CITY OF IOWA CITY

SUMMARY REPORT

FEBRUARY 2018

ecoCity Footprint Tool Pilot

...ecological and carbon footprint analysis for achieving one planet living

FUNDED BY THE USDN INNOVATION FUND

PREPARED BY: BCIT Cora Hallsworth Consulting

SUMMARY

With the support of the Urban Sustainability Directors' Network (USDN) Sustainable Consumption Grant, the ecoCity Footprint Tool (eF Tool) was pilot tested with Iowa City. The objectives of the Sustainable Consumption Grant project were to:

- Assess the eF Tool's suitability for use in a US city
- Identify potential modifications to increase the Tool's utility in a US context
- Create a Consumption-Based Emission Inventory and Ecological Footprint Assessment for Iowa City

This *Summary Report* presents the results of Iowa City's Consumption-Based Emission Inventory and Ecological Footprint, as created by the ecoCity Footprint Tool. It also provides an overview of the data collection methodology and identifies opportunities, challenges and limitations specific to Iowa City.

Background

The ecoCity Footprint Tool enables a community to evaluate its ecological footprint, 'territorial' greenhouse gas (GHG) emissions, and consumption-based GHG emissions. These inventories provide critical data to inform sustainable-consumption and climate mitigation efforts. Since the late '90s, governments have typically created GHG emissions inventories using an in-boundary or territorial approach, which identifies emissions from sources within the particular region. However, this form of inventory does not provide a complete picture of a community's impact on global climate change. It misses the climate impacts associated with the many goods a community consumes, because many of these goods are produced in other regions, often on other continents.

Although climate change is arguably the most pressing environmental issue we are currently facing, we are also bumping up against many other planetary boundaries. Due to unsustainable levels of consumption, global society today is demanding more in a year through consumption of energy and resources than nature can provide, and polluting more than nature can assimilate. The ecoCity Footprint Tool has the capacity to arm a community with the information it needs to act on global climate change and ecological overshoot.

Results

This report presents Iowa City's ecological footprint and Consumption-Based Emission Inventory results for 2015.

 # Planets Required by Iowa City

Ecological Footprint Assessment

The ecological footprint is measured in global hectares (gha) per capita, where a global hectare is a biologically productive hectare with globally averaged productivity for a given year. It is an estimate of how much biologically productive land and water area an individual or population needs to produce all the resources it consumes and to absorb the wastes it generates. Based on current global population and biological productivity levels, an average of 1.7 global hectares is available for each person on the planet.

Results show that Iowa City's *per capita* footprint is 6.7 gha/person.[1] This means that approximately 4 earths would be required to support the global population if everyone had lifestyles comparable to an Iowa City resident.

[1] This per capita footprint includes an estimate of national and provincial services.

Territorial GHG Emission Inventory and Consumption-Based Emission Inventory

The Consumption-Based Emissions Inventory (CBEI) presents the total GHG emissions resulting from consumption of goods and services within a region, regardless of where those goods and services are produced. This form of inventory is generated using the data typically collected for a territorial inventory, including the energy used by buildings and transportation and the emissions associated with solid waste management, in addition to an evaluation of the emissions that result from the production and transport of all goods consumed within the region, as informed by life-cycle assessment data. Total consumption-based emissions for Iowa City were 1,182 $ktCO_2e$[2] in 2015, approximately 200 $ktCO_2e$ more than the territorial emissions (see Figure 1). CBEI emissions for communities with low levels of industry within their borders are typically half that of their territorial emissions, since much of the goods consumed in a community are imported. This is not the case for Iowa City, however since the city is home to a few large manufacturing companies.

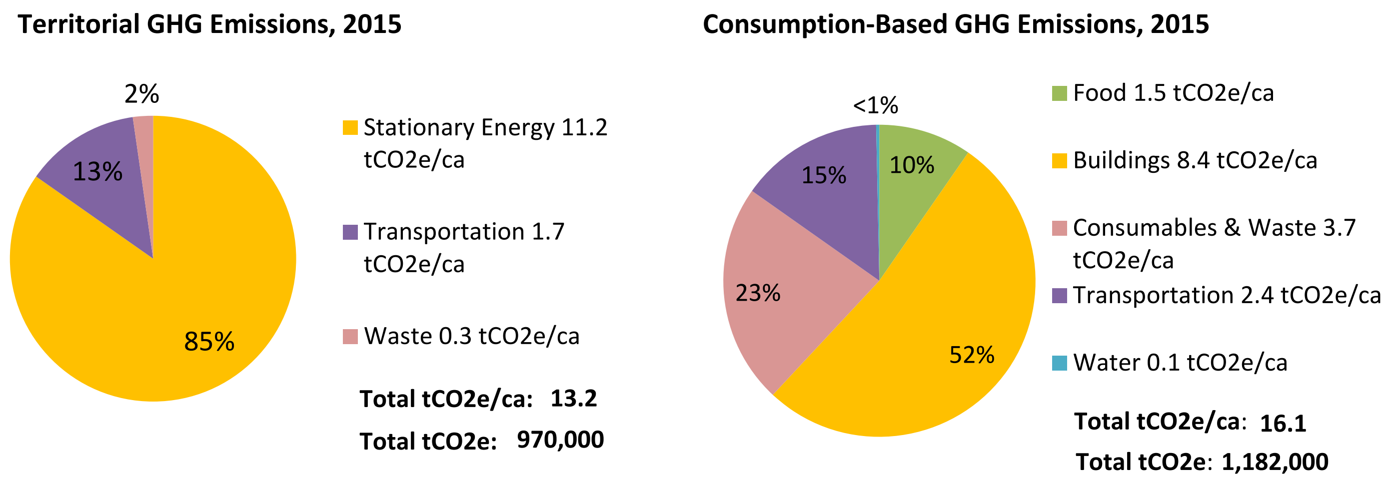

Figure 1: Comparison of Iowa City's 2015 Consumption-Based and Territorial GHG Emissions

Highlights

- For the CBEI, the largest impact category is buildings (52%) followed by consumables and waste (23%); similarly, for the ecological footprint (EF), the largest impact category is buildings (37%), followed by consumables and waste (28%). Food is the impact area in which these results vary most significantly. Food is only 10% of the total for the CBEI, but 25% of the EF; the primary driver for this difference is the land intensity of food production.

FOOD

- Only a small proportion of the impact of food is associated with its transportation, whereas 98% is associated with the amount of land and energy used for agricultural production. Nearly three quarters of food impacts result from production of animal proteins, in particular red meat and dairy products.
- Three-quarters of both the ecological footprint (EF) and the CBEI associated with food result from production of animal proteins, including dairy. The main difference between the EF and the CBEI results is that dairy yields a greater GHG impact due to the energy intensity of its production, and meat yields a greater EF impact due to its intensity in land use demands.

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[2] Where a $ktCO_2e$ is a metric kilotonne (1000 tonnes) of carbon dioxide equivalents.

↳ ***Results demonstrate that the largest priority for reducing Iowa City's food footprint is to target meat and dairy consumption, both in terms of reducing overall consumption levels and in terms of reducing the land and energy demands associated with their production.***

BUILDINGS

- *Operating energy of buildings dominates impacts for both the EF and the CBEI*.

↳ ***The near-term priority should be to improve the efficiency of buildings and accelerate action to transition to 100% renewable energy, with a longer-term objective of ensuring footprint impacts are considered in decisions about building materials.***

CONSUMABLES

- The footprint of consumables and waste is dominated by upstream impacts, namely the energy and materials that go into producing the goods that are consumed in the city. Textiles and paper are a significant component of the consumables and waste footprint.
- The largest impact categories for consumables with respect to the EF are paper (40%), and wood waste, textiles, rubber (33%); whereas for the CBEI the largest impact categories for consumables are wood waste, textiles, rubber (37%), and plastics (36%). These results are explained by the larger land footprint associated with production of paper, and the higher fuel intensity associated with plastic.

↳ ***Results indicate the necessity to prioritize reduction in overall consumption, instead of focusing on end of stream waste management. Emphasis should be placed on priority material types, in particular plastic, paper and textiles.***

TRANSPORTATION

- Sixty two percent of Iowa City's transportation footprint is a result of fuel consumption for private vehicles, and adding the embodied energy of vehicles, private vehicle transportation represents more than 80% of the transportation footprint. Similar to the EF, 90% of the consumption-based emissions for transportation are associated with private vehicle travel.

↳ ***A near term priority is to continue to support a mode-shift away from private vehicle travel, continue to electrify the vehicle fleet (particularly transit); and to reduce the number of vehicles on the road by promoting active transportation, transit, and car-sharing. These initiatives can also reduce the embodied energy for transportation by reducing the overall number of vehicles on the road. The long-term priority should be to promote a compact community that is designed for active transportation and transit.***

The Sustainability Gap

To achieve 'One Planet Living' Iowa City's ecological footprint would need to reduce from 6.7 gha per capita to no more than 1.7 gha per capita. This represents a sustainability gap of 70%. From a climate perspective, in order to achieve the target of maintaining global temperatures below a 2 degree Celsius in warming, GHGs must be reduced to 2 tCO_2e per capita. Given Iowa City's current consumption based GHG per capita emissions of 16.1 tCO_2e, GHG emissions would need to be reduced by 88%; and based on the territorial GHG emissions of 13.2 tCO_2e per capita, they would need to be reduced by 85%.

This report presents a proposed One Planet Scenario, as an example of how Iowa City could reduce its total ecological footprint to 1.7 gha per capita. It also presents a set of example policy and planning interventions to help close this sustainability gap.

Acknowledgements

This report has been prepared by Cora Hallsworth (Principal, Cora Hallsworth Consulting-CHC) and Dr. Jennie Moore (Associate Dean, School of Construction and the Built Environment, BCIT); with contributions and research provided by Daniel Southwick, University of Iowa, Ryan Mackie (CHC), and editing provided by Paramdeep Nahal, BCIT.

The authors would like to thank and acknowledge our project advisors and the many individuals who contributed time to this project. A special thank you to the City of Iowa City staff lead for this project: Brenda Nations, Sustainability Coordinator, and to our project advisors: Babe O'Sullivan (USDN) and Allison Ashcroft (Network Coordinator, CUSP), and the many staff members at Iowa City who contributed data and participated in workshops.

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Acronyms

AFOLU	Agricultural, Forest, and other Commercial Land Uses
BCIT	British Columbia Institute of Technology
CBEI	Consumption-Based Emission Inventory
CLP	Climate Leadership Plan
CMA	Census Metropolitan Area
CRD	Capital Regional District
EF	Ecological Footprint
eF Tool	ecoCity Footprint Tool
gha	Global Hectares
gha/ca	Global Hectares per Capita (person)
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
ICI	Industrial Commercial and Institutional (sectors)
IPPU	Industrial Products and Pollutants
LCA	Life-Cycle Assessment
tCO_2e/ $ktCO_2e$	Tonnes Carbon Dioxide Equivalent / Kilotonnes Carbon Dioxide Equivalent
USDN	Urban Sustainability Directors Network
VKT	Vehicle Kilometers Traveled

Definition of Terms

BASIC and BASIC+	Reporting levels in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).
Built Area	For the eF Tool, Built Area is the total municipal boundary excluding natural areas, where a natural area is a non-serviced area. For example, a treed park would be excluded, but agricultural land is included. In the eF Tool, the Built Area for the transportation sector is reported separately.
CO_2e	Carbon dioxide equivalent (CO_2e) expresses the impact of each different greenhouse gas in terms of the amount of CO_2 (carbon dioxide) that would create the same amount of warming. This enables reporting total greenhouse gas emissions in one measurement.
Embodied Energy	The energy used in creating and delivering a particular material (e.g., consumable good or infrastructure), including the energy used for extraction of raw materials, manufacturing and transportation of the end product.
Embodied Materials	Materials that are utilized in the manufacture of a consumable product or infrastructure, but that do not end up in the finished product. Examples are manufacturing wastage and temporary features used during manufacture.
Urban Metabolism	A study of the flow of energy and materials through the urban system.
Operating Energy	The energy used in the function of a product, building, vehicle, etc.
Scope 1-3	GHG emissions that are generated in-boundary (Scope 1), from grid supplied energy (Scope 2), and generated out-of-boundary (Scope 3).

CONTEXT

Scientists are suggesting that we have entered the Anthropocene era; an era in which humanity is the greatest force shaping earth's terrestrial systems. Currently, 50% of net primary production is in service of the human population and 80% of ecosystems are influenced by humans. [i] As a result, we are bumping up against important planetary boundaries,[ii] and are in a state of "ecological overshoot."[iii]

Ecological overshoot is measured using ecological footprint analysis, which assesses humanity's total demand on nature's services over a one-year period compared to the capability of biologically productive land and sea areas to meet that demand. Global society today is demanding more in a year through consumption of energy and resources than nature can provide, and polluting more than nature can assimilate. Simply stated, it would take 1.5 Earths to sustainably provide the ecological services we currently use.

Climate change is one of these critical areas of overshoot. Recently, Nation States from around the world, including Canada, ratified the Paris Agreement, committing to holding global temperature increase to below 2 degrees Celsius. The signatories are aiming to go beyond this commitment by staying below 1.5 degrees Celsius of warming, which scientists now suggest is the boundary threshold for avoiding the most negative and severe climate change impacts of a changing climate.

Cities account for only 3% of global land use, but they are responsible for the majority of global resource consumption. [iv] It is not the cities that are the problem, but the energy and resource intensity of our urban lifestyles that require vast land areas outside of the city to support it. The discrepancy between the small amount of land occupied by cities and the vast amount of land required to resource urban lifestyles is at the heart of the urban sustainability challenge.

The Ecological Footprint (EF) and the Consumption-Based Emission Inventory (CBEI) can help communities and governments tackle one of the root causes of global ecological overshoot and climate change: individual and collective consumption choices and habits.

What is an Ecological Footprint?

