

KICKSTARTING CIRCULAR ANN ARBOR

Determining indicators, analyzing current models, and building community support for an equitable & resilient circular economy in Ann Arbor, MI



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Abbreviations

- AA** - Ann Arbor
- AAATA** - Ann Arbor Area Transportation Authority (TheRide)
- AADL** - Ann Arbor District Library
- AATS** - Ann Arbor Thrift Shop
- BIPOC** - Black, Indigenous, and People of Color
- BYO** - Bring your own (containers/bags)
- CE** - Circular Economy
- EEIO** - Environmentally-extended Input-Output
- EPA** - Environmental Protection Agency
- GDP** - Gross Domestic Product
- GHG** - Greenhouse Gas
- GIS** - Geographic Information Systems
- HDPE** - High Density Polyethylene
- kg CO₂eq** - kilogram of carbon dioxide equivalent (a unit of Greenhouse Gas emissions)
- LIS** - Library Information Services
- MRF** - Material Recovery Facility
- MSW** - Municipal Solid Waste
- MT CO₂eq** - Metric ton of carbon dioxide equivalent (a unit of Greenhouse Gas emissions)
- OSI** - Office of Sustainability and Innovations
- PET** - Polyethylene Terephthalate
- RAA** - Recycle Ann Arbor
- SEAS** - School for Environment and Sustainability
- SLI** - Sustainable Libraries Initiative
- WARM** - Waste Reduction Model
- WCC** - Washtenaw Community College
- WIOD** - World Input-Output Database

Abstract

The circular economy moves us away from end-of-life resource management strategies to changes in consumer and producer behavior that reduce inputs to the waste stream from the start. Ann Arbor needs metrics to baseline GHG emissions, develop reduction targets and measure progress in building a circular economy according to Strategy 5 of Ann Arbor's Net Zero Plan (A2Zero). This project developed a framework to test and implement a set of metrics related to City of Ann Arbor's circular economy goals of **Decarbonization, Resilience, and Equity**. Life Cycle thinking was applied throughout the project's three main parts: 1) develop municipal circular economy metrics, 2) test and implement a set of metrics for community-scale circular economy through three pilot case studies, 3) stimulate the expansion of the circular economy by businesses, consumers, and policy-makers.

Key deliverables include a locator map to direct consumers to circular economy businesses, three pilot case study reports, an inventory of existing circular economy activities in Ann Arbor, and community outreach materials such as videos to communicate to businesses, nonprofits, and the community at large about the circular economy and recruit their participation. Project outputs will be used by the City of Ann Arbor to establish funding priorities for Solid Waste service and program development and by local business accelerators to tailor programming to circular economy development.

Project Goals & Deliverables



The scope of this project was to assist the City of Ann Arbor's Office of Sustainability & Innovations (OSI) with developing, testing, and implementing a set of metrics for community-scale circular economy (CE) implementation, in order to communicate to businesses, nonprofits, and the community at large about the circular economy and recruit their participation. The set of metrics would also be deployed to determine baseline GHG emissions reductions, and measure progress in building Ann Arbor's circular economy.

This project also addresses structural inequities in three ways: First, businesses in the circular economy tend to be local and small businesses that are at a competitive disadvantage to larger chains that promote overconsumption and disposal rather than repair, reuse, etc. Second, the circular economy fosters management of waste near the point of generation, whereas end-of-life strategies tend to outsource disposal and, as with Ann Arbor (population: 7% Black), whose landfill is in Wayne County (population: 39% Black), landfills and other disposal facilities are frequently cited near lower-income populations and in counties with higher proportions of people of color. Third, reuse and refurbishment may be especially beneficial to lower-income residents.

A literature review and a study design meeting with the clients helped develop the three key metrics of **Decarbonization, Resiliency, and Equity**. The testing phase involved the use of three pilot case studies to understand the applicability and possible availability of data to measure the CE. The case studies focused on three local organizations that do unique work as a part of the CE — Ann Arbor Thrift Shop, Ann Arbor District Library, and Recycle Ann Arbor. The case study reports tested the indicator framework and translated the work of these organizations into attractive storytelling that can be communicated to the public. Other deliverables, including the CE Locator Map and the Inventory Survey, are some of the first steps towards implementing these metrics to quantify and account for the CE activities in the city. Geographic information systems (GIS) data and analysis were utilized to highlight how disparities in service provision across neighborhoods could potentially affect their CE participation. Community outreach and engagement was another important part of the project aiming to get residents and organizations invested in circular strategies to reduce waste and carbon emissions.

