Journal of Environmental Science and Management SI-1: 37-47 (2020) ISSN 0119-1144

Ecological Footprint Accounting of Non-Biodegradable Wastes of Angeles City, Philippines: The Anthropogenic Shift to Biodegradables

ABSTRACT

This study factored the Ecological Footprint Accounting on the Municipal Solid Wastes of Angeles City, Philippines using the Waste Analysis and Characterization Summary for 2015, with projections subdivided into the solid wastes of Angeleṅos, expressed as waste generation per capita, depict the level of waste consumption, quality of urban habitat, and the acceleration on waste disposal based on the population growth rate and diversion rate. The results were quantitatively analyzed using Ecological Footprint Accounting and interpreted in monetary terms through Benefit-Cost Analysis. The major research processes include: Analysis of waste generation per capita; Waste Projections net of targeted diversion on non-biodegradables; Cost Analysis on diverted wastes; and Income Analysis on Recyclables. The waste generation for the next five years will be generated 90% by households; 10% by educational and other institutions. With waste composition of 37% biodegradable, 20% recyclables and 43% non-biodegradable. By the year 2022, the city is expected to generate 159 kg $yr^{-1} \cdot 10^6$ with waste mitigation at a decreasing rate of 96.89% despite the population acceleration at 136% or equivalent to 561,000 constituents. Lastly, the five-year Benefit-Cost Analysis yielded a budgetary savings of PhP395M, equivalent to US$ 7.4M or an average municipal annual cost savings of 39%.

Keywords: *ecological footprint accounting, biodegradable, non-biodegradable, trend analysis, benefit-cost analysis.*

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INTRODUCTION

Mankind is said to be the most intelligent living creature and the steward of the earth. Human intelligence can either pro-create or destroy the ecological environment. Climate change is one of the biggest environmental challenges ever to confront humanity (*Gould and Rudolph 2015*). Its adverse impacts are already felt and catastrophic future effects may intensify exponentially over time if nothing is done to protect the environment. According to the Intergovernmental Panel on Climate Change (*IPCC 2014*), climate change is a critical threat to our survival but the extent of effects on individual regions will vary over time. What is crucial is the ability of different societal and environmental systems to mitigate. In addition, 97% of climate scientists from IPCC surmised that climate-warming trends are very likely due to human activities (*IPCC 2014*) commonly called anthropogenic. The European Environment Agency defines anthropogenic effects as processes, objects, materials or those that are derived from human activities as opposed to those occurring in natural environments without human influences (*European Environment Agency 2018*).

Consequently, knowledge and sensitivity are necessary to understand and reduce man-made stresses that trigger environmental vulnerabilities. Therefore, this places policy goals in our hands (*Zijp et al. 2017*). Municipal Solid Waste (MSW) is costly, hazardous and is a never-ending man-made stress to the environment. Waste Management is a global dilemma of all nations. The driving force to address this is determining how to efficiently mitigate, divert or reduce wastes ending in landfills. While at the same time, the community is empowered to attain environmental sustainability amidst economic advancement that will truly promote social well-being of the present community and the succeeding generation.

Across the globe, waste generation rates are rising. In 2016, the world's cities generated 2×10^{12} kg of solid waste equivalent to a daily waste generation per capita of 740 g (*World Bank 2018*). In the Philippines, the average daily waste generation per capita from 2012 to 2016 is 389 g, which is lesser than the global average waste generation (*World Bank 2018*). Nevertheless, the Philippine government must factor in the Ecological Footprint of urban dwellers comprising 47% of the population, placing the country as the 13th most populous globally with 109 M constituents as of 2020 but with a limited territorial land area of 298,170 km^2 (*Worldometer 2020*). However, there are only 108 approved sanitary landfills as of 2016, which is only 6% of the required total nationwide (*Ruiz 2020; NSWMC 2016; Environmental Management Bureau (EMB) 2019*).

Therefore, this study is about applying the Ecological Footprint Accounting (EFA) tools for Waste Management and addressing the following objectives: to forecast the biodegradable and non-biodegradable wastes after incorporating the target diversification on non-biodegradable wastes; to forecast the waste generation per capita for the year 2018 to 2022; to apply Benefit-Cost Analysis based on projected MSW after waste diversion and accounting of revenues for recyclables and to translate into monetary value the result of EFA. Accordingly, this study can provide a new avenue for EFA as a tool in generating a practical and reliable Budget Analysis on waste diversification.

MATERIALS AND METHODS

Study Area: The City of Angeles

In 1964, Angeles was proclaimed as a city and exercised its autonomous jurisdiction from the province of Pampanga following statutory requirements on municipal revenue and minimum population. Based on the Philippine Statistics Authority (PSA) for the year 2015, the province has a total population of 11.2 M. In the same year, the city's population rose to 411,000, with an average annual growth rate of 4.5% from 2010 to 2015 (*PSA 2015*). Angeles is a first class municipality in Central Luzon, one of the 17 regions in the Philippines with 3,401 population density per km^2 (*Area Ecological Profile 2015*). Currently placed as 813th in the global urban population (*Demographia World Urban Areas 2020*), the city is vying for sustainability amidst economic development.