The ecological footprint helps us understand how consumption affects ecological thresholds in terms of our demand on nature's services and the available ecologically productive land and sea area. It is an estimate of how much biologically productive land and water area an individual or population needs to produce all the resources it consumes and to absorb the waste it generates. It is measured in global hectares (gha) per capita, where a global hectare is a biologically productive hectare with globally averaged productivity for a given year.

What is a Consumption-Based Emissions Inventory?

The consumption approach includes the emissions released to produce goods and services consumed within a region, regardless of where they were originally produced. That is, it estimates global emissions resulting from local consumption habits. Typical emissions inventories include only emissions from sources within a given region's borders; however, with the globalization and integration of our economy, a significant amount of the emissions associated with the production, disposal, and transport of a region's goods occur in other regions. CBEI results can demonstrate the scale to which we are off-loading our consumption-related emissions on to other jurisdictions. This will help encourage strategies that maximize global, and not just local, emission reductions. This form of inventory is of growing interest to governments that are keen to broaden and deepen their sustainability and climate-action efforts.

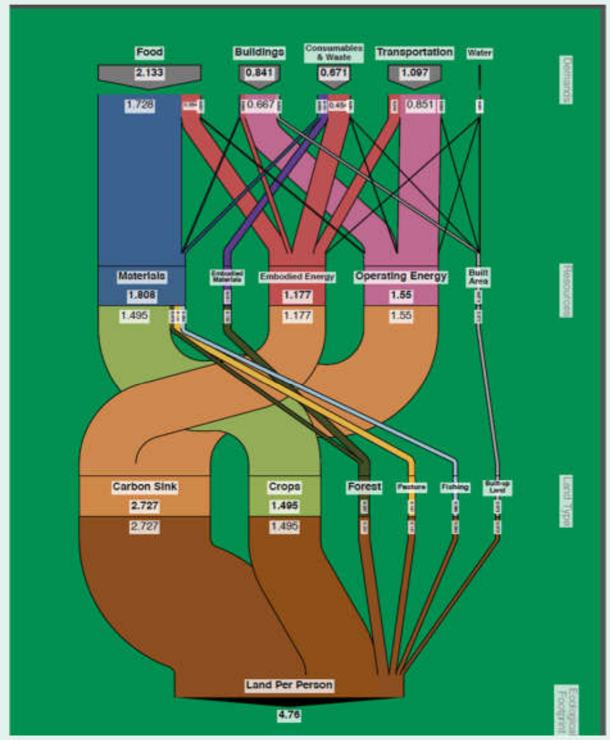
ECOCITY FOOTPRINT TOOL OVERVIEW

Dr. Jennie Moore, Associate Dean at BCIT, created the ecoCity Footprint Tool (eF Tool) as part of her PhD under the supervision of Dr. William Rees, founder of the ecological footprint concept. The goal in creating the eF Tool was to support policy-related decision-making aimed at reversing global **ecological overshoot**, namely by creating a community-scale **ecological footprint** using locally sourced data**.** A prototype of the Tool was initially used by the City of Vancouver in 2006. The outputs from the Tool are highly valued by the City and are informing the strategies, actions, and monitoring methods for their "Greenest City 2020 Action Plan".

The Tool was originally conceived for ecological footprint utility, but it also generates an urban metabolism, a traditional 'territorial' greenhouse gas (GHG) emission inventory, and a consumption-based emissions inventory. These inventories provide critical data to inform sustainable-consumption and climate mitigation efforts.

What is an Urban Metabolism?

The urban metabolism traces the flow of energy and materials through the urban system, and yields the data to inform the footprint and consumption inventory. The urban metabolism can be depicted visually using a SANKEY diagram (see below).



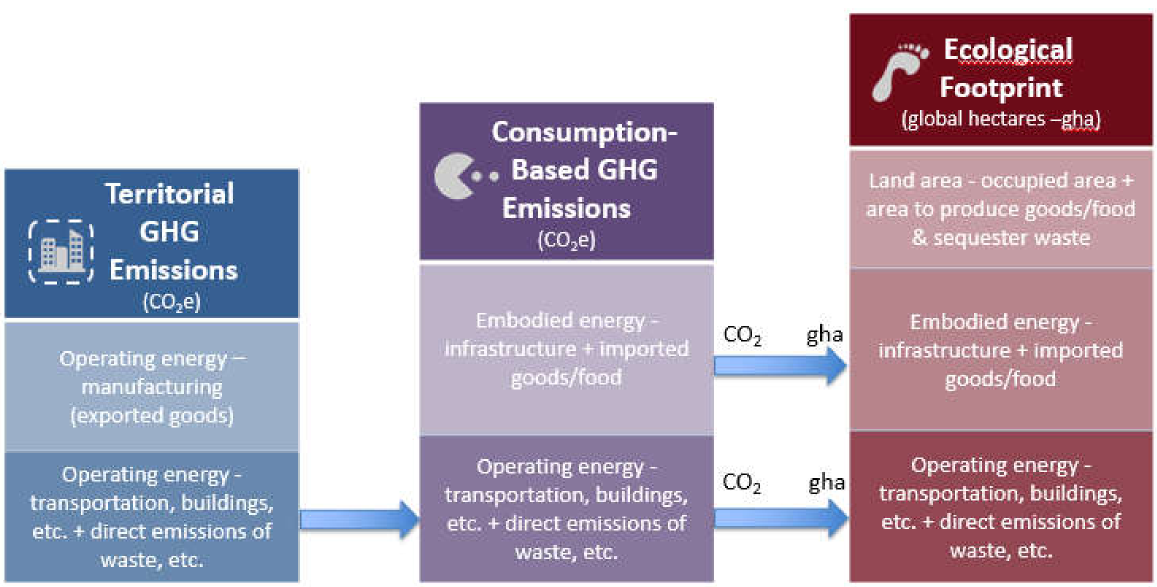


Figure 2 Comparison of the GHG Emission Inventories and Ecological Footprint Approaches

How Does the eF Tool Work?

Many existing ecological footprint and consumption-based greenhouse gas (GHG) inventory tools use the 'compound method' (a top-down approach that uses national and/or econometric data). The eF Tool uses the 'component method', which emphasizes the use of community-based data, and aligns with traditional spheres of planning at the local government level (see Figure 3, below). Real consumption data, collected through an **urban metabolism** study, provides the utility needed to directly link policy intervention to emission outputs at the local government scale. This provides a clear and transparent understanding of how city functions, across all sectors and service areas, affect the footprint. It also enables scenario analyses to forecast which policy interventions and changes could enable reductions in the city's energy and material flows, greenhouse gas (GHG) emissions, and ecological footprint.

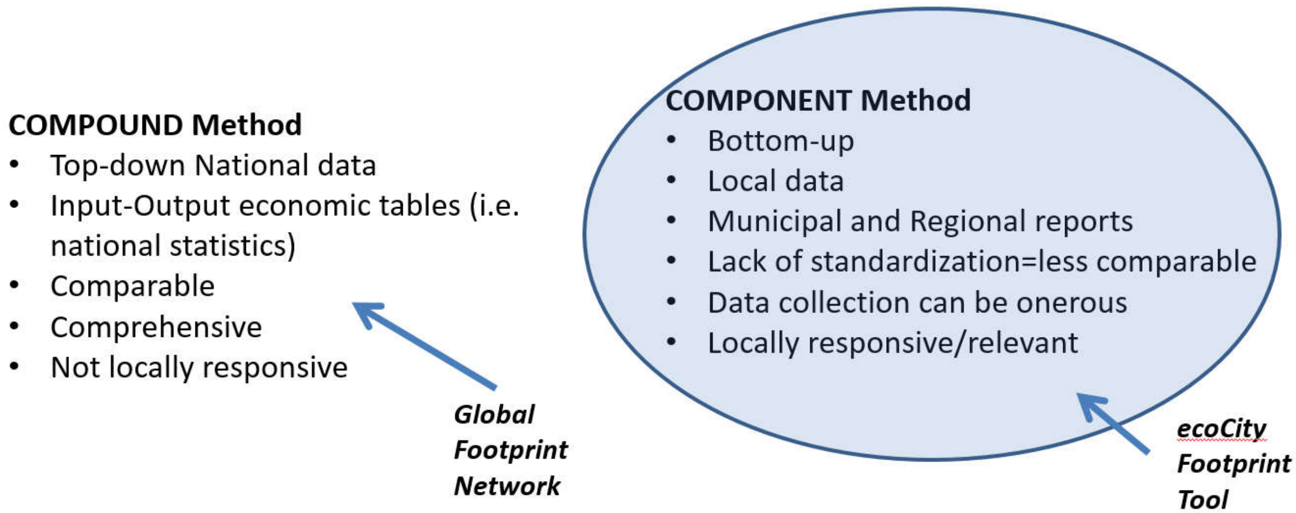


Figure 3 Two Methods for Calculating the Ecological Footprint

ecoCity Footprint Tool Application

Exploring consumption-based inventories and ecological footprints is a way for governments to broaden and deepen their sustainability and climate-action efforts. In particular, they provide a more robust understanding of emission sources and ecological impacts, and they can directly inform sustainable-consumption efforts.

The eF Tool also has the potential to help streamline data collection and reporting due to its capacity to create multiple outputs: the consumption-based inventory, the territorial inventory, as well as the ecological footprint.

PILOT PROJECT OVERVIEW

With the support of the Urban Sustainability Directors' Network (USDN) Sustainable Consumption Grant, the eF Tool was pilot tested with Iowa City. The objectives of the Sustainable Consumption Grant project were to:

- Assess the eF Tool's suitability for use in a US city
- Identify potential modifications to increase the Tool's utility in a US context
- Create a Consumption-Based Emission Inventory and Ecological Footprint Assessment for Iowa City

This project ran in parallel with a USDN Innovation Fund pilot project aimed at refining the Tool to align with new international GHG reporting protocols; scoping out an on-line version of the Tool; creation of user guidance and testing with four additional USDN members (City of Victoria, City of Vancouver, City of North Vancouver, and District of Saanich). Both projects were led by BCIT with the support of a project manager and a team of advisors.

This *Summary Report* presents the results of Iowa City's Consumption-Based Emission Inventory and Ecological Footprint, as created by the ecoCity Footprint Tool. It also provides an overview of the data collection methodology and identifies opportunities, challenges and limitations specific to Iowa City.

Two companion reports provide supplementary information:

- The *Sustainable Consumption Grant Final Report* summarizes the lessons learned in testing the ecoCity Footprint Tool in a US context, particularly an assessment of the Tool's suitability for use in a US city. A summary of recommended refinements to the Tool is also presented.
- The *Innovation Fund Pilot Project Final Report* (to be submitted in January 2018) will present a complete set of lessons learned through piloting with all five communities.

PILOTING IN IOWA CITY

Iowa City participated in this pilot project because of its potential to inform and contribute to climate and sustainability planning efforts. The City is currently creating an updated Community-wide Climate Action and Adaptation Plan, and it is hoped that information gleaned from using the ecoCity Footprint Tool can help inform this planning process. Ecological Footprint and Consumption-Based Emissions Inventory results can also inform a broader set of planning initiatives at the City; including, for example: neighborhood planning, local food strategy planning, sustainable transportation planning, and solid waste management planning. The resulting data and knowledge could also provide framing for communications to residents and business about sustainability and climate action issues.

Iowa City has made substantive climate action commitments over the last decade, starting in 2007 with the signing of the US Mayors' Climate Protection Agreement. In 2008, the City joined the Cities for Climate Protection Campaign and began annually reporting their greenhouse gas (GHG) emissions. Most recently, in 2016, the city joined the Compact of Mayors, now the Covenant of Mayors, and completed their first GHG inventory compliant with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) for the 2015 reporting year.

Municipal Context

Iowa City is located in the state of Iowa, in northern central USA, and had a population of over 73,000 in 2015. The city has a total area of 25 square miles (65 km).[3] A significant proportion of Iowa City's population attend the University of Iowa (UI), located in Iowa City. The smaller Kirkwood Community College is also located in Iowa City. Current enrolment at UI is 30,000[4] and many of these students are considered to be Iowa City residents as they reside in Iowa City for more than six months of the year.

There are several small towns that flank Iowa City such as Coralville and North Liberty. The University of Iowa employs over 27,000 people in the region either directly or in its hospital and clinics. Much of the remaining population is employed by other medical services, local government and academic services independent from UI. Several large engineering and manufacturing plants also operate in the city including Proctor & Gamble, Oral-B, International Automotive Components, Lear, Alpla, and Moore North America.[5]

Both heating and cooling loads for buildings are significant in this climate given that winters are relatively cold (averaging lows of 15°F) and summers are hot and humid (averaging highs of 86°F).[6] The majority of electricity is supplied by MidAmerican Energy Company and by a power plant on the UI campus. MidAmerican is the largest wind energy producer in the USA and as of 2011, 30% of its power generation comes from renewables. The UI power plant uses both coal and biomass and plans to have 40% of campus energy come from renewable energy sources by 2020. By 2025, their goal is to be 100% coal-free.[7]

Both the City and UI have committed to reducing energy use through the construction of Leadership in Energy and Environmental Design (LEED) certified buildings, converting to Light-emitting Diode (LED) lighting and other conservation retrofits. As of 2011, both the city and UI list close to 10 completed LEED projects. UI also runs an Energy Control Center in which energy engineers can monitor and analyze the energy use of all buildings on campus. With this initiative, conservation efforts can be tracked in real time to analyze effectiveness.[8]

Municipal solid waste production per capita for Iowa City is 767 kg (2011). This is slightly higher than the US average of 744 kg and well above most other regions in the world. For example, the European Union (EU) average is 476 kg (2015)[9] and the world average is 234 kg (2013).[10] UI has a goal to reach a 60% waste diversion rate by 2020.[11]There are a number of recycling programs in Iowa City including curbside pickup which is used regularly by 65% of residents and a composting program for yard waste and food scraps; however, diversion rates are still relatively low. It is estimated that 75% (2011) of the waste entering the landfill is recyclable. Methane gas from the landfill and the wastewater treatment plant is captured and a portion of the wastewater methane is utilized, effectively reducing emissions.

