A NATURAL CAPITAL ASSESSMENT AND POST-CONSUMER WASTE ANALYSIS FOR AMCOR

by

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Abstract

Plastic packaging is at the center of our lives as it is found in numerous products used every day. Increasing the sustainability of plastic packaging will have a major impact on the world. As one of the largest and most innovative global packaging companies, Amcor leads the industry, having integrated sustainability into and across its core values.

To understand the best opportunities for improvement, this project analyzed Amcor's full supply chain through a natural capital valuation. The natural capital valuation puts a dollar value on the ecosystems services and externalities associated with Amcor's business. Our preliminary findings led us to conclude that, accounting for GHG emissions, water use and waste generated can make post-consumer resin comparable to virgin resin from a cost perspective. We also found that Amcor is relatively efficient in its own operations when compared to the rest of the supply chain, and should therefore focus on its downstream impacts where it can create the most impact in terms of post-consumer waste.

In focusing on these downstream impacts, we learned quickly that there is minimal data, globally, on plastic packaging waste, its collection, country infrastructure, and perception and education around plastic recovery. A model was created to predict plastic packaging recovery rates for countries where this data does not exist, and also get a better understanding of which factors most influence the plastic packaging recovery rates. We found that total household municipal waste, percent of waste to landfill, and the Gini index have a statistically significant impact on plastic packaging recovery rates. Amcor has an opportunity to focus on these variables when attempting to improve their downstream footprint.

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Introduction

Plastic packaging is at the center of our lives. From the shampoo bottle to the milk carton to the chip bag or granola bar packaging, we interact with plastic packaging dozens of times each day. Because of its ubiquitous influence on our lives, increasing the sustainability of plastic packaging will have a major impact on the world. As one of the largest and most innovative global packaging companies, Amcor leads the industry in sustainability, having integrated sustainability into and across its five core values of Safety, Integrity, Teamwork, Social Responsibility, and Innovation.

Amcor provides responsible rigid and flexible packaging solutions to the food, beverage, healthcare, home and personal care, and tobacco packaging industries. The company is based in Switzerland, with the head office in Australia and the head office for its rigid products business in Ann Arbor, Michigan. The $10 billion-dollar company operates in more than 40 countries employing more than 30,000 people. Amcor's leadership understands the value in understanding its supply chain, from indirect suppliers to the routes for post-consumer waste. For this reason, the company tapped graduate students to complete a research project with two objectives: to provide a natural capital valuation framework and to assess the impacts of its post-consumer waste.

Amcor leadership foresees the risk of its products both in the natural capital used to produce products as well as the waste stream created after consumers are finished with the products. Before investing in new strategies, research into best practices and different options are needed to determine the best option for Amcor and the industry.

Chapter 1: Natural Capital Valuation

Introduction

Several companies have implemented natural capital valuation to better understand the risks faced from environmental impacts. Through natural capital assessments companies can identify missing markets, imperfect markets, and market failures. By combining natural capital valuations and risk assessments, companies better understand and appreciate alternatives and alternative uses, address uncertainty involving supply and demand of natural resources (especially in the future), and respond to government required use of valuations against the restricted, administered, or operating market prices for designing biodiversity/ecosystem conservation programs. Finally, natural resource accounting (for methods such as Net Present Value) requires natural capital valuation.[1]

More business leaders are utilizing natural capital valuations because the tactic allows them to fully comprehend the true value and risks associated with their operations and supply chains. As a strategic risk management tool, natural capital valuation can identify sustainability initiatives to target (e.g. resource extraction, suppliers, other parties that utilize supply chain, waste creation, pollution, etc.), shed light on new unforeseen risks, and protect shareholder value. Furthermore, through monetization to create a unified metric, natural capital valuations allow for the translation of environmental impacts into a business metric to compare different environmental impacts (e.g. land use, emissions, water consumption, etc.).[2] Natural capital valuation reveals a company's true cost of doing business, in terms of what a company could be paying for the services provided by natural processes, such as fresh water, clean air, healthy biodiversity, and productive land. These are costs that are not currently accounted for by companies.[3] Accounting for these costs contributes to a company's competitive environmental strategy, which is why Amcor wanted to complete this analysis for its business.

The Natural Capital Protocol outlines operational, legal and regulatory, financing, reputational and marketing, and societal risks associated with natural capital impacts.[4] Table 1 outlines those risks, and provides examples specific to Amcor operations.

Table 1: *Types of Natural Capital Risk*

Type of Risk	Definition	Examples Specific to Amcor
Operational	Increased costs of normal business activities	● Increased costs of raw materials (i.e. resin or water) due to scarcity
Legal and Regulatory	Increased costs associated with new regulations	● Liability for natural capital impacts (e.g. fines or penalties associated with emissions) ● New regulations (e.g. carbon taxes, carbon cap and trade schemes, or new water charges)
Financing	Increased costs of and reduced access to capital	● Higher interest rates associated with climate change adaptation policies ● Stranded assets due to water scarcity
Reputational and Marketing	Decreased trust with suppliers, customers, and consumers	● Loss of customers to competitors with fewer upstream impacts
Societal	Deteriorating relationships with local communities and stakeholders	● Water use contributing to regional water scarcity ● Health impacts associated with air pollution

However, natural capital valuations vary according to specific industries and even companies, and few have developed, utilized, and publically released natural capital valuation methods specific to their operations. Amcor considers itself a leader in sustainability, and could be the first plastic manufacturer to perform and publish a natural capital assessment. This achievement would not only distinguish Amcor as an industry leader in sustainable practices, but would also give the company a competitive advantage, as it would be in a position to provide this information if necessary for future regulations or certification processes. In addition, Amcor would be in a position to lead the entire plastic and broader manufacturing markets in the use of natural capital assessments.

Methodology

Given the nascent nature of natural capital valuations in the corporate sector, consensus regarding an established and accepted protocol does not exist. The Natural Capital Coalition has outlined a general methodology.[5] Companies that have explored natural capital valuations, including Novo Nordisk[6], Puma[7], and Puma's parent company Kering,[8] have published their natural capital valuation methodologies and findings. Consulting firms such as PwC[9] and Trucost[10] have published more specific documentation relating to quantifying and valuing corporate environmental impacts. Trucost has applied its methodology in several publications, including *Natural Capital at Risk: The Top 100 Externalities of Business,*[11] *Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement*,[12] and *Valuing Plastic: The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry*.[13]

Following a review of these and other sources, we developed the following framework and methodology specific to Amcor:

1. Frame: framing involves making the internal case for conducting a natural capital valuation. We sought to address several objectives for Amcor by conducting a natural capital valuation, including:
    - Provide a baseline from which to compare future valuations;
    - Help Amcor explore new ways of measuring risk;
    - Develop new sustainability metrics;
    - Communicate sustainability metrics, environmental impacts, and sustainability initiatives in a new way to other corporate decision makers and departments;
    - Compare different environmental impacts using a single metric;

- Compare different environmental impacts across the supply chain and the regions in which Amcor operates; and,
- Help meet client sustainability requirements to provide sales advantages

2. Scope: scoping consists of establishing boundaries and defining what to measure in the valuation. This can include conducting a valuation at a material, product, site, business group or unit, or enterprise level. Which components of the value chain to asses should also be defined, including how far upstream and downstream in the supply chain to extend the analysis. A temporal boundary can also be applied. Finally, which environmental key performance indicators (EKPIs) to measure and value should be defined.

   We conducted this natural capital valuation at a high level. Enterprise level metrics were used, and broken down to the regional or country level where applicable. The EKPIs were measured at all upstream tiers and Amcor operations, and from post-consumer waste. The temporal boundary consists of Amcor's 2015 fiscal year (July 2015 through June 2016). The EKPIs considered included greenhouse gases (GHGs), non-GHG air pollutants, land and water pollutants, land use and biodiversity, waste, and, water consumption.

   The chosen EKPIs were GHGs, water quantity, and waste. We chose these EKPIs based on discussion with Amcor personnel and the fact that Amcor currently tracks these metrics. Furthermore, these EKPIs have been shown to constitute the majority (~70%) of plastic product impacts. Current research indicates that land and water pollution, primarily from upstream raw material extraction and processing, constitute between 20 and 30% of global plastic product natural capital impacts.[14,15] However, much of these impacts are associated with the actual good or product that contains plastic, rather than plastic packaging itself. Land and water pollution from plastic packaging in some sectors, such as food, medical and pharmaceutical product, personal products, restaurants, retail, and soft drinks have been shown to be greater than impacts from the product itself. Like land and water pollution impacts in all sectors, the majority of the impacts are associated with upstream material extraction and processing. Based on this information land and water pollution is not likely to constitute a significant percentage of Amcor's direct natural capital impacts.

However, significant land and water pollution impacts could be present in the upstream portions of Amcor's supply chain.

3. Measure and Value: the measure and value stage consists of quantifying the change in the impact driver (e.g. GHG, water use, and/or waste) from corporate operations (i.e. the Quantity (Q)), and determining a valuation coefficient (i.e. the Price (P)), to convert the quantity to a dollar value.

Measure: Quantities

The scope of this analysis included greenhouse gas emissions (GHG), water use, and waste. To understand the impacts across Amcor's supply chain, the emissions were divided into upstream (impacts from direct and indirect Amcor suppliers), Amcor (impacts from Amcor's operations), and downstream (impacts from waste from Amcor operations as well as impacts from post-consumer waste).

Figure 1: *Sources of EKPI Quantities*

	UPSTREAM	AMCOR	DOWNSTREAM
GHG	Scope 2 + Scope 3	Scope 1	Scope 3 Waste + PCW emissions
WATER	Input - Output	Amcor Internal Measurements (EnviroChart)	Model Water used to process waste
WASTE	Not Included	Amcor Internal Measurements (EnviroChart)	PCW Estimates of Ocean and Land Litter

EKPIs were quantified using the following sources:

- GHG: Quantities of greenhouse gas emissions (CO2E) were obtained from Amcor's internal corporate greenhouse accounting metrics, which follow the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) Greenhouse Gas (GHG) Protocol for corporate accounting and reporting.[16] These calculations were extracted from Amcor's internal environmental tracking system (Envirochart) and further broken down into Upstream, Amcor Operations, and Downstream emissions as follows:

i. Upstream: Upstream emissions were defined as all Scope 2 emissions and all Scope 3 emissions, excluding Scope 3 emissions from waste.

ii. Amcor Operations: Plant emissions consist of all Scope 1 emissions.

iii. Downstream: Downstream emissions were defined as Scope 3 emissions from waste. These downstream quantities represent only emissions associated with waste produced at Amcor's plants, and does not account for CO2 emissions associated with post-consumer waste.

We estimated emissions associated with post-consumer waste by calculating the percentage of Amcor's products that end up being treated via landfilling, incineration, and recycling. These percentages are based on country specific waste treatment from various sources (see the Post-Consumer Waste Assessment Chapter, Methodology Section) and World Bank data.[17] We then applied unit process LCA metrics obtained from the Ecoinvent database[18] as conversion factors to determine emissions associated with the different disposal routes of post-consumer waste. We also quantified post-consumer waste that ends up as land and ocean litter using estimates from literature values.[19]

- Water: The amount of water extracted across Amcor's supply chain were obtained as follows:

i. Upstream: Upstream water use quantities were calculated using Environmentally Extended Input-Output models.

ii. Amcor Operations: Plant water use quantities were extracted from Envirochart.

iii. Downstream: Downstream water use quantities were calculated using the quantity of waste produced at Amcor's plants. Waste quantity was converted to a quantity of water use metric using unit process LCA metrics that define the amount of water used to treat a quantity of waste based on the treatment route (i.e. landfilling, incineration, and recycling).[20] These downstream quantities represent only water use associated with waste produced at Amcor's plants, and does not account for water use associated with post-consumer waste.

We estimated water use associated with post-consumer waste by calculating the percentage of Amcor's products that end up being treated via landfilling, incineration, and recycling. These percentages are based on country specific waste treatment from various sources (see Post-Consumer Waste Assessment Chapter, Methodology Section) and World Bank data.[21] We then applied conversion factors obtained from the Ecoinvent database[22] to determine water use associated with post-consumer waste.

- Waste: Treated waste is not an EKPI that can be valued itself. It must be broken out into relative quantities that go through each treatment route (e.g. landfill, incineration, or recycling). The CO2E emissions and water quantity usage associated with different treatments routes are available from LCA database and were included in the categories outlined above.[23] Land litter and ocean waste have no CO2E emissions or water use impacts, so different impacts, such as disamenity and economic impacts, must be used to avoid a value of zero for the mismanagement of waste. Waste generated across Amcor's supply chain were obtained as follows.
  i. Upstream: Waste produced upstream of Amcor's plants were not accounted for in this study.
  ii. Amcor Operations: Waste quantities produced at Amcor's plants were extracted from Envirochart. These quantities were treated as downstream impacts, and were quantified by determining the associated amounts of CO2E emissions and water use, as discussed above.
  iii. Downstream: We estimated quantities of post-consumer waste treated via different treatment routes by calculating the percentage of Amcor's products that end up being treated via landfilling, incineration, and recycling. These percentages are based on country specific waste

treatment from various sources (see appendix) and World Bank data.[24] We also quantified post-consumer waste that ends up as land ocean litter using waste mismanagement estimates from literature values.[25]

Value: Price

Several sources outline comprehensive methodologies for pricing environmental impacts associated with corporate activities. These sources include PWC's Valuing Corporate Environmental Impacts[26] and Trucost's Valuation Methodology.[27] Generally, the following methodologies have been deemed acceptable economic techniques for converting impacts to monetary terms:

- Abatement cost: the cost to remediate or offset an impact;
- Replacement cost, avoided cost, or substitute cost: the cost to replace services or provide substitute services;
- Contingent valuation: an individual's stated willingness to pay for a good, service, or other feature;
- Market pricing: the price of a good or service obtained from a market for which that good or service exists;
- Hedonic pricing: estimates the value of a good or service based on its effect on the market price of another good or service (e.g. water or air quality effects on real estate prices);
- Production function: used to estimate the value of a good or service that contributes to the production of some other commercially marketed good or service;
- Travel cost method: an individual's revealed willingness to pay for a good or service estimated by measuring the cost incurred to visit a site.

This research did not include any primary valuation studies. We conducted literature reviews to identify existing valuation coefficients, methodologies, and/or tools that used these methodologies in order to identify monetary impacts associated with the chosen EKPIs. Valuation coefficients were derived from the following sources:

- CO2: We used a variety of sources to identify a range of costs for CO2E emissions including the social cost of carbon and market values for CO2E.

The market values for each country that Amcor has operations in were identified by researching the price paid on carbon via taxes and/or emission trading. These values were applied to the quantities derived above to present a realistic cost of Amcor's GHG emissions based on actual market conditions that were present at the time of those emissions. Tables of market based prices are presented below (Tables 3 & 4). A Social Cost of Carbon (SCC) was used to present an upper value that represents a holistic, long-term environmental and social cost of GHG emissions.

- Water: Water use was valued according to previously used methodologies identified from literature reviews.[28,29,30] These methodologies link changes in water availability to human health and ecosystem health impacts. Water consumption leads to a decrease in water availability for irrigation and crop production, which leads to malnutrition.[31] The ecosystem health impacts are obtained by modeling the impact of water consumption on Net Primary Productivity (NPP), and changes in NPP to ecosystem service value changes.
- Waste: Waste was valued using the CO2 and water values discussed above, as well as from literature values for values associated with other impacts from post-consumer waste.

4. Apply: the apply stage consists of validating the results, interpreting the findings, and determining what actions can be taken. The results and conclusions of our valuation are presented in subsequent sections.

Detailed Methodology by Impact Category

CO2E

CO2E was chosen to include in the scope of this study for a variety of reasons. Amcor tracks CO2E emissions across its supply chain using the GHG Protocol. Therefore, we were able to determine emissions upstream of Amcor facilities, at Amcor sites, and downstream of Amcor facilities using simple methods. Additionally, CO2E is the easiest natural capital impact to price. Many governments have chosen to tax carbon emissions at some level, and some have established trading schemes designed to reduce CO2E emissions.

Furthermore, although there is no global consensus on a Social Cost of Carbon, there are estimates that can be used for natural capital valuations.

Quantity: Upstream

Upstream CO2E emissions were considered to be emissions that occur because of Amcor's operations, but that occur outside of Amcor's plants, specifically, those that occur because of goods and services delivered to Amcor that allow it to operate. These include Scope 2 emissions, which are associated with emissions that occur to provide energy to Amcor's facilities, and the majority of Scope 3 emissions, which are all other emissions associated with Amcor's operations, but that occur outside of Amcor plants. However, we subtracted Scope 3 emissions associated with waste produced at Amcor's plants from all other Scope 3 emissions. Scope 3 emissions associated with Amcor's waste are considered in downstream impacts.

Quantity: Amcor

Emissions that occur at Amcor's facilities are calculated and reported as Scope 1 emissions.

Quantity: Downstream

Downstream CO2E emissions were considered to be emissions that occur once materials leave Amcor's facilities. These include Scope 3 emissions associated with Amcor's waste, which the company currently tracks, and emissions that occur due to the disposal of Amcor's products after consumer use. In this methodology, we consider GHG impacts from waste treated via landfill and incineration. We quantified GHG emissions associated with waste sent directly from Amcor's plants to landfill and incineration facilities directly from Envirochart.

Downstream impacts associated with post-consumer waste treatment can be calculated by quantifying the amount of waste treated via treatment route and apportioning associated impacts. The methodology for quantifying the amount of post-consumer waste via treatment route is discussed in the Waste section below.

Once this quantity of waste was calculated, we applied plastic disposal unit process LCA metrics from the Ecoinvent database[32] as GHG emission conversion factors to calculate the amount of GHG emissions to treat the quantities of waste. Only GHGs included in the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) Greenhouse Gas (GHG) Protocol for corporate accounting and reporting[33] were quantified. We chose the plastic mixture metrics available in the database, because these are the most representative for estimating the treatment of a broad range of plastic materials. The emissions of these GHGs were converted to kg of CO2 equivalents using GHG Protocol conversion factors obtained from SimaPro.[34] Once converted to CO2 equivalents, the resulting factors were summed together to estimate the kg of GHGs emitted to treat a certain quantity of plastic depending on the waste treatment route (Table 2).

Table 2*: GHG Emission Factors*

GHG Emission Factors	
Incineration (kgCO2E/kg waste) = (Tonne CO2E / Tonne Waste)	Landfill (kgCO2E/kg waste) = (Tonne CO2E / Tonne Waste)
2.34151967756065	0.0896550366091554

These factors are the result of applying the unit process LCA metrics to waste quantities to determine the quantity of GHGs emitted from treated waste, and then converting the GHG emissions to CO2 equivalents.

Pricing

Though science demonstrates that the impacts of emitting GHGs are global, no matter where the GHGs are emitted, there are differences in how countries value the impacts.[35] For example, paying a $5USD/tonne of GHG seems like a low price in the U.S. but may be too much in developing countries like China or Mexico. At this time, there is not a single international market for GHG emissions trading. The current climate change protocol in place, COP 21, leaves abatement strategies to each individual country to decide what is best for its economy. Many countries have developed their own trading scheme or imposed a tax to encourage companies operating within their borders to limit GHG emissions.

This paper focuses on the 36 countries in which Amcor operates. Although it is likely that pieces of Amcor's supply chain are outside of these 36 countries, the model created assumes that all upstream and downstream impacts happen in the same country as production. This assumption was made to simplify the calculations for upstream and downstream impacts.

Pricing Based on Taxes and Trading Schemes

The most popular way to encourage abatement is a market-based solution. At COP 21, many large companies pushed for the agreement to include a market-based solution.[36] Of the countries where Amcor produces plastics, more than half of the countries have instituted some sort of emissions trading scheme (ETS). Some countries, like China, have test markets that exist in select cities, while others, like those in the European Union, have more rigorous markets that have been trading for years.

A variety of sectors are required to participate in ETS, though the specifics vary with each country. For example, the EU's ETS covers CO2E from power and heat generation, energy-intensive industry sectors (e.g. oil refineries, steel production, cement, bulk organic chemicals), and commercial aviation; nitrous oxide from the production of nitric, adipic and glyoxylic acids and glyoxal; and perfluorocarbons from aluminium production.[37] In comparison, the California Cap-and-Trade Program which is linked to the Québec Cap-and-Trade System covers more than 30 different sectors including food manufacturing, transportation, gas extraction, and mining.[38]

The common system for ETS is cap-and-trade. The regulator of the ETS sets a cap on the amount of emissions and issues allowances. Companies turn in an allowance for each tonne emitted, extra allowances can be traded to other companies that exceed the cap.[39] Each year the cap decreases to provide incentives for companies to continue to improve operations.

To determine the price to use for Amcor, we selected the latest fiscal year (July 2015 - June 2016) and found the minimum and maximum price traded over that time period for each ETS market. For the ETS markets that trade in a currency other than the U.S. dollar, the prices were converted to U.S. dollars. Then we organized the data by country and found the average price for each country (see Table 3).

Table 3: *Emission Trading Schemes for the Countries in Which Amcor Operates*

Market	Currency	Min	Max	USD Exchange[40]	USD Min	USD Max	Avg USD Price
China							$4.28
Beijing[41]	*Yuan*	*32.4*	*60*	*0.155*	*$5.03*	*$9.32*	

Market	Currency	Min	Max	USD Exchange[40]	USD Min	USD Max	Avg USD Price
Shanghai (V2013)[42]	*Yuan*	*23.3*	*32*	*0.155*	*$3.62*	*$4.97*	
Shanghai (V2014) [43]	*Yuan*	*5.1*	*16*	*0.155*	*$0.79*	*$2.49*	
Shanghai (V2015) [44]	*Yuan*	*4.21*	*22.5*	*0.155*	*$0.65*	*$3.49*	
Guangdonng[45]	*Yuan*	*8.1*	*19.63*	*0.155*	*$1.26*	*$3.05*	
Shenzhen (V2013)[46]	*Yuan*	*26.59*	*49.01*	*0.155*	*$4.13*	*$7.61*	
Shenzhen (V2014) [47]	*Yuan*	*21.47*	*54.45*	*0.155*	*$3.33*	*$8.46*	
Shenzhen (V2015) [48]	*Yuan*	*25*	*50*	*0.155*	*$3.88*	*$7.77*	
Shenzhen (V2016) [49]	*Yuan*	*44.2*	*48.4*	*0.155*	*$6.87*	*$7.52*	
Tianjin[50]	*Yuan*	*11.2*	*24.1*	*0.155*	*$1.74*	*$3.74*	
Hubei[51]	*Yuan*	*No data*	*No data*				
Chongqing[52]	*Yuan*	*10*	*18*	*0.155*	*$1.55*	*$2.80*	
Canada							$11.97
Alberta[53]	*CAD*	*15*		*0.755*	*$11.32*		
California/ Quebec[54]	*USD*	*12.52*	*12.73*		*$12.52*	*$12.73*	
USA							$9.32

Market	Currency	Min	Max	USD Exchange[40]	USD Min	USD Max	Avg USD Price
California/ Quebec[55]	*USD*	*12.52*	*12.73*		*$12.52*	*$12.73*	
Northeast (RGGI)[56]	*USD*	*4.53*	*7.5*		*$4.53*	*$7.50*	
EU[57]	*Euro*	*4.87*	*8.48*	*1.110*	*$5.41*	*$9.41*	
Belgium							$7.41
Czech Republic							$7.41
Denmark							$7.41
Finland							$7.41
France							$7.41
Germany							$7.41
Ireland							$7.41
Italy							$7.41
Poland							$7.41
Portugal							$7.41
Spain							$7.41
UK							$7.41
New Zealand[58,59]	*NZ Dollar*	*6.55*	*18.2*	*0.668*	*$4.38*	*$12.16*	*$8.27*
Switzerland[60]	*CHF*	*9*	*11.05*	*1.021*	*$9.19*	*$11.28*	*$10.24*
Turkey[61]	*USD 2015*				*$1.30*		*$1.30*

The prices listed are for the period July 2015 through June 2016.

Some countries also include a tax on carbon, often on power generation to create incentives for power companies to use the cleanest energy sources possible. Chile and Mexico both added carbon taxes in the last year, both on the power generation industry.[62] Similar to ETS trading, we researched which countries had a carbon tax in effect for the time period of July 2015 - June 2016. If the tax listed was in a currency other than U.S. dollars, the tax was translated to U.S. dollars (Table 4).

Table 4: *Carbon Taxes for the Countries in Which Amcor Operates*

Market	Currency	Tax Price	USD Exchange[63]	Tax Price in USD
Finland[64]	Euros	50	1.110029	$55.50
Switzerland*	USD	34.20		$34.20
Ireland*	USD	26.17		$26.17
Denmark[65]	DKK	100	0.1489	$14.89
Portugal*	USD	8		$8.00
Chile[66]	USD	5		$5.00
Mexico[67]	USD	3.50		$3.50
Poland*	USD	1		$1.00

The prices listed are for the period July 2015 through June 2016.
**Various sources were reviewed to determine if the countries had an actual carbon tax or an effective carbon tax that is levied through other mechanism. Values were pulled based on estimates from these sources.*[68,69,70]

Of the countries in which Amcor operates, only eight have instituted a carbon tax. Of those eight, six have both a carbon tax and an ETS. In those countries, the carbon tax may act as a floor to the ETS, ensuring the price of carbon never dips below a certain threshold.