Data Used

Secondary government data was utilized for the Benefit-Cost Analysis: the historical waste analysis characterization study (WACS) for the municipality of Angeles City, population index from the Philippine Statistics Authority (PSA), annual tipping fee for the landfill operating cost of Community Environment and Natural Resources Office (CENRO) for the past three years relative to solid waste management, cost of biodegradable and non-biodegradable food packaging materials, the sales price for recyclable plastic bottles, glass bottles and used papers.

Data Analysis

In the study, EFA indicators were combined for solid waste produced by the Angeleṅos, to capture both the level of consumption and quality of urban habitat and population growth rate of the city. First, the consumption level and quality of habitat were reflected based on

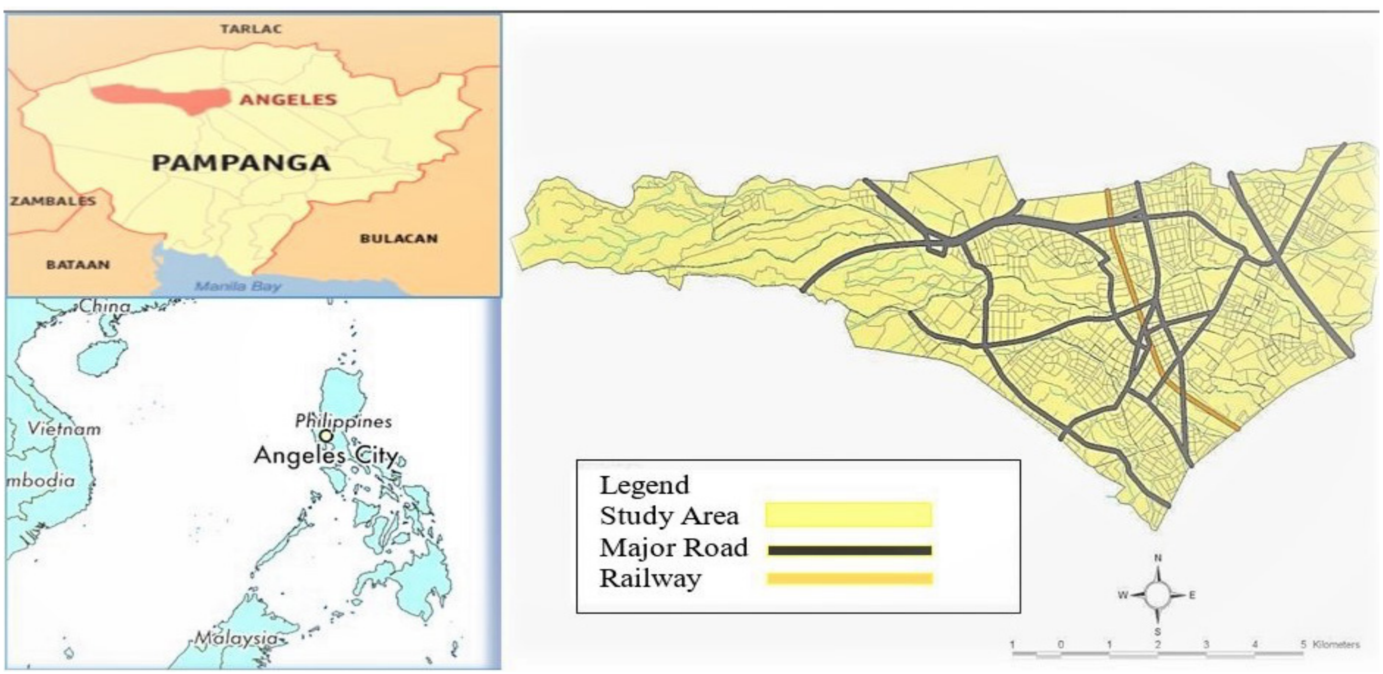


Figure 1. Map of Angeles City, Philippines (*Angeles City Zoning 2012*).

Waste Analysis and Characterization Study (WACS). Second, it was also the basis for the changes in waste composition as to biodegradable, non-biodegradable, recyclable and others. Third, the population growth rate was used in the projection and acceleration of wastes to represent the unit of measure on Ecological Footprint per person. The secondary data from Philippine Government Agencies were used to facilitate Ecological Footprint Analysis and Projections of waste generation per capita net of diversified non-biodegradable. This also includes the trend analysis of municipal wastes based on population growth rate; differential costs analysis of annual tipping fee based on diverted waste from non-biodegradables vs. incremental costs on services for wastes segregation; and accounting of savings on diverted wastes and income from recyclables of households, schools and other institutions. The whole process is called Ecological Footprint Accounting (EFA) on MSW translated into monetary terms to be used in the decision-making process. Similar to the EFA, this study used historical data in order to predict. It involves tracking past anthropogenic pressure on the biosphere's capacity (*Galli 2015*).