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[3] US Census Bureau, 2010 Census. (n.d.). QuickFacts. Retrieved from https://www.census.gov/quickfacts/fact/table/amescityiowa,US/IPE120216

[4] City of Iowa City. (2013).

[5] City of Iowa City. (2013).

[6] National Climatic Data Center. (n.d.). Climate of Iowa. Retrieved from http://www.crh.noaa.gov/images/dvn/downloads/Clim_IA_01.pdf

[7] City of Iowa City. (2013).

[8] City of Iowa City. (2013). Iowa City Sustainability Assessment 2013. Retrieved from https://www.icgov.org/services/sustainability

[9] Eurostat. (n.d.). Municipal Waste Statistics extracted July 2017. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics

[10] World Economic Forum. (Aug 2015). Which countries produce the most waste?. Retrieved from https://www.weforum.org/agenda/2015/08/which-countries-produce-the-most-waste/

[11] City of Iowa City. (2013).

Iowa City has a walk score of 43; this ranking means that most errands require a car.[12] With 77 km (48 miles) of paved bike trails, the city is a Silver Level Bicycle Friendly Community. The transit service ridership is close to 2 million (2011) connecting the UI campus and neighboring communities. UI runs a free bus service on campus that services over 4 million riders annually (2011) and a van service used by about 700 riders to commute to the campus. Efforts by the city to shift to more active transportation between 2007 to 2011 contributed to a 10% reduction in automobile use, a 67% increase in public transportation use, a 52% increase in bicycling, and a 9% increase in walking. In 2011, UI and the City increased the biodiesel content used in their bus fleets to 20% and 10% respectively. The UI vehicle fleet is 52% E-85, hybrid, and electric vehicles. The annual vehicle kilometers traveled per capita in Iowa City is 7,564 (4,700 vehicle miles traveled (VMT) per capita), less than half of the state and country average.[13]

UI received a STARS Gold Rating in 2013 for its sustainability efforts and in 2015, Iowa City received a 4-star rating from the STAR Community Rating System. Over the last decade, Iowa City has seen a steady decline of per capita GHG emissions from 21 tCO_2e (2008) to 18 tCO_2e (2013) and inventory results for the 2015 reporting year also suggest a downward trend in total emissions.[14]

[12] Walkscore. *Living in Iowa City*. Retrieved from: https://www.walkscore.com/IA/Iowa_City
[13] City of Iowa City. (2013).
[14] City of Iowa City. (2013). Iowa City Sustainability Assessment 2013. Retrieved from https://www.icgov.org/services/sustainability

DATA COLLECTION AND ANALYSIS METHODOLOGY

The ecoCity Footprint Tool is aligned with the typical spheres (or categories) of municipal planning. As such, data is collected on the total inputs, in terms of materials, embodied energy, operational energy and built area for each of these categories (see Figure 4). Each of these inputs are evaluated sectorally – that is by residential, institution, commercial and industrial sectors. The eF Tool employs a bottom-up approach, prioritizing the use of community- and regional-scale data sources. However, in cases where local data is not available, assumptions or proxies are utilized.

Study Year

A study year of 2015 was chosen to align with the most recently completed GHG inventory.

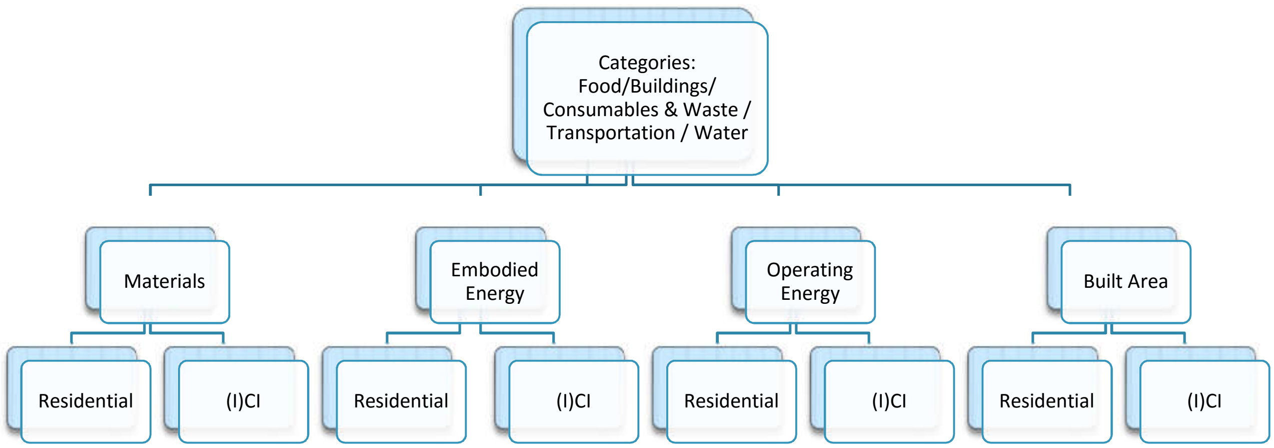

Figure 4: Data Inputs[15]

Key Assumptions and Limitations

An overview of the data inputs required to generate the ecological footprint, CBEI and territorial GHG inventory, and key assumptions and limitations are presented in Table 1. A detailed overview of the methodology, data sources, and challenges and opportunities are presented in Appendix B.

[15] (I)CI refers to light industrial, commercial and institutional sectors.

Table 1: Key Assumptions and Limitations

CATEGORY	INPUTS	EF	CBEI	TERRITORIAL GHG INVENTORY	KEY ASSUMPTIONS AND LIMITATIONS
Food *Food available is measured as a proxy for food consumption and import distances are used to estimate food-kilometers traveled. Energy associated with the production and transportation of imported food is then estimated.*	Embodied energy and materials associated with food production (energy and materials used to produce and transport food)	✓	✓	×	· Food consumption and 'food miles' statistics were not available at the local level; therefore national averages were used as a proxy. An option to make this data more locally relevant would be to conduct a food survey in the future.
	Land used to produce food	✓	×	×	
Buildings and Stationary Energy *The embodied materials, embodied energy, operating energy, and the built area associated with residential, industrial and commercial buildings are evaluated to establish a material-flow analysis, assess the direct and embodied carbon, and evaluate the ecological footprint of these buildings.*	Operating energy used by buildings and related infrastructure	✓	✓	✓	· The study team was unable to obtain tonnage of materials used in buildings. Archetype information already contained within Dr. Moore's ecoCity Footprint Tool was used as a proxy in the absence of local data.
	Embodied energy and embodied materials of buildings	✓	✓	×	
	Built area associated with buildings	✓	×	×	
Consumables and Waste *Data is collected on the:* · *quantity of solid and liquid waste generated by sector (residential, industrial, commercial and institutional) and by material type;* · *method in which materials are managed (i.e., landfilled, incinerated, recycled, composted);* · *energy consumption and emissions associated with waste management facilities, and transportation of waste;* · *material composition and built area associated with waste management facilities.*	Operating energy used in waste management facilities and hauling waste	✓	✓	✓	· The landfill serves a regional community, therefore waste generation rates were pro-rated based on population served by the landfill. This method does not reflect the unique profile of Iowa City residents.
	Direct emissions from waste facilities	✓	✓	✓	
	Embodied energy and materials associated with consumables (as inferred by waste stream)	✓	✓	×	
	Built area associated with waste management	✓	×	×	

<table>
<tr><th>CATEGORY</th><th>INPUTS</th><th>EF</th><th>CBEI</th><th>TERRITORIAL GHG INVENTORY</th><th>KEY ASSUMPTIONS AND LIMITATIONS</th></tr>
<tr><td rowspan="3">Transportation
Evaluates the embodied materials and embodied energy of physical transportation infrastructure and vehicles, operating energy (fuel consumed by vehicles), and physical built area occupied by transportation infrastructure. Data is collected for private and commercial vehicles; transit; aviation travel; marine travel and off road vehicle use.</td><td>Operating energy associated with transportation (fuel use for private and commercial vehicles; aviation; marine vessels and off-road vehicles)</td><td>✓</td><td>✓</td><td>✓</td><td rowspan="3">· State average annual miles driven per capita were used since city-wide estimates did not account for travel out of city limits. State averages likely result in an over-estimate of VMTs due to the high percentage of biking and walking commutes that take place in Iowa City compared to the rest of the State.
· National average air travel estimates were used in the absence of local data.</td></tr>
<tr><td>Embodied energy and embodied materials associated with personal vehicles and transportation infrastructure</td><td>✓</td><td>✓</td><td>✗</td></tr>
<tr><td>Built area associated with transportation</td><td>✓</td><td>✗</td><td>✗</td></tr>
<tr><td rowspan="3">Water
Evaluates the embodied materials, embodied energy, operating energy, and built area impacts of the water distribution and purification system relied on by the municipality.</td><td>Operating energy used in treating and conveying water</td><td>✓</td><td>✓</td><td>✓</td><td rowspan="3">n/a</td></tr>
<tr><td>Embodied energy and embodied materials associated with water infrastructure</td><td>✓</td><td>✓</td><td>✗</td></tr>
<tr><td>Built area associated with water management</td><td>✓</td><td>✗</td><td>✗</td></tr>
</table>

RESULTS

The following presents the results of the assessment of Iowa City's: (1) Ecological Footprint (EF), (2) Consumption-Based Emission Inventory (CBEI), and (3) 'Territorial/GPC GHG emission inventory; as evaluated by the ecoCity Footprint Tool.

It is important to contextualize results with the knowledge that Iowa City's per capita footprint and GHG emissions are increased since the city is home to the University of Iowa, and since the city is home to companies that provide employment for residents in surrounding communities. Students and employees that travel into Iowa City from surrounding communities generate waste and use energy while they are in the City. As a result, the waste generation and energy-use associated with the institutional and commercial sectors in Iowa City is inflated.

Ecological Footprint Assessment

The ecological footprint is measured in global hectares (gha). A global hectare represents the average of all biological productive land and aquatic area on earth for a given year. An ecological footprint is an estimate of how much biologically productive land and water area an individual or population needs to produce all the resources it consumes and to absorb the wastes it generates. Based on current global population and biological productivity levels, an average of 1.7 global hectares is available for each person on the planet.

 # Planets Required by Iowa City

Iowa City's total ecological footprint is 418,000 gha (about 1 million acres).[16] This is an area 64 times bigger than the City's municipal boundary. Iowa City's current *per capita* footprint is 5.7 gha excluding the resource demands associated with national and state services such as the military. If we were to add these national and state services, Iowa City's per capita ecological footprint increases by at least 18%, to 6.7 gha per person. This means that approximately four earths would be required to support the global population if everyone had lifestyles comparable to an Iowa City resident.

If we look at the various components of Iowa City's footprint, as shown in Figure 5, buildings represent the largest impact (37%), followed by consumables and waste (28%), food (25%), and transportation (10%).

[16] Excluding national and state services.

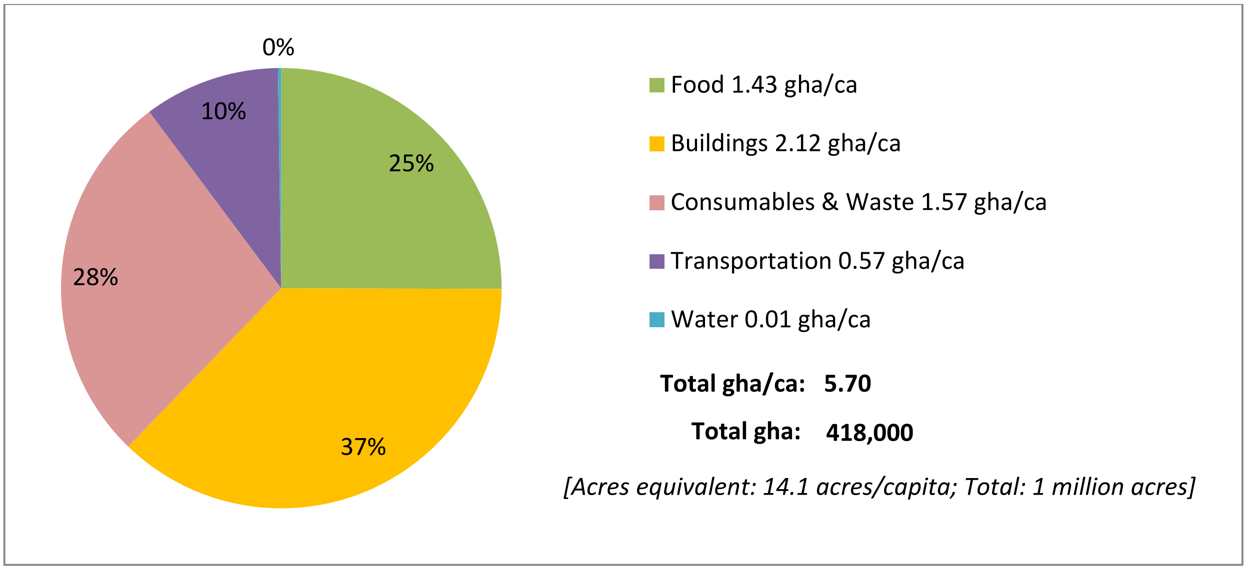

Figure 5: Summary of Ecological Footprint by Activity, 2015 (excluding national and state services)

Food Footprint

In considering the food footprint we see that only a small proportion of the impact is associated with transport of the food, whereas 98% of the footprint is associated with the amount of land and energy that are utilized in growing food (see Figure 6).