The final analysis revolved around the 16 countries that had no ETS or carbon tax. For these countries, we applied a price of zero. Some countries, like Venezuela and Ecuador, do not believe in the idea of a price on carbon.[71] Other countries, like Colombia, are using alternatives to a carbon tax or ETS to cut emissions.[72] And still other countries, like El Salvador, do not have the infrastructure to track carbon emissions. Since countries like this are not able to measure the quantity of GHGs emitted at a country level, it would be impossible to create a carbon tax or ETS.[73]

Social Cost of Carbon (SCC)

Previous natural capital valuations, such as those conducted by Puma, Kering, and Novo Nordisk, have all used a social cost of carbon (SCC) to value corporate environmental damages resulting from CO2E emissions. The SCC is a global marginal damage cost of CO2E emissions that is based on the present value of damages caused by a metric ton of carbon during its entire lifetime. Thus, the SCC attempts to identify a comprehensive metric for the damages of GHG emissions. However, the actual number is dependent on a several factors, such as emission scenarios, discount rate, and equity weighting.[74] Studies that estimate the SCC use a multi-model approach starting with different emissions scenarios, such as those provided by the Intergovernmental Panel on Climate Change (IPCC), as inputs into climate models that predict future changes in climate. The outputs of the climate models are then used as inputs into impact assessment models that predict impacts on society under different future climate change conditions. Societal impacts are then translated to economic costs using economic models. Future costs are discounted back to net present value using a chosen discount rate.[75]

More than 300 studies have attempted to identify the SCC.[76] Two such studies that attempt to value carbon are the UK Stern Review[77] and the 2016 EPA Interagency Working Group on Social Cost of Carbon.[78] These working groups were officially designated by European and the United States governments, respectively. Therefore, they serve as official governmental guidance documents. Climate change models included in these reports include the Policy Analysis of the Greenhouse Gas Effect (PAGE), Dynamic Integrated Climate Economy (DICE), and the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) models. The PAGE model uses increases in global mean temperature to project a cost value that combines economic and non-economic costs of climate change damages, costs of large-scale discontinuities (i.e. extreme weather events), and costs of mitigation (costs minus the benefits of mitigation).[79] The DICE model links increases in global mean surface temperatures to reduced country and region economic outputs through reductions in physical capital and labor. The model accounts for consumption, investment in physical capital stock, and expenditures on emissions reductions, and then solves for the optimal path of savings and emissions reductions over a certain time horizon. The goal of the model is to maximize the discounted sum of all future utilities from consumption.[80] The FUND model combines population, technology, economic, emission, atmospheric chemistry, climate, sea level, and impact models to represent plausible future scenarios. The model can then be used to perform cost-benefit and cost-effectiveness analyses of GHG reduction policies.[81]

The end result of a SCC calculation is a complete measure of GHG emission damages in financial terms. However, because of the methodology, wide ranges of estimates exist. Trucost identified more than 300 studies that attempt to identify the SCC, with estimates ranging from zero to thousands of dollars per metric ton.[82] For the purposes of this report, a SCC of $128/per tonne in 2015 dollars was applied. This represents damages resulting from the worse than business as usual scenario in the 2016 USA Interagency Working Group on Social Cost of Carbon.[83] Thus, this value represents a conservative upper-limit estimate of GHG emission damages.

Water Consumed

Natural capital impacts associated with water include both water consumption and water pollution. Amcor tracks water used at its plants, upstream use quantities can be estimated using environmentally extended input output models, and downstream use quantities can be estimated using waste quantities and water use factors to calculate the amount of water used to treat waste. However, to quantify water pollution would require profiling water discharges from Amcor's plants and other pollution that might occur at Amcor's plants and become deposited in water (such as air pollution). Upstream impacts could be estimated using input output models. Downstream impacts would require modelling water pollution from waste treatment processes. As previously discussed, water pollution is not likely to cause large natural capital impacts from Amcor's direct operations. Based on these considerations, we decided not to include water pollution within the scope of this project.

Quantity: Upstream

As Amcor only tracks water used at its plants, it was necessary to use another method to estimate the upstream impacts. The environmentally extended input output (EEIO) model provides a formula to estimate these impacts. The EEIO model calculates the environmental impacts of both direct and indirect suppliers throughout Amcor's supply chain. For example, this method includes the amount of water used to produce resin (the main input for Amcor products - a direct supplier) as well as the amount of water used to produce oil which is used to produce resin (an indirect supplier). The EEIO is based on input output economics, a technique created by Wassily Leontief, which shows that one company's output is another company's input (resin is an output for resin manufacturers and an input for plastic manufacturers).[84] Using matrix algebra and input output tables representing national economies, it is possible to determine how much of one industry is used to produce a certain amount of another country.

The Eora multi-region input output table (MRIO) database was used as the source of data, as it provides tables for every country Amcor operates in and provides comprehensive environmental satellite accounts for each of the economies in its database.[85,86] The databases for the 36 countries Amcor operates in were downloaded from the Eora website. For each country, the following variables were defined:

- Z: Includes all of the rows and columns corresponding to the country's industries and commodities, but does not include imports, exports, final demand, or primary inputs
- X (Total Output): The sum of each row (including exports and final demand)
- W: Represents Amcor production as a column of all 0's except $1 for the commodity that includes plastic packaging
- P: Environmental satellite account - Total Water Used (measured in m^3)
- I: Identity matrix with the same dimensions as Z (created in MatLab using I=eye(n) with n=the rows & columns of Z)

After defining the variables in the table, the data was inputted into MatLab to calculate the environmental footprint. The following calculations were applied to the defined variables for each country:

1. A=Z*inv(diag(X));
2. Q=(I-A)^-1*W;

3. E=P*(diag(X)^-1);
4. F=E*Q;

F defined the amount of water used to produce $1 of plastic. Finally, to find the total impact of Amcor's operations, the F for each country was multiplied by the total Amcor revenue for 2015-16 (Table 5).

Table 5: *Input-Output Modelling Results*

Country	Water (m^3) for $1 plastic	Total Amcor Revenue (USD)[87]	Total Water used (m^3)
Argentina	0.0160807	$167,568,242.31	2,694,610.41
Australia	0.0180966	$337,192,200.58	6,102,016.74
Belgium	0.0054569	$130,936,130.83	714,506.65
Brazil	0.0468981	$202,198,672.93	9,482,736.94
Canada	0.0113605	$96,582,257.20	1,097,226.11
Chile	0.0059531	$20,918,237.20	124,528.90
China	0.0209351	$365,579,405.25	7,653,449.66
Colombia	0.0563485	$44,384,979.45	2,501,024.97
Czech Republic	0.0073187	$41,231,998.40	301,765.39
Denmark	0.0007812	$94,436,906.20	73,773.85
Dominican Republic	0.0142594	$9,664,097.48	137,804.50
Ecuador	0.0611166	$24,029,798.60	1,468,619.23
El Salvador	0.0264957	$36,658,116.55	971,281.84
Finland	0.0029168	$53,342,976.49	155,589.99
France	0.0063253	$581,605,836.27	3,678,837.12
Germany	0.0013874	$399,885,552.03	554,797.07

Country	Water (m^3) for $1 plastic	Total Amcor Revenue (USD)[87]	Total Water used (m^3)
India	0.1098633	$80,906,000.80	8,888,599.31
Indonesia	0.0057367	$62,287,938.99	357,328.45
Ireland	0.0061008	$20,123,095.08	122,766.19
Italy	0.0064883	$235,580,305.44	1,528,521.89
Mexico	0.0142581	$28,049,878.56	399,938.27
Morocco	0.0301199	$16,742,016.12	504,267.98
New Zealand	0.0085296	$122,772,439.31	1,047,202.74
Peru	0.0130902	$49,669,532.30	650,181.73
Poland	0.0078906	$143,333,689.64	1,130,984.52
Portugal	0.0534098	$90,617,411.57	4,839,859.74
Russia	0.0079798	$61,655,473.35	491,996.75
Singapore	0.0000198	$20,134,050.11	398.32
Spain	0.0028392	$162,407,796.74	461,108.91
Switzerland	0.0005342	$361,222,121.78	192,974.01
Thailand	0.0220902	$133,173,078.51	2,941,815.03
Trinidad & Tobago	0.0101843	$12,048,987.38	122,710.29
Turkey	0.0091675	$57,261,780.19	524,949.64
USA	0.0454736	$2,645,583,212.00	120,304,104.33
UK	0.0012268	$349,386,434.87	428,616.05
Venezuela	0.0073952	$464,661,366.84	3,436,273.01

The variable F represents Water (m^3) for $1 plastic produced and was imported from the MatLab calculations. It was then multiplied by the total Amcor Revenue for the corresponding country to determine the total water used (m^3) throughout Amcor's supply chain.

Quantity: Amcor Operations

Amcor tracks the amount of water used at each of its production plants through its Envirochart software. To find the amount of water used by country, the data for each plant were downloaded from Envirochart and then the plants were aggregated by country.

Quantity: Downstream

Amcor tracks the amount of waste it produces at its operations in Envirochart, so this portion of the downstream impacts can be calculated by quantifying the amount of waste treated via treatment route and apportioning associated impacts. In this methodology, we considered water use impacts from waste treated via landfill and incineration. We quantified the waste sent directly from Amcor's plants to landfill and incineration facilities directly from Envirochart.

We then used plastic disposal unit process LCA metrics from the Ecoinvent database[88] as water use conversion factors to calculate the amount of water used to treat the quantities of waste. These factors represent the volume of water used to treat a certain quantity of plastic depending on the waste treatment route (Table 6). We chose the plastic mixture metric available in the database, because these are the most representative for estimating the treatment of a broad range of plastic materials.

Table 6: *Water Use Factors.*

Water Use Factors			
Incineration (cm^3/kg)	Landfilling (cm^3/kg)	Incineration (m^3/tonne)	Landfilling (m^3/tonne)
174.57	251.75	0.17457	0.25175

These factors are the result of applying the unit process LCA metrics to waste quantities to determine the quantity of water used to treat waste.

We also calculated the amount of water used to treat post-consumer waste. The methodology for this process is discussed in the Waste section below. We applied the same water use factors to our estimate of the quantity of Amcor's products treated via incineration and landfill post-consumer.

Pricing

As discussed above, water impacts are valued by determining changes in malnutrition and ecosystem quality. The detailed approaches to these processes are summarized below. The methodology is consistent with existing accepted methodologies.[89,90]

- Human Health: human health impacts are modeled by calculating the changes in disability adjusted life years (DALYs) due to water consumption. The steps are as follows:
    i. Human health impact factors are available at country levels from scientific publications[91,92] and in the Ecoindicator-99 LCA database.[93] These factors are impact inventory LCA metrics that describe how many disability adjusted life years (DALYs) are lost when a volume of water is consumed. These numbers include several factors that are taken into account, including water scarcity and availability, the amount of water used for agriculture, and malnutrition rates.
    ii. To convert DALYs to a dollar amount, a conversion factor must be used. DALYs are multiplied by the value of a statistical life (VSL) to generate a $/volume of water metric.

    For the VSL, we used a global median value of $46,528/DALY. This number was recommended in the literature, because it does not place any weight on the value of life in any particular country, so we avoid ethical issues of assigning different values of life for each country.[94]

The overall equation for this process is:

HHI ($/cubic meters) = HHIF (DALY/cubic meters) * VSL ($/DALY)

Where: HHI = Human Health Impact

HHIF = Human Health Impact Factor

VSL = Value of a Statistical Life

- Ecosystems: ecosystem impacts are modeled by calculating the change in Ecosystem Service Value (ESV) of an ecosystem through changes in Net Primary Productivity (NPP) due to water consumption. The entire equation on a per country basis for this process is:

$$ESV_{water\ use}\ (\$/area) = Average\ ESV\ (\$/area) * \%\Delta Value_{water\ use}$$

Where: ESV = Ecosystem Service Value

$$Average\ ESV\ (\$/area) = \sum(\%Area_{biome} * ESV_{biome}\ (\$/area)/(\#\ of\ biomes)$$

$$\%\Delta Value_{water\ use} = (V_{baseline} - V_{after})/V_{baseline}$$

$$V\ (\$/area) = e^{(-12.057 + 2.599*\ln(NPP))}$$

$$NPP_{baseline}\ (grams/area) = \sum(\%Area_{biome} * NPP_{biome})/(\#\ of\ biomes)$$

$$NPP_{after}\ (grams/area) = NPP_{baseline} - \Delta NPP_{water\ use}$$

$$\Delta NPP_{water\ use}\ (grams/area) = EQCF\ (expressed\ as\ a\ \%) * NPP_{baseline}$$

EQCF = Ecosystem Quality Change Factor

i. We obtained global average ecosystem service values by terrestrial biome from scientific literature.[95,96,97]

ii. Using GIS, we obtained the area of each of these biomes per country using terrestrial ecoregion and biome[98] and world countries[99] shapefile layers. Using the proportion of biome area in each country and the above land values, we obtained a weighted average value of land per country. The equation for each country is:

Average ESV per Country = ∑(%area of each biome * ESV of each biome)/(number of biomes in that country)

iii. This weighted average ecosystem service value per country accounts for all ecosystem services of the land in that country. Thus, the percentage of that value associated with water needs to be determined. To do this, water use is linked to net primary productivity (NPP) change, and NPP change is linked to value change.[100] This allows us to calculate a percentage value change due to water, which we then multiply the original weighted average value of land per country.

   i. First we calculated a baseline NPP number per country using the % area of each biome per country and average NPP per biome from literature values.[101,102] The equation is:

      Average Baseline NPP per country = ∑(%area of each biome * NPP of each biome)/(number of biomes in that country)

   ii. To calculate the baseline ecosystem service value associated with NPP, we used a relationship from scientific literature that relates NPP to ecosystem service value.[103,104] The equation is:

      $\ln(V) = -12.057 + 2.599*\ln(NPP)$, where V = Value in $\$/m^2$, NPP = Net Primary Productivity in g/m^2

      This equation can also be written as $\mathbf{V = e^{(-12.057 + 2.599*\ln(NPP))}}$

   iii. Using this equation, we calculated $V_{baseline}$ per country based on the average NPP per country from above.

   iv. To calculate the % NPP lost due to water use, the Ecosystem Quality impact inventory LCA metric from the Eco-Invent database[105] is used. These numbers represent the proportion of one m^2 that is degraded per volume of water used on a per country basis. However, because it is derived by estimating the number of plant species lost in a given area, it can also be treated as a percentage decrease in NPP due to water use.

We multiplied that factor by the baseline NPP value to calculate a decrease in NPP. The equation is:

NPP Change After Water Use = (Ecosystem Quality Change Factor per Country) * (Average Baseline NPP per Country)

v. NPP per Country After Water Use can then be calculated. The equation is:

$NPP_{after\ water\ use}$ per Country = Baseline NPP per Country – NPP Change After Water Use per Country

vi. We then calculated the ecosystem service value per country after water use using the equation $V_{after} = e^{(-12.057 + 2.599*\ln(NPPafter\ water\ use))}$

vii. We then calculated the % value change due to water use per country:

%Value Change = $(V_{baseline} - V_{after})/V_{baseline}$

viii. We then calculate the Ecosystem Service Value associated with water use per country:

%Value Change * Weighted Average Country Ecosystem Service Value = Ecosystem Service Value Associated With Water Use

Waste

Waste was included in this study for several reasons. Amcor tracks emissions associated with waste generation at its facilities. Additionally, part of this project involved a post-consumer waste assessment. This involved identifying post-consumer waste treatment route percentages. Therefore, we quantified end-of-life routes for Amcor products using these data. However, we focus only on GHG emissions, water use, and litter and ocean waste impacts. Furthermore, the litter and ocean waste impacts are based on disamenity and economic impacts, respectively. Therefore, our analysis does not include all natural capital impacts, such as land and water pollution and ecosystem degradation.

Quantity: Upstream

The quantity of waste generated and disposed of upstream of Amcor's operations was not included in this assessment.

Quantity: Amcor Operations

Amcor tracks its waste generated at its facilities and disposed of via several treatment routes. We considered the quantity of waste generated at Amcor's plants and treated via landfilling and incineration in this assessment.

Quantity: Downstream

Post-consumer waste impacts depend on the treatment route of plastic after its use.[106] Mismanaged waste results in different impacts than managed waste.[107] We considered landfilling, incineration, recycling, land litter, and ocean litter waste end-of-life routes in our assessment. We estimated regional end-of-life treatment route percentages using post-consumer waste treatment percentages by country (sources included in appendices), World Bank data,[108] and data from academic studies on plastic waste.[109]

Municipal solid waste per country per year was estimated based on waste generation per capita. The quantity of plastic waste produced per country per year was then estimated based on percent plastic in waste stream data per country. We then calculated the amount of mismanaged and littered plastic waste using inadequately managed waste and littered waste percentages by country from scientific literature.[110] These numbers represent the total quantity of waste littered or that results in unintentional litter. Estimates of the quantity of waste entering the ocean per country was obtained from literature values.[111] Final littered plastic waste on land was quantified by subtracting the amount of waste entering the ocean from the total quantity of inadequately managed waste. The remaining quantity of plastic waste that is actually treated was calculated by subtracting ocean and land litter quantities from the overall plastic waste production estimate. Municipal solid waste treatment percentages by country were then applied to the actual quantity of plastic waste treated estimate to determine the estimated quantity of plastic waste via treatment route. These quantities were then divided by the original estimate of total amount of plastic waste produced per country to determine the percentage of waste treated by each end-of-life treatment route per country. Using these country percentages, the average percent of plastic waste treated via incineration, landfilling, and recycling, and the percentage of plastic waste that results as land and ocean litter were derived at country, regional and global levels.

Amcor's total production quantity by country was calculated using internal Amcor data. Regional waste treatment percentages by treatment route were then applied to Amcor's total production by country, depending on what global region that country is in (i.e. North America, Latin America, Europe, Asia, Oceania, and Africa). This conversion derives an estimate of the amount of Amcor's product by treatment route post-consumer. We chose to use regional average waste treatment percentages as opposed to country specific or global averages, because we were able to account for a high percentage (~90%) of total waste treatment, while maintaining some level of specificity by assuming that Amcor's products are consumed and treated in the same region in which they are produced. In contrast, country specific waste treatment percentages were only able to account for the treatment of 80% of Amcor's waste. The quantities we estimated via treatment route are likely not 100% accurate. However, the methodology does provide accurate insight into the scale of downstream impacts.

The next step consists of quantifying the emissions, water use, and/or other impacts associated with waste treatment. We used plastic disposal unit process LCA metrics from the Ecoinvent database[112] as conversion factors to calculate the amount of GHG emissions and water used when treating a plastic waste mixture via landfilling and incineration. Therefore, the amount of emissions and water used for the treatment of those waste quantities were calculated using those conversion factors. These conversion factors are presented in the CO2E and Water sections discussed above. Emissions and water use for recycled waste were both assumed to be zero. Thus, recycled waste is not considered to have a natural capital impact in this assessment. Land and ocean litter are not processed; the cost of land and ocean litter can be estimated directly, so a conversion to GHG emissions and water use are not necessary. The dollar value impact associated with litter and ocean waste are further discussed below.

Pricing

The pricing methodologies discussed above for GHG and water use were also applied to GHG emissions and water use for post-consumer waste.

The cost of litter and ocean waste impacts were estimated using literature values. Impacts of litter are based on average disamenity costs from studies.[113,114,115,116,117,118] Ocean waste impacts are based on estimates of economic impacts of waste in the ocean, specifically on fisheries, tourism, and cleanup costs.[119] The final values used were $10.66/tonne for litter and $252.85/tonne for ocean waste.

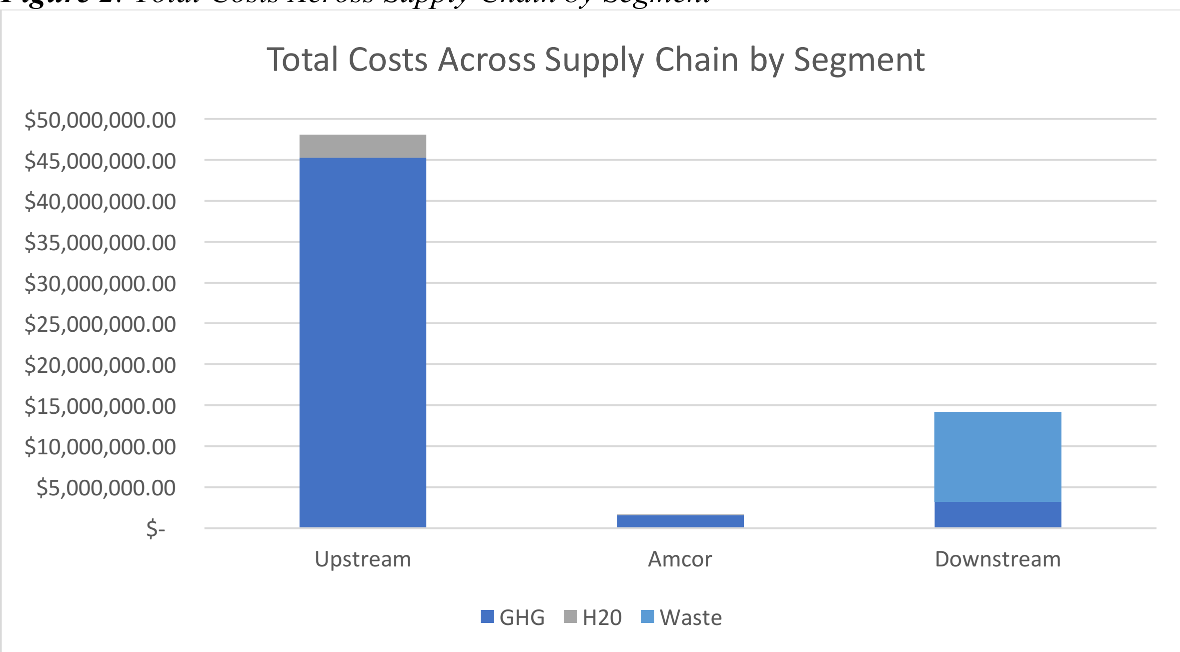
Results and Implications

Amcor's total natural capital valuation is $63,898,196, which is the sum of each impact category for each portion of the supply chain (Table 7). The majority of Amcor's natural capital impacts occur outside of its facilities. Upstream GHG emissions constitute the largest impact, and downstream mismanaged waste constitute the second largest impact. Water impacts are minimal when compared to the other EKPIs.

***Table** 7: Total Amcor Natural Capital Valuation*

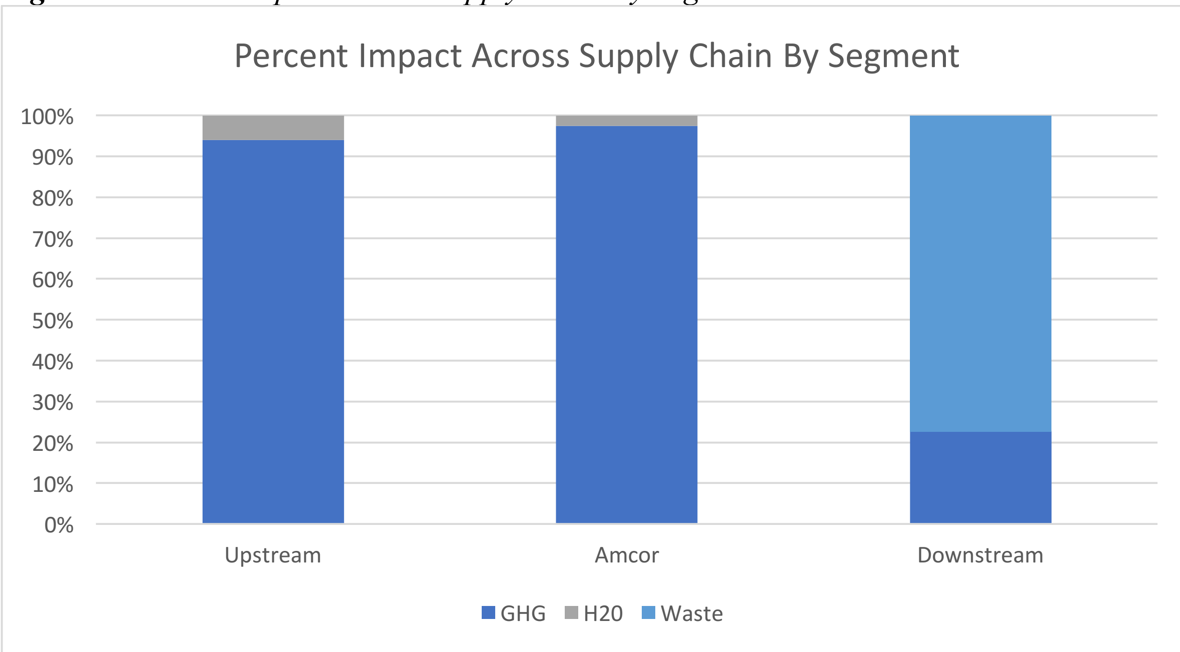
EKPI	Upstream	Amcor	Downstream
GHG	$45,289,044.41	$1,555,185.81	$3,219,445.71
H_20	$2,852,828.12	$41,350.10	$3,292.96
Waste	$-	$-	$10,936,412.02

***Figure 2**: Total Costs Across Supply Chain by Segment*



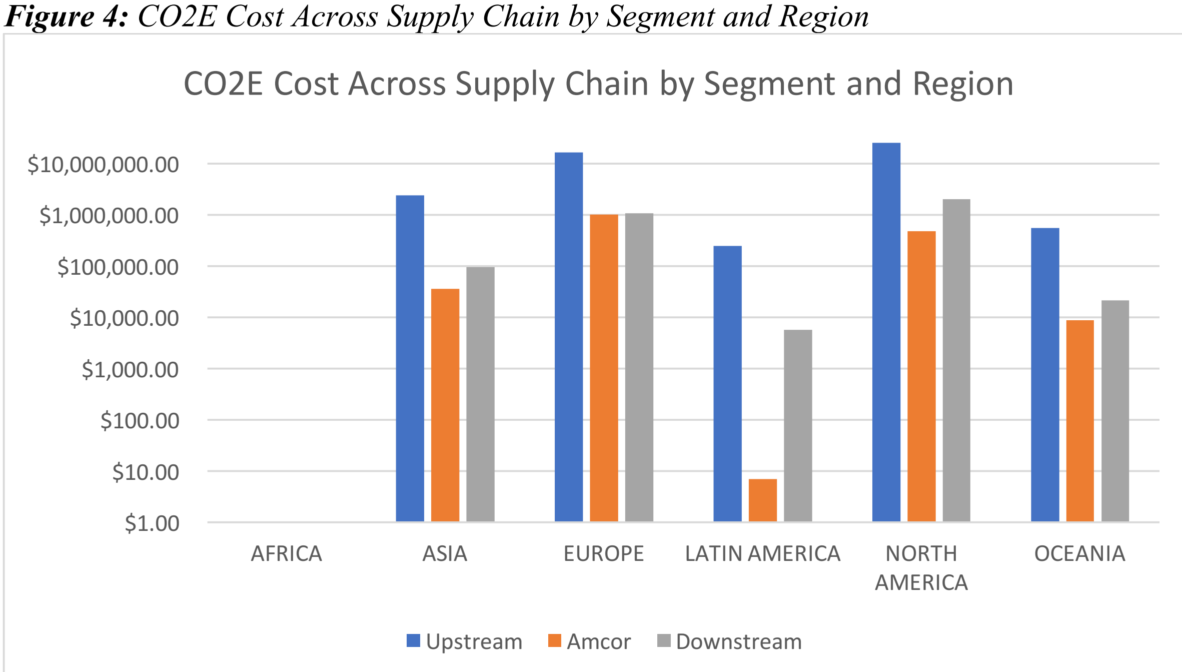
The total natural capital valuation and breakdown by supply chain segment show that upstream impacts are much larger than either Amcor operations or downstream impacts.