The Angeles City's population projection for 2018 to 2022 was based on the population growth rate of 4.5% (*PSA 2015*). The diversification rate of 30% for 2014 with a 5% annual cumulative thereafter was adopted from CENRO-Angeles. Several computations were made to obtain the five-year wastes projection for the entire city of Angeles (**Table 1**). Further, the study depicted the variable unit cost computations of annual tipping fee for landfill based on the trend costs analysis for the year 2013, 2014, and 2015 in relation to the incremental volume generated as the final waste of the municipality of Angeles on the said landfill for the next five years. Lastly, increases in the salaries for personnel services, other related repairs, and maintenance of CENRO and the existing manpower capacity of the said government agency were analyzed to provide reasonable cost projections.

For the cost and benefit analysis, the incremental operating cost on personnel for the next five years less the cost savings on projected diverted annual waste on landfill tipping fee, comprised the economic benefits for the entire municipality budget allotment. Estimated profit from recyclables was illustrated. Further, the probable incremental consumer's cost in utilizing biodegradable food packaging materials was factored in. The process of cost and benefit analysis is the economist's way of handling a problem that converts the effect from units of marginal utility to monetary units (*Johansson and Kristrom 2018*).

RESULTS AND DISCUSSION

Dilemma on Landfills

Solid Waste Management Disposal is a predominant global concern, affecting living conditions, the environment, societal well-being, and economic aspect (*Cervantes et al. 2018*). More importantly, cities around the globe face the problem of acquiring land as dumpsites. Residents and neighborhood reject placing landfills near their respective homes. This "Not in My Back Yard" attitude is known as "Nimby" (*Morrissey and Browne 2004; Oxford Dictionaries 2017*). The insufficiency of sanitary landfills subjects local government units to pay exorbitant tipping fee for solid waste disposal. In the case of Angeles City, PhP 204 M of public funds were obligated for the 2015 annual tipping fee alone (*Angeles City Local Government 2017*). The city does not have its own sanitary landfill.

Landfill can either be a permanently engineered or a temporary waste disposal site with at least a year life span (*Martinico-Pereza et al. 2018; Eurostat 2013*). The landfill is the most widely accepted and prevalent form of disposing MSW due to simpler operational mechanism (*Galarpe and Parilla 2014*) for urban cities and highly

Table 1. The formulas for waste projections using the Waste Analysis and Characterization Summary.

No.	Particular	Computations
1	Waste Generation Rate	Daily waste generation per capita/projected annual population
2	Projected Biodegradable	Biodegradable proportionate share based on WACS · Total Generated Waste
3	Projected Recycles	Recyclables proportionate share based on WACS · Total Generated Waste
4	Projected Residuals for final disposal of Non-biodegradables	Residuals for final disposal proportionate share based on WACS · Total Generated Waste
5	Net Residual Rate	100% less Target Disposal Rate for MSW
6	Net Diverted Residual Waste for Non-Biodegradables	Projected Residuals for final disposal of Non-Bio less diverted waste
7	Projected Annual Waste Generation	Projected Biodegradable + Recyclables + Net Diverted Non-Biodegradable + Special waste

commercialized municipalities (*Kamaruddin et al. 2017*). The cumulative costs and struggle in acquiring a suitable location for the landfill creates a huge dilemma in managing the long-term operating costs of MSW. Nevertheless, landfills must be constructed the soonest before the surrounding environment suffers major adverse impacts (*Meylan et al. 2018*). If left unmitigated, there would be a problem in strategically locating landfills. Worst, residential lands will be filled with toxic wastes and eventually look like landfills.

The Need for a Material Recovery Facility

In order to mitigate the problem on Landfills, a number of cities opted for the use of Material Recovery Facilities (MRF). Section 32 of Republic Act 9003, known as the "Ecological Solid Waste Management Act" mandates that MRFs be established in every barangay or cluster of barangays. These facilities include a solid waste transfer station or sorting station, drop-off center, a composting facility, and a recycling facility. The barangay or cluster of barangays shall allocate a certain parcel of land for the MRF. That said MRF shall receive mixed waste for final sorting, segregation, composting, and recycling. The resulting residual wastes shall be transferred to either a long-term storage, or disposal facility or a sanitary landfill. On the nationwide scale as of 2018, only 32% or equivalent to 13,612 barangays have access to MRF (*NSWMC 2018*).

As part of Angeles City's solid waste management efforts, Ordinance No. 314, S-2012, also known as "An Ordinance Creating the Angeles City Solid Waste Management Board (SWMB) and Establishment of Material Recovery Facility (MRF)," was promulgated (*Area Ecological Profile 2015*). The city established three MRFs, an individual MRF and two clustered MRFs where wastes are sorted accordingly (*Area Ecological Profile 2015*) for 33 barangays (villages). The insufficiency of ideally one MRF in each barangay, exposes the City of Angeles to incur a huge landfill tipping fees. The community should also be aware of the impact of MRFs in the pre-sorting of plastics before recycling. It requires a large amount of energy, often leads to low-quality polymers, costly and time-intensive (*Garcia and Robertson 2017*). With limited resources, there is a tangible need for the city to mitigate waste disposal with its growing population.

Ecological Footprint Accounting and Indicators

A Practical Waste Management Plan must be put in place based on Ecological Footprint Accounting of Municipal Solid Waste (*Galli 2015*). The ecological footprint is used to gauge the exerted degree of consumption of human beings on its ecological environment (*Li et al. 2016*). While rendering ecological assessment is to compare the demand and supply of renewable natural resources or capacity of the ecosystem to provide resources within the capacity limit of its generation (*Gould and Rudolph 2015*), this is not covered by the study.