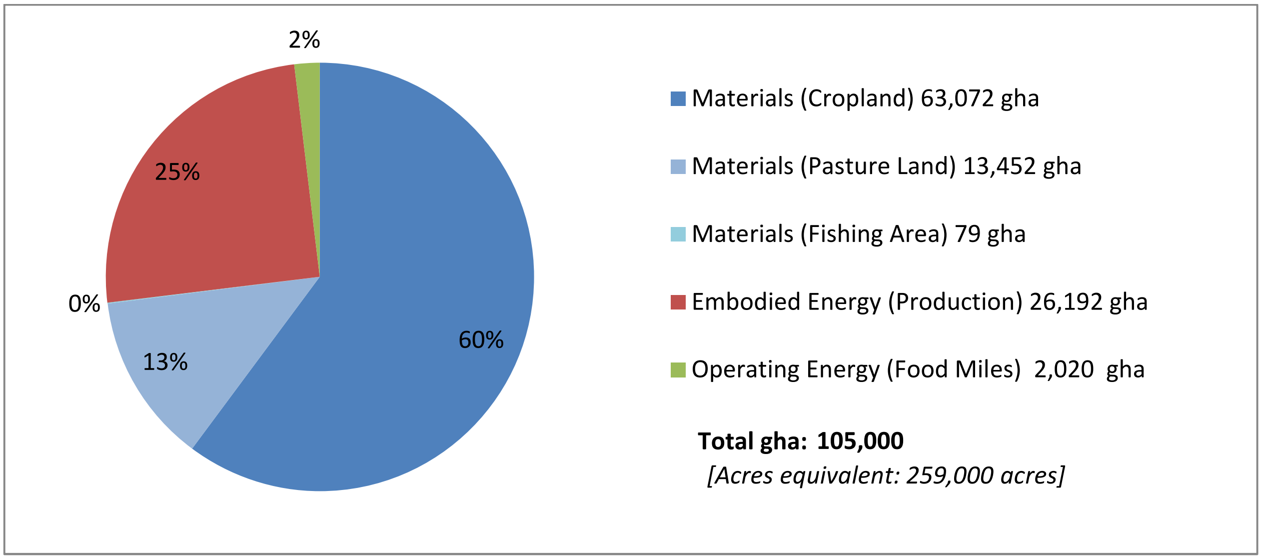

Figure 6: Food Footprint Summary, 2015

When we look at which types of food are having the largest impact on the footprint, nearly three quarters of the footprint is a result of animal proteins, in particular red meat and dairy products (see Figure 7: Food Footprint by Food Type, 2015).

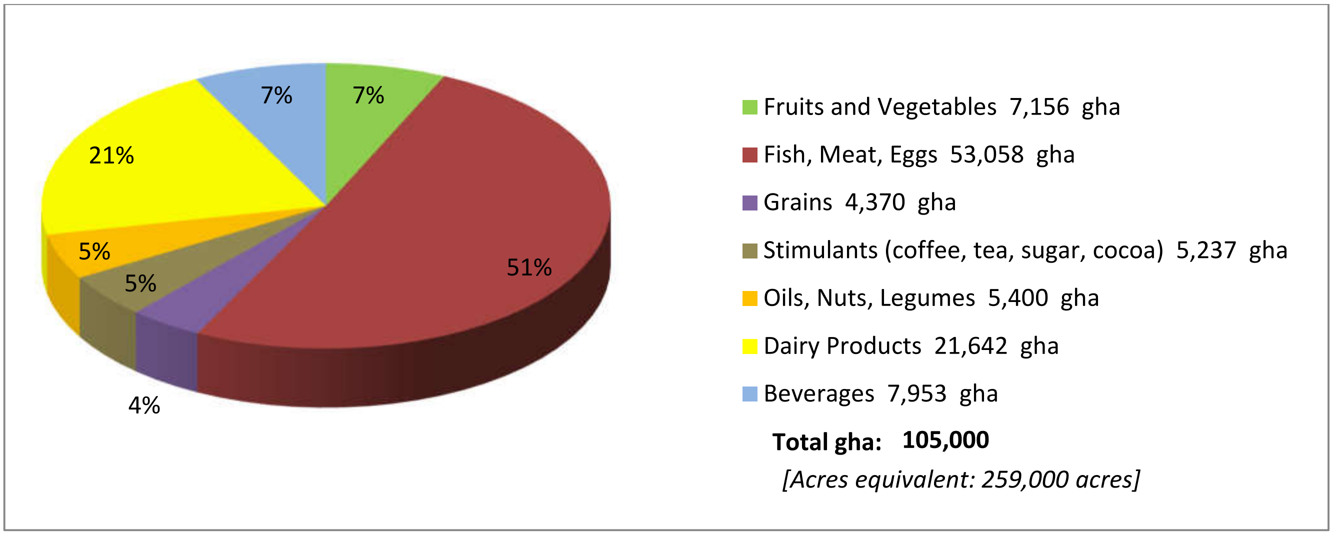

Figure 7: Food Footprint by Food Type, 2015

These results demonstrate that the largest priority for reducing Iowa City's food footprint is to target meat and dairy consumption, both in terms of reducing overall consumption levels and in terms of reducing the land and energy demands associated with their production.

Buildings Footprint

As shown in Figure 8, more than 90 percent of the ecological footprint of Iowa City buildings is a result of operating energy. This is not to say that material choices for buildings are insignificant, but given that the impact of these materials are amortized over the entire lifespan of the building, their overall impact compared to fuel and electricity consumption becomes overshadowed.[17] As the City transitions to lower impact energy sources to operate our buildings, the impact of material choices will make up a greater percentage of the footprint. **The near-term priority should be to improve the efficiency of buildings, with a longer-term objective of ensuring footprint impacts are considered in decisions about building materials over their lifecycle.**

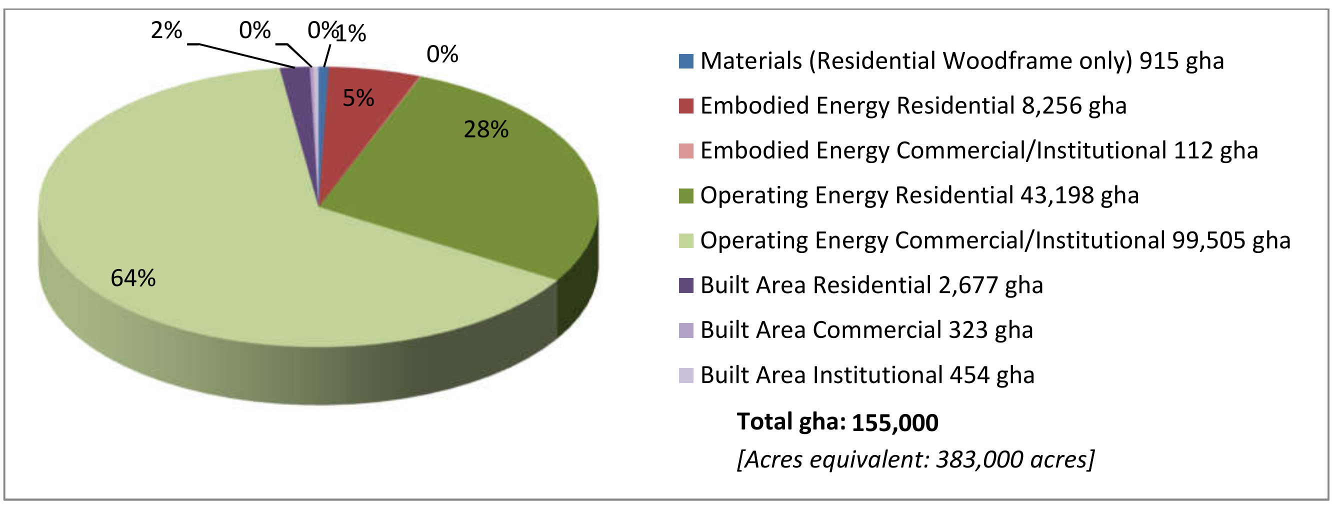

Figure 8: Buildings Footprint Detailed, 2015

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[17] There is an unresolved issue with the data for concrete resulting in under reporting of impacts of commercial/institutional embodied energy on EF and CBEI.

Consumables and Waste Footprint

The footprint of consumables and waste is dominated by upstream impacts, namely the energy and materials that go into producing the goods that are consumed in the city.[18] As shown in Figure 9, these upstream impacts – the embodied materials and embodied energy associated with the consumables – represent 96% of the footprint. Embodied materials are those that are utilized in the manufacture of a consumable product or infrastructure but do not end up in the finished product; and embodied energy is the energy used in creating and delivering a particular material (e.g., consumable good or infrastructure). **Results indicate the necessity to prioritize reduction in overall consumption, instead of focusing on end of stream waste management.**

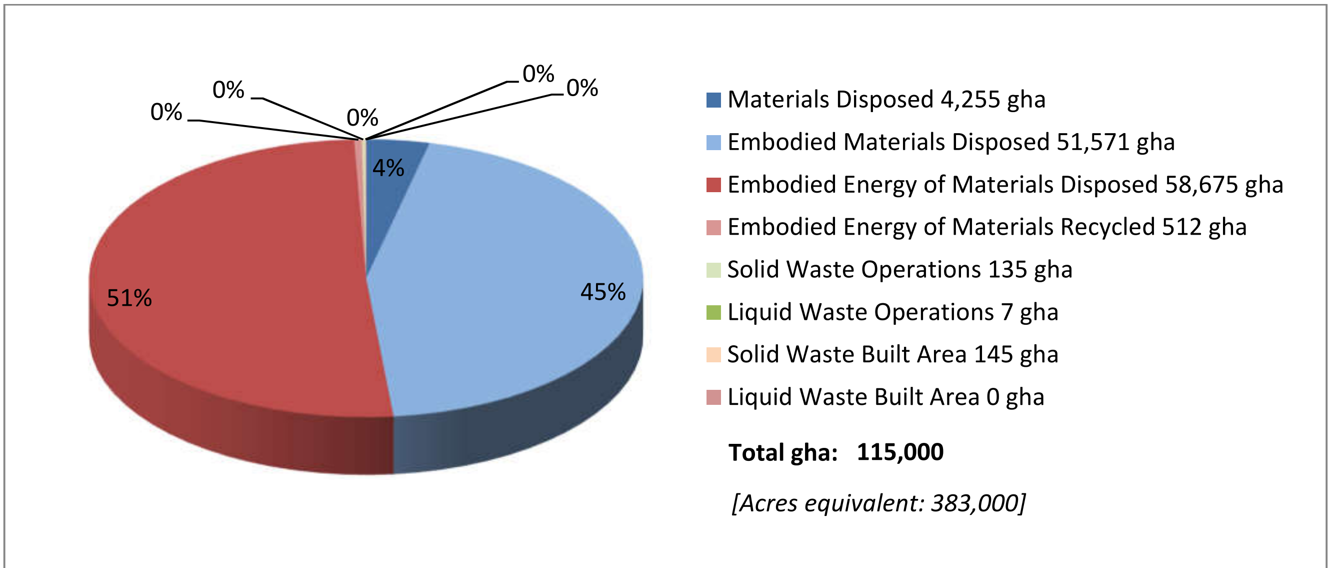

Figure 9: Consumables and Waste Footprint, 2015

It is also instructional to evaluate which consumables are yielding the largest impact on the footprint in order to develop targeted policy and communication measures. As shown in Figure 10, Iowa City's footprint is dominated by paper and "wood waste, textiles, & rubber."[19] Although textiles typically comprise a small portion of the waste stream by weight, their embodied energy and material are very high. Table 1 in Appendix A provides a detailed breakdown of footprint impacts by type (that is, by type of plastic, paper, etc.). **Emphasis should be placed on reducing consumption of priority materials, in particular paper and textiles.**

[18] Operating energy for waste management facilities was not available, as discussed in Appendix A: Methodology, but would be negligible compared to the embodied energy and embodied materials impacts.

[19] Total global hectares is lower in Figure 10 than it is in Figure 9 because Figure 10 only shows the LCA impacts of food, and does not include the EF and GHG impacts associated with waste management (operating energy and direct emissions from waste management).

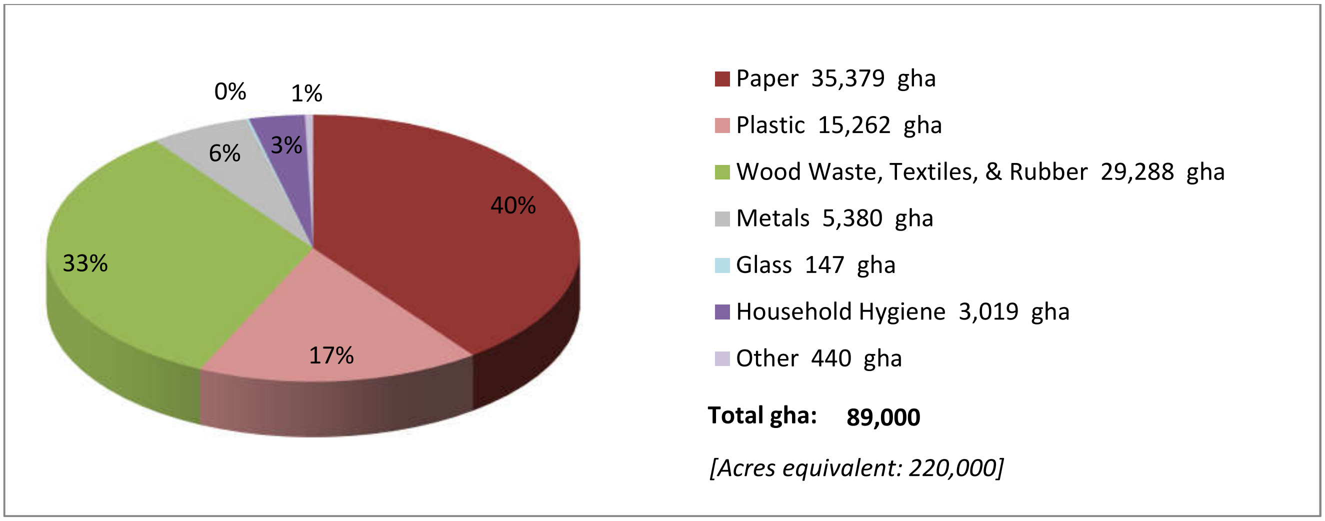

Figure 10: Consumables Footprint by Type, 2015

Transportation Footprint

More than half of Iowa City's transportation footprint is a result of fuel consumption for private vehicles, and if we add in the embodied energy of vehicles, private vehicle transportation represents more than three-quarters of the footprint. **A near term priority is to continue to support a mode-shift away from private vehicle travel, and to electrify the vehicle fleet (particularly transit) and reduce the number of vehicles on the road by promoting active transportation, transit, and car-sharing. There are also opportunities to reduce the embodied energy for transportation through car-sharing and transit.** The long term priority should be promoting compact communities that are designed for active transportation and transit.