Figure 3*: Percent Impact Across Supply Chain by Segment*



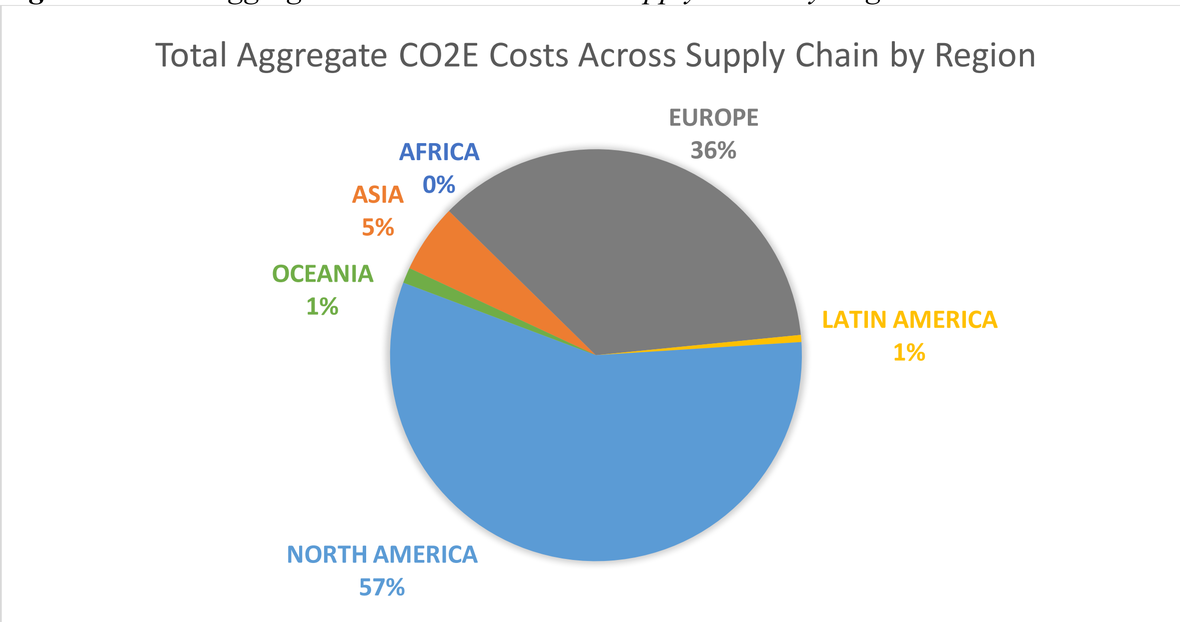
GHG emissions make up the majority of the impacts for both upstream and Amcor operations. Mismanaged waste, specifically ocean litter, makes up the biggest percent impact for downstream.

Figure 4: *CO2E Cost Across Supply Chain by Segment and Region*



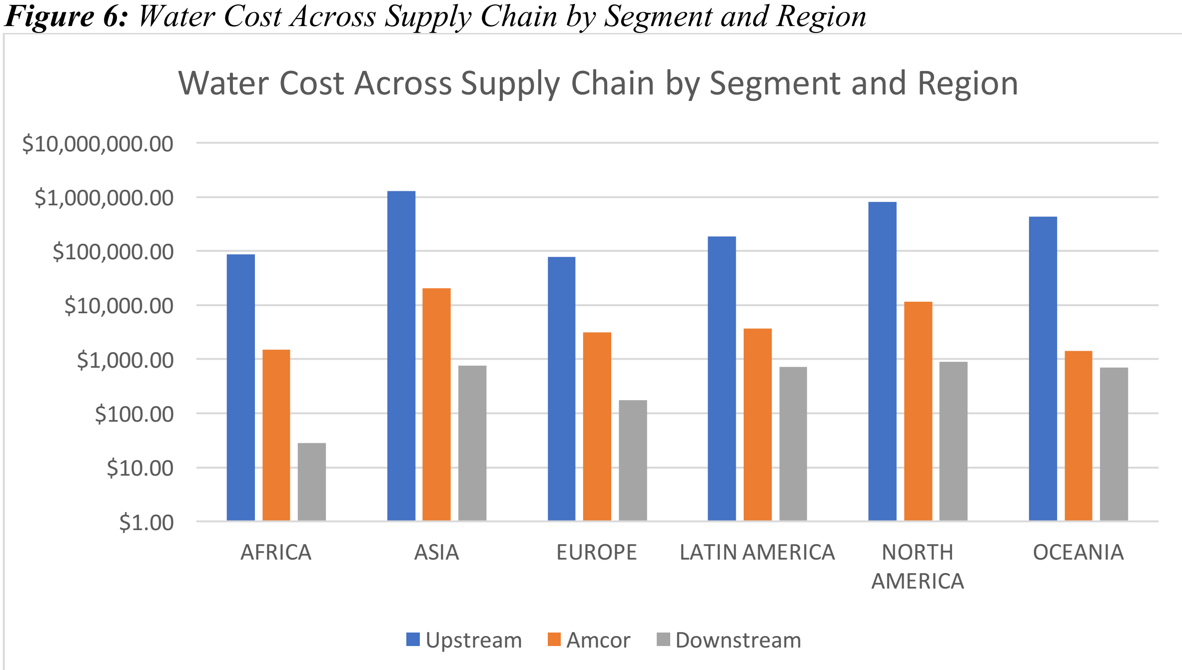
One important detail to note on Figure 4 is that the y-axis is a logarithmic scale, so each line represents an order of magnitude, or 10 times, increase. Generally, upstream CO2E impacts are significantly larger than Amcor and downstream impacts, with costs in the tens of thousands to tens of millions as opposed to thousands to hundreds of thousands.

Figure 5: *Total Aggregate CO2E Costs Across Supply Chain by Region*



Figures 4 and 5 show that costs are not distributed equally by region. The values are a function of how countries price CO2E emissions. Some countries, like Morocco and some countries in Latin America have no pricing mechanism, so costs are not accounted for.

Figure 6: *Water Cost Across Supply Chain by Segment and Region*



Water costs show a consistent trend across regions, with upstream impacts comprising the largest impacts, Amcor water use the second largest impacts, and downstream impacts the third largest. Similar to the CO2E graph, the y-axis scale is also logarithmic. Downstream water use impacts are in the region of tens to hundreds of dollars, Amcor water use impacts are in the thousands to tens of thousands of dollars, and upstream impacts are in the hundreds to millions of dollars.

Figure 7: *Total Water Costs and Quantities by Country At Amcor Plants*

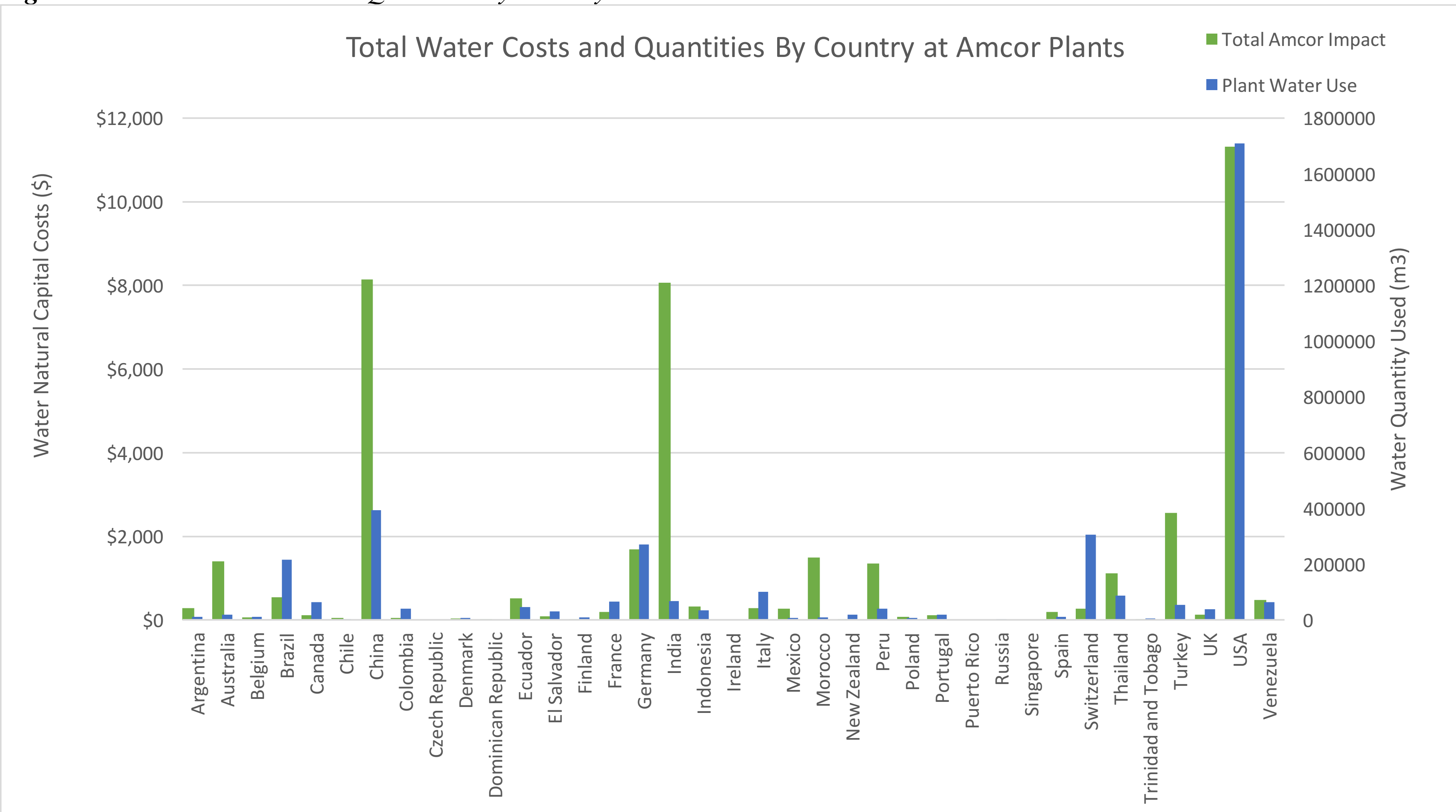
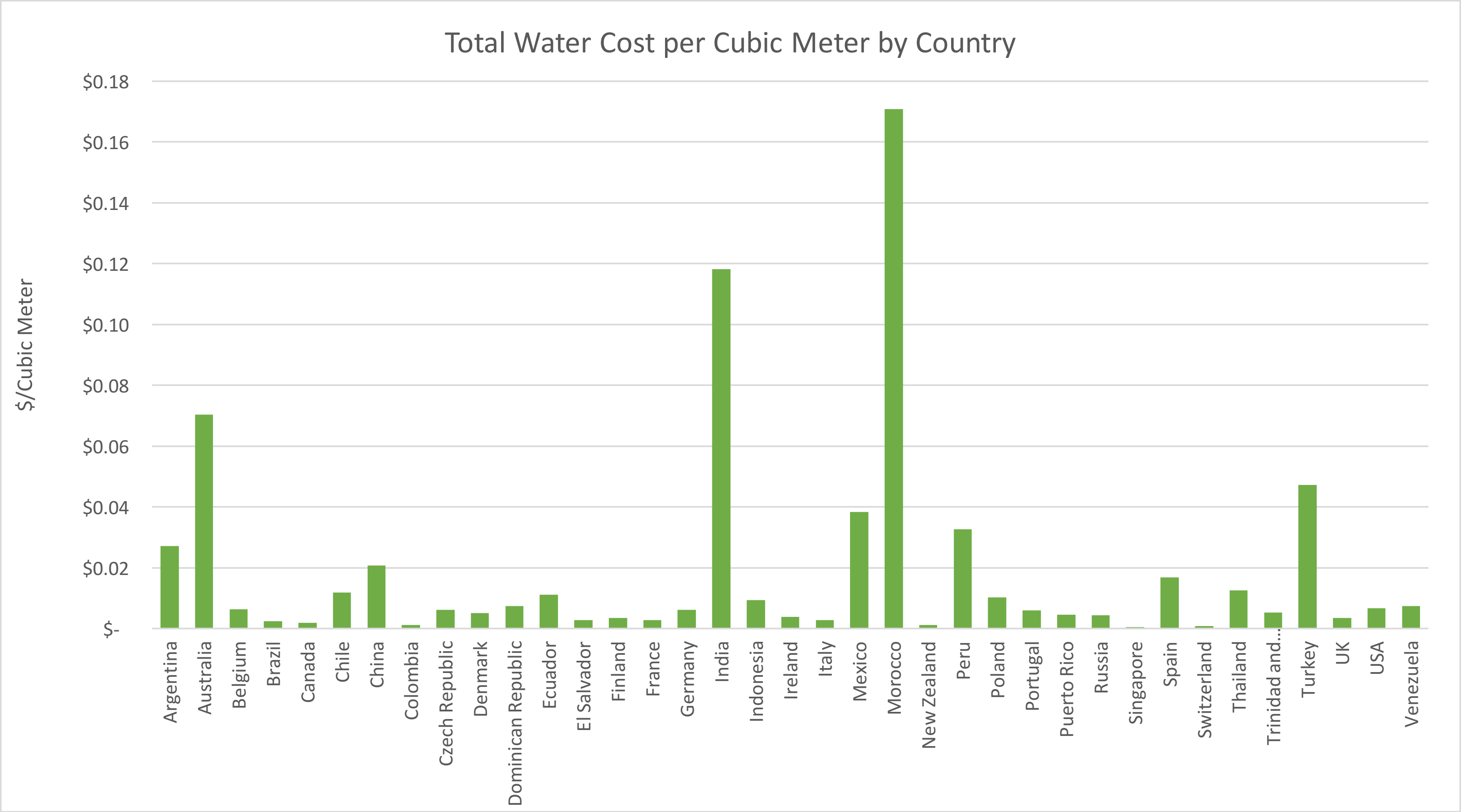


Figure 8: *Total Water Cost per Cubic Meter by Country*



Water quantity use does not necessarily correlate with the natural capital cost of water use. The natural capital cost of water use is a function of water scarcity, so plants that are located in countries that have larger areas of greater water scarcity, such as Australia, China, India, Morocco, Peru, and Turkey, have high natural capital costs due to water use relative to the absolute quantity of water used. The USA has both the highest quantity of water use and natural capital costs, but the costs in the USA are a function of the amount of water used.

Figure 9: *Waste Costs by Region*

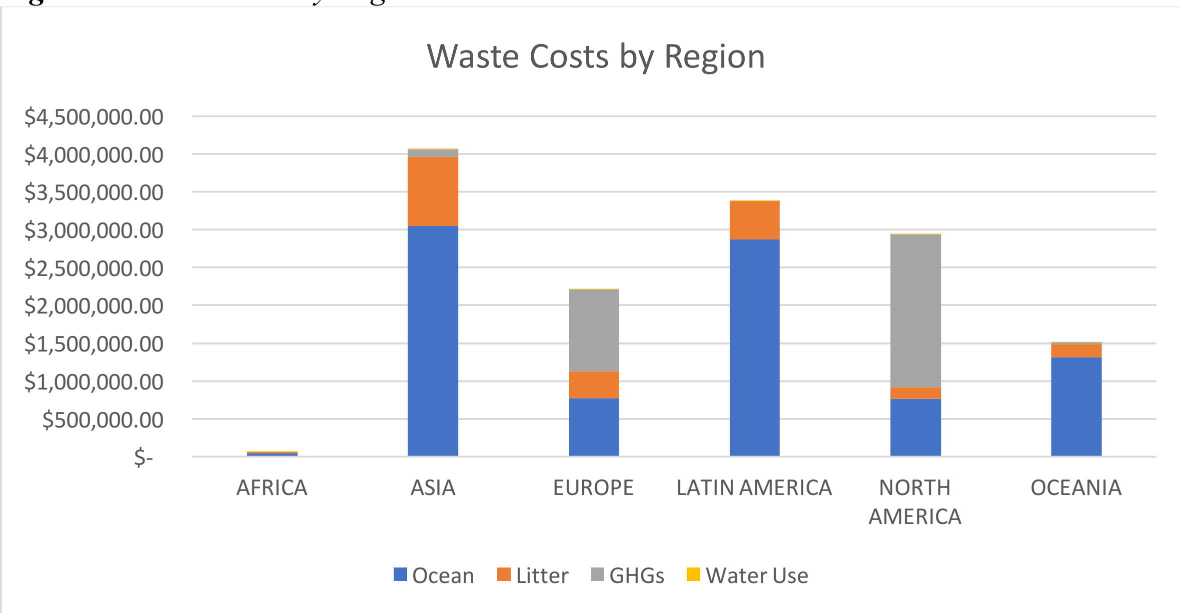


Figure 10: *Post-Consumer Waste Costs by Region*

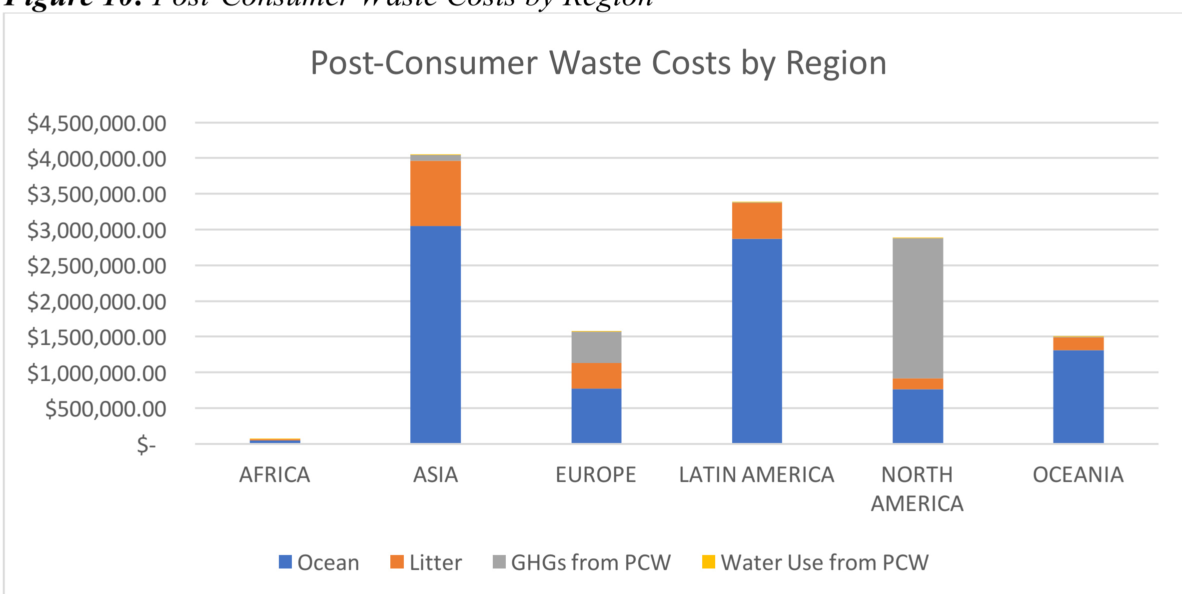


Figure 11: *Post-Consumer Waste Costs by Region*

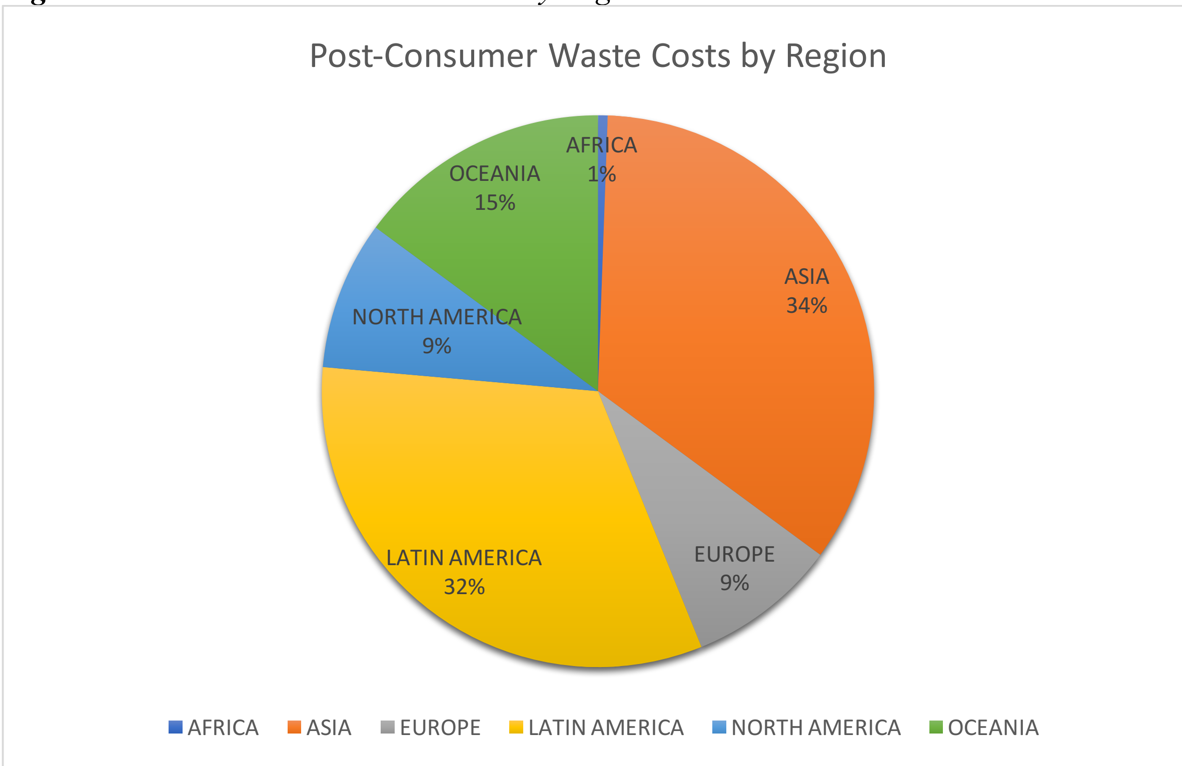
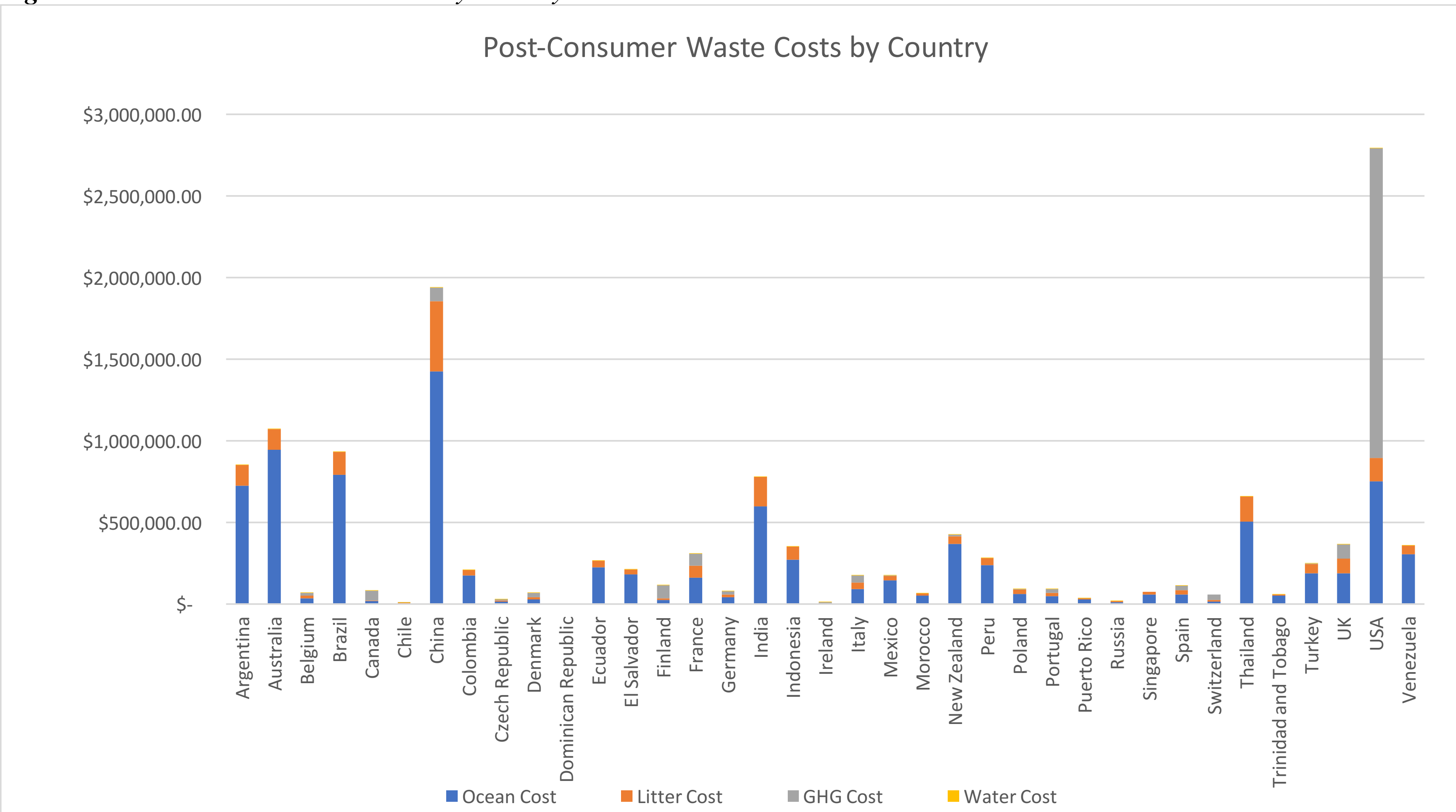


Figure 12: *Post-Consumer Waste Costs by Country*



Downstream impacts from waste, specifically mismanaged waste, constitute the second largest impact associated with Amcor's business operations. These costs are not distributed evenly across business groups or global regions. North America generates significantly more GHG emissions from waste treatment than any other region. This is due to the fact that this region has the highest quantity of post-consumer waste treated via landfilling and incineration. Asia and Latin America have higher ocean waste and litter costs than the other business groups, driven by mismanaged waste. Most of the waste impacts in Oceania occur from mismanaged waste, while about half of the impacts from waste generated in Europe stem from mismanaged waste, and the other half from GHG emissions. However, the USA still has large post-consumer waste costs, particularly because of GHG emissions due to the volume of waste produced in the USA.

Generally, trends in costs across EKPIs vary by region; different regions incur natural capital costs in different areas. For example, Asia, Latin America, and Oceania have the highest waste costs, while Europe and North America have higher CO2E costs. This trend is because Asia, Latin America, and Oceania tend to not price CO2E emissions and mismanage waste, while North America and Europe have better waste management and have more CO2E pricing mechanisms.

Recommendations and Conclusions

Our results validate Amcor's current practices of targeting upstream and downstream portions of its supply chain for sustainability initiatives. Therefore, pursuing both sustainable material sourcing and waste recovery are logical initiatives to continue pursuing. The natural capital valuation can offer several additional opportunities and next steps.