There are four indicators of ecological footprints. namely, the level of consumption, quality of the population, the quality of employment and quality of habitat (*Guo et al. 2018*). Except for the quality of population based on the level of educational attainment, all the three remaining aspects exhibit a positive relationship to the ecological footprint (*Guo et al. 2018*). The author expounded further that the increase in educational level leads to greater awareness on environmental problem. Households exhibit rationality in their behavior causing a reduction in ecological footprint (*Guo et al. 2018*). The level of consumption is also positively correlated with the population level; the higher the population the more ecological footprint is generated (*Guo et al. 2018*). The said author also positively correlated the quality of employment; the greater the number of jobs, the greater the number of businesses generating more qualified pollutants. Additionally, a number of research studies showed a correlation of socio-economic analysis, where higher family financial capacity and educational attainment is associated with higher private or municipal waste collection and less with the application of backyard or open dumping like in the rural areas (*Jain and Tiwari 2015*). Likewise, the quality of habitat in either urban or rural area is an indicator to capture the impact of horizontal buildings that destroy the surface of the land or its ecological footprint (*Guo et al. 2018*).

In this study, EFA indicators were combined for solid waste produced by the Angeleṅos, to capture both the level of consumption and quality of urban habitat and population growth rate of the city. First, the consumption level and quality of habitat were reflected based on Waste Analysis and Characterization Study (WACS). Second, it was also the basis for the changes in waste composition as to biodegradable, non-biodegradable, recyclable and others. Third, the population growth rate was used in the projection and acceleration of wastes to represent the unit of measure on Ecological Footprint per person. The gathered secondary data from Philippine Government Agencies were used to facilitate Ecological Footprint Analysis and Projections.

A number of studies already exists both for the different EFAs. Most research findings for these tools requires scientifically complex computations and high level of environmental understanding on anthropogenic but leaves local government units at a lost in interpreting financial impacts. The application of EFAs on Waste Management Plan have never been made more practical nor financially reflective as to the resulting measurable impact. A number of research studies ends on computing for the waste generation per capita and projections but it leaves decision makers at a lost in valuing the impact of a chosen course of action. This study had linked waste management objectives with EFA tools delineating financial impacts.

Waste Analysis and Characterization Study

Waste analysis and characterization study in Angeles City was a project initiated in 2011 by Philippine Environmental Governance (EcoGov) through the assistance from the U.S. Agency for International Development (USAID) (*EcoGov Project 2011*). WACS generates these basic data: waste generation at source; total waste generation within collection area and in the whole LGU composition of waste generated at source volume; and composition of waste brought to the disposal site; potential percentage of waste for diversion at source and at disposal site; the percentage of generated waste within collection area that are not collected or accounted for (*EcoGov Project 2011*). The WACS integrates solid waste management planning that requires a good analysis of the current situation to provide a relevant information as a capstone for critical planning decisions for MSWM (*EcoGov Project 2011*). Proper planning and budget cost allocation of financial resources of the city lies in accurate waste characterization study.

The Angeles City Environment and Natural Resources Office (CENRO) reported a WACS published in 2015. Based on the summary, the waste composition of the city is 20% recyclables, 37% biodegradable, and 43% non-biodegradable. The 43% non-biodegradable, is the sum of 13% non-biodegradable residuals with potential for diversion and the remaining 30% for landfill disposal. CENRO's WACS reported sources of wastes; 90% from households, 8% from the educational institution, 2% from commercial and other institutions (*Area Ecological Profile 2015*). Waste diversion refers to activities that reduce or eliminate the amount of solid waste from waste disposal facilities (*RA 9003; SEPO 2017*). The municipality of Angeles had established a target diversion rate of 30% starting 2014 with a cumulative increase of 5% annually. This diversion rate was incorporated in the study. The higher the percentage of biodegradables than non-biodegradables indicates a better quality of waste ending as final solid waste for disposal in the landfill.

Biodegradable vs. Non-biodegradable

To reach policy goals regarding sustainable management programs on MSW, knowledge is required on both the types and magnitudes of man-made stresses posed on the ecosystem as well as on its vulnerabilities (*Zijp et al. 2017*). Modern day to day activities has been influenced by traditional synthetic polymers or commonly called plastics. Polypropylene and polyethylene have been produced from non-renewable petrochemicals and is known to be detrimental to the environment due to their non-biodegradable nature (*Jain and Tiwari 2015*). Non-biodegradable is defined as material substances that generally cannot be decomposed by microorganism even after a hundred years, nor in the event of technological intervention such as thermal decomposition that may further lead to the generation of various toxic substances, which in turn cause hazards to the environment (*Hair O'right International Corporation 2013*). Contrariwise, biodegradable is the ability to decompose naturally through the existence of micro-organisms in the environment that converts materials into natural substances such as water, carbon dioxide, compost or artificial additives, dependent on the surrounding environmental condition such as location and temperature (*Chen 2013; Ahmed et al. 2018*).