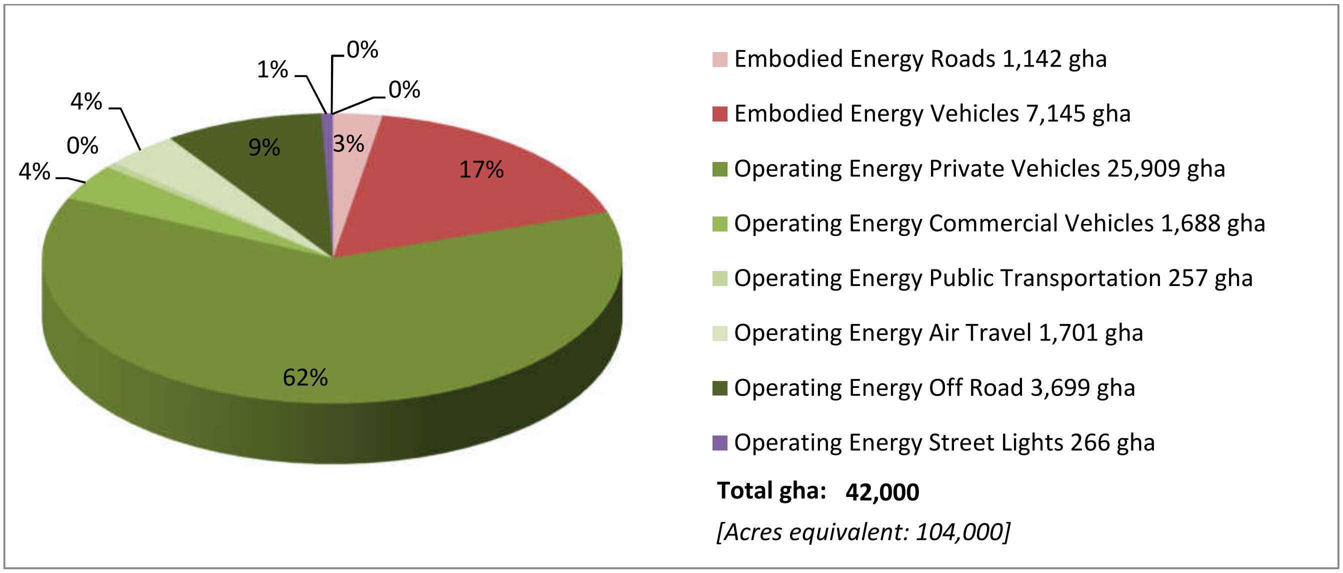

Figure 11: Transportation Footprint in Detail, 2015

Territorial GHG Emission Inventory

Through enhancements as part of the pilot project, the eF Tool now provides a territorial GHG emission inventory which is compliant with GPC reporting protocols. A comprehensive GPC inventory has already been prepared for the City. For this report we therefore present only summary information on the territorial emission inventory, for the purposes of comparison with the Consumption-Based Emission Inventory. As shown in Figure 12, the total territorial emissions for Iowa City are 970 ktCO_2e,[20] or 13.2 tC02e per capita.

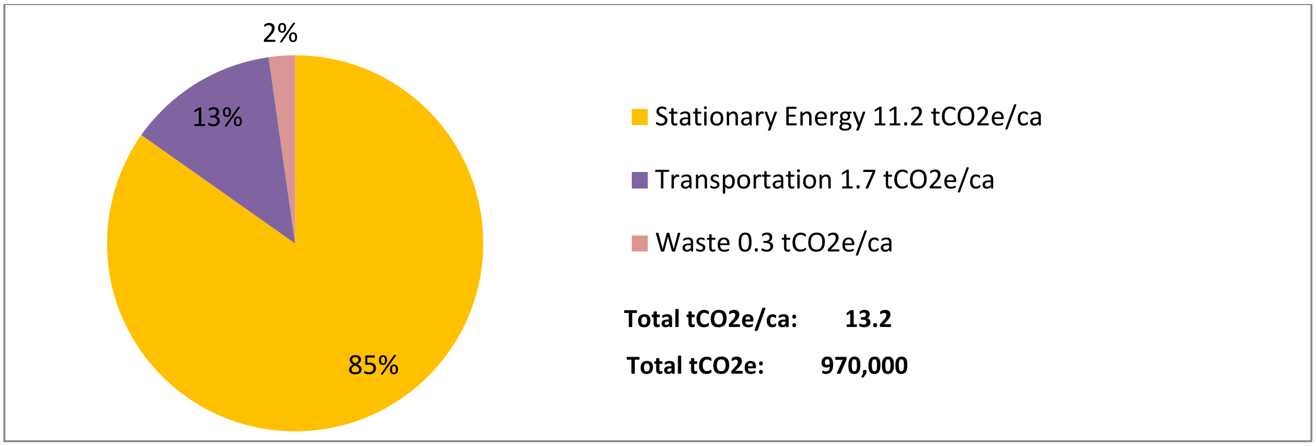

Figure 12: Territorial GHG Emissions Inventory (GPC Basic Inventory)

Consumption-Based Emission Inventory

As previously noted, the Consumption-Based Emission Inventory (CBEI) presents the total GHG emissions resulting from consumption of goods and services within a region, regardless of where those goods and services are produced. This form of inventory is generated using the data typically collected for a territorial inventory, including the energy used by buildings and transportation and the emissions associated with solid waste management; in addition to an evaluation of the emissions that result from the production and transport of all goods consumed within the region, as informed by life-cycle assessment data.

For communities with low levels of industry, total consumption-based emissions are typically double territorial GHG emissions, since much of the emissions associated with consumables are being generated outside of the community's borders. However, for communities like Iowa City, which are home to large manufacturing companies or large universities, this may not be the case. Total consumption-based emissions for Iowa City were 1,182 ktCO_2e in 2015 (see Figure 13), approximately 200 ktCO_2e more than the territorial emissions (see Figure 12).

For the CBEI, the largest impact category is buildings (52%) followed by consumables and waste (23%); this is similar to the EF results where the largest impact category is buildings (37%) followed by consumables and waste (28%). Food impacts are the area in which these results vary most significantly. Food is only 10% of the total for the CBEI, but 25% of the EF; the primary driver for this difference is the land intensity of food production.

[20] Carbon dioxide equivalent (CO2e) expresses the impact of each different greenhouse gas in terms of the amount of CO_2 (carbon dioxide) that would create the same amount of warming. This enables reporting total greenhouse gas emissions in one measurement. 1 kilotonne equals 1000 tonnes.

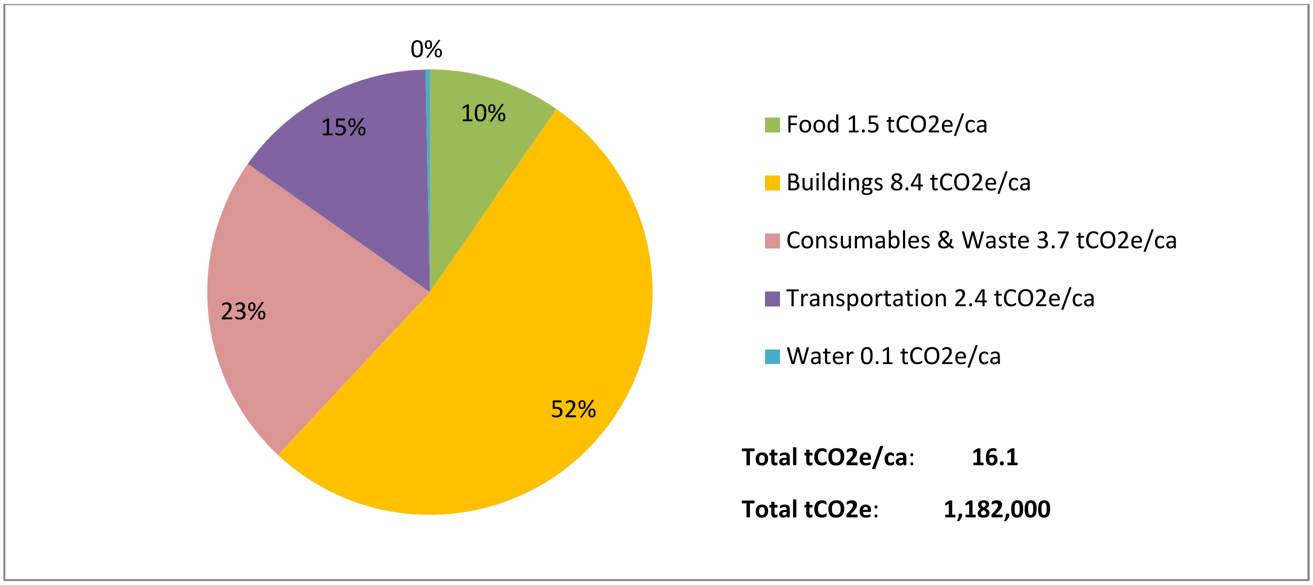

Figure 13: Summary of GHG Emissions from Consumption, 2015

CBEI of Food

To inform policy and planning decisions it is important to consider the varying contributions of each of the food types to the overall food emissions. Figure 14 shows that, similar to the EF, the majority of the CBEI for food is a result of animal proteins and dairy (74%). The main difference between the EF and the CBEI results are that dairy yields a greater GHG impact due to the energy intensity of dairy production, and meat yields a greater EF impact due to its intensity in land use demands.

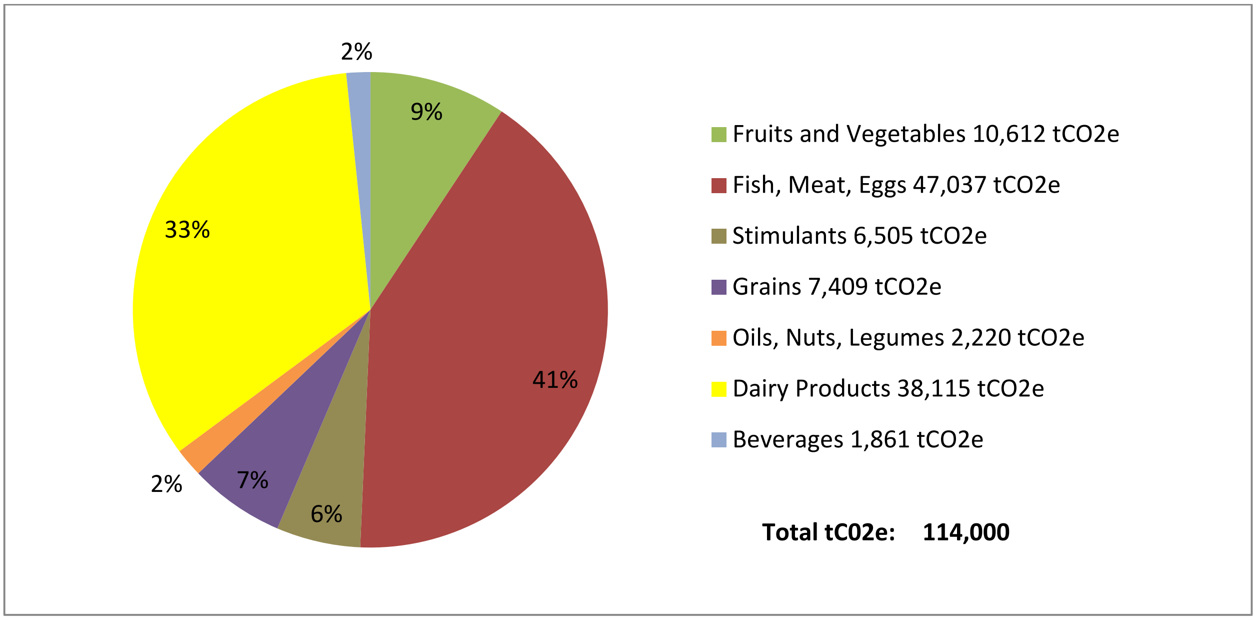

Figure 14: Greenhouse Gas Emissions Inventory of Food, 2015

CBEI of Buildings

As with the EF, the operating energy of buildings dominates the impact on the CBEI. There is an unresolved issue with the data for concrete resulting in under reporting the impacts of commercial/institutional embodied energy, however, it is expected that changes will not impact the overall emissions significantly.