The natural capital costs we present are undervalued overall for several reasons. For example, we did not consider additional impacts that could have been valued, such as land use and biodiversity loss, or water, land, and air pollution. However, based on other natural capital valuations prepared for the plastics product industry, the majority of these impacts are believed be insignificant. Based on those reports, the EKPIs that we valued constitute ~70% of natural capital impacts associated with the plastic industry as a whole.[120,121]

Natural capital costs create a proxy for risk of operating at a country and regional level. Because the value represents profit at risk, the costs can be factored into strategic planning decisions, like where and how to expand operations. Many countries have already integrated GHG taxes and/or emissions trading schemes, and many more are planning to implement GHG pricing mechanisms in the future. Therefore, some of these costs will likely be inevitable in the long term. Increased water scarcity may lead to increased operating costs and stranded assets, making investments in water scarce regions more risky.

The values presented in this report serve as baseline metrics to track circular economy initiatives. If natural capital costs are taken into account, post-consumer resin can be viewed equally if not more economically viable than virgin resin. With circular economy practices that increase the use of post-consumer resin and decrease the use of virgin resin production, we would expect to see both downstream waste and upstream GHG and water costs decrease.

We also recommend that Amcor evaluate whether internal carbon pricing initiatives make sense for its business. Carbon prices can be used to drive emission reduction goals by first setting those goals, and then back-calculating a carbon price that ensures that goal is met by the target date. Other companies use existing policies in place in the countries in which they operate to better understand how emissions reductions translate directly to reduced operating costs. Other companies, like Microsoft, charge its business units a standard flat fee on emissions, and use the resulting fund to subsidize energy efficiency or carbon offset projects.[122]

Natural capital impacts can also be incorporated into existing LCA methodology, which can translate into simplified comparison and communication of the benefits of choosing one product over another. This practice has potential to lead to sales advantages if customers can better understand what differentiates one product over another.

Downstream impacts are undervalued because we were not able to quantify ecosystem impacts associated with marine debris. The current data on these impacts is limited, and additional research is needed to quantify ecosystem service values that would allow linking plastic impacts, such as animal entanglement, plastic digestion, or the leaching of chemical additives, to a dollar value impact.[123] Therefore, additional next steps can include following trends in this research.

Even though the results are undervalued, the post-consumer waste impacts constitute the second highest cost in our impact categories. It is therefore important to understand how Amcor can mitigate this. The Post-Consumer Waste Chapter of this paper outlines actions that can be taken in this area. Additionally, since estimates of post-consumer waste impacts rely on the weight of waste disposed of by country/region and treatment route, Amcor may want to begin tracking the weight of all products sold by division in order to more accurately understand where products are used and ultimately disposed.

Chapter 2: Post-Consumer Waste

Introduction

As established in the previous chapter, post-consumer waste makes up a significant component of Amcor's natural capital costs. As Amcor strives to be a responsible producer of plastic packaging, it is important to understand the state of plastic packaging recovery in order to understand the impact of Amcor's footprint. This chapter focuses on our evaluation of end-of-life options in the regions in which Amcor operates, as well as uncover which variables have the most significant impact on plastic recovery.

This part of the project initially aimed to focus on end-of-life options for flexible plastic packaging. While glass, aluminum, and rigid plastics have traditionally dominated packaging in the consumer products space, flexible plastic packaging is growing in use, particularly over the last decade.[124] However, there are post-consumer waste concerns as there are currently very few options other than landfilling or incineration for consumers to dispose of this type of packaging after use. With increasing interest in product circularity and alarming reports on the amount of plastic in our oceans,[125] there is pressure to find a more sustainable solution for post-consumer flexible plastic packaging waste.

After researching into this topic, the team found that information on recycling efforts for flexible plastic packaging is extremely limited, since recovery considerations are still nascent. This report includes research findings on the difficulties in recycling flexible plastic packaging, as well as an analysis on general plastic recovery rates. With varying rates of plastic recovery across countries, along with varying levels of reported recovery information, the team focused on understanding the state of plastic recovery rates in the areas in which Amcor operates. The team created a model to evaluate the key factors that impact recovery rates in a country, with the intention that the research would be relevant for flexible plastic packaging as the recovery movement for that material grows.

Literature Review

Environmental Tradeoffs of Flexible Plastic Packaging

Flexible plastic packaging is made up of multiple layers of mixed-material plastic films, such as polyethylene (PE), polypropylene (PP), nylon, aluminum, and film laminates, and often takes the form of pouches or sachets. Everyday items such as nuts, sugars, tuna fish, frozen meat or vegetables, and pet food that used to be sold in jars or cans can now be found in flexible packages. As of 2015, flexible packaging had become the second largest packaging segment in the US, representing 19% of the $164 billion US packaging market.[126] Demand for this type of packaging is projected to increase 3.3% annually through 2019.[127]

Flexible plastic packaging is appealing because it is durable, can be put into different innovative forms, can be transparent so consumers can see the products, and is often re-sealable so product freshness is maintained.[128] Another often touted benefit of flexible plastic packaging is that it has a lower environmental impact compared to other types of packaging in several areas such as requiring less material to create and fewer greenhouse gas emissions to transport.

Compared to traditional packaging such as glass, aluminum or rigid plastic, flexible plastic packaging is more lightweight, uses less material, and emits fewer greenhouse gases.[129] Because of this, flexible plastic packaging often comes out ahead compared to other types of traditional packaging in lifecycle assessments.[130] For example, the Flexible Packaging Association cites a study that found that, for equal amounts of pasta sauce, 26 truckloads of unfilled glass jars would be needed versus just one truckload of unfilled flexible pouches.[131]

Despite the benefits of flexible plastic packaging, a significant tradeoff occurs at the end-of-use phase. There currently are very few options to recycle flexible plastic packaging, which the large majority of this waste flowing into landfills or litter. The reason for this are manifold: flexible plastic packaging is extremely difficult to recycle due to their multi-layer structure; the incentive to create infrastructure to handle this material is weak because of the complexity of the material, lack of market demand, and low volume; and lack of consumer access.[132]

Flexible Plastic Packaging Post-Consumer Waste Challenges

While recycling rates for rigid plastics, namely PET bottles, have been maintained at relatively high levels, flexible plastic products continue to present a variety of issues for material recovery facilities (MRF) and the recycling ecosystem as a whole. One of the primary issues are MRFs' inability to effectively sort flexible plastic into a reusable product. This process is usually time-, energy-, and money-intensive as flexible products contain multiple layers of different forms of plastic that need to be separated during the recycling process. Even if these layers are separated, flexible plastic often ends up sorted with paper products due to its weight (and the fact that flexible packaging often contains paper components). One study conducted by the Materials Recovery for the Future initiative found that 88% of all flexible packaging tested sorted with paper.[133]

Flexible plastic products also frequently fall victim to contamination during the recycling process. Many of these products are used for food packaging and are not properly cleaned by consumers before entering the recycling stream. This contamination makes it more difficult to sell recycled flexible plastic in end markets. As a result, the current state of MRF infrastructure does not have the capabilities to process flexible plastic in a high-volume, cost-effective manner.

In the event that MRFs were able to process flexible plastic (through technological advancements and capital investment), there would still be issues related to volume. Recycled products need sufficient end-markets in order to justify the cost of collection and processing them in the first place. As a result, high volumes of these products are often needed to achieve economies of scale and profitable margins. Flexible plastic has a very low weight-to-volume ratio than products that are traditionally recycled (e.g. rigid plastic, paper, glass, aluminum). For example, flexible plastic packaging accounted for only 1.6% of the total municipal waste stream as of 2012.[134] This makes it less economically viable to invest in collection and sorting infrastructure needed to efficiently recycle flexible packaging.[135]

Another aspect of infrastructure that poses problems for flexible plastic is consumer access. The majority of communities in the United States do not allow for the recycling of flexible plastic. This, in part, is due to the fact that MRF infrastructure is currently unable to process these materials. Furthermore, those that do allow the recycling of flexibles often lack sufficient education and resources to enable the average consumer to recycle flexibles properly (e.g. reducing the potential for contamination).

Attention towards the issue of flexible plastic packaging is likely to increase, as policies and consumer awareness of the issue grow. One policy that has enjoyed some success, both with flexibles as well as other materials, has been Extended Producer Responsibility (EPR). EPR encourages, and in some cases requires, producers to integrate environmental costs of their goods throughout their life cycles, and more specifically emphasizes the need to design-for-recycling. Countries and regions that have implemented EPR policies have generally resulted in higher collection and recycling rates, reduced public expenditures on waste management, and reduction in overall waste management costs.[136] Policies such as these may provide motivation for companies and interest groups to find a more sustainable solution for flexible plastic packaging end-of-life.

Consumer sentiment is also a driver to find a solution for flexible waste end-of-life, as consumers may be demand solutions or alternatives so their packaging can be recovered and used for other purposes, rather than languish in landfills or pollute the environment. According to Rokka, J. and Uusitalo, L., there are four distinct preference clusters for packaging: green consumers, price sensitive, brand loyal, convenience seeking.[137] With green-packaging consumers consisting of 33 percent of the market, it is worthwhile for marketers to craft their products to appeal to this environmentally sensitive consumer base.[138] Companies have been feeling some of this pressure from consumers and are responding. For example, Procter and Gamble is pledging to make 90 percent of its packaging recyclable by 2020.[139] For packaging producers, while consumer preference to increase their plastic packaging recycling may be increasing, without improved formal collection and infrastructure globally (i.e. recovered plastic packaging supply) and large scale organizations buying this recovered plastic packaging (i.e. recovered plastic packaging demand), this consumer interest and increased willingness to pay[140] will not bear much weight in improved sustainability of plastic packaging materials, designs, and uses.

Methodology

To investigate the flexible plastic packaging recovery rate, the team underwent two phases of analysis as outlined below.

Phase I: Research into Flexible Plastic Packaging

The team originally sought to collect the flexible plastic packaging recycling rates in the countries in which Amcor operates. Research was conducted online and through the University of Michigan library system. However, we soon found that this data was extremely difficult to collect and seemed nonexistent. The team assumed that the difficulty was related to the issues that we outlined above. With flexible plastic packaging recovery still very nascent, metrics are severely limited.

An additional part of this phase was to conduct primary interviews with industry experts at the following companies which, like Amcor, are also engaged in plastic recovery: AluFoil, American Chemistry Council, Dow, Ellen MacArthur Foundation, Ocean Conservancy, and Procter & Gamble. Key insights from experts contacted are included below, as they helped shape the next phase of our methodology:

- Because flexible packaging is such a new and fast-growing packaging segment, there is significantly less data publically available. This can be seen in how, for example, the US Environmental Protection Agency does not track this kind of packaging yet in their sustainable materials packaging report.[141] The American Chemistry Council tracks on annual basis the reclamation of polyethylene film and bags in the United States and Canada.
- The lack of a demand for flexible plastic packaging also impacts the creation of a solution to this post-consumer waste issue. There are currently no large-scale companies with contracts to purchase this recovered and reclaimed flexible packaging, so governments and organizations are doing little to invest the time and money to sort this material.[142] A Trucost report,[143] sponsored by Dow Chemical and the American Chemistry Council, analyzed the environmental cost of plastic packaging use and the risk of switching to alternatives. The report, though, was not able to collect or predict data at a country or city level, instead using regional or global data. While a good tool to understand why our project and Amcor's involvement in pushing the boundaries of sustainability is so important, it was not able to provide us with the data points we needed.[144]

- One of the reasons for the lack of data on flexible plastic packaging recovery is that the amount of manual work required for organizations to ascertain this rate has been a large deterrent to date.[145] Gathering material recovery data for countries around the world is a difficult process. The Ellen MacArthur Foundation admits that data on the plastic packaging category in general has been difficult for them to find, even though they have spent an extensive amount of timing researching plastic packaging and its role in the environmental and economic ecosystem.[146] Beyond the United States, it has been incredibly difficult for them to collect recovery, infrastructure, or collection rate data globally.[147] For non-US locations, the Foundation has made very rough estimates on recovery metrics after looking at general waste treatment, including how much of waste is landfilled, incineration rates, overall municipal waste recycling efforts, and share of general waste that is plastics.

- The extent to which recycling and recovery data differs significantly by country and needs to be considered in the analysis. Some countries have very little infrastructure in place for collection; other countries have as many as seven bins for consumers to choose from when making item discard decisions.[148] Many countries simply do not have the formal infrastructure to collect anything beyond PET bottles.[149]

- A reason why reliable recovery data can be difficult to come across is that many developing countries have federal or private infrastructure that is lacking, but have an informal sector that represents a large portion of waste collection activities. Informal workers, also called waste pickers, often times provide the sole source of waste collection, and collect recyclable items for direct reuse or providing them as inputs to be transformed in exchange for money. Waste pickers are an important and often unrealized element of measuring post-consumer waste in developing countries. Given the presence of this informal sector in many countries, and its centralization in urban areas, the Ocean Conservancy recommended inclusion of urban demographic, behavior, collection, and recycling data in a post-consumer waste recovery rate model, as key predictors.[150]

- While information on flexible plastic packaging is hard to come by, a helpful tool that can be provided for a large global plastic packaging manufacturer such as Amcor is an overview of the state of waste and plastic packaging affairs in each country that they operate in. Tracking the source of this information will allow Amcor to continually update their understanding of the flexible packaging landscape, how recovery efforts are improving, and where to involve themselves to make the most impactful change.[151]

After conversations with the industry experts and Amcor, the team decided to focus on overall plastic recovery rates, which are assumed to be comprised mostly of rigid plastic. With a longer time in the market, awareness and recovery infrastructure of traditional plastic are higher, resulting in greater availability and accuracy of data. The intention was then to understand which variables have the most impact in plastic recycling rates, and use that information to predict advancements in flexible plastic packaging recycling rates.

Phase II: Regression Model to Determine Plastic Recovery Rates

The team sought to find the plastic recovery rate for the countries in which Amcor operates, with the intention to extrapolate findings to flexible plastic packaging recovery rates. While recovery data for some countries was relatively easy to find due to a governmental database (i.e., Eurostat), this information was more difficult to come by for many countries in South America and Asia. In order for Amcor to estimate the plastic recovery rates for the countries in which data was not available, the team decided to create a regression model that could predict the range of plastic recovery rates for a specific country after inputting key independent variables. The model would identify the most important factors in determining plastic recovery rates by country, which Amcor could then input and then see the calculated recovery rate. Additionally, the variables that turn out to be most impactful on recovery rates could be used to inform the areas to focus on for flexible plastic packaging recovery efforts.

Country Selection

The team focused on collecting information on the 30 countries below. These countries were chosen because they are either countries in which Amcor operates and there was plastic recovery or recycling data available, or they are countries with available data in the same region as ones in which Amcor operates in and have this type of information available even though they are not countries in which Amcor operates in.

Table 8: *Countries in Regression Model*

Americas	Asia	Europe
Argentina	China	Belgium
Brazil	Japan*	Czech Republic
Canada	Indonesia	Denmark
Chile	India	Finland
Colombia	South Korea*	France
Costa Rica*	Thailand	Germany
Mexico		Ireland
United States		Italy
		Netherlands
		Poland
		Portugal
		Russia
		Spain
		Switzerland
		Turkey
		United Kingdom

* denotes country in which Amcor does not have manufacturing operations

Variable Selection

From our literature review and primary interviews, the team identified 17 variables that influence plastic recovery efforts. The independent variables are displayed below, under four main categories:

Table 9: *Independent Variables in Regression Model*

Municipal Solid Waste	Waste Infrastructure	Demographics	Human Development
• Total municipal solid waste (tonnes) • Overall recycling rate (%) • Percent of waste to landfill (%) • Percent of waste incinerated (%) • Plastic waste as a percent of total municipal solid waste (%)	• Number of waste pickers • Presence of waste pickers (yes/no binary) • Policy (presence of extended producer responsibility requirements)	• Total population • Urban population • Population density (persons/sqkm) • Land area (sqkm)	• Human Development Index • Education Index • Life Expectancy • Gross domestic product (GDP) per capita • GINI Index

Municipal Solid Waste: The variables selected under this category capture the recovery (recycling and incineration) of a country. The metrics include the total amount of municipal solid waste that is produced and the percent of the total waste that is comprised of plastic waste. In addition, the team examined the overall recycling rate, the percent of waste of landfill, and the percent of waste that is being incinerated.

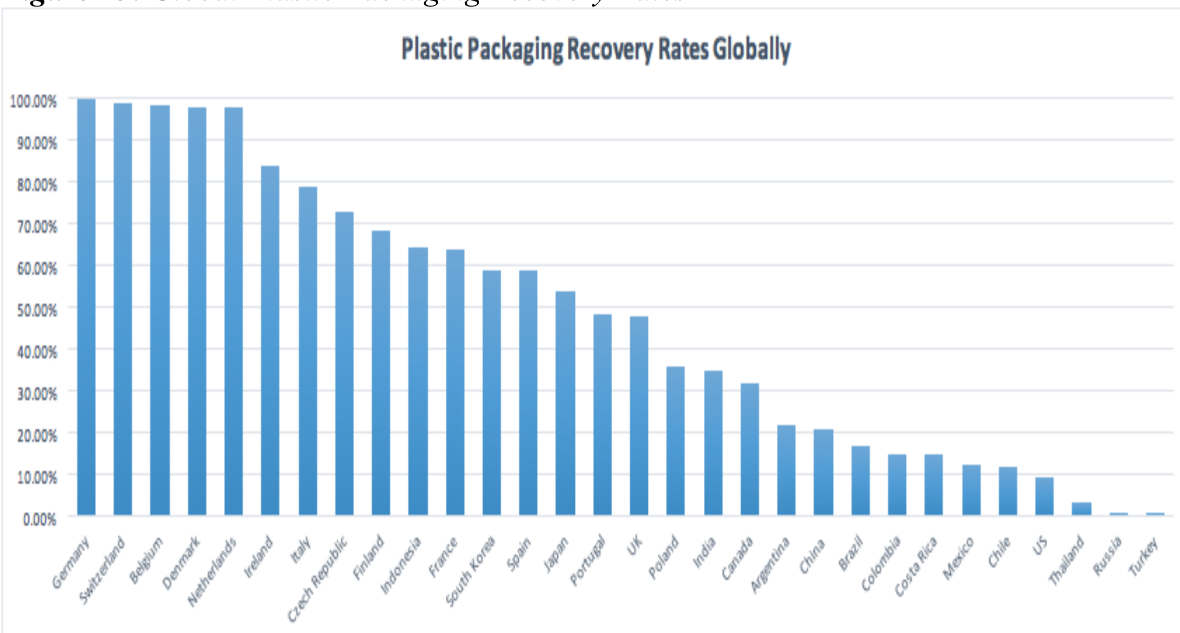
Waste Infrastructure: Countries vary in their degree of sophistication in their waste infrastructure and waste recovery policy. To capture this variance, the team used metrics around waste pickers, both the estimated number of waste pickers (based on guidance from the Ocean Conservancy that in developing nations, about 1% of a country's urban population are waste pickers.) and the presence of waste pickers. The presence of extended producer responsibility requirements was used to represent waste recovery policy.

Demographics: Overall population and land area metrics were examined to see how population size, density, and land area size impact plastic recovery rates. These metrics include a country's total population, its urban population, population density, and land area.

Human Development: The team also wanted to assess the level of a country's human development and its potential impact on plastic recovery. The team used the Human Development Index, which is published by the United Nations Development Programme. This index calculates human development per country by taking into account life expectancy at birth, education through both expected and average years of schooling, and the standard of living through the gross national index per capita. The team examined the Human Development Index as a regression variable by itself, as well as broken out into its three variables. The GINI Index was used to take into consideration income inequality. This metric measures the degree of inequality in the distribution of family income in a country.[152]

Dependent Variable: The y-variable for the regression model was the recovery rate of plastic packaging.

Figure 13: *Global Plastic Packaging Recovery Rates*



Note on Data Quality

	percent of wast (total) to landfil	Total Househol Municipal Wast	Waste Picker Presence (binary)	percent of waste incinerated	urban population	Gini Index	Life Expectancy	waste picker #s (1% of urban populatio	Urban population (% of total)	Land area (sqkm)	population (in thousands)	Education Index	Total plastic waste	GDP/capita (2015)	Policy	population density
Percent of waste (total) to landfill	1.00															
Total Household Municipal Waste	0.13	1.00														
Waste Picker Presence (binary)	**0.58**	0.31	1.00													
percent of waste incinerated	**-0.88**	-0.11	**-0.62**	1.00												
Urban population	0.22	**0.76**	0.35	-0.14	1.00											
Gini Index	0.76	0.23	0.65	-0.68	0.23	1.00										
Life Expectancy	-0.51	-0.15	-0.38	0.54	-0.39	-0.31	1.00									
Waste picker #s (1% of urban population)	0.22	**0.76**	0.35	-0.14	1.00	0.23	-0.39	1.00								
Urban population (% of total)	-0.35	-0.13	-0.21	0.34	-0.45	-0.04	0.52	-0.45	1.00							
Land area (sqkm)	0.43	0.59	0.23	-0.36	0.49	0.34	-0.40	0.49	-0.05	1.00						
Population (in thousands)	0.23	**0.61**	0.33	-0.15	0.95	0.15	-0.48	0.95	-0.58	0.38	1.00					
Education Index	-0.64	-0.10	**-0.59**	0.53	-0.47	-0.62	0.59	-0.47	**0.58**	-0.12	-0.56	1.00				
Total plastic waste	-0.20	0.20	-0.18	0.21	0.11	0.13	0.18	0.11	0.15	0.03	-0.03	0.10	1.00			
GDP/capita (2015)	**-0.71**	0.01	-0.49	**0.70**	-0.29	-0.57	**0.65**	-0.29	0.39	-0.18	-0.33	**0.77**	0.09	1.00		
Policy	-0.41	0.09	-0.47	0.46	0.08	-0.67	0.20	0.08	-0.05	-0.02	0.11	0.48	-0.06	0.45	1.00	
Population density	**-0.54**	-0.06	-0.29	**0.52**	0.13	**-0.51**	0.05	0.13	-0.08	-0.37	0.25	0.04	0.11	0.18	0.33	1.00

Although data on municipal solid waste plastic recovery was more available than flexible plastic packaging waste, there was still a large variance in the quality of the data that we used for our project. Some countries measure and report this data more closely than others. Areas in which informal recycling consists of a large part of the country's overall recovery infrastructure also makes concrete numbers hard to track down. Furthermore, sources that were used may have defined recycling slightly differently. For example, some countries' recovery rates specify that the rates are for plastic packaging whereas others just had metrics for plastic as a whole. Sources and estimates of data quality are provided in Appendix 1.

Model Selection

Regression Model Variations

Multiple models were tested to discover which variables were most significant. First a correlation test was conducted between all independent variables, to get a better understanding of how each variable relates, and how to interpret various model results.

Figure 14: *Variable Correlations*

Through this we were able to see that percent of waste to landfill and percent of waste incinerated have a strong negative correlation, due to their mutual exclusivity. Additionally, though, percent of waste to landfill is also negatively correlated to GDP per capita and population density. These correlations provide interesting insight into the relationship between the density of populations an improvement in infrastructure and formal and informal collection are necessary to maintain living standards. Total household municipal waste is strongly and positively correlated with percent of waste incinerated, which highlights the struggle of space limitations and an effort to capture energy as waste continues to increase. The presence of waste pickers is negatively correlated with Education Index, demonstrating that waste pickers tend to have a larger presence in countries with a lower Human Development Index. The GINI Index is negatively correlated with population density, which indicates that as population density and urbanization increases, inequality decreases. The GINI Index is an interesting variable to interpret, however. While most developed European nations tend to have GINI coefficients between 0.24 and 0.36, developing countries have GINI coefficients over a large range of 0.25 to 0.71.[153][154]

Final Model

Figure 15: *Final Model Summary*

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.89
R Square	**0.79**
Adjusted R Square	**0.77**
Standard Error	0.16
Observations	30.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3.00	2.57	0.86	32.71	**0.00**
Residual	26.00	0.68	0.03		
Total	29.00	3.25			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 90.0%*	*Upper 90.0%*
Intercept	**1.21039091855**	0.18	6.80	**0.000****	0.84	1.58	0.91	1.51
percent of waste (total) to landfill	**-0.65461460679**	0.14	-4.61	**0.000****	-0.95	-0.36	-0.90	-0.41
Total Household Municipal Waste	**-0.00000000139**	0.00	-2.26	**0.033****	0.00	0.00	0.00	0.00
Gini Index	**-0.01038119768**	0.01	-1.71	**0.099***	-0.02	0.00	-0.02	0.00

** Statistically significant at a 5% significance level
* Statistically significant at a 10% significance level

The model has an R Square and Adjusted R Square of 0.79 and 0.77, respectively, indicating the model has high explanatory power, and the model is not depleted by unnecessary independent variables. The F-test is close to zero. Residual plots show a good spread but some relationship