Deliverable	Goal(s)
<p>Circular Economy Strategies and Indicator Framework on 3 metric themes:</p> <ul style="list-style-type: none"> ● Decarbonization ● Resilience ● Equity <p>And a list of indicators to gauge the Circular Economy activity in the city.</p>	<ul style="list-style-type: none"> ● To create an indicator based framework for measurement of the Circular Economy progress in the City of Ann Arbor
<p>Inventory Survey:</p> <p>A citywide circular economy inventory survey and Report</p>	<ul style="list-style-type: none"> ● To estimate greenhouse gas emissions saved by circular economy (CE) activity. ● To test the indicators, i.e., to determine what kind of data CE practitioners can give us. ● To showcase CE activity in Ann Arbor to policymakers, city staff, and residents. ● To encourage investment in the CE.
<p>Circular Economy Locator Map:</p> <p>An interactive map and database on the City of Ann Arbor website to display progress toward Circular economy to the public and policymakers</p>	<ul style="list-style-type: none"> ● To showcase Circular Economy activity in Ann Arbor to policymakers, City Staff, and residents. ● To help residents identify the organizations that are part of the pre-existing Circular Economy of Ann Arbor. ● To encourage investment in the CE.
<p>Pilot Projects:</p> <ul style="list-style-type: none"> ● Ann Arbor Thrift Shop ● Ann Arbor District Library ● Recycle Ann Arbor 	<ul style="list-style-type: none"> ● To estimate greenhouse gas emissions saved by Circular Economy (CE) activity. ● To test the indicators, i.e., to determine what kind of data CE practitioners can give us.
<p>Community Outreach:</p> <ul style="list-style-type: none"> ● Assist with the development of a series of community stories (written or video) about the circular economy ● Assist with virtual and in-person community engagement and outreach efforts 	<ul style="list-style-type: none"> ● To showcase Circular Economy activity in Ann Arbor to policymakers, city staff, and residents. ● To help residents identify the organizations that are part of the pre-existing Circular Economy of Ann Arbor. ● To educate the residents about the Circular Economy and how it benefits the community.



Prior Work

Individual Concept Paper Summaries

As a part of an assignment for our introductory circular economy theme class, all members of our team did a brief literature review to write a concept paper. All of these concept papers were related to some aspect of the circular economy at the city level. This work really solidified some of our concepts related to circular economy and gave us invaluable insight into the academic definitions and standards. Learning about the themes that the academic literature explored and tested, helped streamline the structure of our project and contribute to the project design, in collaboration with our clients. Following are the summaries of each of our concept papers.

City-Level Implementation of Quantitative and Qualitative CE Strategies

Ananya Shah

My aim for this concept paper was to highlight some of the key approaches to implement indicator-based Circular Economy strategies in the academic literature. The reviewed studies found that cities focus on the 3Rs (Recycle, Reuse and Reduce) for social consumption, industries, businesses, and urban infrastructure and that municipalities prioritize waste management, green building materials, and energy recovery. Studies also showed that different stakeholders prioritize different circular economy indicators, but a strategy that agrees with almost all stakeholders' priorities can be achieved by forming a coalition. There were some recommendations for incorporating systems thinking as a core indicator in the circular economy implementation framework and educating local authorities about circular economy options to address skill and knowledge gaps due to a lack of CE programs at all levels of education.

Community Engagement & Environmental Justice

Brooke Troxell

I wanted to explore how community engagement initiatives might be related to environmental justice agendas and how both might support circular economy initiatives at the city level. I thought this topic was appropriate for our project since community engagement is one of the key methods the City of Ann Arbor is looking to use to develop its Circular Economy Strategy. Asad et al (2017) argue that community engagement strategies must be robust enough to survive the ever-shifting city demographics and leadership, but flexible enough to continuously include and elevate those ever-shifting voices. I think this duality is also important to keep in mind when considering metrics and strategies for circular economy initiatives in the City of Ann Arbor. Barriguete (2021) takes this concept of duality and applies it specifically to a circular economy in cities as they highlight prosperity, habitability, and resiliency as the main priorities for the contributions of circular economies in cities. Public authorities have a serious role in perpetuating circularity as they have the policy mechanisms,

leadership tools, and engagement strategies needed to make effective change. Including many voices from the community is essential to achieve a truly sustainable alternative to the current linear economic models (Mies & Gold, 2021). Hirvilammi (2020) also emphasizes the importance of a holistic approach to indicators to avoid trade-offs and contradictions between social, environmental, and economic policies.