Plastic bags were introduced in 1970's (*Haritz and Dove 2018*) and gained an increasing conventional usage both from suppliers and consumers. Conventional plastics have been used for decades in a diverse range of applications, however, many are resistant to degradation, leading to environmental pollution (*Karamanlioglu and Robson 2013*). It was projected that global production is expected to exceed 500 teragram by 2050 (*Haritz and Dove 2018*). Based on the scientific facts, plastic bags can persist up to 1,000 years without being decomposed by sunlight and/or microorganisms (*Haritz and Dove 2018*). Diverting biogenic waste and recycling more glass, metals, paper, and plastics would also significantly reduce landfilling rates (*Meylan et al. 2018*).

As environmental concerns become more prominent, the quest for inventive environment-friendly packaging and alternative sources of bioplastic is now part of business entities' corporate social responsibility along with the production of cost-effective biodegradable products (*Jain and Tiwari 2015*). Bioplastics are now consciously being considered because of their numerous scientifically documented benefits like saving fossil resources, environmental sustainability and the feasibility of creating jobs in future-oriented sectors. Since they originated from a renewable source, bioplastics are perceived to be environment-friendly than a non-renewable composition of traditional plastic (*Jain and Tiwari 2015*).

Reduce, Reuse and Recycle

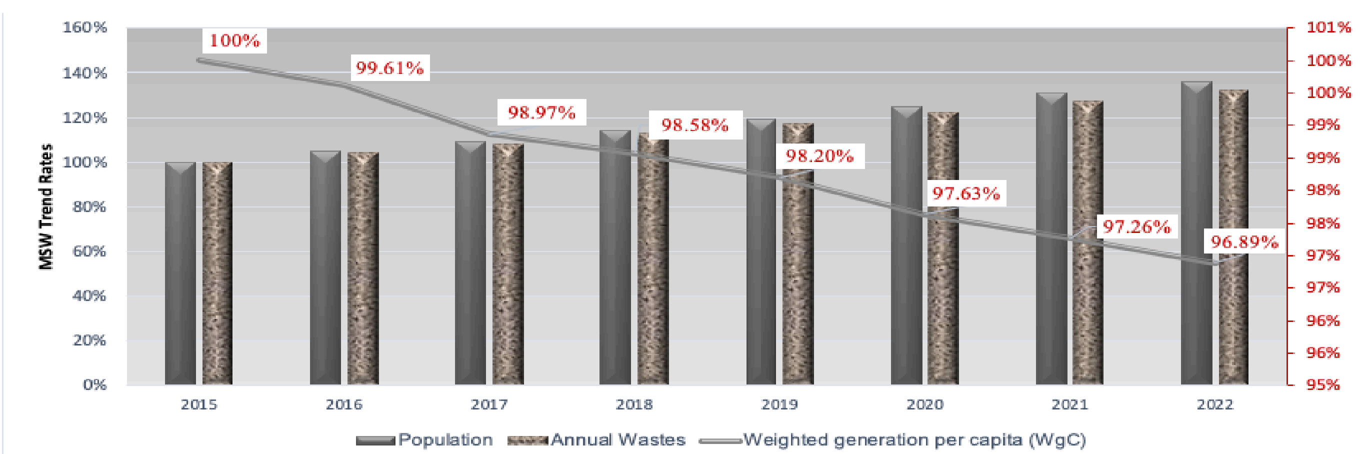
Innovation is a key driver of productivity and economic growth. Efforts leading to the creation and implementation of green growth policies are within the boundaries of innovation and could possibly change consumer's behavior towards ecological awareness (*Organization for Economic Co-operation and Development 2017*). Internationally, one of the fundamental concepts for a sustainable society is the implementation of 3Rs (reduce, reuse, and recycle) approach to waste management (*Yano and Sakai 2016*). The "reduce" aspect, has the highest priority, and also refers to waste prevention, implies similar concepts and definitions among nations. Similarly, the Organization for Economic Co-operation and Development (OECD) categorizes waste prevention into strict avoidance, reduction at source, and productreuse.

In the case of OECD, the concept of recycling is included within the definition of waste prevention. In the same context, "reduce" and "reuse" are together referred to as 2R (reduce, reuse) in the Asian region.

Presented on the Waste Atlas First Annual Waste Report in 2013 is a summary of waste generation per capita (WgC) in relation to the human development index and recycling rate of ASEAN countries (*Atlas Waste 2013*). The Human Development Index (HDI) measures the average achievements in a country based on the three basic dimensions of human development: a long and healthy life, knowledge and a decent standard of living. In the ASEAN Region, Singapore rank highest in HDI of 0.87 with WgC of 485.5 kg yr^{-1} and with the highest recycling rate of 59%. While the Philippines rank 5th in terms of HDI of 0.64, with WgC of 266.5 kg a^{-1} and low recycling rate of 5% (**Table 2**). One way of mitigating MSW is through recycling that supports circular economy by means of creating income to informal waste picker and extending the end-life cycle of a resources. Thus, the study presented also the projected income generated from recyclables.