Figure 16: *GINI Index Residual Plot*

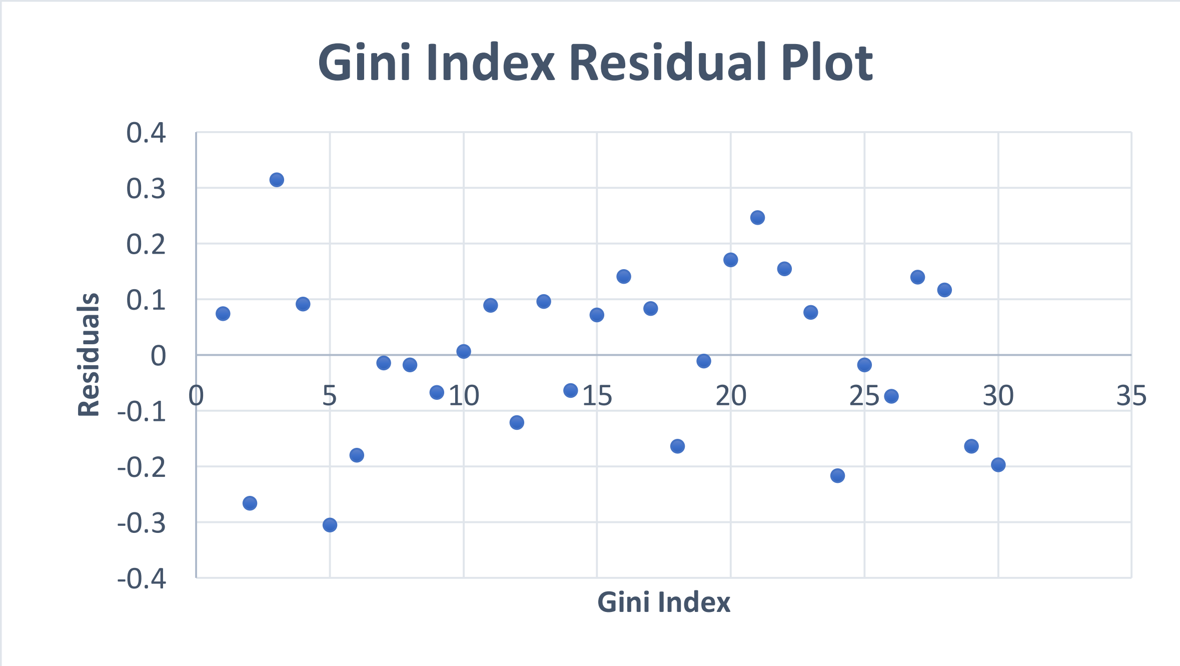


Figure 17: *Total Household Municipal Waste Residual Plot*

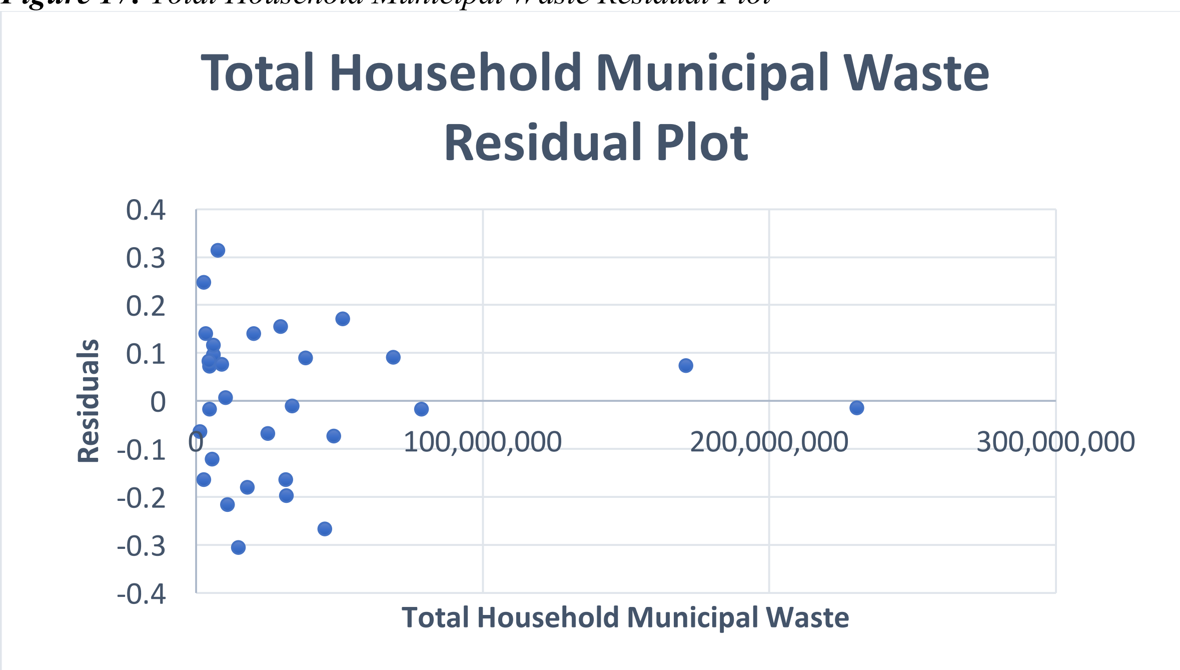
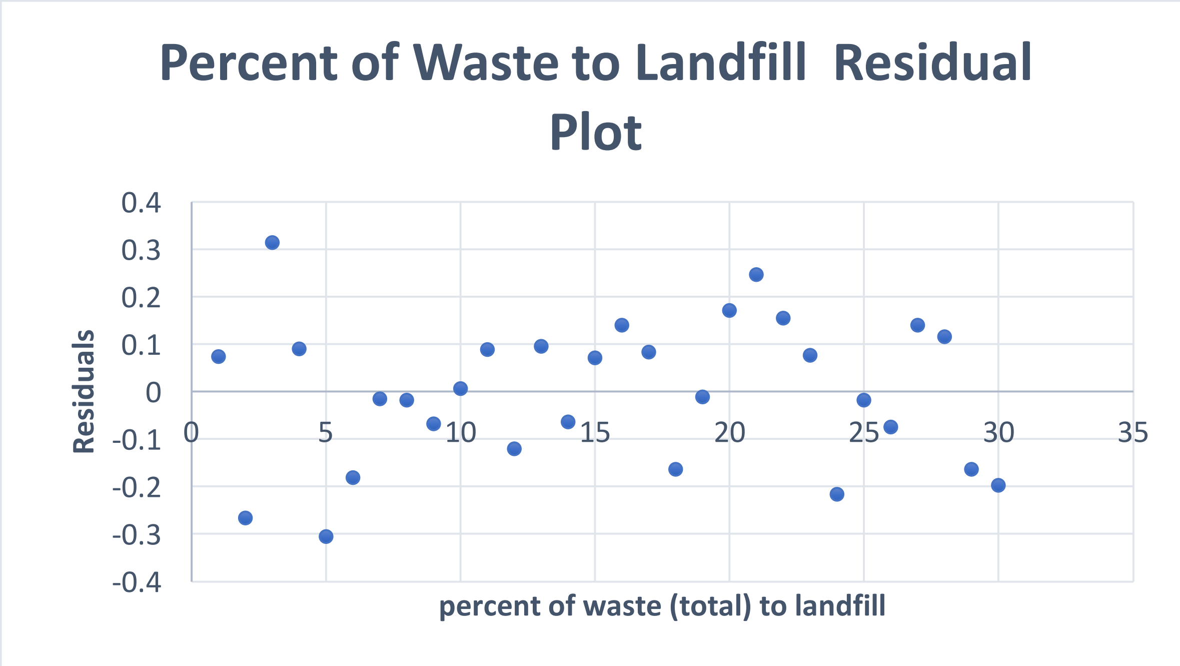


Figure 18: *Percent of Waste to Landfill Residual Plot*



Results and Implications

The model highlights three variables that appear to have the most significant impact on plastic recovery rates. These include: percent of waste (total) to landfill, total household municipal waste, and the GINI Index. Percent of waste to landfill had the highest level of significance with a p-value close to 0, followed by total household municipal waste, and then the GINI Index with a p-value of 0.10. Additionally, the coefficients for each of these variables are -0.65, close to 0, and -0.01 respectively.

$$\begin{aligned} recovery\ rate &= \beta_0 + \beta_1 total\ houshold\ municipal\ waste \\ &+ \beta_2 percent\ of\ waste\ to\ landfill + \beta_3 Gini\ index + \varepsilon \end{aligned}$$

It is intuitive that each of these variables would have a significant impact on plastic recovery rates. As the percent of waste going to landfills increases, the percent of waste available to be recovered decreases. Similarly, as the amount of total household municipal waste increases, the percent of plastic recovered decreases (assuming that there are no improvements and/or investments in infrastructure to process this additional MSW). Lastly, as wealth becomes more evenly distributed, as indicated by a higher GINI Index score, the plastic recovery rate decreases.

There are multiple implications that can be drawn from this model that are relevant for Amcor and other corporations attempting to influence the plastic recovery rate. It will be useful for Amcor to keep these three variables in mind when developing projects and partnerships in the future, as they are some of the most important levers for improving plastic recovery rates. The model indicates that projects aimed at diverting more waste from landfills as well as decreasing the total amount of municipal solid waste generated will have the most significant impact on improving recovery rates. For example, partnering with local municipalities to raise consumer awareness around recycling best practices could potentially improve landfill diversion rates and in turn increase the plastic recovery rate.

Another important implication of this model is its replicability for flexible plastics. As previously mentioned, data collection on flexible plastic recovery is in its nascent stage and will likely take at least 2-3 years before sufficient data is available for analysis. Once data becomes available, a similar methodology could be used to identify the most significant variables affecting flexible recovery rates. Lastly, the model could be used to predict a range of plastic recovery rates for countries where such data is not available. For example, the model could predict a country's plastic recovery rate if the percent of waste to landfill, total household municipal waste, and GINI Index data were available. While this number would not be 100% accurate, it would provide a benchmark estimate when no such plastic data is available.

Recommendations and Conclusions

In addition to Amcor, there are several other organizations actively involved in finding solutions to the post-consumer flexible plastic packaging waste conundrum. Dow Chemical is intensely involved in pushing the plastic packaging recovery envelope and improving the supply of recovered products through investing in efforts to shift consumer behavior towards recycling and improve the fundamental components that have restricted plastic packaging recovery so far. The company has invested in new labels to grasp consumer attention and make recycling rules more accessible, as well as conducted extensive resin

R&D to alter the very multilayer component that makes plastic packaging so technically challenging to transform.[155]

In addition to the public policy, groups of private companies and nonprofits have also developed EPR consortiums aimed at improving end-of-life management for specific products. These groups generally command a large portion of the market share for each product, and as a result have the influence necessary to shift the industry towards improved recycling practices. One of the most successful examples of private sector-initiated EPR is the Carton Council, which is a consortium of carton producers including Elopak, Evergreen Packaging, SIG, and Tetrapak. Through efforts devoted to building infrastructure, improving collection, and raising awareness, the group has been able to raise carton recycling rates from approximately 18% in 2009 to over 60% in 2017.[156] Similar groups have been formed for other products that currently have low recycling rates. The Flexible Film Recycling Group (FFRG), for example, is working to improve the collection and recycling of flexible films through similar methods as the Carton Council. The FFRG has made advancements in terms of both tracking and increasing the recovery of plastic bags and film. More specifically, the volume of plastic bags and film recovered has increased 79% since 2005 to approximately 1.17 billion pounds.[157] However, plastic bags and film make up a small percentage of the total flexible packaging market and are not included in Amcor's portfolio of products.

This project also highlighted the sheer difficulty in finding data on plastic recovery rates. In order to make a meaningful impact on the packaging sustainability space, Amcor should invest in a global, environmental ministry interview process to more accurately understand flexible packaging recovery rates with both formal and informal collection. PET is the only plastic that is followed through its entire lifecycle. Data collection mechanisms for value added multi-layer products must be undertaken, globally, at the country and city level, to truly understand the footprint. Also, investments must be made into global databases for plastic packaging, with a particular focus on Asia and Latin America. Without accurate reporting, improvement efforts cannot be measured and tracked.

Appendices

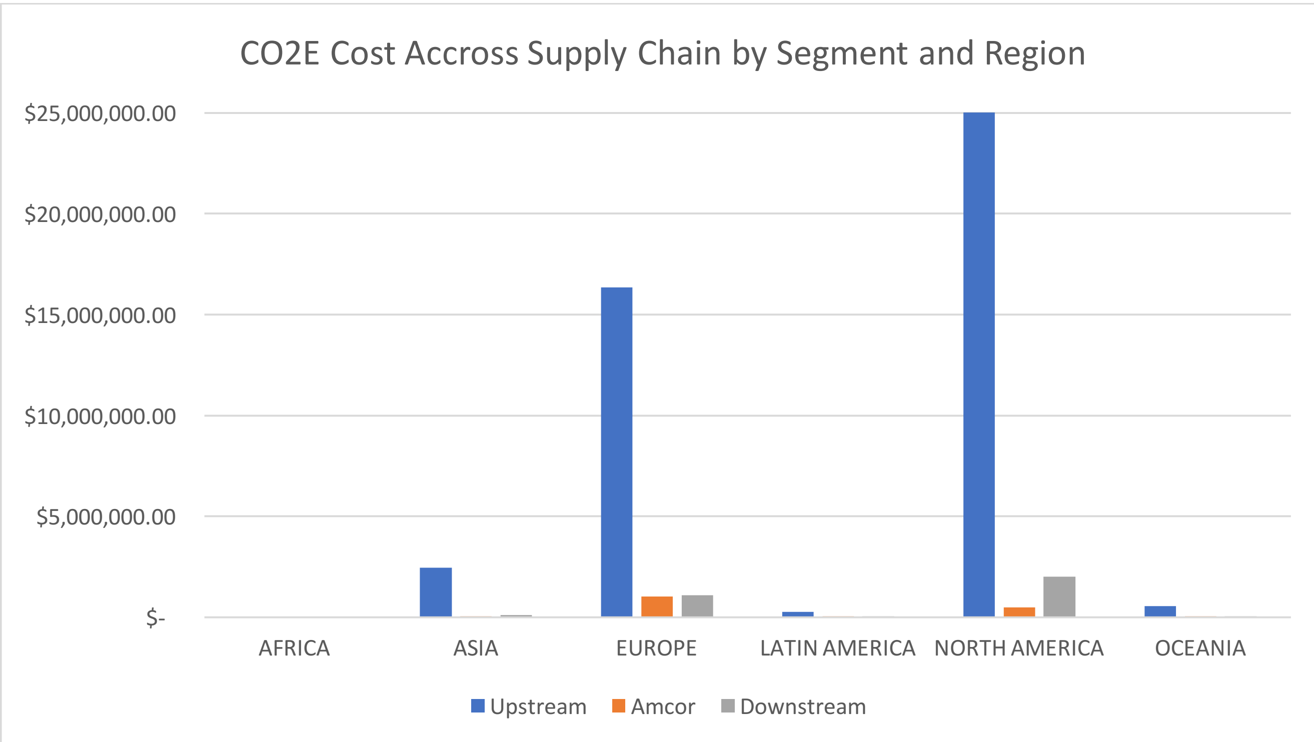
Appendix 1: Natural Capital Valuation Calculation Tables and Additional Graphs

GHG Calculations by Country

QUANTITY (tn)							PRICE (dlls)		TOTAL COST					
Country	Scope 1	Scope 2	Scope 3	Scope 3 (waste)	Post-Consumer Waste Emissions	Emissions Total	Average	Tax	Amcor Operations Scope1*Average	Upstream (Scope 2,3)	Downstream (scope 3 waste)	Post-Consumer Waste Emissions	Total Market Cost	Social Cost
Argentina	1,074.51	203,990.43	25,350.00	131.73	4,512.52	235,059.19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 30,087,575.77
Australia	13,573.87	132,938.01	59,481.00	2,386.32	3,306.64	211,685.84	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 27,095,787.51
Belgium	9,422.50	90,508.78	3,022.00	5,296.69	2,149.29	110,399.25	$ 7.41	$ -	$ 69,815.48	$ 693,011.01	$ 39,245.50	$ 15,925.02	$ 817,997.01	$ 14,131,103.94
Brazil	380.89	240,084.92	12,052.90	361.50	4,921.54	257,801.75	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 32,998,624.30
Canada	4,447.78	104,042.19	12,200.08	532.16	5,002.40	126,224.61	$ 11.97	$ -	$ 53,253.03	$ 1,391,762.36	$ 6,371.46	$ 59,893.48	$ 1,511,280.33	$ 16,156,750.27
Chile	37.38	9,259.49	1,219.00	130.46	33.34	10,679.67	$ -	$ 5.00	$ -	$ 52,392.43	$ 652.29	$ 166.72	$ 53,211.43	$ 1,366,997.12
China	6,758.69	459,626.11	94,950.00	2,544.00	18,929.55	582,808.34	$ 4.28	$ -	$ 28,902.12	$ 2,371,528.24	$ 10,878.89	$ 80,948.22	$ 2,492,257.47	$ 74,599,467.97
Colombia	176.70	48,308.61	5,518.50	170.94	1,091.52	55,266.27	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,074,082.36
Czech Republic	5,812.00	27,265.25	3,546.00	529.66	852.68	38,005.59	$ 7.41	$ -	$ 43,063.69	$ 228,294.23	$ 3,924.49	$ 6,317.91	$ 281,600.31	$ 4,864,716.12
Denmark	4,023.00	53,437.33	2,916.00	3,680.45	1,722.36	65,779.13	$ 7.41	$ 14.89	$ 29,808.19	$ 839,101.08	$ 54,801.86	$ 25,645.87	$ 949,357.00	$ 8,419,728.90
Dominican Republic	-	511.13	3,176.00	1.80	-	3,688.92	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 472,182.05
Ecuador	111.20	59,858.28	9,132.00	35.92	1,401.44	70,538.84	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 9,028,970.88
El Salvador	488.90	52,241.07	3,091.00	42.31	1,121.95	56,985.23	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,294,108.89
Finland	2,271.20	44,584.34	7,579.20	2,869.57	1,458.51	58,762.82	$ 7.41	$ 55.50	$ 16,828.33	$ 2,895,152.21	$ 159,265.12	$ 80,949.62	$ 3,152,195.28	$ 7,521,641.27
France	46,057.21	457,972.44	6,022.50	11,541.49	9,973.22	531,566.85	$ 7.41	$ -	$ 341,258.29	$ 3,437,944.29	$ 85,516.03	$ 73,895.99	$ 3,938,614.60	$ 68,040,557.11
Germany	12,486.50	130,666.05	10,248.00	2,128.14	2,497.48	158,026.17	$ 7.41	$ -	$ 92,518.02	$ 1,044,094.71	$ 15,768.34	$ 18,504.95	$ 1,170,886.02	$ 20,227,350.25
India	1,904.34	173,070.02	29,714.05	580.54	7,944.24	213,213.19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 27,291,288.09
Indonesia	3,931.53	84,398.72	11,469.00	1,542.09	3,589.28	104,930.62	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 13,431,119.47
Ireland	80.79	3,496.35	473.10	77.06	199.28	4,326.58	$ 7.41	$ 26.17	$ 598.61	$ 103,880.39	$ 2,016.69	$ 5,215.27	$ 111,710.95	$ 553,802.34
Italy	10,154.37	223,737.93	11,612.00	8,281.70	5,599.17	259,385.17	$ 7.41	$ -	$ 75,238.23	$ 1,743,812.02	$ 61,362.80	$ 41,486.72	$ 1,921,899.77	$ 33,201,301.54
Mexico	87.13	42,700.97	11,007.00	16.64	905.47	54,717.21	$ -	$ 3.50	$ -	$ 187,977.88	$ 58.24	$ 3,169.15	$ 191,205.28	$ 7,003,802.80
Morocco	386.78	9,813.37	3,526.00	225.80	58.99	14,010.94	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,793,400.56
New Zealand	1,058.54	61,928.25	4,549.90	1,333.57	1,281.82	70,152.08	$ 8.27	$ -	$ 8,753.56	$ 549,739.08	$ 11,027.90	$ 10,600.01	$ 580,120.56	$ 8,979,466.79
Peru	98.12	70,192.50	8,594.90	62.02	1,490.92	80,438.47	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 10,296,123.99
Poland	7,589.20	99,450.12	15,173.00	736.81	3,714.46	126,663.59	$ 7.41	$ 1.00	$ 56,231.75	$ 114,623.12	$ 736.81	$ 3,714.46	$ 175,306.14	$ 16,212,940.16
Portugal	8,169.50	71,633.91	4,668.50	4,543.50	2,935.20	91,950.61	$ 7.41	$ 8.00	$ 60,531.45	$ 610,419.32	$ 36,347.97	$ 23,481.58	$ 730,780.32	$ 11,769,677.92
Puerto Rico	0.76	1,123.38	102.30	8.84	175.65	1,410.93	$ 9.32	$ -	$ 7.05	$ 11,423.31	$ 82.38	$ 1,637.10	$ 13,149.84	$ 180,598.69
Russia	4,044.00	14,151.83	2,424.00	168.74	710.72	21,499.29	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,751,908.61
Singapore	10.29	12,570.64	1,690.00	77.36	744.05	15,092.35	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,931,820.25
Spain	6,459.50	99,688.09	17,295.00	2,697.80	3,596.57	129,736.96	$ 7.41	$ -	$ 47,861.30	$ 866,779.63	$ 19,989.17	$ 26,648.61	$ 961,278.72	$ 16,606,331.40
Switzerland	6,096.00	48,114.00	-	3,467.67	972.49	58,650.16	$ 10.24	$ 34.20	$ 62,404.81	$ 1,645,498.77	$ 118,594.31	$ 33,259.16	$ 1,859,757.05	$ 7,507,220.39
Thailand	2,315.50	157,124.80	25,355.00	3,265.34	6,707.10	194,767.74	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 24,930,270.37
Trinidad and Tobago	32.92	14,741.89	3,458.00	172.92	310.46	18,716.19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,395,672.21
Turkey	5,809.70	50,611.08	6,139.00	1,940.67	2,504.01	67,004.47	$ 1.30	$ -	$ 7,552.61	$ 73,775.11	$ 2,522.87	$ 3,255.22	$ 87,105.81	$ 8,576,571.89
UK	17,132.90	262,598.33	23,388.00	5,004.50	11,760.44	319,884.16	$ 7.41	$ -	$ 126,945.26	$ 2,118,999.55	$ 37,080.54	$ 87,138.31	$ 2,370,163.65	$ 40,945,172.81
USA	46,525.11	2,002,495.97	605,748.20	5,582.62	203,789.56	2,864,141.46	$ 9.32	$ -	$ 433,614.04	$ 24,308,835.65	$ 52,030.03	$ 1,899,318.66	$ 26,693,798.39	$ 366,610,106.58
Venezuela	16,760.80	21,935.74	5,425.00	119.05	1,888.38	46,128.96	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5,904,506.96
Grand Total	**245,770.11**	**5,640,872.31**	**1,051,316.13**	**72,288.36**	**319,852.69**	**7,330,099.60**			**$ 1,555,185.81**	**$ 45,289,044.41**	**$ 718,273.67**	**$ 2,501,172.04**	**$ 50,063,675.92**	**$ 938,252,748.57**

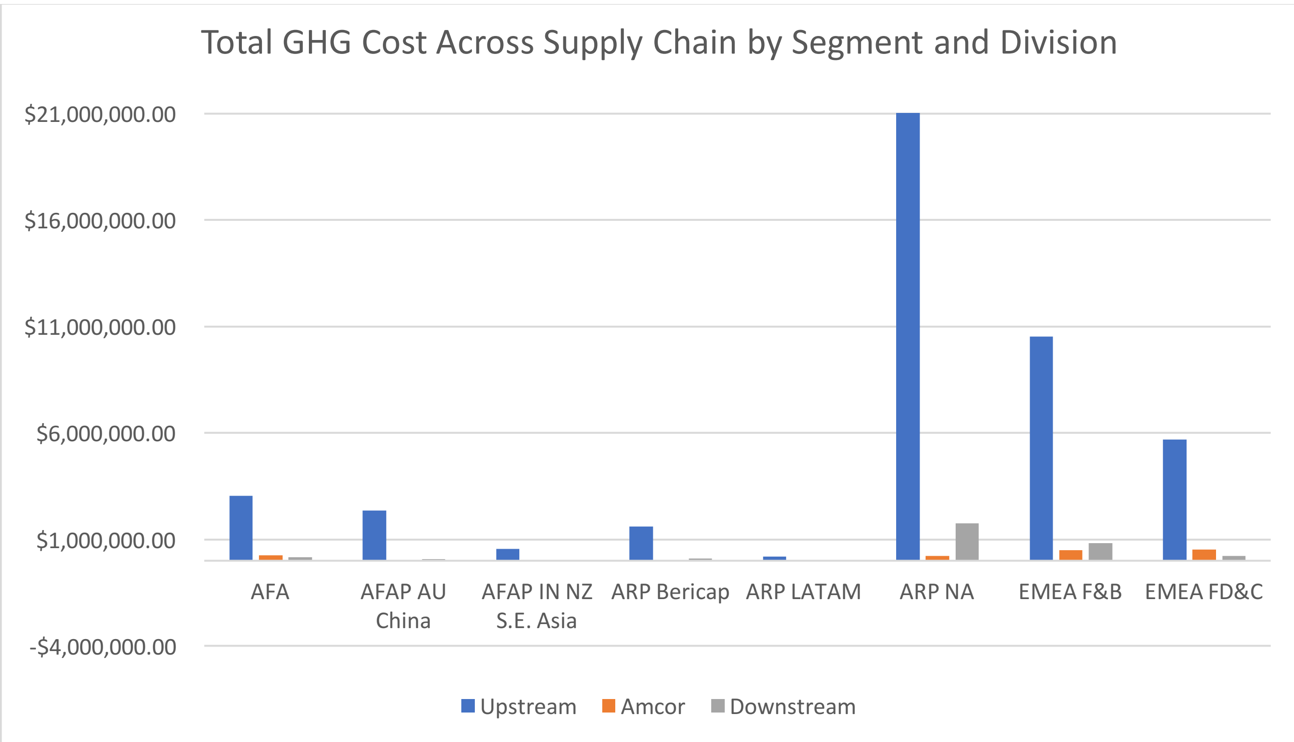
GHG Calculations by Geographic Region

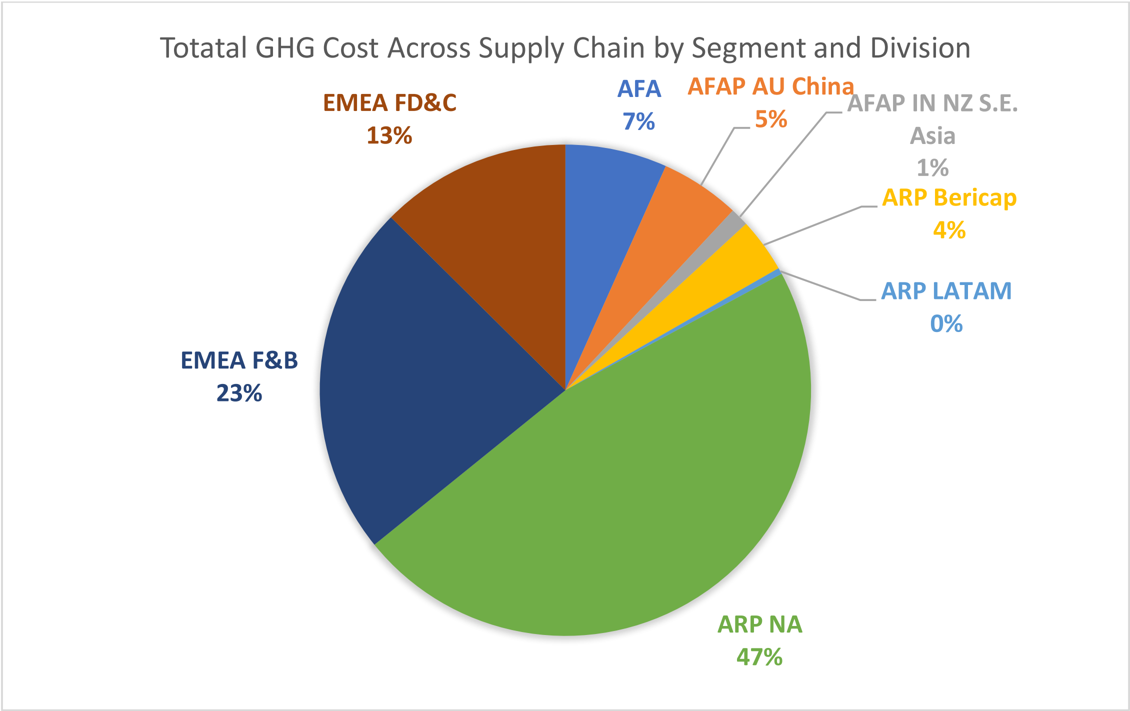
	QUANTITY (tn)						TOTAL COST					
Row Labels	Sum of Scope 1	Sum of Scope 2	Sum of Scope 3	Sum of Scope 3 (waste)	Sum of Post-Consumer Waste Emissions	Sum of Emissions Total	Sum of Amcor Operations Scope1*Average	Sum of Upstream (Scope 2,3)	Sum of Downstream (scope 3 waste)	Sum of Post-Consumer Waste Emissions2	Sum of Total Market Cost	Sum of Social Cost
AFRICA	386.78	9,813.37	3,526.00	225.80	58.99	14,010.94	$ -	$ -	$ -	$ -	$ -	$ 1,793,400.56
ASIA	20,730.05	937,401.37	169,317.05	9,950.00	40,418.23	1,177,816.70	$ 36,454.73	$ 2,445,303.35	$ 13,401.76	$ 84,203.44	$ 2,579,363.28	$ 150,760,538.06
EUROPE	139,798.67	1,627,304.75	108,367.30	51,023.76	48,141.87	1,974,636.35	$ 1,023,103.40	$ 16,341,610.34	$ 634,649.61	$ 442,183.48	$ 18,441,546.83	$ 252,753,452.76
LATIN AMERICA	19,249.31	764,948.39	88,126.60	1,254.13	17,853.18	891,431.61	$ 7.05	$ 251,793.62	$ 792.91	$ 4,972.96	$ 257,566.55	$ 114,103,246.03
NORTH AMERICA	50,972.89	2,106,538.16	617,948.28	6,114.78	208,791.96	2,990,366.07	$ 486,867.07	$ 25,700,598.01	$ 58,401.49	$ 1,959,212.14	$ 28,205,078.72	$ 382,766,856.85
OCEANIA	14,632.41	194,866.26	64,030.90	3,719.89	4,588.46	281,837.92	$ 8,753.56	$ 549,739.08	$ 11,027.90	$ 10,600.01	$ 580,120.56	$ 36,075,254.30
Grand Total	245,770.11	5,640,872.31	1,051,316.13	72,288.36	319,852.69	7,330,099.60	$ 1,555,185.81	$ 45,289,044.41	$ 718,273.67	$ 2,501,172.04	$ 50,063,675.92	$ 938,252,748.57