Underlying Concepts and Importance of City-Level Circular Economy

Tariku Negassa

My concept paper highlights the importance of the circular economy to tackle current social-environmental pressing sustainability challenges including global warming, environmental injustice, and natural resource depletion. Therefore, the shift from take-make-waste process to circular economy ways of sustainable development is increasingly becoming necessary for socio-environmental resiliency and sustainability through making holistic approach changes to our production and consumption systems. The model of production and consumption needs to change in such a way that the unsustainable linear take-make-waste system is transformed into processes that reduce natural resources consumption, increase input of renewable and recycled resources, reduce material loss and waste, reduce pollutants and GHG emissions, maximize utility and durability of products, and maximize other social-environmental components of sustainability. As cities and other urban settlements comprising half of the global population and generating more than half of the global GDP are increasingly transforming their production and consumption to this model, comprehensive analysis for implementing, monitoring, and measuring circularity at the city level is required for a successful transition. One of these analyses is applying metrics for assessing GHG emissions reductions in cities and urban settlements. These analyses could also minimize the lack of common understanding as to the best models, holistic frames, and criteria to measure and monitor circularities.

Limitations of current Circular Economy studies

Zhaoqianyi Ji

There are still many limitations in current CE studies, especially in light of environmental sustainability. For example, the definition of CE system boundaries is ambiguous, and challenges exist regarding the governance and management of the CE-type inter-organizational and inter-sectoral material and energy flows. Since our project focuses on the city level, which seeks to build relationships between several stakeholders, we would consider these challenges and deal with some issues in the future by learning from literature and practice. In the meantime, this project can help highlight pathways to enhance contribution to CE and help policymakers use 'resource-miser' indicators such as value-per-weight and labor-input-per-weight ratios rather than GDP when considering CE. Another task we can do is in the communication aspect, we could use communication and information strategies to raise the awareness of manufacturers and the public about their responsibility for products throughout their service lives.

The development of circular economy (CE) metrics

Jane (Zijun) Wei

My part provides a review of the development of circular economy (CE) metrics. Metrics are required to quantify both the circularity of products and services and their contribution to the CE. These metrics can further/also be utilized in both designing business strategies and policies as well as emphasizing sustainable options based on evidence (Corona, Shen, Reike, Carreón, & Worrell, 2019). However, there is no consensus on what the key metrics should be. All the papers are evaluating the same types of metrics, but all identify different things as the most important CE requirements for these metrics. The existing measuring approaches have a reductionist interpretation of sustainability aspects with single metrics selected to represent whole sustainability dimensions (Calzolari, Genovese, & Brint, 2022). One example is that 80% of the studies employ economic indicators, with cost-based measures being prevalent. Environmental aspects are often restricted to very simplified indicators with an established carbon-centric point of view, and a relevant gap is the absence of explicit metrics regarding process or materials' circularity. Only 18% of the Calzolari et al (2019) samples consider the social dimension, and no agreement on the stakeholders to be involved. The major challenges of current CE metrics relate to difficulties in all-sustainability-dimension measurement, the evaluation of the scarcity of used materials, and underrepresentation of the consequences of material downcycling (Corona et al, 2019).

Literature Review

The team made early assessments and identification of related literature using circular economy (CE and GHG emission) keywords from the recent publications (2015–2022) and identified 35 useful publications on circular economy definitions, metrics, limitations, implementations and community engagements. In addition to these, the client also made an extensive literature review and summary that was incorporated and used for background CE information and takeaways for the project. According to the team's literature review in collaboration with the Office of Sustainability & Innovations (OSI), we found that CE metrics at municipal-level, although well-researched, is still in its infancy. Across literature there have been inconsistencies in defining CE. A study by Papageorgiou et al. (2021) reviewed 15 indicator-based frameworks of CE and matched them across 12 themes, namely:

- **Reduced input of resources,**
- **Reduced pollutant and GHG emission levels,**
- **Reduced material losses and waste,**
- **Increased input of renewable and recycled resources,**
- **Maximized utility and durability of products,**
- **Creating businesses and jobs at all skill level,**
- **Value added creation and distribution and other outcomes,**
- **Increased social wellbeing,**
- **Designing for circular economy,**
- **Educating for circular economy**
- **Investing for circular economy,**
- **Governance for circular economy and other contextual indicators.**

They concluded that none of the CE frameworks included all 12 themes. Overarchingly, the environmental aspects of CE were focused on, with only 6 of the 15 frameworks including sustainable development as a part of the circular economy. About 8 considered social aspects such as social wellbeing, value, and job creation whereas some papers defined CE as a mere recirculation of materials.

