uncontrolled Dump	Controlled Dumpsite	Landfill
3/Katammia	45	-	2	2
1/Al-Salam city	45			
2/15th Might city	75			
2/Abo-Rawash	65% for a plant			

Fig. 10. The number of composting plants and their efficiencies in Cairo

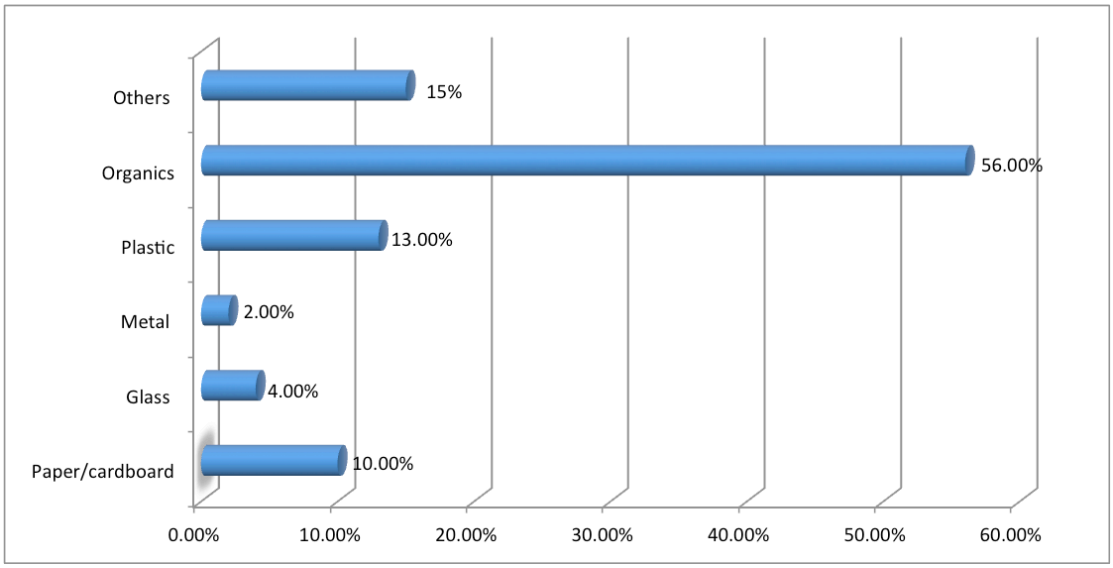

Fig. 11. Municipal solid waste composition in Cairo (2012)

At the same time, the dumping sites in the city are the big issue. The Egyptian government enacted Presidential Decree No. 86 in 2010, which regulates the closure of existing dumping sites and landfills at Greater Cairo, and allocating five new sites outside the belt of Greater Cairo.[22]

Table 2: Open dump Sites in Cairo

Open dump sites	Waste Inflow (tons/day)	Life Expectancy (in years)	Starting Date
Quatamia	1000	10	1989
Nasr City	800	15	1991
Es-Salam	700	3	1993
Al- Nahda	700	3	1993
Al Wafa wa Al Amal	500	10	1993
Total	3700		

[22]http://cairoclimatetalks.net/sites/default/files/EN%20Annual%20Report%20on%20Waste%20in%20Egypt_2013.pdf

4. Sub indicators summary

Based on the prior research and further information on these three international cities, each sub indicator is listed below. In this section, the descriptions of each criterion in each sub indicator are replaced by the rough comparison of the three cities. Red represents the lowest level, green represents the medium level, and black represents the lowest level. Sometimes, one same color shows twice in the same row because two cities display about the same level of solid waste performance.

Table 3: Indicator 1C: Quality of the waste collection and street cleaning service

No.	Criterion	Comparison		
		New York City	Hilo	Cairo
1C.1	Appearance of waste collection points			
1C.2	Effectiveness of street cleaning			
1C.3	Effectiveness of collection in low income districts			
1C.4	Efficiency and effectiveness of waste transport			
1C.5	Appropriateness of service planning and monitoring			
1C.6	Health and safety of collection workers			

Table 4: Indicator 2E: Degree of environmental protection in waste treatment and disposal

No.	Criterion	Comparison		
		New York City	Hilo	Cairo
2E.1	Degree of control over waste reception and general site			

	management			
2E.2	Degree of control over waste treatment and disposal			
2E.3	Degree of monitoring and verification of environmental controls			
2E.4	Efficiency of energy generation and use (used for energy recovery facilities only)			
2E.5	Degree of technical competence in the planning, management and operation of treatment and disposal			
2E.6	Occupational health and safety			