Projections on annual wastes characterization net of diverted non-biodegradable waste of Angeles City

The five-year projection on solid wastes of Angeles City revealed an upward trend and have a positive correlation with population growth: for 2018 the projection is $136 \cdot 10^6$ kg yr^{-1}, equivalent to 113% of 2015; for 2019 the projection is $141 \cdot 10^6$ kg yr^{-1}, equivalent to 117%; for 2020 is $147 \cdot 10^6$ kg yr^{-1}, equivalent to 122%; for 2021 at 153·106 kg.yr^{-1}, equivalent to 127% and $159 \cdot 10^6$ kg yr^{-1} for 2022 equivalent to 132% of change (**Table 3**).In contrast, the waste generation per capita



	2015	2016	2017	2018	2019	2020	2021	2022
Municipal Solid Waste(MSW) in kg $a^{-1} \cdot 10^6$	120	125	130	136	141	147	153	159
Population in thousand	411	430	450	470	491	514	537	561
Waste generation per Capita (wgc) in kg a^{-1}	292	291	290	288	287	286	285	283

*based on trend growth rate on 2014 WACS of 1.0024

**based on CENRO's targeted diversion rate derived per reported Waste Analysis Characterization Summary 2014

Figure 3. The projected trend analysis of Angeles City's wastes.

(WgC) is expected to have a downward trend net of target diverted non-biodegradable residuals using 2015 as the base line for 292 kg yr^{-1}. The annual waste generation per capita is expected to be 288 kg yr^{-1} for 2018 equivalent to 99% and 283 kg yr^{-1} for 2022 or equivalent to 97%.

The Cost and Benefit Analysis on the anthropogenic shift to bio-degradable materials.

The projected annual diverted wastes from non-biodegradable to biodegradable would generate a savings of PhP 16M, equivalent to US$ 298,000 for 2018 and

Table 2. The ASEAN Ranking on Human Development Indices, Waste generation per capita and Recycling and recycling rate (*Atlas Waste 2013*).

Country	HDI	WgC	Recycling Rate (%)
Brunei	0.84	319	0
Indonesia	0.62	255	7
Laos	0.52	246	0
Malaysia	0.76	378	0
Myanmar	0.48	161	***
Philippines	0.64	267	5
Singapore	0.87	486	59
Thailand	0.68	265	11
Vietnam	0.59	216	***

*Human Development Index
**Waste generation per capita (measured in kilogram per capita for a year period)
*** No available data

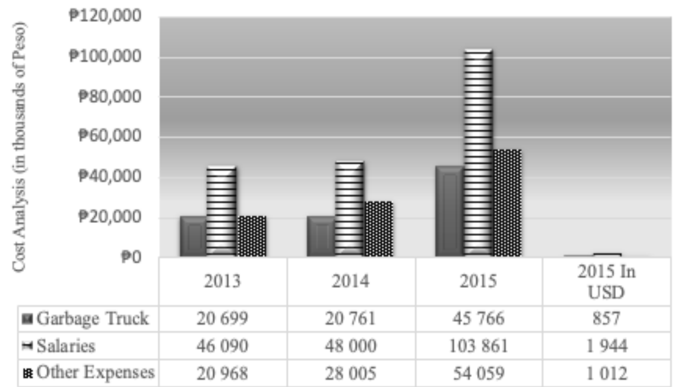


Figure 4. Historical costs analysis of municipal solid wastes.

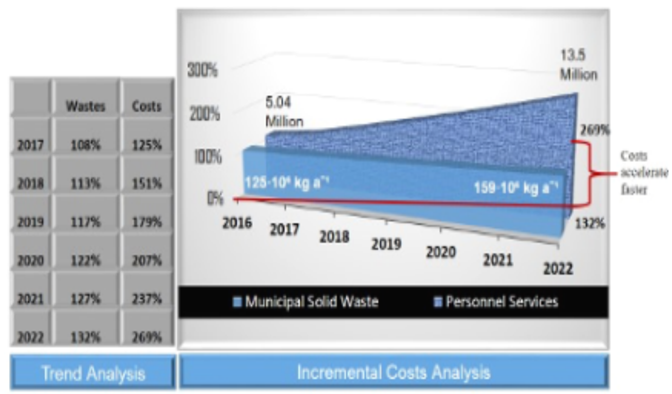


Figure 5. Differential analysis on waste generation vs. costs.

Table 3. Five-year projection on waste characterization of Angeles City based on diversion rate set by the City of Angeles and Philippine Statistics Authority population growth of 4.5%.