Past Research by the City of Ann Arbor

Being sustainability-forward, the City of Ann Arbor considers municipal solid waste (MSW) management an important part of its carbon neutrality plan. In addition to the management of MSW, the Office of Sustainability and Innovations at the City of Ann Arbor has been actively involved in researching CE activity in the city. The research also involved publishing a paper in MDPI journal Sustainability, ['Envisioning a Circular Economy: The Journey of One Mid-Sized Midwestern City.'](#)





Introduction

Climate change is a global issue with considerable local effects – at the county, city or even neighborhood level. These effects place part of the burden, the opportunity of adapting to, and chance of mitigating the effects of climate change on localities and municipalities. With a large concentration of people and resources, cities operate at a scale that can have potential global impacts. To tap into this potential and address the climate crisis, the city council of Ann Arbor, Michigan, USA unanimously decided in 2019 to chart a path to achieve carbon neutrality by 2030 and drafted the [A2Zero Climate Action Plan](#) (City of Ann Arbor, 2019). The A2Zero Climate Action Plan is a living document that considers current developments, inputs from key stakeholders and impacts on the community. It consists of six core strategies:

- 1. Power our electrical grid with 100% renewable energy.**
- 2. Switch our appliances and vehicles from gasoline, diesel, propane, coal, and natural gas to electric.**
- 3. Significantly improve the energy efficiency in our homes, businesses, schools, places of worship, recreational sites, and government facilities.**
- 4. Reduce the miles we travel in our vehicles by at least 50%.**
- 5. Change the way we use, reuse, and dispose of materials.**
- 6. Enhance the resilience of our people and our place.**

As a part of Strategy 5, the City of Ann Arbor budgeted \$270,000 to create and implement a Circular Economy Strategy (City of Ann Arbor Office of Sustainability and Innovation, n.d.). Emphasis was placed on fostering a circular economy (CE) in Ann Arbor because municipal solid waste (MSW) is a major contributor of greenhouse gas (GHG) emissions, accounting for about 3% of Ann Arbor's total GHG emissions (City of Ann Arbor Office of Sustainability and Innovations, n.d.). This 3% metric, however, is not reflective of the total GHG emissions as it excludes the scope 3 emissions, which is a target of Circular Economy practices. A Zero Waste Task Force was formed, and we were enlisted to help develop and promote this strategy.

A key finding of past research is that production and consumption of goods as well as their end-of-life management play a role in carbon emissions and that circularity can become a vital instrument for mitigation. The City of Ann Arbor's Office of Sustainability and Innovations (OSI) has been working with partners to build a roadmap and formulate their path forward toward end-of-life resource management and CE. One of the partners, Next Cycle Michigan, published a report that estimated that 84% of MSW disposed in Michigan across businesses, residential, and commercial facilities is recoverable (Next Cycle Michigan, 2020). To effectively incorporate MSW in a CE strategy, the City of Ann Arbor first needs to develop a framework to quantify city-wide circular activities.

CE has the potential to generate jobs and save energy while reducing resource depletion and waste (Papageorgiou et al., 2021). Shifting from a linear economy to a circular economy requires metrics and reporting systems. Examples of these metrics and reporting systems might include decoupling economic growth from resource use through lowering materials input, maximizing the usability of products, minimizing waste generation, building social support networks, and creating living-waged jobs with benefits.

Delineating and implementing OSI's CE Strategy is a mammoth task due to the diverse and loosely defined metrics in scientific and industry literature. While there can be consistent CE metrics throughout different sectors, the most impactful metrics differ by location or industry. No established CE metrics or indicators are addressing the measurement of CE with a holistic approach (Corona et al., 2019). The existing measurement approaches have a reductionist interpretation of sustainability aspects with single metrics selected to represent whole sustainability dimensions (Calzolari, Genovese, & Brint, 2022). This is exemplified by the fact that 80% of studies reviewed by Calzolari et al. (2019) almost exclusively employed economic indicators, with cost-based measures being the most prevalent. Environmental aspects are often restricted to very simplified indicators with an established carbon-centric point of view. Metrics that measure process or material circularity are a large research gap. Only 18% of the studies Calzolari et al. (2019) sampled considered the social dimension of sustainability and there was no agreement on appropriate stakeholders to involve. One of the major challenges of current circular economy metrics is the oversimplification of sustainability measurement, the evaluation of the scarcity of used materials, and the underrepresentation of the consequences of material downcycling (Corona et al., 2019).

Building on the previous research and interactions from city-wide stakeholders that were already involved in circular practices such as recycling, repairing and reselling services, the OSI determined three metric themes: **Decarbonization, Resiliency, and Equity**. The City's long-term goal is to establish "circular economy" as a core City value on par with carbon neutrality, equity, and climate action (mitigation), which would mean that projects in Departments and service areas across the City would be evaluated for their capacity to advance circular economy practices. Outputs will also be used by local business accelerators (SPARK, WCC, New Center) to tailor programming to circular economy development.