Table 5: Indicator 3R: Quality of 3Rs – reduce, reuse, recycle – provision

No.	Criterion	Comparison		
		New York City	Hilo	Cairo
3R.1	Source separation of 'dry recyclables'			
3R.2	Quality of recycled organic materials			
3R.3	Focus on the top levels of the waste hierarchy			
3R.4	Integration of community and/or informal recycling sector with the formal SWM system			
3R.5	Environmental protection in recycling			
3R.6	Occupational health and safety			

Table 6: Indicators 4U and 4P: Degree of user and provider inclusivity

4U - Degree of user inclusivity	4P - Degree of provider inclusivity

No.	Criterion	Comparison			No.	Criterion	Comparison		
		New York City	Hilo	Cairo			New York City	Hilo	Cairo
4U.1	Equity of service provision				4P.1	Legal framework			
4U.2	The right to be heard				4P.2	Representation of the private sector			
4U.3	Level of public involvement				4P.3	Role of the 'informal' and community sector			
4U.4	Public feedback mechanism				4P.4	The balance of public vs. private sector interests in delivering services			
4U.5	Public education and awareness				4P.5	Bid processes			
4U.6	Effectiveness in achieving behavior change				4P.6				

Table 7: Indicator 5F: Degree of financial sustainability

No.	Criterion	Comparison		
		New York City	Hilo	Cairo
5F.1	Cost accounting			
5F.2	Coverage of the available budget			
5F.3	Local cost recovery – from			

	households			
5F.4	Affordability of user charges			
5F.5	Pricing of disposal			
5F.6	Access to capital for investment			

Table 8: Indicators for sound institutions and proactive policies: 6N – National framework and 6L – Local institutions

6N - Adequacy of national framework for solid waste management (SWM)					6L - Degree of local institutional coherence				
No.	Criterion	Comparison			No.	Criterion	Comparison		
		New York City	Hilo	Cairo			New York City	Hilo	Cairo
6N.1	Legislation and regulations				6L.1	Organizational structure/coherence			
6N.2	Strategy/policy				6L.2	Institutional capacity			
6N.3	Guidelines and implementation procedures				6L.3	City-wide SWM strategy and plan			
6N.4	National institution responsible for implementing SWM policy				6L.4	Availability and quality of SWM data			
6N.5	Regulatory control/enforcement				6L.5	Management, control and supervision of service delivery			
6N.6	Extended producer responsibility (EPR) or Product				6L.6	Inter-municipal (or regional) cooperation			

	Stewardship (PS)								

As showed above, Cairo performs well in collecting and sorting the waste due to the Zabbaleen group, not only in appropriateness, but also effectiveness. In contrast, Cairo needs to improve the health and safety of the collections workers. In addition, Cairo performs poorly in its environmental protection, such as taking control of producing as least waste as possible. As for the indicators in the governance aspect, Cairo truly needs to improve its financial sustainability. Cairo, in general, is good at informal waste collection, but it needs more policy-making, education, and the like to increase the awareness of the public in order to implement potential proposals efficiently.

New York City, as comparatively high-income city, has less of an issue dealing with its organic waste, as well as in the governance aspect. Not to mention in financial sustainability, New York City also performs great in achieving behavior change and pubic feedback mechanism. As for legislations and regulations, policy and strategy, and implementation procedures, New York City is also taking the lead among the three cities.

5. Summary and conclusion

Based on the above tables about sub indicators, the thesis is also dedicated to develop radar diagrams to show audience a visualized image of how three cities perform comparatively in solid waste management. In this metrics, three colors in the above tables represent three levels of points. Black is 1 point, green is 2 points, and red is 3 points. With this methodology, the thesis was able to create radar diagrams by using quantitative figures through rough comparison.