Year	Waste generation per Capita Rate*	Population Projection in thousand	Waste Generation per Capita in $kg\ d^{-1} \cdot 10^3$	Bio-degradable in $kg\ d^{-1} \cdot 10^3$	Recyclables in $kg\ d^{-1} \cdot 10^3$	Residual waste intended for final disposal in $kg\ d^{-1} \cdot 10^3$	Residual waste potential for Diversion in kg	Target Waste Diversion **	Percentage of remaining Non-bio	Net Residual Diverted Non-bio in $kg\ d^{-1} \cdot 10^3$	Adjusted MSW Projection in $kg\ d^{-1} \cdot 10^3$	Annual Projection in $kg\ d^{-1} \cdot 10^6$	Trend Rates	wgc $kg\ a^{-1}$
2015	0.839	411	345	126	69	105	45	35%	65%	29	329	120	100%	292
2016	0.841	430	362	133	72	110	47	40%	60%	28	343	125	104%	291
2017	0.843	450	379	139	76	115	49	45%	55%	27	357	131	108%	290
2018	0.845	470	397	145	79	121	51	50%	50%	26	371	136	113%	289
2019	0.847	491	416	152	83	127	54	55%	45%	24	386	141	117%	287
2020	0.849	514	436	160	87	133	56	60%	40%	23	402	147	122%	286
2021	0.851	537	457	167	91	139	59	65%	35%	21	419	153	127%	285
2022	0.853	561	479	175	96	146	62	70%	30%	19	436	159	132%	283
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

* based on trend growth rate on 2014 WACS of 1.0024
**based on CENRO's targeted diversion rate derived per reported Waste Analysis Characterization Summary 2014

can go as high as PhP 27 M, equivalent to US$ 504,000 on 2022 and a total of PhP 106 M within the five-year period, equivalent to US$ 2 M (using Bangko Sentral ng Pilipinas exchange rate of $1= 53.43 PhP dated 31 August 2018)(**Table 4**). The computation of the cost savings was based on the cost per tons of PhP 1,700 generated by dividing the 2017 annual sanitary tipping fee for the Landfill amounting to PhP 204 M over the 2017 annual waste volume of 120 x 10^3 kg yr^{-1}. The income from recyclables is projected to yield PhP 318M for the year 2018 to 2022 using a selling price of PhP 2 per kilo of recyclables (**Table 5**) out of 159 x 140 kg yr^{-1}.

The estimated annual increase in volume of MSW will also increase the cost of personnel services of CENRO based on trend analysis of operating expenses of the said agency. The actual operating expenditure of CENRO Angeles City for 2017 was PhP 8.2 M (PhP 6.3 M for personnel services add-up PhP 1.9 M for maintenance and other expenses). And the increase in volume per metric ton has an additional labor cost of PhP 252 per megagram of solid waste. There are no apparent increases in maintenance and other expenses between 2016 and 2017. Hence, increases is attributable to personnelservices of CENRO amounting to PhP 1.3 M, generating 25% increase in costs for 2017 and is expected to increase up to PhP 8.5 M after five years. The estimated 169% increase in 2022 will result into an aggregate costs of PhP 14.8 M or equivalent to US$ 277,000 (**Table 6**).

A minimal incremental cost of 0.23 cents is expected for a small size biodegradable bag as compared to non-

Table 4. The five-year projected cost savings on Annual Tipping Fee based on the diverted non-biodegradables.

			(B · C)	(D · 365 days)	(E · Php 1 700)*	(F / Php 53.43)
Year	Residual with potential for Diversion in kg $d^{-1}\cdot10^3$	Diversion Rate	Diverted Non-Bio kg $d^{-1}\cdot10^3$	Diverted Non-Bio kg $d^{-1}\cdot10^3$	Cost-Savings on Landfill Tipping Fee (in thousands of Peso)	Cost-Savings on Landfill Tipping Fee (in thousands of US Dollar)
2018	51	85%	26	9 380	15 946	298
2019	54	85%	30	10 804	18 367	344
2020	56	85%	34	12 368	21 026	394
2021	59	85%	38	14 032	23 854	446
2022	62	85%	43	15 825	26 903	504
Total Savings					**106 096**	**1 986**
A	B	C	D	E	F	G

* based on 2017 annual tipping fee cost allocation (PhP 204 M/120 10^3 kg = PhP 1,700)

Table 5. Projections on Recyclables.

A	B	C	D	E	F	G	H
		B x 365 days		**Cx2/1 000**	**E x 89,72%**	**E x 8.53%**	**E x 1.75%**
Year	**Recyclables in kg/d 10^3**	**Recyclables in kg/yr 10^3**	**Selling Price /kilo**	**Income (Millions of PhP)**	**Municipality Income**	**Schools**	**Other Institutions**
2015	69	25,185	2	50	45	4	1
2016	72	26,280	2	53	47	4	1
2017	76	27,740	2	55	50	5	1
2018	79	28,835	2	58	52	5	1
2019	83	30,295	2	61	54	5	1
2020	87	31,755	2	64	57	5	1
2021	91	33,215	2	66	60	6	1
2022	96	35,040	2	70	63	6	1
2015-2022		238,345		477	428	41	8
2018-2022		159,140		316	286	27	6
Percentage Share					89.72%	8.53%	1.75%

Table 6. The projected incremental costs on Personnel Services based on projected wastes in Angeles City, Philippines.