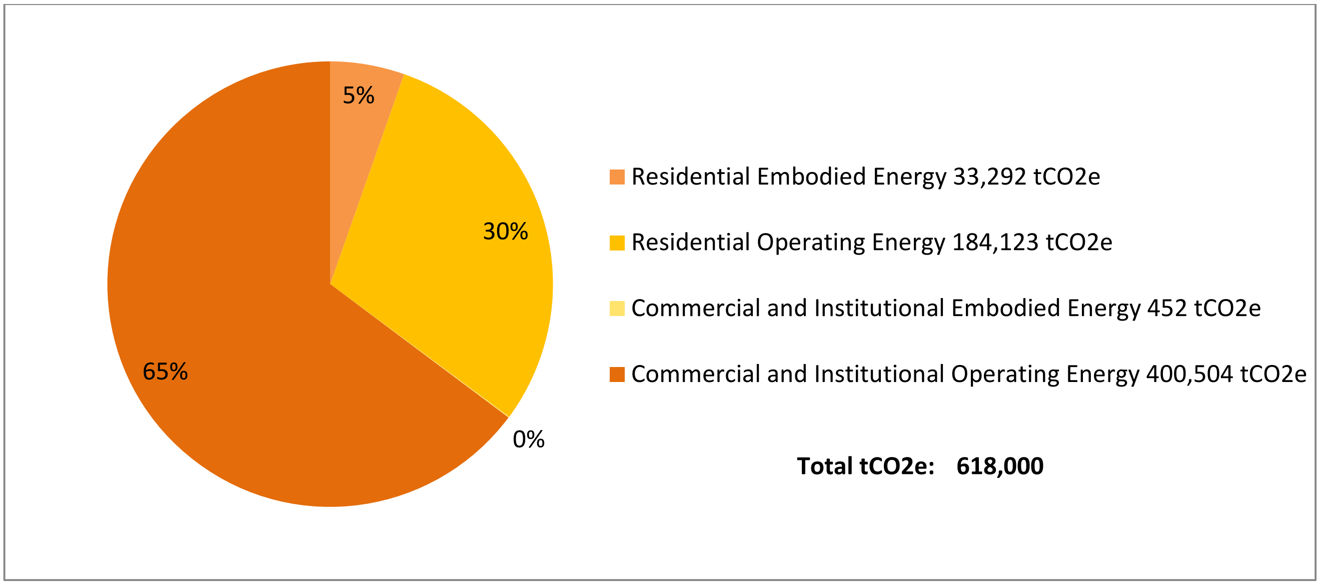

Figure 15: GHG Emissions Inventory of Buildings, 2015

CBEI of Consumables

The CBEI for consumables shows that the largest GHG impact is due to wood waste, textiles, and rubber (37%), as shown in Figure 16.[21] However, in contrast to the EF, the consumption-based emissions are higher from plastics (36%, compared to 17% for the EF); and much less for paper (10%, compared to 40% for the EF). These results are explained by the larger land footprint associated with production of paper and the higher fuel intensity associated with plastic. Table 1 in Appendix A provides a detailed breakdown of GHG impacts by type (that is, by type of plastic, paper, etc.).

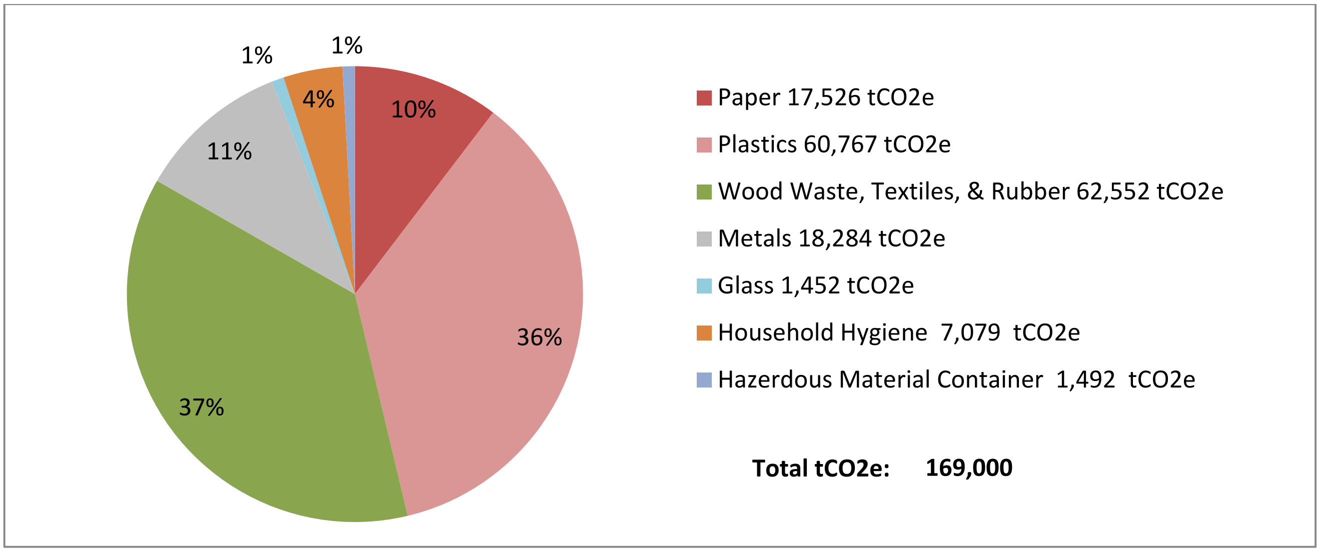

Figure 16: GHG Emissions Inventory of Consumables, 2015

[21] Total emissions are lower in Figure 16 than they are in Figure 13 because Figure 16 only shows the LCA impacts of food, and does not include the GHG impacts associated with waste management (operating energy and direct emissions from waste management), however the ratios remain the same.

CBEI of Transportation

Similar to the EF, the majority of the consumption-based emissions for transportation are associated with private vehicle travel (88%), as shown in Figure 17.

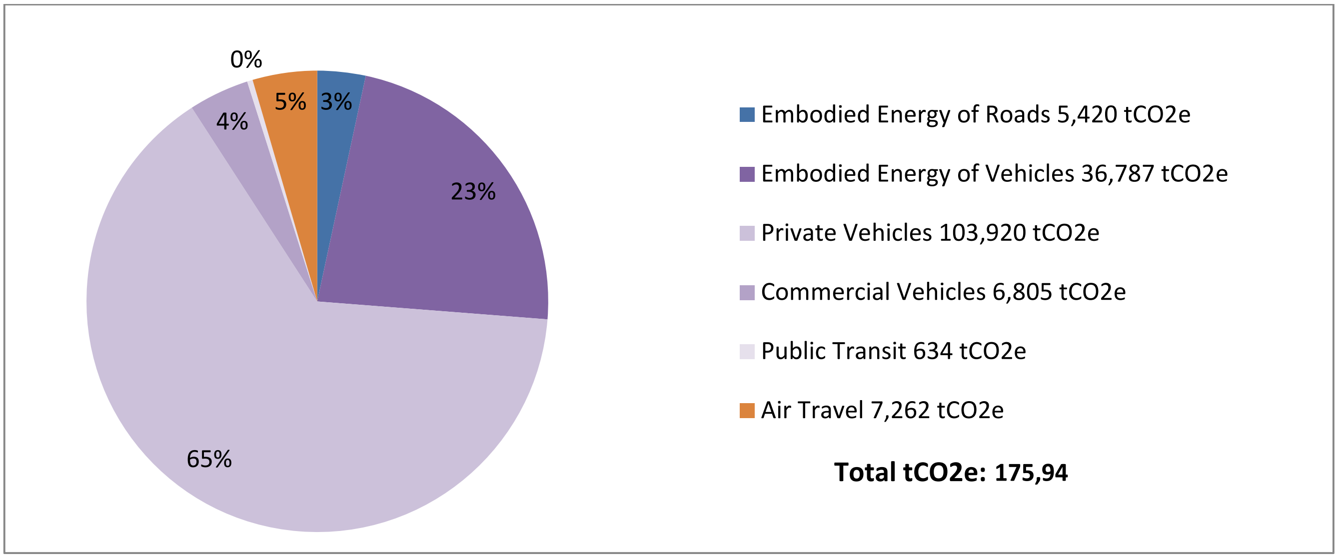

Figure 17: Greenhouse Gas Emissions Inventory of Transportation, 2015

THE SUSTAINABILITY GAP

To achieve 'One Planet Living' Iowa City's ecological footprint would need to reduce from 6.7 gha per capita (with added national and state services – such as the military) to 1.7 gha per capita. This represents a sustainability gap of 70%. From a climate perspective, in order to achieve the target of maintaining global temperatures below a 2 degree Celsius in warming, GHGs must be reduced to 2 tCO_2e per capita. Given Iowa City's current CBEI per capita emissions of 16.1 tCO_2e, GHG emissions would need to be reduced by 88%; and based on the GPC per capita emissions of 13.2 tCO_2e, they would need to be reduced by 85%.

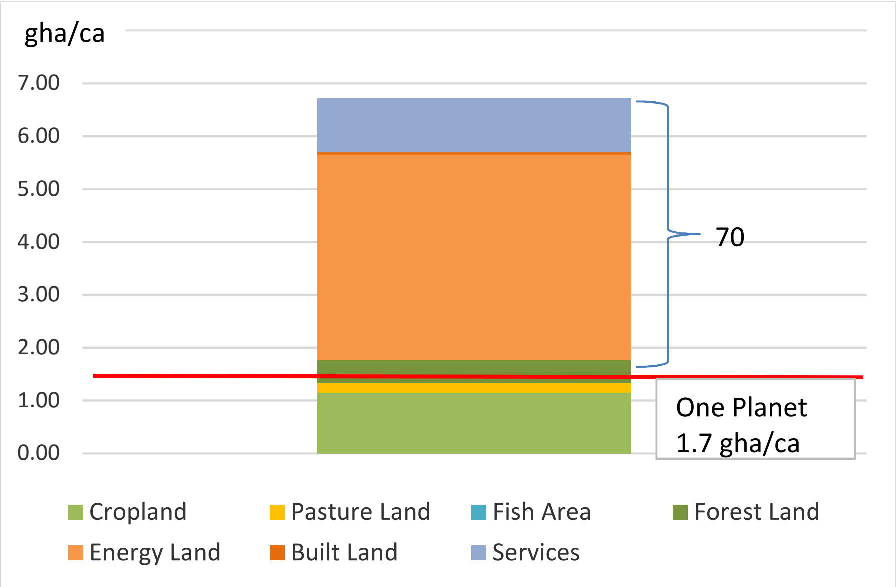

Figure 18: Sustainability Gap, 2015 (including national and state services)

ONE PLANET SCENARIO

A One Planet Scenario for Iowa City is proposed below. This is an example of how Iowa City could reduce its total ecological footprint from 5.7 to 1.7 gha per capita (excluding national and state services).

MEASURE	EF reduction (gha/capita)
Reduce red meat 50% substituting poultry	0.21 gha/ca
Reduce dairy 50% no substitutes	0.15 gha/ca
Reduce food waste post purchase 50%[22] (with exception of oils, nuts, legumes only 30%)	0.49 gha/ca
Eliminate fossil based heating/cooling (i.e. no natural gas or coal)	1.24 gha/ca
Improve electrical energy efficiency 80%	0.56 gha/ca
Reduce paper consumption 75%	0.41 gha/ca
Reduce textile consumption 75%	0.27 gha/ca
Reduce plastic consumption 75%	0.15 gha/ca
Reduce consumables (except paper, textiles, and plastics) 60%	0.037 gha/ca
Reduce emissions from privately owned gasoline vehicles 50%	0.36 gha/ca
Reduce emissions from privately owned diesel vehicles 50%	0.02 gha/ca
Reduce emissions from diesel powered commercial vehicles 50%	0.01 gha/ca
Reduce emissions from off road gas-powered vehicles 50%	0.02 gha/ca
Reduce emissions from off road diesel-powered vehicles 50%	0.01 gha/ca
Reduce electrical consumption by street lights 50%	0.001 gha/ca

* An alternative option is to reduce the carbon intensity of electricity. In fact, MidAmerican has made a commitment to transition to 100% renewable electricity. A 100% renewable electricity supply would achieve a reduction of 0.7 gha/ca.

The cumulative results of implementing these measures are shown in Figure 19.

[22] The focus is on post purchase waste, rather than the waste that occurs in the supply chain.

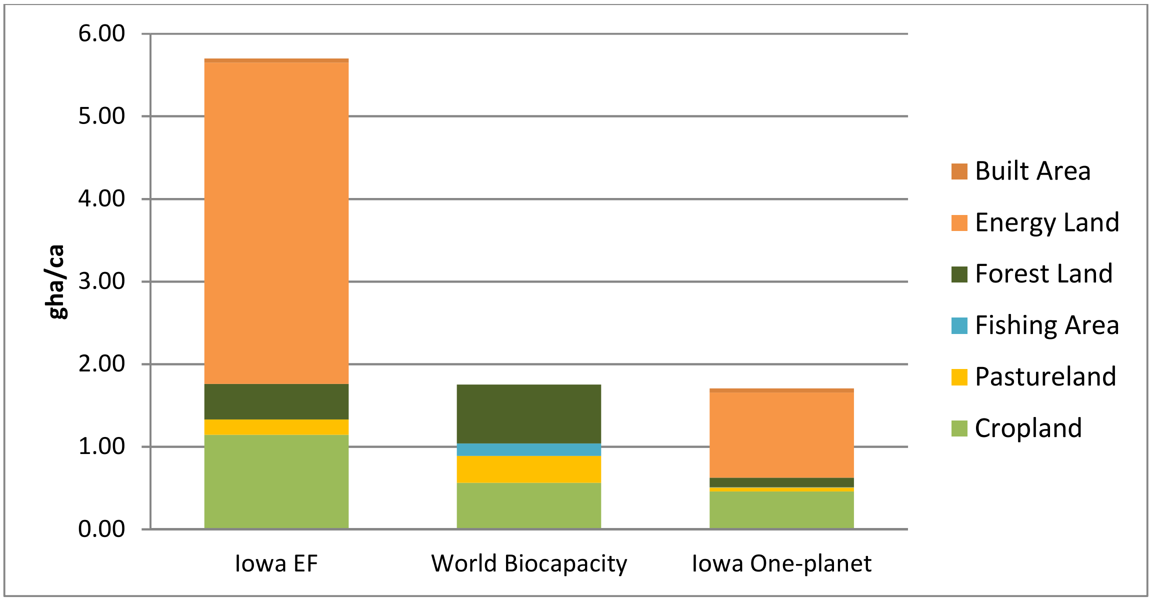

Figure 19: Iowa City's Current Ecological Footprint Compared to a One Planet Scenario

POLICY RESPONSES AND INTERVENTIONS

While a typical territorial GHG inventory identifies the emissions that are occurring within a community's borders, the ecological footprint and consumption-based approach broadens the analysis to consider global ecological and carbon impacts. Local government staff can use data from the ecoCity Footprint Tool to identify activities and consumption habits that are having the greatest impact on their community's contribution to global climate change and ecological overshoot. They can then implement informed policy interventions to best reduce these impacts. The ultimate objective is to achieve One Planet Living; and with respect to climate change, that means mitigating our emissions to the extent that we do not increase our planet's temperature more than 1.5 degrees Celsius.