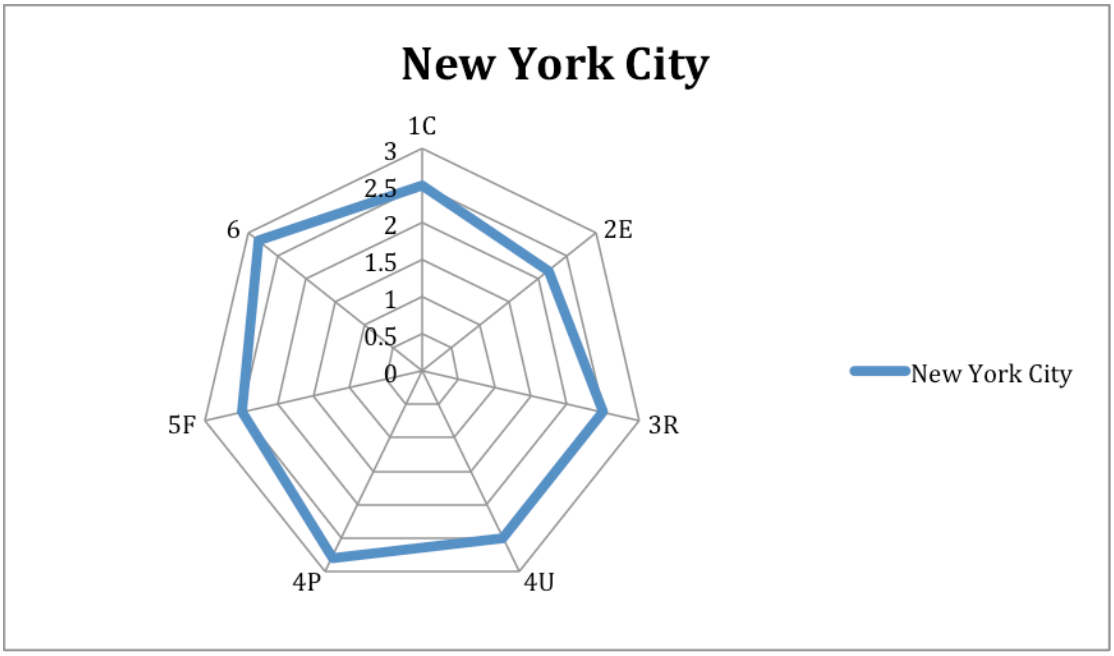

Fig. 12. Radar diagram summarizing the 6 Wasteaware ISWM benchmark indicators for New York City

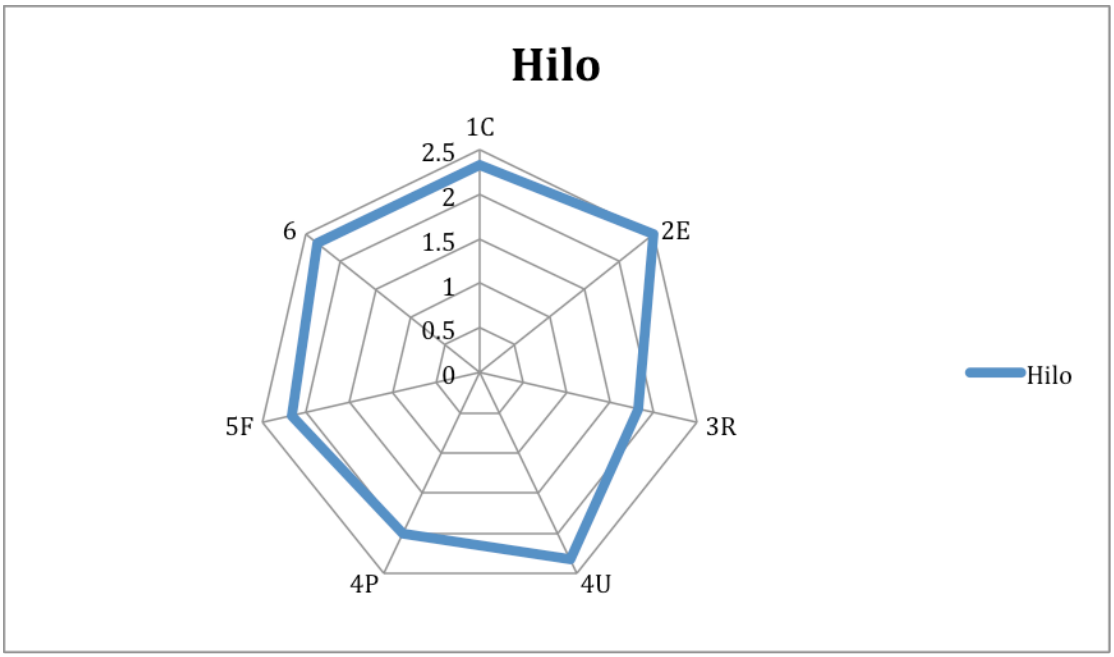

Fig. 13. Radar diagram summarizing the 6 Wasteaware ISWM benchmark indicators for Hilo