GHG Calculations by Division

	QUANTITY (tn)						TOTAL COST					
Row Labels	Sum of Scope 1	Sum of Scope 2	Sum of Scope 3	Sum of Scope 3 (waste)	Sum of Amcor Operations Scope1*Average	Sum of Post-Consumer Waste Emissions	Sum of Emissions Total	Sum of Upstream (Scope 2,3)	Sum of Downstream (scope 3 waste)	Sum of Post-Consumer Waste Emissions2	Sum of Total Market Cost	Sum of Social Cost
AFA	29,474.15	310,362.51	47,374.90	5,999.81	262,367.24	14,217.94	$ 407,429.31	$ 3,036,285.08	$ 53,722.13	$ 127,457.44	$ 3,479,831.89	$ 52,150,952.05
AFAP AU China	20,332.56	592,564.12	154,431.00	4,930.32	28,902.12	22,236.18	$ 794,494.18	$ 2,371,528.24	$ 10,878.89	$ 80,948.22	$ 2,492,257.47	$ 101,695,255.48
AFAP IN NZ S.E. Asi	9,220.20	489,092.43	72,777.95	6,798.90	8,753.56	20,266.50	$ 598,155.98	$ 549,739.08	$ 11,027.90	$ 10,600.01	$ 580,120.56	$ 76,563,964.99
ARP Bericap	379.98	139,245.16	18,615.00	527.88	4,381.90	8,825.41	$ 167,593.43	$ 1,617,130.98	$ 5,934.79	$ 91,073.32	$ 1,718,521.00	$ 21,451,959.27
ARP LATAM	19,211.17	736,208.53	86,605.90	1,000.99	-	17,441.52	$ 860,468.11	$ 187,977.88	$ 58.24	$ 3,169.15	$ 191,205.28	$ 110,139,918.43
ARP NA	23,412.24	1,721,269.68	560,149.60	931.87	219,691.41	189,134.78	$ 2,494,898.18	$ 21,301,235.29	$ 8,745.24	$ 1,765,286.35	$ 23,294,958.29	$ 319,346,967.21
EMEA F&B	74,234.67	910,978.34	80,413.90	37,037.75	501,816.61	31,537.64	$ 1,134,202.30	$ 10,533,014.73	$ 518,661.38	$ 304,886.76	$ 11,858,379.49	$ 145,177,894.39
EMEA FD&C	69,505.13	741,151.54	30,947.88	15,060.83	529,272.96	16,192.72	$ 872,858.10	$ 5,692,133.11	$ 109,245.11	$ 117,750.77	$ 6,448,401.95	$ 111,725,836.75
Grand Total	245,770.11	5,640,872.31	1,051,316.13	72,288.36	1,555,185.81	319,852.69	$ 7,330,099.60	$ 45,289,044.41	$ 718,273.67	$ 2,501,172.04	$ 50,063,675.92	$ 938,252,748.57




Totatal GHG Cost Across Supply Chain by Segment and Division
EMEA FD&C
13%
AFA
7%
AFAP AU China
5%
AFAP IN NZ S.E.
Asia
1%
ARP Bericap
4%
ARP LATAM
0%
EMEA F&B
23%
ARP NA
47%

Water Calculations by Country

	QUANTITY (m3)					PRICE (dlls)		
Country	Upstream Water Use	Plant Water Use	Downstream Water Use for Treatment of Amcor Waste	Downstream Water Use for Treatment of Post-Consumer Waste	Total Water Used	Ecosystem Quality Change (ha/m^3)	Ecosystem Impact Price ($/ha)	Human Health Impact Price ($/m3)
Argentina	2,694,610.41	10,452.00	11.67	12,671.08	2,717,745.16	4.75E-05	535.02	1.68E-03
Australia	6,102,016.74	19,987.00	701.76	9,284.98	6,131,990.48	1.45E-04	484.67	0.00E+00
Belgium	714,506.65	10,385.00	398.84	1,361.44	726,651.93	1.57E-05	403.98	0.00E+00
Brazil	9,482,736.94	215,717.00	96.71	13,819.62	9,712,370.27	8.90E-06	179.67	9.07E-04
Canada	1,097,226.11	64,174.00	40.57	3,312.76	1,164,753.44	1.29E-05	143.60	0.00E+00
Chile	124,528.90	4,217.00	14.08	93.63	128,853.61	2.66E-05	176.52	7.17E-03
China	7,653,449.66	394,164.60	163.68	8,972.72	8,056,750.67	2.30E-05	265.11	1.46E-02
Colombia	2,501,024.97	40,695.00	4.39	3,064.96	2,544,789.33	4.66E-06	96.18	6.79E-04
Czech Rep	301,765.39	2,505.00	15.36	540.12	304,825.87	1.54E-05	397.27	5.91E-05
Denmark	73,773.85	8,100.00	258.71	1,091.00	83,223.57	1.40E-05	365.47	0.00E+00
Dominican	137,804.50	2,420.00	0.12	-	140,224.62	9.06E-06	184.02	5.72E-03
Ecuador	1,468,619.23	46,753.00	6.37	3,935.21	1,519,313.81	9.65E-06	197.05	9.21E-03
El Salvador	971,281.84	30,579.00	1.81	3,150.41	1,005,013.06	7.50E-06	227.71	1.10E-03
Finland	155,589.99	8,438.00	210.37	923.88	165,162.24	1.62E-05	212.53	2.05E-06
France	3,678,837.12	66,747.60	775.15	6,317.40	3,752,677.27	1.46E-05	196.85	0.00E+00
Germany	554,797.07	270,895.00	98.25	1,582.00	827,372.31	1.55E-05	399.51	2.32E-05
India	8,888,599.31	68,204.00	79.08	3,765.62	8,960,648.01	3.97E-05	352.91	1.04E-01
Indonesia	357,328.45	34,055.00	-	1,701.34	393,084.79	3.53E-06	76.55	9.17E-03
Ireland	122,766.19	237.00	1.35	126.23	123,130.77	1.22E-05	323.35	0.00E+00
Italy	1,528,521.89	100,850.00	556.24	3,546.72	1,633,474.84	1.34E-05	212.71	0.00E+00
Mexico	399,938.27	7,123.00	2.60	2,542.55	409,606.42	6.35E-05	481.62	7.82E-03
Morocco	504,267.98	8,764.00	-	165.65	513,197.63	1.13E-04	700.27	9.17E-02
New Zeala	1,047,202.74	20,037.00	161.02	3,599.34	1,071,000.10	9.05E-06	126.14	0.00E+00
Peru	650,181.73	41,286.00	1.62	4,186.48	695,655.84	1.27E-05	183.04	3.04E-02
Poland	1,130,984.52	7,014.00	1.27	2,352.87	1,140,352.66	2.02E-05	500.06	9.12E-05
Portugal	4,839,859.74	19,798.00	237.29	1,859.26	4,861,754.29	1.92E-05	309.01	0.00E+00
Puerto Ric	455,861.32	382.00	20.44	493.24	456,757.00	1.25E-05	369.19	0.00E+00
Russia	491,996.75	3,110.00	117.14	450.19	495,674.08	1.16E-05	162.84	2.50E-03
Singapore	398.32	775.90	4.41	352.69	1,531.31	3.73E-06	79.85	1.96E-04
Spain	461,108.91	11,395.00	182.81	2,278.20	474,964.92	3.45E-05	486.56	0.00E+00
Switzerlan	192,974.01	305,822.00	238.99	616.01	499,651.01	5.60E-06	156.77	4.35E-06
Thailand	2,941,815.03	88,420.00	35.80	3,179.21	3,033,450.03	1.32E-05	391.03	7.40E-03
Trinidad ar	122,710.29	5,159.00	8.69	871.76	128,749.73	4.54E-06	149.87	4.59E-03
Turkey	524,949.64	54,363.00	105.49	1,186.92	580,605.05	5.26E-05	419.67	2.51E-02
UK	428,616.05	37,957.80	194.11	7,449.49	474,217.45	1.14E-05	304.18	0.00E+00
USA	120,304,104.30	1,708,985.60	724.57	134,956.39	122,148,770.85	3.10E-05	210.35	9.91E-05
Venezuela	3,436,273.01	64,780.00	13.41	5,302.54	3,506,368.96	1.01E-05	208.23	5.35E-03
Grand Tot	186,543,027.82	3,784,747.50	5,484.17	251,103.90	190,584,363.39			

	TOTAL COST														
Country	Upstream Water Use Ecosystem Impact	Upstream Water Use Human Health Impact	Total Upstream Impact	Amcor Water Use Ecosystem Impact	Amcor Water Use Human Health Impact	Total Amcor Impact	Water Use From Plant Waste Treatment Ecosystem Impact	Water Use From Plant Waste Treatment Human Health Impact	Total Plant Waste Impact	PCW Treatment Ecosystem Impact	PCW Treatment Human Health Impact	Total PCW Treatment	Total Country Costs
Argentina	$ 68,478.91	$ 4,538.57	$ 73,017.48	$ 265.62	$ 17.60	$ 283.22	$ 0.30	$ 0.02	$ 0.32	$ 322.01	$ 21.34	$ 343.36	$ 73,644.38
Australia	$ 428,834.11	$ -	$ 428,834.11	$ 1,404.64	$ -	$ 1,404.64	$ 49.32	$ -	$ 49.32	$ 652.52	$ -	$ 652.52	$ 430,940.59
Belgium	$ 4,531.76	$ -	$ 4,531.76	$ 65.87	$ -	$ 65.87	$ 2.53	$ -	$ 2.53	$ 8.63	$ -	$ 8.63	$ 4,608.79
Brazil	$ 15,163.64	$ 8,603.65	$ 23,767.29	$ 344.95	$ 195.72	$ 540.67	$ 0.15	$ 0.09	$ 0.24	$ 22.10	$ 12.54	$ 34.64	$ 24,342.84
Canada	$ 2,032.53	$ -	$ 2,032.53	$ 118.88	$ -	$ 118.88	$ 0.08	$ -	$ 0.08	$ 6.14	$ -	$ 6.14	$ 2,157.61
Chile	$ 584.71	$ 892.29	$ 1,476.99	$ 19.80	$ 30.22	$ 50.02	$ 0.07	$ 0.10	$ 0.17	$ 0.44	$ 0.67	$ 1.11	$ 1,528.29
China	$ 46,667.44	$ 111,459.21	$ 158,126.65	$ 2,403.45	$ 5,740.32	$ 8,143.77	$ 1.00	$ 2.38	$ 3.38	$ 54.71	$ 130.67	$ 185.38	$ 166,459.18
Colombia	$ 1,120.92	$ 1,698.97	$ 2,819.89	$ 18.24	$ 27.64	$ 45.88	$ 0.00	$ 0.00	$ 0.00	$ 1.37	$ 2.08	$ 3.46	$ 2,869.23
Czech Rep	$ 1,846.21	$ 17.83	$ 1,864.04	$ 15.33	$ 0.15	$ 15.47	$ 0.09	$ 0.00	$ 0.09	$ 3.30	$ 0.03	$ 3.34	$ 1,882.95
Denmark	$ 377.47	$ -	$ 377.47	$ 41.44	$ -	$ 41.44	$ 1.32	$ -	$ 1.32	$ 5.58	$ -	$ 5.58	$ 425.82
Dominican	$ 229.75	$ 788.65	$ 1,018.40	$ 4.03	$ 13.85	$ 17.88	$ 0.00	$ 0.00	$ 0.00	$ -	$ -	$ -	$ 1,036.29
Ecuador	$ 2,792.61	$ 13,529.72	$ 16,322.33	$ 88.90	$ 430.71	$ 519.62	$ 0.01	$ 0.06	$ 0.07	$ 7.48	$ 36.25	$ 43.74	$ 16,885.75
El Salvador	$ 1,658.80	$ 1,071.05	$ 2,729.84	$ 52.22	$ 33.72	$ 85.94	$ 0.00	$ 0.00	$ 0.01	$ 5.38	$ 3.47	$ 8.85	$ 2,824.65
Finland	$ 535.68	$ 0.32	$ 536.00	$ 29.05	$ 0.02	$ 29.07	$ 0.72	$ 0.00	$ 0.72	$ 3.18	$ 0.00	$ 3.18	$ 568.98
France	$ 10,573.02	$ -	$ 10,573.02	$ 191.83	$ -	$ 191.83	$ 2.23	$ -	$ 2.23	$ 18.16	$ -	$ 18.16	$ 10,785.24
Germany	$ 3,435.56	$ 12.88	$ 3,448.45	$ 1,677.51	$ 6.29	$ 1,683.80	$ 0.61	$ 0.00	$ 0.61	$ 9.80	$ 0.04	$ 9.83	$ 5,142.69
India	$ 124,532.30	$ 926,394.00	$1,050,926.29	$ 955.56	$ 7,108.41	$ 8,063.97	$ 1.11	$ 8.24	$ 9.35	$ 52.76	$ 392.46	$ 445.22	$1,059,444.83
Indonesia	$ 96.56	$ 3,275.28	$ 3,371.84	$ 9.20	$ 312.15	$ 321.35	$ -	$ -	$ -	$ 0.46	$ 15.59	$ 16.05	$ 3,709.25
Ireland	$ 484.30	$ -	$ 484.30	$ 0.93	$ -	$ 0.93	$ 0.01	$ -	$ 0.01	$ 0.50	$ -	$ 0.50	$ 485.74
Italy	$ 4,356.85	$ -	$ 4,356.85	$ 287.46	$ -	$ 287.46	$ 1.59	$ -	$ 1.59	$ 10.11	$ -	$ 10.11	$ 4,656.01
Mexico	$ 12,231.32	$ 3,126.20	$ 15,357.52	$ 217.84	$ 55.68	$ 273.52	$ 0.08	$ 0.02	$ 0.10	$ 77.76	$ 19.87	$ 97.63	$ 15,728.77
Morocco	$ 39,903.17	$ 46,221.28	$ 86,124.45	$ 693.50	$ 803.31	$ 1,496.81	$ -	$ -	$ -	$ 13.11	$ 15.18	$ 28.29	$ 87,649.55
New Zeala	$ 1,195.49	$ -	$ 1,195.49	$ 22.87	$ -	$ 22.87	$ 0.18	$ -	$ 0.18	$ 4.11	$ -	$ 4.11	$ 1,222.66
Peru	$ 1,511.45	$ 19,754.33	$ 21,265.78	$ 95.98	$ 1,254.38	$ 1,350.36	$ 0.00	$ 0.05	$ 0.05	$ 9.73	$ 127.20	$ 136.93	$ 22,753.12
Poland	$ 11,424.20	$ 103.14	$ 11,527.34	$ 70.85	$ 0.64	$ 71.49	$ 0.01	$ 0.00	$ 0.01	$ 23.77	$ 0.21	$ 23.98	$ 11,622.82
Portugal	$ 28,714.63	$ -	$ 28,714.63	$ 117.46	$ -	$ 117.46	$ 1.41	$ -	$ 1.41	$ 11.03	$ -	$ 11.03	$ 28,844.53
Puerto Ric	$ 2,103.72	$ -	$ 2,103.72	$ 1.76	$ -	$ 1.76	$ 0.09	$ -	$ 0.09	$ 2.28	$ -	$ 2.28	$ 2,107.85
Russia	$ 929.34	$ 1,229.28	$ 2,158.62	$ 5.87	$ 7.77	$ 13.65	$ 0.22	$ 0.29	$ 0.51	$ 0.85	$ 1.12	$ 1.98	$ 2,174.75
Singapore	$ 0.12	$ 0.08	$ 0.20	$ 0.23	$ 0.15	$ 0.38	$ 0.00	$ 0.00	$ 0.00	$ 0.11	$ 0.07	$ 0.17	$ 0.76
Spain	$ 7,740.38	$ -	$ 7,740.38	$ 191.28	$ -	$ 191.28	$ 3.07	$ -	$ 3.07	$ 38.24	$ -	$ 38.24	$ 7,972.97
Switzerlan	$ 169.41	$ 0.84	$ 170.25	$ 268.48	$ 1.33	$ 269.81	$ 0.21	$ 0.00	$ 0.21	$ 0.54	$ 0.00	$ 0.54	$ 440.81
Thailand	$ 15,184.59	$ 21,763.41	$ 36,948.00	$ 456.39	$ 654.13	$ 1,110.52	$ 0.18	$ 0.26	$ 0.45	$ 16.41	$ 23.52	$ 39.93	$ 38,098.90
Trinidad ar	$ 83.50	$ 563.52	$ 647.02	$ 3.51	$ 23.69	$ 27.20	$ 0.01	$ 0.04	$ 0.05	$ 0.59	$ 4.00	$ 4.60	$ 678.86
Turkey	$ 11,588.11	$ 13,165.00	$ 24,753.10	$ 1,200.05	$ 1,363.35	$ 2,563.39	$ 2.33	$ 2.65	$ 4.97	$ 26.20	$ 29.77	$ 55.97	$ 27,377.44
UK	$ 1,486.30	$ -	$ 1,486.30	$ 131.62	$ -	$ 131.62	$ 0.67	$ -	$ 0.67	$ 25.83	$ -	$ 25.83	$ 1,644.43
USA	$ 784,483.73	$ 11,922.69	$ 796,406.42	$ 11,144.02	$ 169.37	$ 11,313.39	$ 4.72	$ 0.07	$ 4.80	$ 880.03	$ 13.37	$ 893.40	$ 808,618.01
Venezuela	$ 7,226.84	$ 18,386.53	$ 25,613.37	$ 136.24	$ 346.62	$ 482.86	$ 0.03	$ 0.07	$ 0.10	$ 11.15	$ 28.37	$ 39.52	$ 26,135.86
Grand Tot	$ 1,644,309.41	$ 1,208,518.71	$2,852,828.12	$ 22,752.89	$ 18,597.22	$ 41,350.10	$ 74.36	$ 14.36	$ 88.72	$ 2,326.38	$ 877.86	$ 3,204.24	$2,897,471.19

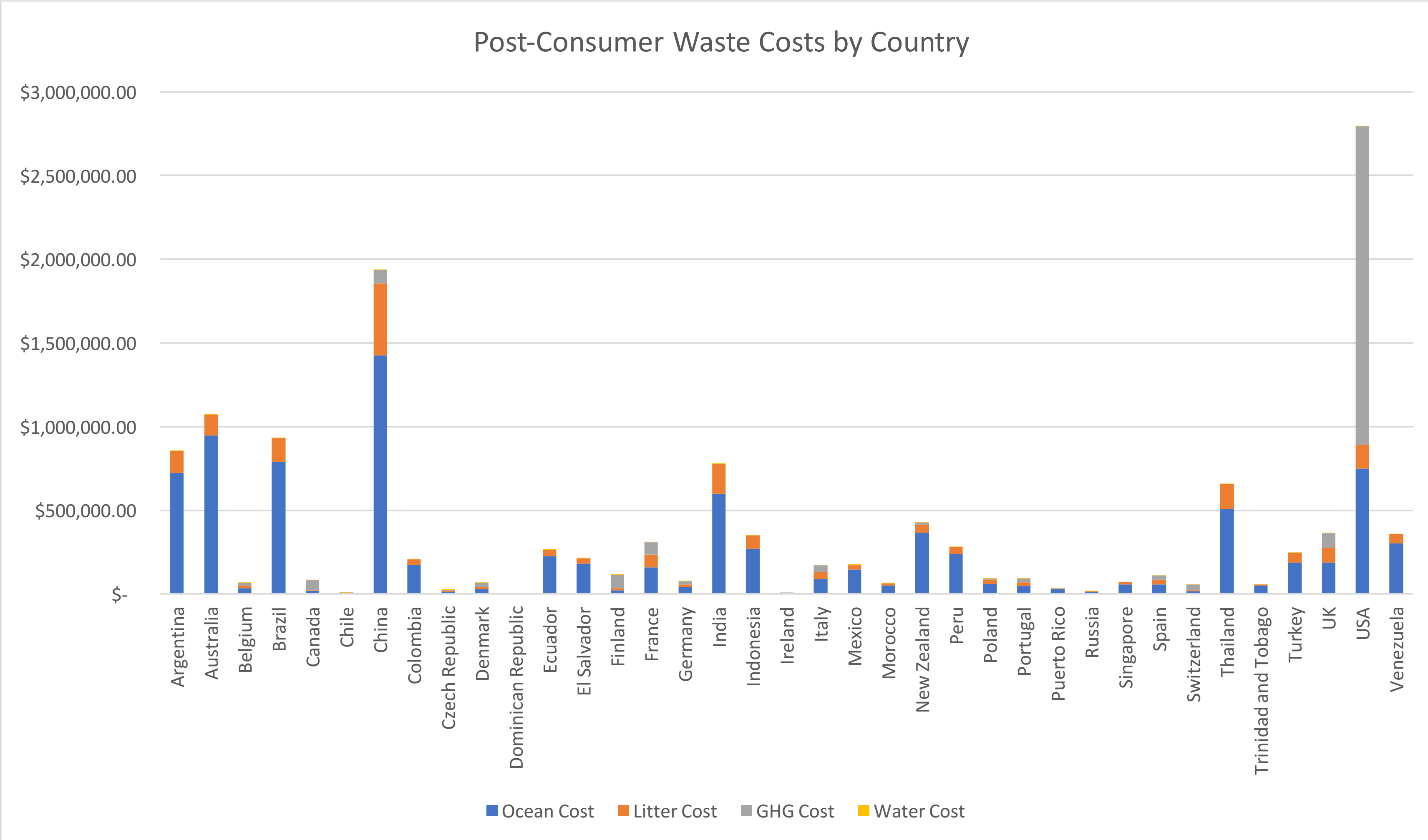
Water Calculations by Geographic Region

	QUANTITY (m3)				
Row Labels	**Sum of Upstream Water Use**	**Sum of Plant Water Use**	**Sum of Downstream Water Use for Treatment of Amcor Waste**	**Sum of Total Country Costs**	**Sum of Downstream Water Use for Treatment of Post-Consumer Waste**
AFRICA	504,267.98	8,764.00	-	87,649.55	165.65
ASIA	20,366,540.41	639,982.50	388.46	1,295,090.35	19,158.49
EUROPE	14,676,098.13	853,254.40	3,285.86	81,256.52	30,494.82
LATIN AMERICA	22,445,571.41	469,563.00	181.93	190,535.89	50,131.47
NORTH AMERICA	121,401,330.41	1,773,159.60	765.14	810,775.63	138,269.15
OCEANIA	7,149,219.48	40,024.00	862.78	432,163.25	12,884.33
Grand Total	**373,086,055.64**	**7,569,495.00**	**10,968.34**	**5,794,942.37**	**502,207.80**

	TOTAL COST												
Row Labels	**Sum of Upstream Water Use Ecosystem Impact**	**Sum of Upstream Water Use Human Health Impact**	**Sum of Total Upstream Impact**	**Sum of Amcor Water Use Ecosystem Impact**	**Sum of Amcor Water Use Human Health Impact**	**Sum of Total Amcor Impact**	**Sum of Water Use From Plant Waste Treatment Ecosystem Impact**	**Sum of Water Use From Plant Waste Treatment Human Health Impact**	**Sum of Total Plant Waste Impact**	**Sum of PCW Treatment Ecosystem Impact**	**Sum of PCW Treatment Human Health Impact**	**Sum of Total PCW Treatment**	**Total Supply Chain Cost (Upstream, Amcor, Downstrream)**
AFRICA	$ 39,903.17	$ 46,221.28	$ 86,124.45	$ 693.50	$ 803.31	$ 1,496.81	$ -	$ -	$ -	$ 13.11	$ 15.18	$ 28.29	$ 87,649.55
ASIA	$ 198,069.12	$ 1,076,056.97	$ 1,274,126.08	$ 5,024.88	$ 15,178.50	$ 20,203.39	$ 4.62	$ 13.54	$ 18.16	$ 150.64	$ 592.08	$ 742.73	$ 1,295,090.35
EUROPE	$ 76,605.11	$ 1,364.29	$ 77,969.40	$ 3,095.00	$ 16.19	$ 3,111.19	$ 14.69	$ 0.30	$ 14.99	$ 159.53	$ 1.41	$ 160.94	$ 81,256.52
LATIN AMERICA	$ 113,186.16	$ 72,953.48	$ 186,139.64	$ 1,249.10	$ 2,429.84	$ 3,678.94	$ 0.75	$ 0.45	$ 1.20	$ 460.30	$ 255.81	$ 716.11	$ 190,535.89
NORTH AMERICA	$ 786,516.26	$ 11,922.69	$ 798,438.95	$ 11,262.90	$ 169.37	$ 11,432.27	$ 4.80	$ 0.07	$ 4.87	$ 886.17	$ 13.37	$ 899.54	$ 810,775.63
OCEANIA	$ 430,029.60	$ -	$ 430,029.60	$ 1,427.51	$ -	$ 1,427.51	$ 49.50	$ -	$ 49.50	$ 656.63	$ -	$ 656.63	$ 432,163.25
Grand Total	$ 3,288,618.83	$ 2,417,037.42	$ 5,705,656.24	$ 45,505.77	$ 37,194.44	$ 82,700.21	$ 148.72	$ 28.72	$ 177.44	$ 4,652.76	$ 1,755.73	$ 6,408.49	$ 2,897,471.19