CE Strategies and Indicator Framework

City of Ann Arbor’s Circular Economy Strategies

We worked with the City of Ann Arbor to establish a circular economy (CE) definition, relevant metrics, and a measurable indicator framework. It was necessary to clarify definitions because much of the current literature emphasizes a circular economy as an industrial and/or economic system (Kirchherr et al., 2017). However, the City of Ann Arbor asserts that social and cultural transformation is needed in order to have an effective municipal-scale circular economy (A2Zero., n.d.).

The OSI adopted the definition of CE as “The current economic model is a linear economy. A traditional linear economy extracts natural resources, manufactures products, and sells products through a series of value-adding steps. A circular economy, in comparison, focuses on reprocessing and recirculating products and materials”. Since this CE working group has been working on the CE, it has revised this definition to make it less product-focused and more attentive to the social justice dimensions of the CE. The OSI now defines CE as, “an economic system that generates value by reusing, repairing, sharing, lending, and promoting all activities that give goods and resources a new life or extend the useful life of an item.”

The circular economy strategy in Ann Arbor aims to “**decarbonize, build social resilience, and repair inequities**”, thus a circular economy should be created by community members/consumers, businesses, nonprofits, and varying levels of governments. We utilized a practical model called “R9” (Figure 1) which we adapted from Kirchherr, Reike, and Hekkert’s (2017) work.

The majority of metrics we found during the literature review looked at recycling rates, energy intensity, water used, waste collected, etc. (Calzolari et al., 2022). These metrics might not be realistic data to collect from small businesses like secondhand or repair shops. The City views circularity as creating a circulation system for materials that is sustainable for the environment, economy, and society.

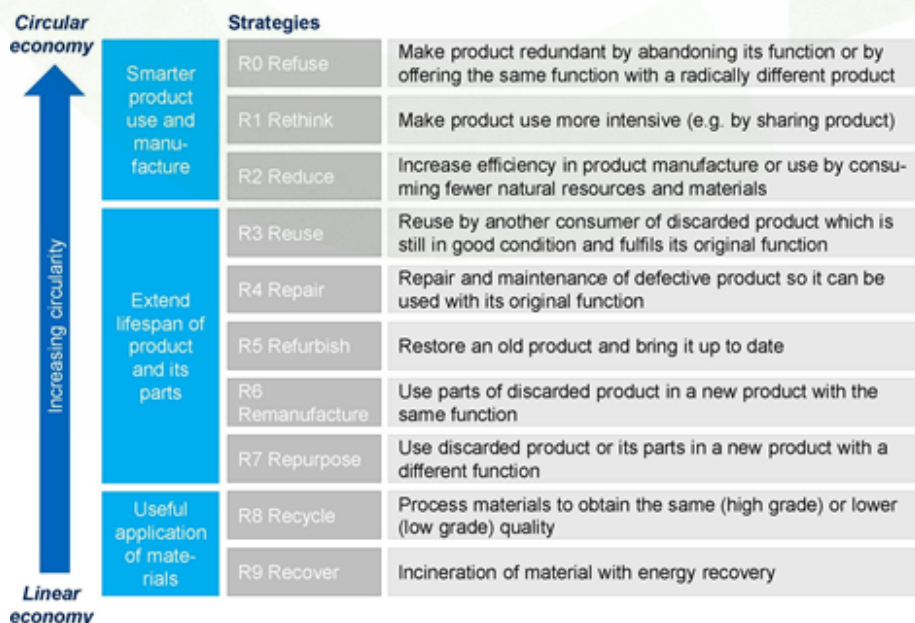


Figure 1. R9 model from Kirchherr, Reiki & Hekkert (2017)

Indicator Framework

In this project, "indicators" are the measurements of actions/accomplishments observed at the sites we study that advance each of the three metrics. In prior research, reviewed papers focused on developing indicators to track, measure, or assess the CE (Corona et al., 2019; Pauliuk, 2018), while this is helpful for our own metrics development, there was not much related to small business circularity or community change.

Given the lack of established indicators that center equity and resilience, we developed a novel framework to categorize indicators based on their alignment with CE strategies and measurement scopes. We focused on metrics that may work for small businesses and those with ethics/social benefits. After brainstorming, we set the goals, actions, and measurable indicators for each of the CE metric themes – Decarbonization, Resiliency, and Equity. The City of Ann Arbor is innovative in its recognition that no municipality can reach circularity through new products and new technologies alone but must motivate community members and local governments to change consumption and procurement practices. Thus, the selected indicators also incorporated the perspectives from an action tracker documenting ideas and feedback from community gatherings and collaborator meetings that OSI organized (see Appendix 5). See Figure 2 for a complete description of the complete indicator framework.