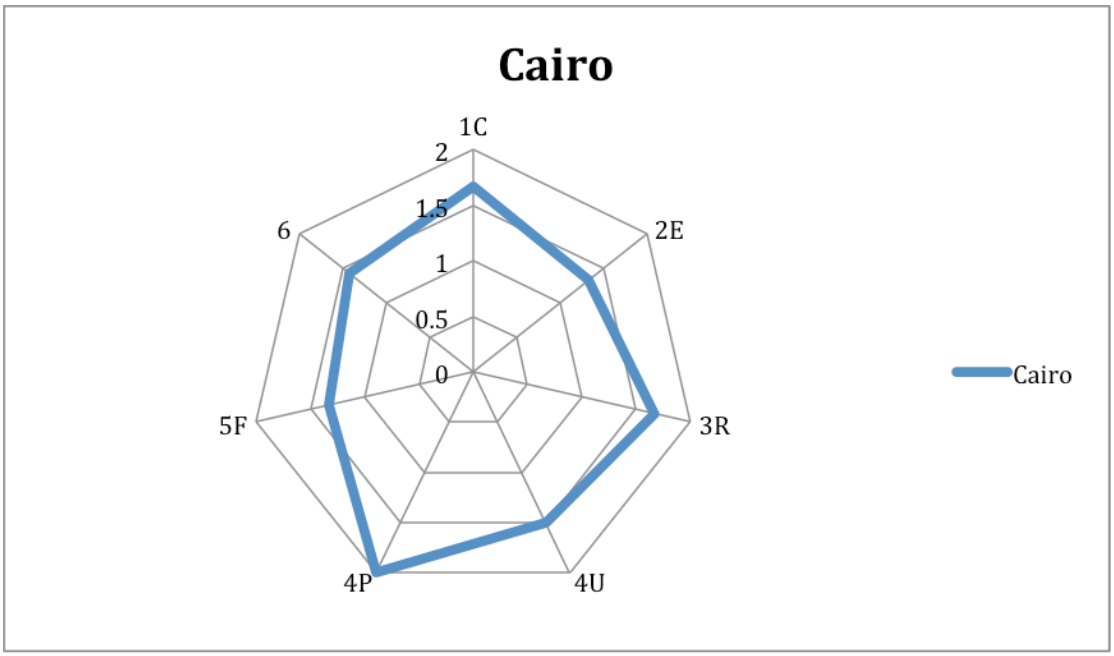

Fig. 14. Radar diagram summarizing the 6 Wasteaware ISWM benchmark indicators for Cairo

As it shows in the radar diagrams, New York City carry out the best solid waste management among these three cities in this metrics, followed by Hilo and Cairo. In the radar diagram of Cairo, it covers the least area. Even though the sub indicator of 4P indicates a fairly competitive figure, the rest of the sub indicators are not performing so well.

To make it more obvious, a comparative radar diagram is also created, in which the radar diagrams of all three cities are combined, which is more visualized.