One-planet living refers to a lifestyle that, if adopted by everyone, could be supported indefinitely by the regenerative capacity of Earth's ecosystems.

- *Wackernagel and Rees 1996*

CBEI and EF results highlight the need for the municipality, and other levels of governments, to support a shift to a more sustainable pattern of consumption. This could include:

- Enacting policies and regulations to (1) influence consumers and (2) ensure that more sustainable options are available.
- Communicating the impact of purchasing decisions to residents, and encouraging their adoption of sustainable consumption behaviors.

Consideration of the CBEI and EF results can effectively shift some key areas of policy and planning decision making. In particular, they highlight the necessity to:

- *Target the resource and climate impacts associated with food production and disposal.*
  For Iowa City, 10% of CBEI emissions and 25% of the EF are due to food consumption.
- *Decrease red meat and dairy consumption by substituting with legumes and white meat and reduce food waste.*
  For Iowa City, red meat and dairy consumption is responsible for about 40% of the food component of the EF.
- *Ensure that local food production has low resource intensity (in terms of fossil energy use and land area).*
  For Iowa City, 98% of the food footprint is associated with energy and land requirements, while transportation represents only 2% of the food footprint.
- *Shift the focus from waste reduction to consumption reduction.*
  For Iowa City, 96% of the footprint associated with goods consumed is due to production and transport, rather than use and disposal.
- *Reduce the consumption and disposal of textiles, which have a very high ecological impact even though their portion of the waste stream is comparatively smaller.*
- *Reduce vehicle ownership and support this shift through effective land use planning.*
- *Eliminate emissions from propane and natural gas usage in residential, commercial and institutional buildings.*

Potential Action Areas for Iowa City

High-level actions for each sphere of municipal planning are presented below. This is not an exhaustive list, it is recommended that the City review results in detail and use these results to inform upcoming policy, planning and communication efforts.

Planning Sphere	Key Objectives	Instrument
FOOD	Reduce food waste Reduce meat and dairy consumption Obtain local data on food consumption impacts	· Promote sharing economy opportunities (e.g., community gardens). · Promote diet shifts (e.g., 'Meatless Mondays' Oregon; Celebrate the Harvest campaigns). · Adopt advanced purchasing standards (e.g., Emeryville Good Food Purchasing Program, EPA West Coast Forum on Materials and Climate's Climate Friendly Purchasing Toolkit). · Implement food waste reduction campaigns (e.g., Canada's Love Food Hate Waste; US EPA's Food too Good to Waste; NRDC Save the Food Campaign). · Undertake a food survey to gain knowledge about local food consumption and impacts so as to track progress toward goals.
BUILDINGS & INFRA-STRUCTURE	Increase efficiency (envelope 1st approach) Use building materials with lower embodied energy	· Implement government purchasing policies to favor recycled content/reused building materials. · Provide incentives for smaller and more energy efficient homes, and renewable technology incentives for homes and business. · Building codes that promote energy and material efficiency
CONSUMABLES	Reduce the volume of individually owned goods Increase reuse	· Promote sustainable consumption behaviors (e.g., Vancouver's Green Bloc Neighborhood Challenge). · Promote sharing economy opportunities (e.g., clothes swaps). · Promote 'smart' buying practices – focusing on durability and buying fewer clothes (e.g., Oregon DEQ's Make Every Thread Count). · Support and promote Repair Cafés and Fix-it clinics and the local repair industry.
TRANSPORTATION	Reduce vehicle ownership Decrease vehicle travel Improve efficiency of vehicle fleet Better understand inter-urban transportation demand	· Ensure neighborhood plans contribute to compact urban development, smaller homes and walkable neighborhoods. · Support and promote bike-sharing and car-sharing programs. · Continue to expand Active Transportation Initiatives. · Undertake an 'Inter-urban' Transportation Demand Survey to gain a better understanding of residents out of boundary transportation habits (e.g., cruise, aviation). · Increase electronification of fleet.

City Initiatives

There are also overarching initiatives that the City can undertake to create a shift to more sustainable patterns of consumption, such as

- Update goal and target setting: consider adjusting emission reduction goals to reflect this new information (e.g., Eugene, Oregon has developed science-based targets that used consumption-based emissions to set its "carbon budget", and a similar approach is being considered in Europe).
- Integrate EF and CBEI results into reporting: include these results alongside the traditional territorial GHG emission inventory.
- Incorporate sustainable consumption principles into economic and community development strategies; for example, by implementing policies and bylaws that would attract low-carbon producers, promote work force development in the repair and reuse industries, and drive community investment in shared public goods such as arts, libraries, parks and recreation.

> *Green Bloc is an innovative ecological footprint challenge that is being piloted in four Vancouver neighborhoods, using a streamlined version of the ecoCity Footprint Tool. Through Green Bloc, community members are measuring their household ecological footprint, developing neighborhood action plans, and delivering neighborhood enhancing, and footprint-reducing, projects in their communities. The first pilot neighborhood – Riley Park – already reduced their footprint by 12% between 2013 and 2015. (See http://greenbloc.lighterfootprint.ca/)*

- Engage with other levels of government to encourage and promote policies and regulations to shift to more sustainable patterns of consumption; in particular,
  - 'Design for the Environment' [23] practices that increase the longevity and reduce the resource intensity of products, and expand the potential for product reuse and recycling.
  - Product labelling to encourage the purchase of lower impact goods.
  - Expand extended producer responsibility programs to reduce waste disposal.
- Use accessible framing, communications and metrics to advance sustainable consumption objectives as a means of engaging residents and businesses to shift to more sustainable consumption habits (e.g., 'One Planet Living' framing and metrics). Local governments are uniquely positioned to reach and influence these key stakeholders with the goal of building awareness, changing attitudes, and shifting consumption patterns.

> *In Vancouver, a collaborative group of non-governmental organizations are partnering with the City to actively bringing together a community of action around the Lighter Footprint goal. They are revealing and linking projects and partners across Vancouver, as well as encouraging new efforts in key impact areas, with the goal of helping Vancouver become a One-Planet City. (See: http://lighterfootprint.ca/)*

[23] Design for the Environment is a design approach that focuses on minimizing environmental and health impacts of products and processes. The US EPA Safer Choice program promotes adoption of these principles (see: https://www.epa.gov/saferchoice/design-environment-alternatives-assessments

Additional Resources and Tools

Although the use of ecological footprint and CBEI results to inform community planning is a new and emerging area, there are some useful resources to guide governments and community builders in this work, for example:

USDN Sustainable Consumption Toolkit:

Launched in 2015, it includes a conceptual overview and a database of local actions. A refresh/update is planned for early 2018 (see: http://sustainableconsumption.usdn.org/)

Life-Cycle Assessment studies:

The Oregon Department of Environmental Quality has produced several studies related to food and food-specific products such as wine and tomatoes.

Climate Friendly Purchasing Toolkit:

A resource for institutional purchasing from a consortium of west coast cities and states containing modules on a number of product categories such as IT, infrastructure, and food.

The Stockholm Environment Institute Working Paper: Reducing Greenhouse Gas Emissions Associated with Consumption: A Methodology for Scenario Analysis

Summarizes a methodology for constructing long-term scenarios of a transition to low-GHG consumption; and provides results of applying this methodology in Seattle, Washington (see: https://tinyurl.com/yaahjena).

NEXT STEPS

The BCIT project team is currently exploring opportunities to continue to refine the ecoCity Footprint Tool and to continue to work with the existing pilot communities.

Goals for the next phase of work are to:

- Roll-out an accessible version of the eF Tool, either via an online platform or in a downloadable format.
- Establish a peer exchange group consisting of the current pilot communities and future users of the Tool. This network will provide the opportunity to share in the learning of how the ecological footprint and CBEI results can be used to inform policy and planning at the municipal level.
- Continue to evolve the functionality of the eF Tool, including interactive scenario analysis capacity and adding capacity to enable the evaluation of the footprint impact associated with land use changes.

APPENDIX A: LCA DATA FOR CONSUMABLES AND WASTE

The following presents the life-cycle assessment (LCA) data for the consumables by material type. This information is useful in targeting policy, planning and communication efforts to priority materials.

Table 2: Life-Cycle Assessment Data for Consumables by Material Type

Detail by Consumption	tCO2e/product	tCO2e	tCO2/t product	tCO2	LCA Factor **energy**	Embodied Energy Foot **gha**	LCA FACTOR **materials-crops**	LCA FACTOR **materials-forests**	Embodied Materials Footprint **gha**	Total LCA Factor **(gha/tonne)**	Footprint	**gha**
Paper		**16,087**		**16,087**								
Printed Paper	0.70	3,899	0.70	3,899	0.18	1,003		**1.29**	**7,186**	1.47	8,188.31	gha
News Print	0.85	1,354	0.85	1,354	0.21	336		**1.13**	**1,806**	1.34	2,141	gha
Cardboard and Boxboard	0.66	5,274	0.66	5,274	0.17	1,358		**1.47**	**11,746**	1.64	13,104	gha
Telephone Directories	0.70	1,470	0.70	1,470	0.21	441		**1.13**	**2,373**	1.34	2814	gha
Other	0.70	4,091	0.70	4,091	0.21	1,227		**1.29**	**7,539**	1.50	8,766	gha
Plastic		**60,517**		**60,517**								
Film (bags)	3.38	25,023	3.38	25,023	0.85	6,287				0.85	6,287	gha
PET	4.93	2,701	4.93	2,701	1.23	674				1.23	674	gha
HDPE	2.92	1,467	2.92	1,467	0.73	367				0.73	367	gha
PVC	1.99	1,361	1.99	1,361	0.5	342				0.5	342	gha
Other	3.38	29,965	3.38	29,965	0.85	7,529				0.85	7,529	gha
Organic Waste												
Food waste (not to include in the EF)		-		-		-						
Yard and Garden		-		-		-						
Wood Waste	0.72	-	0.72	-	0.18	-		**0.41**	-	0.59	-	gha
Textile	15.00	**59,584**	15.00	**59,584**	3.76	14,936	**3.14**		12,473	6.9	27,409	gha
Rubber	6.37	**3,492**	5.42	**2,968**	1.6	877	**1.83**		**1,003**	3.43	1,879	gha
Other						-	**0.05**		-	0.05	-	gha
Metals		**21,374**		**18,168**								
Ferrous Food/Drink Packaging not Recycled	1.80	741	1.53	630	0.45	185				0.45	185	gha
Ferrous Other	1.80	6,589	1.53	5,601	0.45	1,644				0.45	1,644	gha
Non-Ferrous and Bimetallic	12.82	14,044	10.89	11,937	3.21	3,517				3.21	3,517	gha
Glass		**1,246**		**1,246**		-						
Food/Drink Packaging	0.65	-	0.65	-	0.16	-				0.16	-	gha
Other	0.65	1,246	0.65	1,246	0.16	307				0.16	307	gha
Household Hygiene		**8,328**		**7,079**		-						
Diapers	3.20	8,328	2.72	7,079	0.8	2,082	**0.36**		**937**	1.16	3,019	gha
Sanitary Napkins/Tampons	3.20	-	2.72	-	0.8	-	**0.36**		-	1.16	-	gha
Other	3.20	**57,858**	2.72	**49,179**	0.8	14,464	0.36		6,509	1.16	20,973	gha
Hazardous material Container	12.82	**1,755**	10.89	**1,492**	3.21	440				3.21	440	gha
Electronic waste	3.38	**2,624**	3.38	**2,626**	0.85	660				0.85	660	gha
TOTAL		232,866		167,142		**58,675**			**51,571**		110,246	gha
										Cross-check	110,246	gha

APPENDIX B: DATA COLLECTION METHODOLOGY

The following provides a detailed summary of the methodology and sources utilized in creating Iowa City's ecological footprint and GHG inventories. It also presents challenges and opportunities associated with the data collection process.

A detailed overview of the methodology by which ecological footprints are generated in the ecoCity Footprint Tool are provided in Dr. Moore's thesis: Moore, Jennie Lynn (2013). Getting Serious About Sustainability: Exploring the Potential for One-Planet Living in Vancouver. A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy, School of Community and Regional Planning, University of British Columbia. Available at: http://pics.uvic.ca/sites/default/files/uploads/publications/moore_jennie-UBC_0.pdf

Research Principles

The following guidelines were applied when making decisions about data sources:

i) Accuracy: The goal is to achieve a high degree of accuracy, where accuracy is the degree of closeness to a measured value's actual value. (This is in contrast to precision, in which the goal is to have measurements conform with one another.)

ii) Subsidiarity: Locally produced data is preferred, especially when local authorities trust the source's validity and use it to inform policies and management practices. Locally derived data reflect the nuance of the local community being profiled and can resonate more readily with local authorities who use these same data points to inform their work.

iii) Conservatism: In cases where two data sources equally meet the accuracy and subsidiarity criteria, the final decision is based on which data point represents a more conservative estimate. The purpose of this approach is to avoid overstating consumption amounts.

Food

Evaluates the land area, materials, embodied and operational energy including for transportation of food from field to table. Food available is measured as a proxy for food consumption and import distances are used to estimate food-kilometers traveled. The energy associated with the production and transportation of imported food is then estimated.

Embodied Materials and Energy [Food]

Methodology & Sources

National average daily per capita food consumption was divided by (1-% waste) then multiplied by 365 days/year to estimate the total amount of food required per person and multiplied by the population.