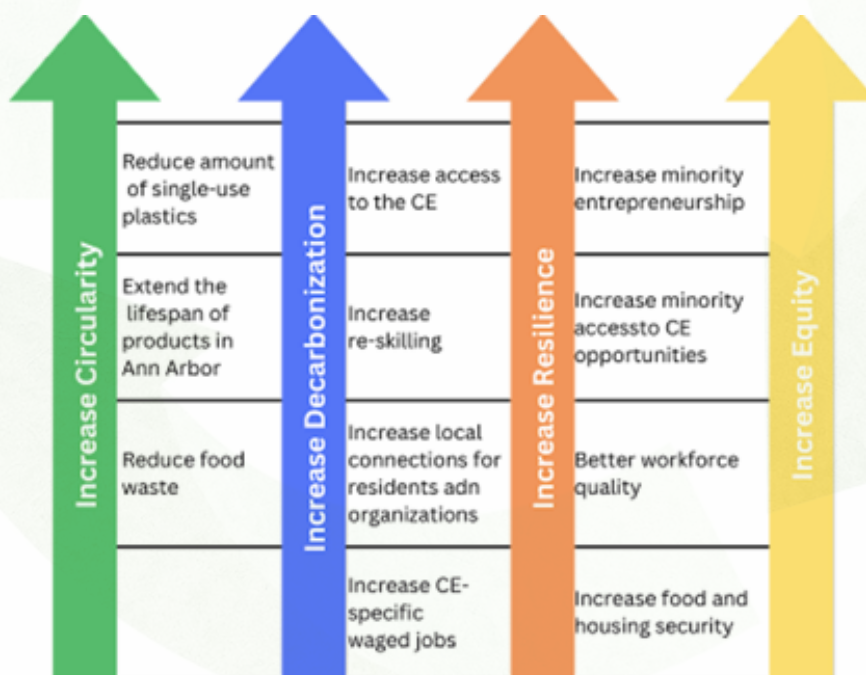


Figure 2. CE indicator framework

Pilot Project Case Studies



In order to test and implement a set of indicators for community-scale circular economy pilots, analyze current circularity models, and build community support for an equitable and resilient circular economy, we needed to determine realistic data availability. Following our team's literature review (see Prior Work section) and an initial set of stakeholder interviews (thrift shop, resettlement services¹, bike repair shop, refillery², food co-op, craft school, neighborhood association, maker space, restaurant, food bank, urban garden nonprofit), we identified three organizations for further discussion around ways to support and expand the CE - Ann Arbor Thrift Shop (AATS), Ann Arbor District Library (AADL), and Recycle Ann Arbor (RAA). These discussions helped us better frame the CE and identify new opportunities to implement it more systematically at the municipal level.

Pilot case studies were conducted with organizations in three CE sectors: resell/reuse (AATS), sharing services (AADL), and recycling (RAA). We interviewed the leaders of the organizations and analyzed public and privately-provided data about operations and circularity impacts to determine which indicators might be useful across other CE organizations in Ann Arbor. The analysis and findings of the three case studies are in the following sections.

1 - Resettlement services refer to the range of assistance and support provided to refugees, asylum seekers, and other displaced persons who are seeking to rebuild their lives in a new location. These services are designed to help these individuals and families integrate into their new communities and become self-sufficient as quickly as possible.

2 - A refillery is a store or shop that sells household items and personal care products in bulk, allowing customers to bring their own containers and refill them with the amount of product they need.

Pilot Project 1: Ann Arbor Thrift Shop

Ann Arbor Thrift Shop (AATS) is a non-profit 501(c)(3) organization and is currently a partner of the City of Ann Arbor's Circular Economy Initiative.

The AATS workgroup included Brooke Troxell, Jane Wei, and Lisa Disch. The information here is shared with AATS' review and approval. Sincere thanks to Cathi Duchon, AATS Volunteer, for giving us a tour of the facility, providing helpful information, and reviewing this report for accuracy.

This case study will provide:

- I. An overview of AATS
- II. Information on AATS operations that support project metrics: decarbonization, resiliency, and equity.
- III. A summary of AATS operations and CE opportunities

Overview

From its inception, Ann Arbor Thrift Shop (AATS) has had the purpose: To receive, collect and sell donated goods, housewares, and other merchandise to help meet the emergency social service needs of our community. AATS offers quality donated merchandise at affordable prices. The retail space features a meticulously organized and aesthetically pleasing display of donated goods, evoking the ambiance of a high-end boutique or department store. Proceeds from the sale of items are donated to support social service agencies that aid the Ann Arbor community. Because of the combination of recirculating donated goods which extends the lifespan of products and their commitment to supporting the Ann Arbor community, AATS is an exemplary example of a resiliency- and equity-focused CE organization.