Waste Calculations by Country

	QUANTITY (tn)		PRICE ($)				
Country	Sum of Amcor Product To Ocean	Sum of Amcor Product Littered	Ocean Cost	Litter Cost	Total Cost	GHG Cost*	Water Cost*
Argentina	2,865.20	12,065.07	$ 724,454.64	$ 128,583.49	$ 853,038.13	$ -	$ 343.36
Australia	3,741.14	11,732.94	$ 945,929.99	$ 125,043.77	$ 1,070,973.76	$ -	$ 652.52
Belgium	136.63	1,497.66	$ 34,546.09	$ 15,961.27	$ 50,507.36	$ 15,925.02	$ 8.63
Brazil	3,124.91	13,158.68	$ 790,121.05	$ 140,238.62	$ 930,359.67	$ -	$ 34.64
Canada	72.85	331.10	$ 18,420.10	$ 3,528.74	$ 21,948.84	$ 59,893.48	$ 6.14
Chile	21.17	89.15	$ 5,353.00	$ 950.10	$ 6,303.11	$ 166.72	$ 1.11
China	5,641.36	40,327.47	$ 1,426,393.05	$ 429,790.02	$ 1,856,183.06	$ 80,948.22	$ 185.38
Colombia	693.05	2,918.38	$ 175,235.85	$ 31,102.62	$ 206,338.47	$ -	$ 3.46
Czech Republic	54.20	594.16	$ 13,705.41	$ 6,332.29	$ 20,037.70	$ 6,317.91	$ 3.34
Denmark	109.49	1,200.16	$ 27,683.89	$ 12,790.74	$ 40,474.62	$ 25,645.87	$ 5.58
Dominican Republic	-	-	$ -	$ -	$ -	$ -	$ -
Ecuador	889.84	3,747.00	$ 224,991.11	$ 39,933.68	$ 264,924.79	$ -	$ 43.74
El Salvador	712.38	2,999.74	$ 180,121.10	$ 31,969.70	$ 212,090.81	$ -	$ 8.85
Finland	92.72	1,016.31	$ 23,443.09	$ 10,831.37	$ 34,274.46	$ 80,949.62	$ 3.18
France	633.99	6,949.49	$ 160,302.28	$ 74,064.16	$ 234,366.44	$ 73,895.99	$ 18.16
Germany	158.76	1,740.28	$ 40,142.71	$ 18,547.06	$ 58,689.77	$ 18,504.95	$ 9.83
India	2,367.53	16,924.40	$ 598,620.26	$ 180,371.75	$ 778,992.01	$ -	$ 445.22
Indonesia	1,069.67	7,646.61	$ 270,462.43	$ 81,493.70	$ 351,956.14	$ -	$ 16.05
Ireland	12.67	138.86	$ 3,203.15	$ 1,479.95	$ 4,683.10	$ 5,215.27	$ 0.50
Italy	355.94	3,901.58	$ 89,996.98	$ 41,581.14	$ 131,578.11	$ 41,486.72	$ 10.11
Mexico	574.93	2,420.95	$ 145,367.43	$ 25,801.27	$ 171,168.71	$ 3,169.15	$ 97.63
Morocco	197.38	1,379.37	$ 49,907.15	$ 14,700.62	$ 64,607.76	$ -	$ 28.29
New Zealand	1,450.26	4,548.30	$ 366,691.87	$ 48,473.49	$ 415,165.36	$ 10,600.01	$ 4.11
Peru	946.65	3,986.26	$ 239,357.50	$ 42,483.57	$ 281,841.07	$ -	$ 136.93
Poland	236.13	2,588.29	$ 59,703.55	$ 27,584.72	$ 87,288.27	$ 3,714.46	$ 23.98
Portugal	186.59	2,045.29	$ 47,178.25	$ 21,797.68	$ 68,975.93	$ 23,481.58	$ 11.03
Puerto Rico	111.53	469.65	$ 28,200.17	$ 5,005.25	$ 33,205.42	$ 1,637.10	$ 2.28
Russia	45.18	495.24	$ 11,423.55	$ 5,278.00	$ 16,701.55	$ -	$ 1.98
Singapore	221.74	1,585.13	$ 56,066.35	$ 16,893.49	$ 72,959.84	$ -	$ 0.17
Spain	228.63	2,506.15	$ 57,808.73	$ 26,709.26	$ 84,517.99	$ 26,648.61	$ 38.24
Switzerland	61.82	677.65	$ 15,631.10	$ 7,222.01	$ 22,853.11	$ 33,259.16	$ 0.54
Thailand	1,998.84	14,288.79	$ 505,398.08	$ 152,282.74	$ 657,680.82	$ -	$ 39.93
Trinidad and Tobago	197.12	830.07	$ 49,841.80	$ 8,846.42	$ 58,688.22	$ -	$ 4.60
Turkey	746.24	5,334.55	$ 188,684.30	$ 56,852.93	$ 245,537.24	$ 3,255.22	$ 55.97
UK	747.61	8,194.85	$ 189,028.79	$ 87,336.62	$ 276,365.42	$ 87,138.31	$ 25.83
USA	2,967.83	13,488.63	$ 750,404.24	$ 143,755.06	$ 894,159.30	$ 1,899,318.66	$ 893.40
Venezuela	1,199.02	5,048.94	$ 303,166.62	$ 53,809.06	$ 356,975.67	$ -	$ 39.52
Grand Total	**34,871.01**	**198,867.12**	**$ 8,816,985.65**	**$ 2,119,426.37**	**$ 10,936,412.02**	**$ 2,501,172.04**	**$ 3,204.24**


Post-Consumer Waste Costs by Country
$3,000,000.00
$2,500,000.00
$2,000,000.00
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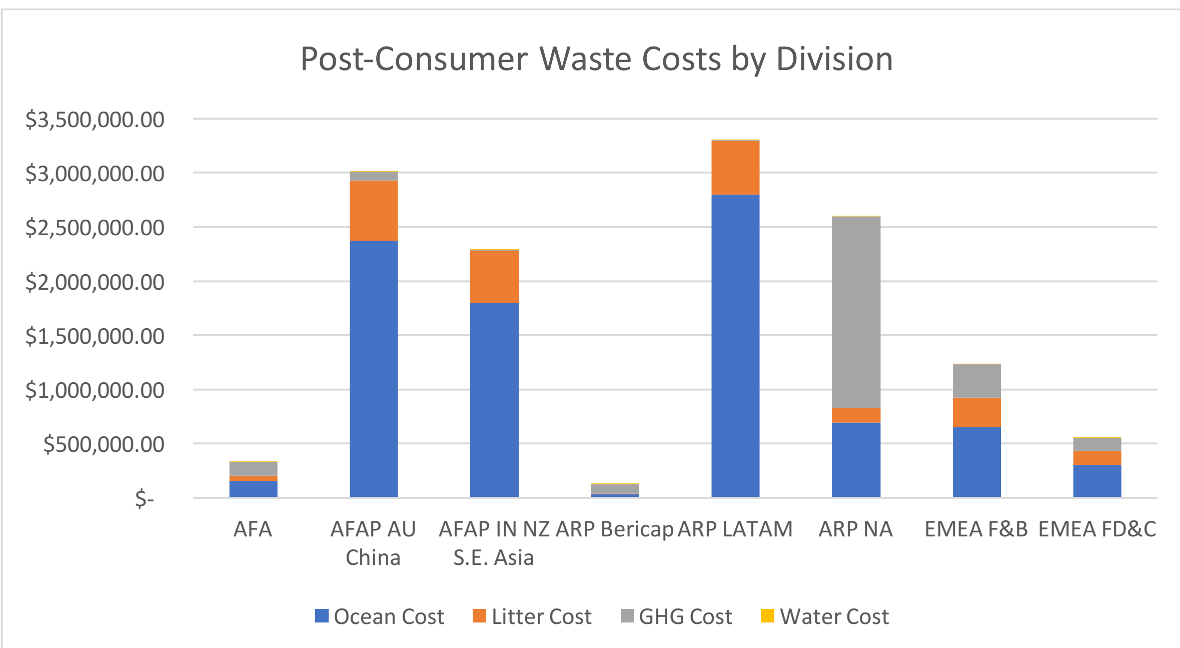
Argentina
Australia
Belgium
Brazil
Canada
Chile
China
Colombia
Czech Republic
Denmark
Dominican Republic
Ecuador
El Salvador
Finland
France
Germany
India
Indonesia
Ireland
Italy
Mexico
Morocco
New Zealand
Peru
Poland
Portugal
Puerto Rico
Russia
Singapore
Spain
Switzerland
Thailand
Trinidad and Tobago
Turkey
UK
USA
Venezuela
Ocean Cost
Litter Cost
GHG Cost
Water Cost

Waste Calculations by Geographic Region

QUANTITY (tn)			PRICE ($)		
Row Labels	Sum of Amcor Product To Ocean	Sum of Amcor Product Littered	Ocean Cost	Litter Cost	Total Cost
AFRICA	197.38	1,379.37	$ 49,907.15	$ 14,700.62	$ 64,607.76
ASIA	12,045.39	86,106.93	$ 3,045,624.47	$ 917,684.64	$ 3,963,309.11
EUROPE	3,060.35	33,545.98	$ 773,797.57	$ 357,516.26	$ 1,131,313.83
LATIN AMERICA	11,335.81	47,733.88	$ 2,866,210.26	$ 508,723.80	$ 3,374,934.06
NORTH AMERICA	3,040.69	13,819.73	$ 768,824.34	$ 147,283.80	$ 916,108.13
OCEANIA	5,191.39	16,281.24	$ 1,312,621.86	$ 173,517.26	$ 1,486,139.12
Grand Total	**34,871.01**	**198,867.12**	**$ 8,816,985.65**	**$ 2,119,426.37**	**$ 10,936,412.02**

Waste Calculations by Division

Division	Ocean Cost	Litter Cost	GHG Cost	Water Cost
AFA	$ 158,839.70	$ 46,112.82	$ 127,457.44	$ 56.70
AFAP AU China	$ 2,372,323.04	$ 554,833.78	$ 80,948.22	$ 837.91
AFAP IN NZ S.E. Asia	$ 1,797,238.98	$ 479,515.18	$ 10,600.01	$ 505.49
ARP Bericap	$ 32,497.37	$ 6,225.53	$ 91,073.32	$ 28.19
ARP LATAM	$ 2,800,121.11	$ 496,993.63	$ 3,169.15	$ 711.30
ARP NA	$ 696,441.69	$ 133,417.44	$ 1,765,286.35	$ 826.12
EMEA F&B	$ 655,349.80	$ 272,465.53	$ 304,886.76	$ 154.81
EMEA FD&C	$ 304,173.95	$ 129,862.46	$ 117,750.77	$ 83.72
Total	**$ 8,816,985.65**	**$ 2,119,426.37**	**$ 2,501,172.04**	**$ 3,204.24**



Appendix 2: Model Database

	percent of waste (total) to landfill	Total plastic waste	population density	Waste Picker Presence (binary)	waste picker #s	Urban population	Land area (sqkm)	Gini Index	Education Index	Life Expectancy	GDP/capita (2015)	percent of waste incinerated	population (in thousands)	urban population	Recycling rate of municipal waste	Total Household Municipal Waste	Human Development Index	Policy	Plastic packaging recovery rate
China	62%	16%	146.57201	1	7678.83	56%	9,388,211	42.16	0.61	75.3	$8,027.7	21%	1,371,220	767883.20	17.50%	170,809,000	1	1	21%
Japan	1%	20%	347.19996	0	1180.71	93%	364,560	32.11	0.808	83.6	$34,523.7	78%	126,958	118071.38	21.00%	44,874,000	2	1	54.00%
Indonesia	70%	14%	142.17713	1	1390.84	54%	1,811,570	39.47	0.603	70.8	$3,346.5	2%	257,564	139084.46	4.00%	7,650,000	0	1	64.60%
India	75%	3%	440.95753	1	4326.47	33%	2,973,190	35.15	0.473	66.4	$1,598.3	5%	1,311,051	432646.67	0.00%	68,800,000	0	1	35%
Thailand	70%	11%	133.02151	1	339.80	50%	510,890	37.85	0.608	74.4	$5,814.8	5%	67,959	33979.68	14.00%	14,640,000	1	0	3%
South Korea	16%	8%	208.91385	1	415.06	82%	38,691	30.2	0.865	70	$27,221.5	25%	50,617	41505.97	49.00%	17,786,000	2	1	59%
US	54%	13%	35.17644	1	2635.63	82%	9,147,420	41.06	0.89	78.9	$56,115.7	12%	321,419	263563.43	34%	230,515,642	2	1	9.37%
Brazil	58%	16%	24.86768	1	1787.49	86%	8,358,140	51.48	0.661	73.9	$8,538.6	0%	207,848	178748.88	2%	78,600,000	1	0	17.00%
Canada	67%	4%	3.95226	1	293.98	82%	9,903,510	33.68	0.85	81.5	$43,248.5	5%	35,852	29398.45	27%	25,103,034	2	1	31.90%
Colombia	76%	12%	43.46886	1	366.54	76%	1,109,500	53.5	0.602	74	$6,056.1	0%	48,229	36653.81	1%	10,251,187	1	0	15.00%
Mexico	95%	7%	65.33976	1	1003.44	79%	1,943,950	48.2	0.638	77.5	$9,005.0	0%	127,017	100343.60	3%	38,101,759	1	0	12.50%
Argentina	64%	15%	15.86470	1	381.34	92%	2,780,400	42.67	0.783	76.3	$14,715.0	0%	41,450	38134.00	11%	5,692,000	1	0	22%
Chile	100%	11%	24.13903	1	158.58	90%	756,102	50.45	0.746	80	$15,732.0	0%	17,620	15858.00	10%	6,142,000	1	1	12%
Costa Rica	75%	11%	94.16079	1	37.51	77%	51,500	48.53	0.654	79.9	$10,185.0	0%	4,872	3751.44	9%	1,280,000	1	0	15%
Belgium	1%	6%	373.15694	0	110.60	98%	30,280	27.59	0.812	80.5	$40,324.0	43%	11,286	11060.01	55.00%	4,708,000	2	1	98.30%
Czech Republ	53%	4%	136.49904	0	77.02	73%	77,210	26.1	0.866	77.7	$17,548.3	18%	10,551	7702.39	25.40%	3,337,000	2	1	72.90%
Denmark	1%	2%	133.61021	0	49.95	88%	42,262	29.08	0.873	79.4	$51,989.3	53%	5,676	4994.88	44.30%	4,485,000	2	1	97.90%
Finland	12%	11%	18.11003	0	46.05	84%	303,890	27.12	0.815	80.5	$42,311.0	48%	5,482	4604.89	32.50%	2,738,000	2	1	68.30%
France	26%	10%	117.60482	1	534.47	80%	547,557	33.1	0.816	81.8	$36,205.6	35%	66,808	53446.70	39.20%	33,399,000	2	1	64%
Germany	0%	23%	231.49112	0	610.60	75%	348,900	30.13	0.884	80.7	$41,313.3	31%	81,413	61059.86	63.80%	51,046,000	2	1	99.80%
Ireland*	42%	12%	68.05727	0	29.24	63%	68,890	32.52	0.887	80.7	$61,133.7	18%	4,641	2923.64	37%	2,693,000	2	1	84%
Italy	26%	6%	203.29668	1	419.53	69%	294,140	35.16	0.79	82.4	$29,957.8	19%	60,802	41953.44	42.50%	29,524,000	2	1	78.90%
Netherlands	1%	20%	501.92553	0	152.43	90%	33,690	27.99	0.894	81	$44,299.8	47%	16,937	15242.87	50.90%	8,855,000	2	1	97.80%
Poland	44%	11%	126.08756	0	231.80	61%	306,190	32.08	0.825	76.4	$12,554.5	13%	37,999	23179.69	32.30%	10,863,000	2	1	35.80%
Portugal*	50%	12%	113.00145	0	65.20	63%	91,605	36.04	0.728	79.9	$19,222.2	24%	10,349	6519.65	30%	4,710,000	2	1	48.50%
Russia**	96%	12%	8.75973	0	1066.32	74%	16,376,870	41.59	0.78	68	$9,092.6	0%	144,097	106631.64	67%	48,000,000	1	1	1.00%
Spain	55%	13%	92.46531	0	371.35	80%	500,210	35.89	0.794	82.1	$25,831.6	12%	46,418.27	37134.62	32.60%	20,151,000	2	1	59%
Switzerland***	0%	15%	210.00767	0	61.32	74%	39,516	31.64	0.844	82.6	$80,945.1	47%	8,287	6132.37	34.00%	6,030,000	2	1	99%
Turkey****	88%	12%	102.21253	1	574.26	73%	769,630	40.18	0.652	75.3	$9,125.7	0%	78,666	57426.06	0.00%	31,283,000	1	1	1%
UK	23%	12%	267.49808	0	540.65	83%	241,930	32.57	0.86	80.5	$43,876.0	31%	65,138	54064.73	43.70%	31,567,000	2	1	48.10%

Appendix 3: Regression Model Variable Sources

Variable	Source(s)	Year(s)	Data Quality
Plastic Packaging Recovery Rate			
Plastic Packaging Recovery Rate	Eurostat[158]	2015	High
	OECD[159]	2015	High
	Asian Institute of Technology[160]	2015	Medium
	Plastic Waste Management Institute[161]	2015	Medium
	International Multidisciplinary Research Journal[162]	2012	Medium
	World Academy of Science, Engineering and Technology[163]	2012	Medium
	EPA[164]	2016	Medium
	Injection Molding Network[165]	2014	Low
	Multi-Material Stewardship Manitoba[166]	2013	Low
	Plastics Europe[167]	2015	Medium
	Environmental Protection Agency: Advancing Sustainable Materials Facts and Figures[168]	2013	High
	Statcan: Waste Disposal by Source[169]	2015	High

Variable	Source(s)	Year(s)	Data Quality
	Export.gov: Mexico – Plastic Materials//Resins[170]	2016	Low

Municipal Solid Waste			
Total municipal solid waste (tons)	Eurostat[171]	2012	High
	International Finance Corporation: Municipal Solid Waste Management: Opportunities for Russia (2012)[172]	2012	Medium
	Environmental Protection Agency: Advancing Sustainable Materials Facts and Figures[173]	2013	High
	Statcan: Waste Disposal by Source	2015	High
	Eurostat[174]	2015	High
	International Solid Waste Association[175]	2014	Medium
	Asian Institute of Technology[176]	2015	Low
	AIT/UNEP Regional Resource Center for Asia and the Pacific[177]	2015	Medium
Overall recycling rate (%)	Statista[178]	multiple	High
	World Bank	2015	High
	United Nations Statistics Division[179]	2014	High
	Journal of Material Cycles and	2014	Medium

	Waste Management[180]		
	Environmental Protection Agency: Advancing Sustainable Materials Facts and Figures	2013	High
	Statcan: Waste Disposal by Source	2015	High
	AIT/UNEP Regional Resource Center for Asia and the Pacific	2015	Medium
	Organisation for Economic Co-operation and Development (OECD), "Municipal Waste", OECD Environmental Statistics (database)[181]	2015	High
	International Finance Corporation: Municipal Solid Waste Management: Opportunities for Russia (2012)	2010	Medium
	International Finance Corporation: Municipal Solid Waste Management: Opportunities for Russia (2012)	2010	Medium
Percent of waste to landfill (%)	Eurostat	2015	High
	Organisation for Economic Co-operation and Development (OECD), "Municipal Waste", OECD Environmental Statistics (database)	2015	High
	International Finance Corporation: Municipal Solid Waste Management: Opportunities for Russia (2012)	2010	Medium
	Department of Energy: Waste to Energy Information Administration[182]	2016	High

	Statcan: Waste Disposal by Source	2015	High
	Mexico News Network[183]	2015	Medium
Percent of waste incinerated (%)	Organisation for Economic Co-operation and Development (OECD), “Municipal Waste”, OECD Environmental Statistics (database)	2015	High
	International Finance Corporation: Municipal Solid Waste Management: Opportunities for Russia (2012)	2010	Medium
	Department of Energy: Waste to Energy Information Administration[184]	2016	High
	Statcan: Waste Disposal by Source[185]	2015	High
	Mexico News Network[186]	2015	Medium
	Eurostat	2015	High
Plastic waste as a percent of total municipal solid waste (%)	World Bank, “What a Waste”[187]	2012	High
	Eurostat	2015	High

Waste Infrastructure			
Presence of waste pickers (yes/no binary)	Global Alliance of Waste Pickers[188]	2016	Low
Policy (presence of extended producer	Pro Europe[189]	2017	High

responsibility requirements)			

Demographics			
Total population	World Bank[190]	2015	High
Urban population	World Bank[191]	2015	High
Population density (persons/sqkm)	World Bank[192]	2015	High
Land area (sqkm)	World Bank[193]	2015	High

Human Development			
Human Development Index	United Nations Development Programme[194]	2014	High
Education Index	United Nations Development Programme	2014	High
Life Expectancy	United Nations Development Programme	2014	High
GINI Index	CIA World Factbook[195]	Various	High
Gross domestic product (GDP) per capita	World Bank[196]	2015	High

Additional Sources that Informed the Waste Model:
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[1] Pascual et al. (2010) The Economics of Ecosystems and Biodiversity – Chapter 5: The economics of valuing. Available online at http://doc.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-5-The-economics-of-valuing-ecosystem-services-and-biodiversity.pdf. Accessed 2 Jan. 2017.

[2] Hartmann, T (2014). Global Nature Fund. How Business Values Natural Capital. Available online at http://www.business-biodiversity.eu/global/download/%7BSYYFGQIDSY-6242014124559-MRIRELADKC%7D.pdf. Accessed 2 Jan. 2017.

[3] Puma (2011). PUMA's Environmental Profit and Loss Account for the year ended 31 December 2010. Available online at http://glasaaward.org/wp-content/uploads/2014/01/EPL080212final.pdf. Accessed 2 Jan. 2017.
[4] Natural Capital Coalition. Protocol. Available online at http://naturalcapitalcoalition.org/protocol/. Accessed 2 Jan. 2017.
[5] Natural Capital Coalition. Protocol. Available online at http://naturalcapitalcoalition.org/protocol/. Accessed 2 Jan. 2017.
[6] Novo Nordisk (2014). Novo Nordisk's environmental profit and loss account. Available online at http://www2.mst.dk/udgiv/publications/2014/02/978-87-93178-02-1.pdf. Accessed 3 Jan. 2017.
[7] Puma (2011). PUMA's Environmental Profit and Loss Account for the year ended 31 December 2010. Available online at http://glasaaward.org/wp-content/uploads/2014/01/EPL080212final.pdf. Accessed 3 Jan. 2017.
[8] Kering (2014). Kering Environmental Profit and Loss Account (E P&L). Available online at http://www.kering.com/en/sustainability/results. Accessed 3 Jan. 2017.
[9] PwC (2015). Natural Capital - risks and opportunities. Available online at http://www.pwc.co.uk/services/sustainability-climate-change/total-impact/natural-capital-exploring-the-risks.html. Accessed 3 Jan. 2017.
[10] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 3 Jan. 2017.
[11] Trucost (2013). Natural Capital at Risk: The Top 100 Externalities of Business. Available online at https://www.trucost.com/publication/natural-capital-risk-top-100-externalities-business/. Accessed 3 Jan. 2017.
[12] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 3 Jan. 2017.
[13] UNEP (2014). VALUING Plastic: The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Jan. 2017.
[14] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 14 Mar. 2017.
[15] " UNEP (2014). VALUING Plastic: The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Nov. 2016.
[16] World Resources Institute and World Business Council for Sustainable Development. Corporate Standard: Greenhouse Gas Protocol. Available online at http://www.ghgprotocol.org/standards/corporate-standard. Accessed 5 Mar. 2017.
[17] World Bank (2012). What a Waste: A Global Review of Solid Waste Management. Available online at http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf. Accessed 13 Mar. 2017.
[18] Ecoinvent Database (2014). Disposal, plastics mixture to sanitary landfill and plastics mixture to municipal incineration. Available at: http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[19] "Plastic waste inputs from land into the ocean | Science." http://science.sciencemag.org/content/347/6223/768. Accessed 13 Mar. 2017.
[20] Ecoinvent Database (2014). Disposal, plastics mixture to sanitary landfill and plastics mixture to municipal incineration. Available at: http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[21] World Bank (2012). What a Waste: A Global Review of Solid Waste Management. Available online at http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf. Accessed 13 Mar. 2017.
[22] Ecoinvent (2014). Home. Available online at http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[23] Ecoinvent (2014). Home. Available online at http://www.ecoinvent.ch/ [Accessed: November 3, 2016].