National average daily per capita food consumption was obtained from:

- U.S. Department of Agriculture (USDA). (2013). *Retail commodity intakes: Mean amounts of retail commodities per Individual, 2007-08.* Retrieved from https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/ficrcd/FICRCD_Intake_Tables_2007_08.pdf

- Statista. (n.d.). *Per capita consumption of cocoa beans in the United States from 2000 to 2015 (in pounds)*. Retrieved from https://www.statista.com/statistics/184209/per-capita-consumption-of-cocoa-beans-in-the-us-since-2000/
- Polis, C. (June 2011). *By the numbers: What Americans drink in a year.* Retrieved from http://www.huffingtonpost.com/2011/06/27/americans-soda-beer_n_885340.html

National average food losses were obtained from:

- Gunders, D. (August 2012). *Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill.* Retrieved from https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Food waste percentages were obtained from:

- United States Environmental Protection Agency (EPA). (April 2016). *America's food waste problem.* Retrieved from https://www.epa.gov/sciencematters/americas-food-waste-problem

Challenges and Opportunities

Local data for food consumption was not available so national data was used as a proxy.

Operating Energy [Food-Kilometers]

Methodology & Sources

Food miles traveled were derived using Google Earth to find the distance to the location with the largest production of each individual food type. The average distance traveled for processing domestically grown foods was found to be 500 miles. This distance was added to each category of food that is primarily produced within the United States.

Food Import data was obtained from:

- United Stated Department of Agriculture. (n.d.). *U.S. Food Imports.* Retrieved from https://www.ers.usda.gov/data-products/us-food-imports/us-food-imports/

Challenges and Opportunities

There are multiple components of transportation during the production, processing, and distribution of food (i.e., transportation of seeds, processing, and retail). On average, the addition of 500 miles to the total transportation distance, for each food type, is likely to be an underestimate of the total transportation demand associated with food. Food comes from multiple sources, but due to the complexity of analyzing the sources of all food types, averages have been adopted. Improvements could be made by analyzing each food category individually.

Buildings and Stationary Energy

Evaluates the materials, embodied and operational energy; and the built area associated with residential, industrial and commercial buildings to establish a material-flow analysis, assess the direct and embodied carbon, and evaluate the ecological footprint of buildings.

Embodied Materials and Energy [Buildings and Stationary Energy]

Methodology & Sources

The number of commercial, institutional and residential buildings as well as an estimated composition of each building type are required to evaluate the embodied materials and energy associated with the building stock. Residential units are divided into categories depending on building types (e.g., single family detached house, apartment, etc.). Commercial and industrial buildings are differentiated based on height as this is a significant indicator of their material composition.

The ecoCity Footprint Tool contains calculations and assumptions to derive the embodied materials and energy associated with the total materials contained within the buildings, which were developed through Dr. Moore's original ecological footprint study of the City of Vancouver, and are summarized in Dr. Moore's 2013 thesis. Specifically, for a prescribed set of building archetypes, building material composition is assigned while average lifespan and floor area can be altered to reflect local conditions. The material composition estimates were derived using the Athena Impact Estimator for Buildings Tool. The archetypes created for the Vancouver 2013 study have been used in this inventory, as they are considered to be comparable, with the exception of average lifespan of buildings which was extended to 80 years for residential buildings and 130 years for institutional/commercial buildings. (In Vancouver the lifespan was 40 years and 75 years respectively.)

Information on the number of each building archetype was obtained from:

- Margaret Vogel, Admin Services Coordinator, for the campus planning department of the University of Iowa.
- Iowa City, Iowa housing data. Retrieved from http://www.towncharts.com/Iowa/Housing/Iowa-City-city-IA-Housing-data.html
- Non-University Buildings numbers were obtained from Tim Hennes, Senior Building Inspector for the City of Iowa City

Challenges and Opportunities

The study team was unable to obtain tonnage of materials used in buildings. Archetype information already contained within Dr. Moore's ecoCity Footprint Tool was used as a proxy in the absence of local data. This proxy data is based on the building archetypes present in Vancouver, BC. It was deemed that the building types in Iowa City were comparable to those in Vancouver. Namely, most of the residential stock is wood frame, as are the majority of commercial and institutional buildings which are less than five stories tall. Buildings greater than five stories tall are considered to be concrete. The creation of local archetypes could be an area of future study.

Operating Energy [Buildings and Stationary Energy]

Methodology & Sources

To calculate operating energy data is required on the annual consumption of electricity, natural gas, and other heating fuels; broken down by sector. Energy lost through transmission and fugitive emissions is also collected or estimated. Carbon footprints are then calculated using Iowa specific emissions factors.

Energy consumption data was accessed from Iowa City's Global Protocol for Community Scale GHG Emissions (GPC) report (2015 GHG Emissions Inventory), as reported in Iowa City Community-wide Greenhouse Gas Emissions: Inventory Update, June 2017. Retrieved from https://www8.iowa-city.org/weblink/0/edoc/1587170/ICGreenhouseGasUpdate-2017.pdf

Additional energy use data was obtained from Metrix –Community Energy Usage - a program that tracks municipal energy usage by type.

Built Land Area [Buildings and Stationary Energy]

Methodology & Sources

Built area includes all non-road areas that have been paved for parking or built-up for residential, industrial, and commercial use. Lane miles and built area of streets, lanes, and sidewalks were obtained using GIS (Geographic Information System) sources provided by Killy Laughead, Sr. Engineering Technician, City of Iowa City Engineering Department.

Consumables and Waste

Evaluates the materials, embodied energy and embodied materials, and land area associated with the production and disposal of products in the municipal waste stream.

Data is collected on:

- the type and quantity of solid and liquid waste generated in Iowa by sector (residential, industrial, commercial and institutional) and by material type;
- the method in which these materials are managed (i.e., landfilled, incinerated, recycled or composted);
- the energy consumption and emissions associated with the waste management facilities, and the transportation of the waste; and
- the material composition and built area associated with waste management facilities.

The embodied energy of materials involved in the operation and delivery of waste is also included as an indirect impact of waste production.

The various outputs draw from different components of this data set:

- The GPC inventory includes direct GHG emissions associated with handling solid and liquid waste.
- The Consumption-Based Emission Inventory (CBEI) includes the embodied emissions associated with the production and transport of the materials that were consumed as represented by the disposed materials. It also includes the direct emissions associated with disposing the waste stream, but does not include the impact of the recyclables stream as this would be captured within the LCA of the consumed goods; which would result in double counting of impacts.
- The ecological footprint includes the CBEI emissions plus the impact of the built area associated with handling the waste stream.

Embodied Materials, Embodied Energy and Operating Energy [Consumables and Waste]

Methodology & Sources

Solid waste data is collected disaggregated by sector, material type, and destination (i.e., landfill, recycling, or composting). Data on waste sorting, annual landfill volumes, recycled materials, landfill fuel usage, and landfill flare volumes were obtained from the City of Iowa City landfill division.

The embodied materials and energy of consumables, meaning the material and energy used in the production and supply chain, is estimated using lifecycle assessment data that is built-into the Tool. These were developed through Dr. Moore’s original ecological footprint study of the City of Vancouver and are summarized in Dr. Moore’s 2013 thesis.

Liquid waste, flows, loadings, and distance of piping were obtained from City of Iowa City Wastewater Division and the built area of the wastewater facility was estimated using Google Earth. Volumes of concrete contained within the wastewater facility were calculated by measuring the "as-built" plans of the entire facility and the addition of all components.

Challenges and Opportunities

The landfill serves a regional community; therefore, waste generation rates were pro-rated based on population served by the landfill. This method does not reflect the unique profile of Iowa City residents.

Solid and Liquid Waste Built Area [Consumables and Waste]

Methodology & Sources

Total area committed to waste management was estimated using Google Maps.

Transportation

Evaluates the embodied materials and embodied energy of physical transportation infrastructure and vehicles, operating energy (fuel consumed by vehicles), and physical built area occupied by transportation infrastructure.

Embodied Materials and Energy and Built Area [Transportation]

Methodology & Sources

Built area for transportation includes road length and paved right-of-way width. The quantity of roadway and the road material composition is used along with LCA data to evaluate the embodied energy of transportation infrastructure. Built area was obtained using GIS (Geographic Information System). GIS data was provided by Killy Laughead, Sr. Engineering Technician, City of Iowa City Engineering Department.

LCA data that identifies the embodied energy of paving materials was obtained from the Dr. Moore's previous ecological footprint assessment for Vancouver (Moore, 20013).

Operating Energy [Transportation]

1. Road Transportation

Methodology & Sources

The average number of miles driven per capita per-year was multiplied by the City population to obtain the total miles driven by citizens.

The number of vehicles of each type were divided by the total number of registered vehicles to obtain a percentage of the fleet by car type. The fleet percentages (by vehicle type) were multiplied by the total miles traveled to obtain the miles traveled by each vehicle category. The miles traveled by each vehicle type was divided by the fuel efficiency of the corresponding vehicle type to derive the volume of fuel used per year.

The breakdown of the number of vehicles of each type for Johnson County, Iowa was obtained from: Iowa Department of Transportation. (2015). *Calendar Year 2015 vehicle registrations summary.* Retrieved from http://www.iowadot.gov/mvd/stats/regis2015.pdf

Other years' data for vehicle registration is available at:

Iowa Department of Transportation. (n.d.). Motor vehicle division: Statistics and research studies. Retrieved from https://iowadot.gov/mvd/factsandstats#vehiclestats

Average number of miles driven per capita (State of Iowa) was obtained from:
Megna, M. (July 2016). *Average miles driven per year by stat*e. Retrieved September 27, 2017, from http://www.carinsurance.com/Articles/average-miles-driven-per-year-by-state.aspx

Average fuel efficiency per vehicle type was obtained from:
United States Department of Energy. (n.d.). *Maps and Data*. Retrieved from https://www.afdc.energy.gov/data/

Vehicle Miles Traveled (VMT) within city limits was also available from the Iowa Department of Transportation (IDOT); however, this was not used (as explained in challenges and opportunities):
Iowa Department of Transportation. (2015). *Annual Vehicle Miles of Travel.* Retrieved from https://iowadot.gov/maps/msp/vmt/clvmt15.pdf.

Challenges and Opportunities

The study team decided to use state average annual miles driven per capita, rather than the vehicle miles traveled within city limits, due to the vehicle miles traveled (VMT) method missing all trips outside of the city. However, the chosen approach will result in an over-estimate of VMTs due to the high percentage of biking and walking commutes that take place in Iowa City compared to the rest of the State. Furthermore, due to total miles being disaggregated by percentage of fleet by vehicle type, miles are assigned assuming that each individual vehicle drives the same number of miles per year regardless of type.

2. *Air Travel*

Methodology & Sources

An average value of the annual US per capita miles traveled by an airplane was multiplied by the population size of Iowa City. The resulting total miles traveled was multiplied by the average amount of fuel consumed, per mile of travel, by airplane.

$$\left[\frac{avg\ mi\ flown}{capita * year} \div mpg\right]\ x\ \frac{3.785\ L}{Gal}\ x\ population$$

$$\frac{1055\ miles}{yearxperson}\, x \frac{1\ Gal}{90\ miles}\, x \frac{3.7854\ l}{1\ Gal}\, x 73415\ people\ = 3257665\ \text{L/yr}$$

US per capita average yearly air miles traveled was obtained from Carboncounter.org

Per capita fuel efficiency of a passenger plane was obtained from:

- Quora. (n.d.). *How many miles per gallon does a typical airplane consume on, say, an SFO-JFK flight?* Retrieved from https://www.quora.com/How-many-miles-per-gallon-does-a-typical-airplane-consume-on-say-an-SFO-JFK-flight

- Bureau of Transportation Statistics. (n.d.). *Table 1-40: U.S. Passenger-Miles (Millions).* Retrieved from https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_40.html

Water

Evaluates the materials, embodied energy, operating energy, and built area impacts of the water purification and distribution system relied on by the municipality.

Embodied Materials and Energy [Water]

Methodology & Sources

Information on the size of the dams were obtained from the Iowa 2010 River Dam inventory:

- United States, Iowa Department of Natural Resources. (n.d.). *The 2010 River Dam Inventory*. Retrieved from http://www.iowadnr.gov/portals/idnr/uploads/riverprograms/dam_chap2.pdf

Iowa City has two water treatment plants; one is for the University and one for the City. Information on both was obtained by contacting the corresponding staff. At the City, this data was held by Iowa City Water Treatment Division. Staff provided total volume treated, distance of piping, and operating energy. Built areas data was not available and was therefore estimated using Google earth.

The ecoCity Footprint Tool has built-in assumptions established from previous research (Moore, 2013) that enables the calculation of the embodied energy of materials utilized in the water system infrastructure.

Operating Energy [Water]

Methodology & Sources

Operating energy for the water treatment and pumping system was obtained from the 2015 GHG emission inventory.

Built Area [Water]

Methodology & Sources

Area estimates for the watershed and water supply related infrastructure, including roads (length and width), buildings, and dams; and protected area and reservoir area were obtained from GIS sources provided by Killy Laughead, Sr. Engineering Technician, City of Iowa City Engineering Department and estimated using Google Maps.

IPPU and AFOLU

Industrial Products and pollutants (IPPU) and Agricultural, Forest, and other Commercial land uses (AFOLU) are important dimensions of a GPC compliant BASIC+ inventory. The ecological footprint and CBEI output however does not include these sources, as energy use and emissions from these sectors are already captured in the evaluation of consumables and waste.

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[i] WWF (World Wide Fund for Nature). (2014). *Living Planet Report.* Gland Switzerland: World Wide Fund for Nature. Retrieved from: http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/ (accessed on 12 November, 2015).

[ii] Rockström, J., et.al. (2009). Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society,* 14(2): 32. Retrieved from: http://www.ecologyandsociety.org/vol14/iss2/art32/ (accessed on 5 October 2015).

[iii] Wackernagel, M. and W. Rees. (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island BC: New Society Publishers. Retrieved from: http://cdn1.footprintnetwork.org/Living_Planet_Report_2014_summary.pdf (accessed on 26 October 2015).

[iv] WWF (World Wide Fund for Nature). (2014). *Living Planet Report.* Gland Switzerland: World Wide Fund for Nature. Retrieved from: http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/ (accessed on 12 November, 2015).