Inventory Management

Ann Arbor Thrift Shop sells new and gently-used clothing and accessories like bags, jewelry, and shoes for women, men, and children; home decor, housewares, china, and linens; antiques, art, vintage treasures, and collectives; and books, DVDs, and CDs. Ann Arbor Thrift Shop is run entirely by volunteer members and has been continuously operating since 1932. AATS has over 300 members who help accept, sort, price and sell the donated items in their retail shop. AATS organizes its volunteers into different positions each day to help the organization run smoothly. Some of these positions include:

- Greeter: welcomes customers, enforces mask mandate, enforces 18-person social distancing limit
- Mercher: replenishes stock in the retail space of the store, keeps goods in the retail space organized
- Marker: attaches price tags, rotates items on display based on price tag color
- In-gatherer: receives donations, sorts donations
- Clerk: sells items, takes money, and bags items

Spatial Organization

AATS serves the circular economy by enhancing the experience of thrift shopping leading to a lower carbon footprint of the surrounding community. Set up just as a department store (Figure 3), AATS is meticulously organized to provide a pleasurable shopping experience and provide smooth operations. The retail space is organized by categories like shoes, children's clothing, books, linens, craft supplies, housewares, jewelry, handbags, women's clothes, and men's clothes. Women's clothes are further organized by type of item, size, and color. Men's clothes are sorted by type of item and size. At the front of the shop is retail space AATS calls "the Cubes" that displays specialty and/or seasonal items. There are also three dressing rooms available in the retail space. The back portion of the building is not open to customers. It is very well-organized with spaces for off-season merchandise, sorting of donated goods, tagging of donated goods, and supply racks for replenishing stock in the retail space.

The clothing and shoe stocks are marked by price tags with different colors. The colors are changed every 2 weeks so that volunteers can know how long items have been on display in the retail space. If an item has not been purchased within 8 weeks, it will be removed from the retail space. This system is usually just applied to women's clothing because they receive fewer donations of men's items.

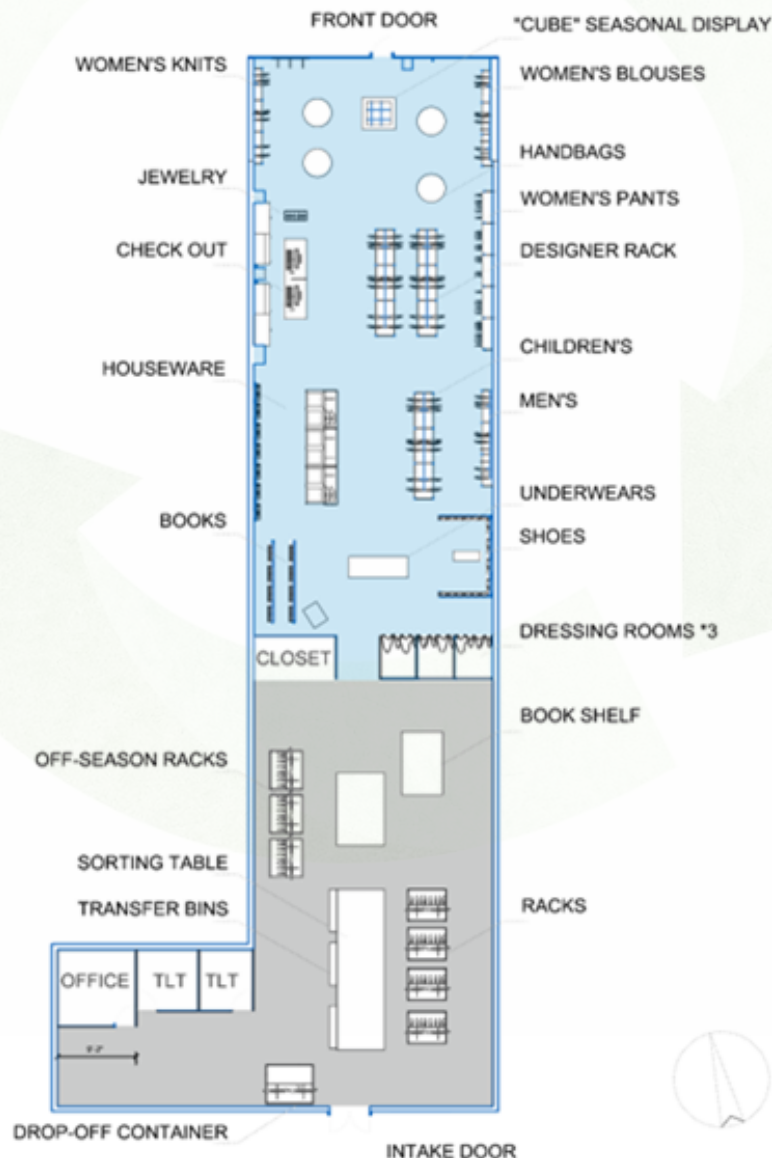


Figure 3. Floor Plan of Ann Arbor Thrift Shop

Metrics

Decarbonization

Ann Arbor Thrift Shop contributes to decarbonization through re-selling gently used goods, preventing purchases of new items, and keeping unwanted items out of landfills. Reusing the garment avoids both the production burden and the disposal burden, at the relatively small environmental cost of reselling it. Thus, reselling and reusing clothes and home supplies can help reduce the carbon footprint by preventing new production and purchase.