[24] World Bank (2012). What a Waste: A Global Review of Solid Waste Management. Available online at http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf. Accessed 13 Mar. 2017.
[25] "Plastic waste inputs from land into the ocean | Science." http://science.sciencemag.org/content/347/6223/768. Accessed 13 Mar. 2017.
[26] PwC (2015). Natural Capital - risks and opportunities. Available online at http://www.pwc.co.uk/services/sustainability-climate-change/total-impact/natural-capital-exploring-the-risks.html. Accessed 2 Jan. 2017.
[27] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 2 Jan. 2017.
[28] Food and Agriculture Organization of the United Nations (2015). Natural Capital Impacts in Agriculture. Available online at http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Natural_Capital_Impacts_in_Agriculture_final.pdf. Accessed 14 Mar. 2017.
[29] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 5 Mar. 2017.
[30] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 14 Mar. 2017.
[31] Rosegrant, Mark W. and Ringler, Claudia and Zhu, Tingju, Water for Agriculture: Maintaining Food Security Under Growing Scarcity (November 2009). Annual Review of Environment and Resources, Vol. 34, pp. 205-222, 2009. Available at SSRN: https://ssrn.com/abstract=1599085 or http://dx.doi.org/10.1146/annurev.environ.030308.090351
[32] Ecoinvent Database (2014). Disposal, plastics mixture to sanitary landfill and plastics mixture to municipal incineration. Available at: http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[33] World Resources Institute and World Business Council for Sustainable Development. Corporate Standard: Greenhouse Gas Protocol. Available online at http://www.ghgprotocol.org/standards/corporate-standard. Accessed 5 Mar. 2017.
[34] MJ Goedkoop, PRé Consultants (2010). Greenhouse Gas Protocol V1.01. Obtained from SimaPro 8.1.1.16. [Accessed: March 27, 2016].
[35] "Stern Review: The Economics of Climate Change." 2009. 3 Oct. 2016 <http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf>
[36] “COP21: Business seeks global carbon pricing at climate summit.” 2015. December 6. Financial Times. https://www.ft.com/content/e11d8346-98f8-11e5-95c7-d47aa298f769 Accessed 26 March 2017.
[37] “The EU Emissions Trading System.” <https://ec.europa.eu/clima/policies/ets_en> Accessed 26 March 2017.
[38] “Summary of California’s Cap-and-Trade Program.” <https://www.c2es.org/us-states-regions/action/california/cap-trade-regulation#sub5> Accessed 26 March 2017.
[39] “What is the emissions trading scheme and does it work?” The Guardian. 2011. 7 June. < https://www.theguardian.com/environment/2011/jun/07/ets-emissions-trading>
[40] "Historical Exchange Rates Tool & Forex History Data | OFX." <https://www.ofx.com/en-us/forex-news/historical-exchange-rates/> Accessed 5 Oct. 2016.
[41] "Beijing Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/beijing-carbon-market/. Accessed 5 Apr. 2017.
[42] "Shanghai Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shanghai-carbon-market/. Accessed 5 Apr. 2017.
[43] "Shanghai Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shanghai-carbon-market/. Accessed 5 Apr. 2017.
[44] "Shanghai Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shanghai-carbon-market/. Accessed 5 Apr. 2017.
[45] "Guangdong Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/guangdong-carbon-market/. Accessed 5 Apr. 2017.

[46] "Shenzhen Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shenzhen-carbon-market/. Accessed 5 Apr. 2017.
[47] "Shenzhen Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shenzhen-carbon-market/. Accessed 5 Apr. 2017.
[48] "Shenzhen Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shenzhen-carbon-market/. Accessed 5 Apr. 2017.
[49] "Shenzhen Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/shenzhen-carbon-market/. Accessed 5 Apr. 2017.
[50] "Tianjin Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/tianjin-carbon-market/. Accessed 5 Apr. 2017.
[51] "Hubei Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/hubei-carbon-market/. Accessed 5 Apr. 2017.
[52] "Chongqing Carbon Market | ChinaCarbon.net.cn." http://chinacarbon.net.cn/chongqing-carbon-market/. Accessed 5 Apr. 2017.
[53] IETA (2015). ALBERTA: AN EMISSIONS TRADING CASE STUDY. Available online at https://ieta.wildapricot.org/resources/Resources/Case_Studies_Worlds_Carbon_Markets/alberta_case_study-may2015.pdf. Accessed 5 Apr. 2017.
[54] "California Cap-and-Trade Program Summary of Auction Settlement ...." https://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf. Accessed 5 Apr. 2017.
[55] "California Cap-and-Trade Program Summary of Auction Settlement ...." https://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf. Accessed 5 Apr. 2017.
[56] "Auction Results - Regional Greenhouse Gas Initiative." https://www.rggi.org/market/co2_auctions/results. Accessed 5 Apr. 2017.
[57] "auctions by the transitional common auction platform - European ...." 30 Jun. 2016, https://ec.europa.eu/clima/sites/clima/files/ets/auctioning/docs/cap_report_201606_en.pdf. Accessed 5 Apr. 2017.
[58] "NZU:ERU Chart - Carbon Forest Services." http://www.carbonforestservices.co.nz/nzueru-chart.html. Accessed 5 Apr. 2017.
[59] "CommTrade Carbon." https://www.commtrade.co.nz/. Accessed 5 Apr. 2017.
[60] Switzerland Auctions. <https://www.emissionsregistry.admin.ch/crweb/public/auction/list.do;jsessionid=23ACC59C096434D27DF0564185DFEE92?org.apache.struts.taglib.html.TOKEN=e2bbc722ac5b9be090f9fb3520cea7c2> Accessed 15 Oct. 2016.
[61] "State of the Voluntary Carbon Markets 2016 - Forest Trends." 22 May. 2016, http://www.forest-trends.org/documents/files/doc_5242.pdf. Accessed 5 Apr. 2017.
[62] "Chile becomes the first South American country to tax carbon." Reuters. 2014 27 September. <http://uk.reuters.com/article/carbon-chile-tax-idUKL6N0RR4V720140927>
[63] "Historical Exchange Rates Tool & Forex History Data | OFX." https://www.ofx.com/en-us/forex-news/historical-exchange-rates/. Accessed 5 Apr. 2017.
[64] "FINLAND: INVENTORY OF ESTIMATED BUDGETARY ... - OECD." http://www.oecd.org/site/tadffss/FIN.pdf. Accessed 5 Apr. 2017.
[65] "Environmental Taxes in Denmark | CFE portal." http://www.cfe-eutax.org/taxation/environmental-taxes/denmark. Accessed 5 Apr. 2017.
[66] "Chile becomes the first South American country to tax carbon | Reuters." 27 Sep. 2014, http://uk.reuters.com/article/carbon-chile-tax-idUKL6N0RR4V720140927. Accessed 5 Apr. 2017.
[67] "Carbon Tax in Mexico." https://www.thepmr.org/system/files/documents/Carbon%20Tax%20in%20Mexico.pdf. Accessed 5 Apr. 2017.
[68] "All the World's Carbon Pricing Systems in One Animated Map ...." 17 Nov. 2014, http://www.sightline.org/2014/11/17/all-the-worlds-carbon-pricing-systems-in-one-animated-map/. Accessed 5 Apr. 2017.
[69] "carbon pricing watch 2016 - Open Knowledge Repository - World Bank." 25 Sep. 2015, https://openknowledge.worldbank.org/bitstream/handle/10986/24288/CarbonPricingWatch2016.pdf. Accessed 5 Apr. 2017.

[70] "Options and Considerations for a Federal Carbon Tax | Center for ...." https://www.c2es.org/publications/options-considerations-federal-carbon-tax. Accessed 5 Apr. 2017.
[71] "U.S. said to engage in talks on carbon market rules." 2015 19 October. <https://www.bloomberg.com/news/articles/2015-10-19/u-s-said-to-propose-fallback-global-emissions-trading-markets>
[72] "Colombia to launch voluntary carbon credit trading." 2014 31 October. <http://in.reuters.com/article/colombia-carbontrading-idINL1N0SP2QT20141030>
[73] "Promoting sustainable energy integration in Central America." 2010 September. <http://pdf.usaid.gov/pdf_docs/Pnady222.pdf>
[74] UNEP (2014). VALUING Plastic: The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Nov. 2016.
[75] PwC (2015). Valuing corporate environmental. Available online at http://www.pwc.co.uk/services/sustainability-climate-change/total-impact/natural-capital-exploring-the-risks.html. Accessed 3 Oct. 2016.
[76] PwC (2015). Natural Capital - risks and opportunities. Available online at http://www.pwc.co.uk/services/sustainability-climate-change/total-impact/natural-capital-exploring-the-risks.html. Accessed 3 Jan. 2017.
[77] "Stern Review: The Economics of Climate Change." 2009. 3 Oct. 2016 <http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf>
[78] "Technical Support Document - The White House." 2016. 3 Oct. 2016 <https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf>
[79] "PAGE model - Climate CoLab." 2016. 3 Oct. 2016 <http://climatecolab.org/wiki/-/wiki/page/PAGE>
[80] "Report Attachment - Epa." 2016. 3 Nov. 2016 <https://yosemite.epa.gov/ee/epa/eerm.nsf/vwan/ee-0564-114.pdf>
[81] "FUND - Climate Framework for Uncertainty, Negotiation and Distribution." 2007. 3 Nov. 2016 <http://www.fund-model.org/>
[82] UNEP (2014). VALUING Plastic: The Business Case for Measuring, Managing, and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Nov. 2016.
[83] "Technical Support Document - The White House." 2016. Available online at https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf. Accessed 3 Oct. 2016.
[84] Murray, J. and M. Lenzen. 2010. Introduction to input-output analysis. In J. Murray and R. Wood (Eds). The Sustainability Practitioner's Guide to Input-Output Analysis. Common Ground Publishing.
[85] Manfred Lenzen, Keiichiro Kanemoto, Daniel Moran, Arne Geschke. "Mapping the Structure of the World Economy" Environmental Science & Technology, 46(15), pp.8374-8381, 2012.
[86] Manfred Lenzen, Daniel Moran, Keiichiro Kanemoto, Arne Geschke. "Building Eora: a Global Multi-Region Input-Output Database at High Country and Sector Resolution" Economic Systems Research, 25(1), pp.20-49, 2013.
[87] Amcor Data on Sales Revenue for FY2016 by country
[88] Ecoinvent Database. 2014. Disposal, plastics mixture to sanitary landfill and plastics mixture to municipal incineration. Available at: http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[89] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 5 Mar. 2017.
[90] Food and Agriculture Organization of the United Nations (2015). Natural Capital Impacts in Agriculture. Available online at http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Natural_Capital_Impacts_in_Agriculture_final.pdf. Accessed 5 Mar. 2017.
[91] Pfister, S., Koehler, A., and Hellweg, S. (2009). Assessing the Environmental Impacts of Freshwater Consumption in LCA. Environmental Science & Technology 43 (11), 4098-4104 DOI: 10.1021/es802423e.

[92] Pfister, S. (2011). Environmental evaluation of freshwater consumption within the framework of life cycle assessment. DISS. ETH NO. 19490. ETH ZURICH.
[93] Pfister, et. al. (Eco-Indicator 99) (2009). Human health and ecosystem quality impact data. Accessed January 26, 2017.
[94] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 5 Mar. 2017.
[95] Costanza et al. (1998). The value of ecosystem services: putting the issues in perspective. Ecological Economics 25, 67-72.
[96] De Groot et al. (2012). Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services 1(1), 50-61.
[97] Costanza et al. (2014). Changes in the global value of ecosystem services. Global Environmental Change 26, 152-158.
[98] Olson, D.M., E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'Amico, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, J.F. Lamoreux, T.H. Ricketts, I. Itoua, W.W. Wettengel, Y. Kura, P. Hedao, and K. Kassem. 2001. Terrestrial ecoregions of the world: A new map of life on Earth. BioScience 51(11):933-938.
[99] ArcGIS. World Countries Shapefile. Available online at https://www.arcgis.com/home/item.html?id=3864c63872d84aec91933618e3815dd2. Accessed 28 Mar. 2017.
[100] Trucost (2015). TRUCOST'S VALUATION METHODOLOGY. Available online at http://www.gabi-software.com/fileadmin/GaBi_Databases/Thinkstep_Trucost_NCA_factors_methodology_report.pdf. Accessed 5 Mar. 2017.
[101] Chapin et al. (2011). Principles of Terrestrial Ecosystem Ecology Available online at http://www.springer.com/us/book/9781441995032. Accessed 13 Mar. 2017.
[102] Bolin, B., Degens, E.T., Kempe, S., Ketner, P. (1977). The global carbon cycle. SCOPE 13. John Wiley, New York.
[103] Costanza et al. (1998). The value of ecosystem services: putting the issues in perspective. Ecological Economics 25, 67-72.
[104] Costanza et al. (2007). Biodiversity and ecosystem services: A multi-scale empirical study of the relationship between species richness and net primary productivity. Ecological Economics 61(2-3), 478-491.
[105] Pfister, et. al. (Eco-Indicator 99). 2009. Human health and ecosystem quality impact data. Accessed January 26, 2017.
[106] UNEP (2014) Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry.
[107] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 14 Mar. 2017.
[108] World Bank (2012). What a Waste: A Global Review of Solid Waste Management. Available online at http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf. Accessed 13 Mar. 2017.
[109] Jambeck et al. (2015). "Plastic waste inputs from land into the ocean. Science 347 (6223), 768-771 DOI: 10.1126/science.1260352.
[110] Jambeck et al. (2015). "Plastic waste inputs from land into the ocean. Science 347 (6223), 768-771 DOI: 10.1126/science.1260352.
[111] Jambeck et al. (2015). "Plastic waste inputs from land into the ocean. Science 347 (6223), 768-771 DOI: 10.1126/science.1260352.
[112] Ecoinvent Database. 2014. Disposal, plastics mixture to sanitary landfill and plastics mixture to municipal incineration. Available at: http://www.ecoinvent.ch/ [Accessed: November 3, 2016].
[113] Nahman, A. 2014. Pricing landfill externalities: emissions and disamenity costs in Cape Town, South Africa. Waste Management, 31 (9-10), pp. 2046-56. doi:10.1016/j.wasman.2011.05.015
[114] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 25 Mar. 2017.

[115] Eshet, T., Baron, M. and Shechter, M. 2007. Exploring Benefit Transfer: Disamenities of Waste Transfer Stations. Environ- mental and Resource Economics, 37 (3), pp. 521-547. Available from: doi: 10.1007/s10640-006-9047-6.

[116] PwC (2015). Natural Capital - risks and opportunities. Available online at http://www.pwc.co.uk/services/sustainability-climate-change/total-impact/natural-capital-exploring-the-risks.html. Accessed 3 Jan. 2017.

[117] Cambridge Econometrics, EFTEC & WRc (2003). A study to estimate the disamenity costs of landfill in Great Britain, Defra

[118] ExternE (2004). New results of ExternE, after the NewExt and ExtenE-Pol projects. http://www.externe.info

[119] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 14 Mar. 2017.

[120] Trucost (2016). Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement. Available online at https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf. Accessed 14 Mar. 2017.

[121] UNEP (2014) Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Nov. 2016.

[122] Camuzeaux, J. (2016). How Companies Set Internal Prices on Carbon. http://blogs.edf.org/markets/2016/12/08/how-companies-set-internal-prices-on-carbon/. Accessed April 5, 2017.

[123] UNEP (2014) Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry. Available online at http://www.unep.org/pdf/ValuingPlastic/. Accessed 3 Nov. 2016.

[124] Mohan, Anne Marie. “Can we solve the flexible film recovery puzzle?” Packaging World, 17 Jan 2016. http://www.packworld.com/sustainability/recycling/canwesolveflexiblefilmrecoverypuzzle.

[125] World Economic Forum and Ellen MacArthur Foundation, The New Plastics Economy – Catalysing action (2017, http://www.ellenmacarthurfoundation.org/publications).

[126] Mohan, Anne Marie. “Can we solve the flexible film recovery puzzle?” Packaging World, 17 Jan 2016. http://www.packworld.com/sustainability/recycling/canwesolveflexiblefilmrecoverypuzzle.

[127] “Converted Flexible Packaging.” Freedonia, Oct 2015, http://www.freedoniagroup.com/industry-study/converted-flexible-packaging-3333.htm.

[128] “Can We Recycle Flexible Plastic Packaging?” Plastics Make It Possible, 14 Dec 2016, https://www.plasticsmakeitpossible.com/plastics-recycling/can-recycle-flexible-plastic-packaging/.

[129] Mohan, Anne Marie. “Can we solve the flexible film recovery puzzle?” Packaging World, 17 Jan 2016. http://www.packworld.com/sustainability/recycling/canwesolveflexiblefilmrecoverypuzzle.

[130] Johnson, Jim. “Speakers: Pouch Makers Must Be Proactive on End-of-Life Issues.” Plastics News, 18 June 2015, www.plasticsnews.com/article/20150618/NEWS/150619901.

[131] “Sustainable Packaging.” Flexible Packaging Association, https://www.flexpack.org/sustainable-packaging/.

[132] Johnson, Jim. “Speakers: Pouch Makers Must Be Proactive on End-of-Life Issues.” Plastics News, 18 June 2015, www.plasticsnews.com/article/20150618/NEWS/150619901.

[133] Johnson, Jim. “Early research into recycling flexible packaging shows promise.” Plastics News, 12 April 2016, http://www.plasticsnews.com/article/20160412/NEWS/160419974/early-research-into-recycling-flexible-packaging-shows-promise.

[134] Homepage, Flexible Packaging Association, https://www.flexpack.org/.

[135] Hopewell, Jefferson, Robert Dvorak, and Edward Kosior. “Plastics Recycling: Challenges and Opportunities.” Philosophical Transactions of the Royal Society B: Biological Sciences 364.1526 (2009): 2115–2126, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2873020/

[136] “The State of Play on Extended Producer Responsibility (EPR): Opportunities and Challenges.” OECD, 10 June 2014, https://www.oecd.org/environment/waste/Global%20Forum%20Tokyo%20Issues%20Paper%2030-5-2014.pdf.

[137] Rokka, J. and Uusitalo, L. (2008), Preference for green packaging in consumer product choices – Do consumers care?. International Journal of Consumer Studies, 32: 516–525.

[138] Rokka, J. and Uusitalo, L. (2008), Preference for green packaging in consumer product choices – Do consumers care?. International Journal of Consumer Studies, 32: 516–525. doi:10.1111/j.1470-6431.2008.00710.x

[139] Royte, Elizabeth. “Consumers Love Squeezable Plastic Pouches for Food - Too Bad Recyclers Hate Them.” Pacific Standard, Pacific Standard, 5 Jan. 2016, psmag.com/consumers-love-squeezable-plastic-pouches-for-food-too-bad-recyclers-hate-them-ad7cf0e46db9.

[140] Kimberly Klaiman, David L. Ortega, Cloé Garnache, Consumer preferences and demand for packaging material and recyclability, Resources, Conservation and Recycling, Volume 115, December 2016, Pages 1-8, http://www.sciencedirect.com/science/article/pii/S0921344916302130

[141] Personal Interview, Emily Tipaldo, American Chemical Council. 7 December 2016.

[142] Personal Interview, Emily Tipaldo, American Chemical Council. 7 December 2016.

[143] “Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement.” Trucost, July 2016, https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf.

[144] Zhang, Han. Personal Interview, Dow Chemical. 24 October 2016.

[145] Defruyt, Sander. Personal Interview, Ellen MacArthur Foundation. 19 December 2016.

[146] Defruyt, Sander. Personal Interview, Ellen MacArthur Foundation. 19 December 2016.

[147] Defruyt, Sander. Personal Interview, Ellen MacArthur Foundation. 19 December 2016.

[148] Zhang, Han. Personal Interview, Dow Chemical. 24 October 2016.

[149] Defruyt, Sander. Personal Interview, Ellen MacArthur Foundation. 19 December 2016.

[150] Danielson, Joi. Personal Interview, Ocean Conservancy. 18 January 2017.

[151] Houlder, Graham. Personal Interview, AluFoil. 5 December 2016.

[152] “Country Comparison: Distribution of Family Income: Gini Index.” CIA: The World Factbook, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html. Accessed March 2017.

[153] Bellù, Lorenzo Giovanni, and Paolo Liberati. "Inequality Analysis: The Gini Index." *EASYPOL*. Food and Agriculture Organization of the United Nations, FAO. <http://www.fao.org/docs/up/easypol/329/gini_index_040en.pdf>.

[154] “Income Inequality Measures.” *Journal of Epidemiology and Community Health* 61.10 (2007): 849–852. *PMC*. Web. 18 Apr. 2017.

[155] Zhang, Han. Personal Interview, Dow Chemical. 24 October 2016.

[156] “Carton Recycling Access Reaches New Heights.” Carton Council, 26 Jan 2016, “http://swana.org/Portals/0/News/IndustryWatch/02-2016/Carton%20Council%20-%202015%20Progress.pdf.

[157] “2014 National Postconsumer Plastic Bag & Film Recycling Report.” Moore Recycling Associates Inc, January 2016, https://plastics.americanchemistry.com/Education-Resources/Publications/2014-National-Postconsumer-Plastic-Bag-Film-Recycling-Report.pdf.

[158] “Recycling rates for packaging waste.” Eurostat, http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=ten00063&language=en, 2014.

[159] Reducing Barriers to International Trade in Non-hazardous Recyclable Materials and Waste: Exploring the Environmental and Economic Benefits." Organisation for Economic Co-operation and Development, <http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=COM/TAD/ENV/JWPTE(2008)27/ANN&docLanguage=En>

[160] Suwannapan, Tantima, "Assessment of Beverage Carton Waste in Thailand Using Material Flow Analysis." *Asian Institute of Technology*. <http://faculty.ait.ac.th/visu/public/uploads/images/pdf/2014/tantima.pdf>

[161] Plastic Products, Plastic Waste and Resource Recovery." *PWMI Newsletter* 11.1 (1988): 1-16. Plastic Waste Management Institute. <https://www.pwmi.or.jp/ei/siryo/ei/ei_pdf/ei46.pdf

[162] Lodha, Gaurav, and M.W. Sheikh. "Plastic Pollution in Cities of Mumbai and Thane."*International Multidisciplinary Research Journal* 1.4 (<http://www.rhimrj.com/admin/upload/-upload-NOV14010419.pdf>

[163] Truc, Nguyen Thi Thanh, Chi-Hyeon Lee, Byeong-Kyu Lee, and Srinivasa Reddy Mallampati. "Separation of Hazardous Brominated Plastics from Waste Plastics by Froth Flotation after Surface Modification with Mild Heat-Treatment." World Academy of Science, Engineering and Technology,. <http://waset.org/publications/10003189/separation-of-hazardous-brominated-plastics-from-waste-plastics-by-froth-flotation-after-surface-modification-with-mild-heat-treatment>.

[164] "Advancing Sustainable Materials Management: Facts and Figures." *EPA*. Environmental Protection Agency, 12 Apr. 2017. <https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures>.
[165]"Recent European and American Waste Plastics Recycling." Injection Molding Network. <http://injectionmolding.0086zhusu.com/zhusu_1/content/?1060.html>.
[166] Paben, Jared. "How Plastic Packaging Stewardship Is Playing out in Canada." Plastics Recycling Update, 27 Dec. 2016. <https://resource-recycling.com/plastics/2016/07/19/how-plastic-packaging-stewardship-is-playing-out-in-canada/>.
[167] "Plastics – the Facts 2016." *PlasticsEurope*. European Association of Plastics Recycling & Recovry Organization. Web. <http://www.plasticseurope.org/documents/document/20161014113313-plastics_the_facts_2016_final_version.pdf>
[168] Environmental Protection Agency - Advancing Sustainable Materials: https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf
[169] "Waste Disposal by Source." Statcan, http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/envir25a-eng.htm, 2014.
[170] "Mexico – Plastic Materials/Resins." Export.gov, https://www.export.gov/article?id=Mexico-Plastic-Materials-Resins, 2016.
[171] "Municipal waste by waste operations." Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasmun&lang=en, 2015.
[172] "Municipal Solid Waste Management: Opportunities for Russia." International Finance Corporation, http://www.ifc.org/wps/wcm/connect/a00336804bbed60f8a5fef1be6561834/PublicationRussiaRREP-SolidWasteMngmt-2012-en.pdf?MOD=AJPERES, 2012.
[173] "Advancing Sustainable Materials." Environmental Protection Agency, https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf, 2013.
[174] "Your Key to European Statistics." *Recycling Rate of Municipal Waste - Eurostat*. Eurostat. Web. 18 Apr. 2017. <http://ec.europa.eu/eurostat/web/products-datasets/-/t2020_rt120>.
[175] "Global Recycling Markets: Plastic Waste." International Solid Waste Association, n.d. Web. <https://www.iswa.org/fileadmin/galleries/Task_Forces/TFGWM_Report_GRM_Plastic_China_LR.pdf>.
[176] Visvanathan, C., and Integrated Research System For Sustainability Science (Ir3S), The University Of Tokyo. "Http://www.ir3s.u-tokyo.ac.jp/3e-nexus/pdf/022414/session02-01.pdf." Asian Institute of Technology, n.d. Web. <http://www.ir3s.u-tokyo.ac.jp/3e-nexus/pdf/022414/session02-01.pdf>.
[177] "Municipal Waste Status Report." *AIT/UNEP Regional Resource Center for Asia and the Pacific* (2010): n. pag. Web. <http://www.rrcap.ait.asia/Publications/MW_status_quo.pdf>.
[178] *Statista*. The Statistics Portal. <https://www-statista-com.proxy.lib.umich.edu/>.
[179] *UNSD Environmental Indicators*. United Nations Statistics Division. <https://unstats.un.org/unsd/environment/qindicators.htm>.
[180] Chaerul, Mochammad. "Recycling of Plastic Packaging Waste in Bandung City, Indonesia."*SpringerLink*. Springer Japan, 18 Oct. 2013. <https://link.springer.com/article/10.1007/s10163-013-0201-2>.
[181] "Municipal Waste", OECD Environmental Statistics, http://www.keepeek.com/Digital-Asset-Management/oecd/environment/environment-at-a-glance-2015_9789264235199-en#page52, 2015.
[182] "Waste to Energy Information Administration." Department of Energy, http://www.eia.gov/energyexplained/index.cfm/data/index.cfm?page=biomass_waste_to_energy, 2016.
[183] "Waste to Energy Plant." Mexico News Network, http://www.mexiconewsnetwork.com/adventure/waste-energy-plant/, 2015.
[184] "Waste to Energy Information Administration." Department of Energy, http://www.eia.gov/energyexplained/index.cfm/data/index.cfm?page=biomass_waste_to_energy, 2016.
[185] "Waste Disposal by Source." Statcan, http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/envir25a-eng.htm, 2014.
[186] "Waste to Energy Plant." Mexico News Network, http://www.mexiconewsnetwork.com/adventure/waste-energy-plant/, 2015.
[187] "What a Waste: A Global Review of Solid Waste Management." World Bank, http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf, 2012.

[188] Global Alliance of Waste pickers, http://globalrec.org/
[189] ProEurope, http://www.pro-e.org/Introduction-to-PRO-EUROPE.html, 2017.
[190] Population, total." World Bank, http://data.worldbank.org/indicator/SP.POP.TOTL, 2015.
[191] "Urban population." World Bank, http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS, 2015.
[192] "Population density (people per sq. km of land area." World Bank, http://data.worldbank.org/indicator/EN.POP.DNST?locations=AL, 2015.
[193] "Land area." World Bank, http://data.worldbank.org/indicator/AG.LND.TOTL.K2, 2015.
[194] "Human Development Reports." *Human Development Data (1990-2015) | Human Development Reports*. UNITED NATIONS DEVELOPMENT PROGRAMME. 18 Apr. 2017. <http://hdr.undp.org/en/data>.
[195] "Country Comparison: Distribution of Family Income: Gini Index." CIA: The World Factbook, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html. Accessed March 2017.
[196] "GDP per capita." World Bank, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD, 2015.
[197] Journal of Material Cycles and Waste Management, Official Journal of the Japan Society of Material Cycles and Waste Management (JSMCWM) and the Korea Society of Waste Management (KSWM)
[198] Encyclopedia of Consumption and Waste: The Social Science of Garbage, http://sk.sagepub.com.proxy.lib.umich.edu/reference/consumption-waste