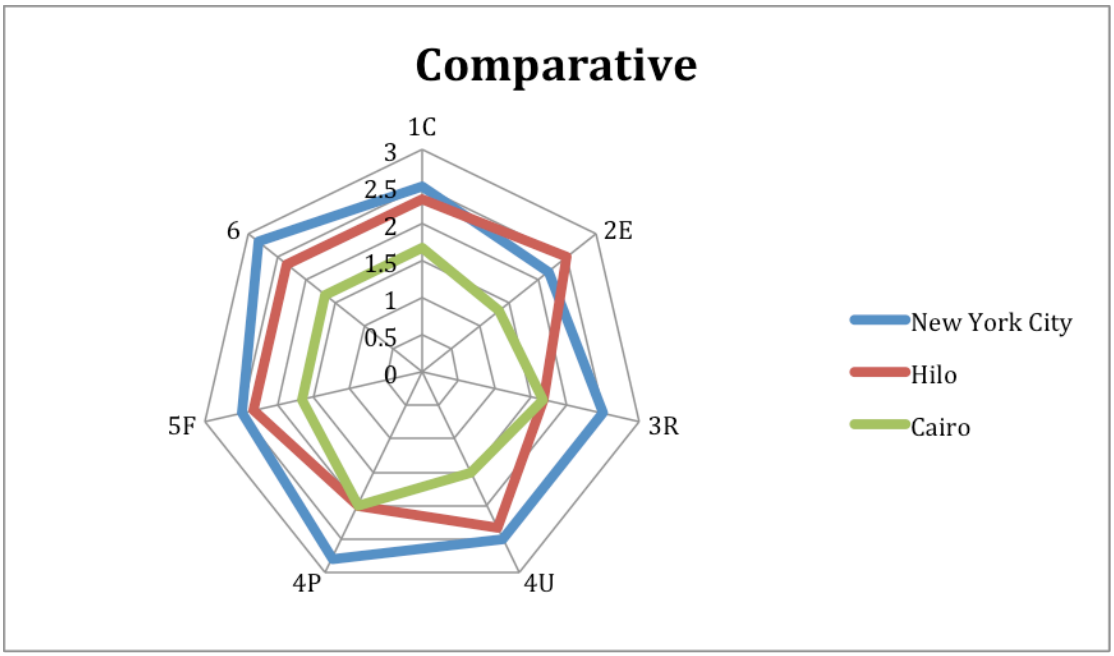

Fig. 15. The comparative radar diagram summarizing the 6 Wasteaware ISWM benchmark indicators for all three cities

In the comparative radar diagram, it is clear that New York City has the largest area; Hilo is catching up very closely. Especially in 2E, Hilo stands out by outscoring New York City, the rest of the sub indicators, Hilo is only lagging behind by a bit. Cairo stands in the middle, surrounded by the diagrams of both New York City and Hilo. Certainly Cairo needs to catch up both in the physical aspect and the governance aspect, and Hilo needs to improve in the governance aspect as well.

Table 9: Summary results for the Wasteaware ISWM benchmark indicators in three case study cities

No	Category	Indicator	Results		
City			New York City	Hilo	Cairo
Country			US	US	Egypt
Backgroung information on the city					
B1	Country income level	World Bank income category	$58,856	$49,450	$19,324
B2	Population	Total population of the city	8620000	43000	19500000
B3	Waste generation	MSW generation (tons/year)	14000000	246000	5475000
Key waste-related data					
W1	Waste per capita	MSW per capita (tons/year)	1.62	5.72	0.28
W2	Waste composition:	4 key fractions - as % of total waste generated			
W2.1	Organic	Organics (food and green wastes)	14.60%	32.90%	56%
W2.2	Paper	Paper and card	27%	21.30%	10%
W2.3	Plastics	Plastics	12.80%	7.10%	13%
W2.4	Metals	Metals	9.10%	13.20%	2%
Physical components					
1C	Public health - waste collection		2.5	2.33	1.67
2E	Environmental control - waste treatment and disposal		2.33	2.5	1.34
3R	Resource management - reduce, reuse and recycle		2.5	1.8	1.67
Governance factors					
4U	Inclusivity		2.5	2.33	1.5
4P			2.67	2.5	2
5F	Financial sustainability		2.5	2	1.34
6N	Sound institutions, proactive policies		2.83	2.33	1.5
6L			2.83	2.33	1.5

To illustrate the use of the ISWM indicators, Table 9 presents the results for a selection of three cities, ranging from low- to high-income; the data presented are taken from the sub-indicators section. It also shows the selected background information on the city, such as income level and population, as well as the key waste-related data, followed by the indicators for both physical components and governance aspects.

As we can tell from the above table, considering the waster generation and population, we can calculate the waste per capita. In the waste composition, Cairo has the most organic waste composition. Low-income countries/cities tend to have larger organic waste composition. While New York City has a 14.6% organic waste composition, and Hilo has a 32.9% organic waste composition, which is relatively high. Interestingly, New York City has a fair amount of paper waste composition than the other two cities. Regarding the physical components, Hilo performs well in environmental control, whereas New York City and Cairo perform much better in public health and resource management. As for governance factors, New York City shows a great competitiveness in financial sustainability and sounds institutions. Hilo performs well in 4P inclusivity and financial sustainability, but it's still lagging behind

New York City. Same with Cairo in 4P inclusivity; however, the financial sustainability of Cairo still needs to catch up.

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