	2017	2018	2019	2020	2021	2022
Projected wastes in $kg \cdot a^{-1} \cdot 10^3$	130 280	135 530	141 034	146 784	152 775	158 998
Increases per annum	4,989	5,250	5,504	5,751	5,991	6,223
Multiply Labor cost in $kg \cdot a^{-1} \cdot 10^3$	252	252	252	252	252	252
Incremental Cost in Millions of Peso	1.26	1.32	1.39	1.45	1.51	1.57
Accumulated Increases in Millions of Peso	1.26	2.58	3.97	5.42	6.93	8.49
Percent Increase	**25%**	**51%**	**54%**	**107%**	**137%**	**169%**

*Actual costs on personnel services in 2016 and 2017 amounted to PhP 5.04 and 6.3 M, respectively.
**For 2016 projected wastes is 125,291 kg $a^{-1}10^3$
***Estimated total pesonnel costs for 2022 would be PhP 14.8 M, (6.3M+8.49M), equivalent to US$253,000

biodegradable. Thus, the minimal incidental cost has a high probability of acceptance to households (**Table 7**). The least cost option to shift from plastic food packaging to biodegradable would be paper packaging with a differential cost of PhP 1.0 to PhP 2.0 for two-division and four-division, respectively (**Table 8**). The incremental benefits for the constituent of Angeles City from recyclables once sold to junk shop traders at a selling price rate of PhP 2.00 kg^{-1} of recyclables is projected to generate PhP 440 M for the City of Angeles, PhP 26 M from educational institutions and PhP 11 M from commercial institutions for a period of five years.

Analysis of Angeles City Environment

The positive effects on the environment of biodegradable materials would decelerate the Ecological Footprint of Angeleṅos within the City's territory. The awareness on projected solid waste management costs shall facilitate a reliable cost budget for the municipality for the next five years. The declining environmental quality and negatively increasing ecological footprint due to population growth and urban congestion shall affect the livability of the City.

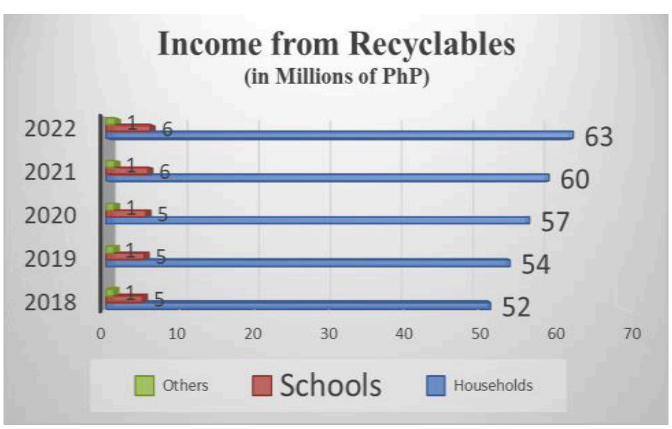


Figure 6. Income from Recyclables.

Table 7. The Differential Cost Analysis of bio vs. non-biodegradable conventional bag.

Size	Amount in Peso: Non-Bio	Bio	Difference	Volume/ Kilo	Additional Cost to consumers
Small	125	285	160	700	0.23
Medium	235	470	235	500	0.47
Large	400	780	380	400	0.95

Table 8. Differential Cost Analysis of food packaging materials.

	Amount in Peso				Differential Costs vs. Plastic		
Food Packaging	Plastic	Paper	Cornstarch	Styro	Paper	Cornstarch	Styro
2 Division	4	5	8	6	1	4	2
4 Division	6	8	12	10	2	6	4

CONCLUSIONS AND RECOMMENDATIONS

A vital outcome of this study illustrates a "bigger picture" of how Ecological Footprint Accounting Tools on waste management could generate Financial Data. The sizeable amount of government funds allocated to municipal solid waste management could be saved through shifting into biodegradable materials, proper segregation and conversion of recyclables into income.

The Cost and Benefit Analysis on the anthropogenic shift to biodegradable materials yielded on the beneficial side. In 2017, the City of Angeles incurred an annual tipping fee for the Sanitary Landfill, which amount to PhP 204 M and is projected to continuously increase in the succeeding years. For the next five year period (2018 to 2022), the city could save an estimated amount of PhP 106 M for landfill tipping fee and utilization of Material Recovery Facility for waste segregation and once residual non-biodegradable waste with potential for diversification is realized. Sold recyclables would reduce wastes while expected to generate a sales revenue of PhP 318 M across all types of institutions and from households for 2018 to 2022. On the negative side, the operating expenditures for personnel services is expected this is due to labor cost needed for waste segregation with an aggregate amount of PhP28.7 M for the same inclusive years. To summarize, the projected five-year benefit-cost analysis of proper solid waste reduction, segregation, and reverting back recyclables to the economy could yield a positive budgetary savings of Php 395.3 M, equivalent to US$7.4 M that could instead accommodate construction of 5,560 classrooms. The shift from non-biodegradable to biodegradable would entail minimal cost to consumers but beneficial to society for the next five years or even decades. The positive effects on the environment for the most needed mandatory utilization of biodegradable materials would decelerate the Ecological Footprint of the people of Angeles within the City territory.

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ACKNOWLEDGMENT

The author would like to acknowledge the CENRO-Region III for entrusting their valuable data for Waste Analysis Characterization Study. The study was funded by CHED-DILG and presented in the 2018 International Conference for Sustainable Environmental Technology (ICSET) hosted by Mapua University. The author also salutes the ICSET organizers and *Laus deo Semper* to Holy Angel University (the author's alma mater).