Carbon Foot Printing of Thrifted Apparel

In order to assess annual potential benefits from thrifted apparel and its associated carbon dioxide equivalent footprint with limited data on sales income, we used the environmentally extended input-output (EEIO) model to quantify the environmental impacts embodied. We used the World Input-Output Database³ (WIOD) (2016) and deployed CO2 satellite accounts⁴ to calculate production-based emissions, i.e. direct emissions in the textile manufacturing industry. Concerning many textile products manufactured overseas, WIOD provided input from industries located in other countries. We determined that the direct carbon emissions savings from the annual thrift shop operation was up to 8,900 kg CO2 eq.

A Circular Economy Within a Circular Economy

Any items that AATS cannot sell in its retail space are rerouted to other organizations that can sell, donate, or recycle those items. Poor quality or unsellable textiles are sold to Midwest Recycling & Midwest Unity. Other donated items with higher value are recirculated to online marketplaces. These third-party sales account for about 6% of AATS revenue. Through these third-party sales, items can be better utilized and thus have a significant reduction on the overall carbon footprint. Below shows a list of the third-party marketplaces and goods recirculated through them:

- BrickLink - Legos
- Dawn Treader Book Shop - valuable books
- Ebay/Paypal - high-end items and antiques, New Yorker magazines, calendars
- Encore Online - antiques, Waterford, sterling, antique toys
- Encore Records - LPs
- Give My Books - book overflow
- Hope Clinic - diapers, health care items
- Humane Society - towels
- Kiwanis - furniture, toys
- Lewis Jewelers - gold jewelry pieces
- Lions - prescription eyeglasses
- Midwest Recycling - unsellable soft goods, purses, shoes
- Mission Booksellers - book overflow
- The RealReal - luxury/designer clothing, shoes, and handbags
- Scrap Box - material and craft items
- West Side Books - valuable books

3 - WIOD (World Input-Output Database) is a global economic database that provides information on the production and consumption of goods and services in different countries and regions. It can also be used to analyze the environmental impact of economic activity, including greenhouse gas emissions.

4 - CO2 satellite accounts can be integrated into WIOD to provide a more comprehensive picture of CO2 emissions from economic activity. By combining satellite data on CO2 concentrations with economic data from WIOD, it is possible to estimate the carbon footprint of different economic sectors, countries, and regions.

Resiliency

Resiliency is the ability to respond and adapt to stresses and challenges such as climate change, economic downturns, and other life-altering shifts. In the context of the CE, attributes of resiliency include fostering complex networks of connections between people, organizations, and businesses; sharing knowledge and resources; and building social networks to reduce consumerism and waste. Ann Arbor Thrift Shop, which is known primarily as a prized retail shop and an important charitable organization, exemplifies resiliency in many ways. It creates connections between unwanted donated items and people who need or want them. It creates connections in Ann Arbor and beyond by finding the best use for items it can't sell. Finally, it creates connections with Ann Arbor social service organizations through donations (more information below: Support of Social Services).

Equity

In the context of the City of Ann Arbor's circular economy, equity means recognizing and repairing social harms of the past, making sure people have present needs met, and creating the pathways for a diverse, intercultural, and interdisciplinary future. AATS does this by donating to local social service organizations and providing vouchers to community members in need.

Support of Social Services

In the last 5 years, Ann Arbor Thrift Shop has given more than \$1.5 million to help Ann Arbor individuals and families in need through a "hot line" response system. This social service aid is earned through the sale of items in the AATS retail store. For many years, AATS has offered emergency aid to help individuals and families who are struggling with poverty, recent unemployment, substance abuse, houselessness, or other emerging challenges to meet their emergency housing/utilities or health-related needs. To increase the effectiveness of their charitable giving, the Thrift Shop shifted, in this current year 2022-2023 (year begins on August 1) to making Emergency Grants to 501 c 3 agencies. That program has distributed a total of \$436,00 in emergency grants to 15 agencies to receive monthly grants for emergency house-related needs and emergency medical needs and 2 agencies to receive monthly grants for food insecurity. These grants are provided to agencies who have the internal capacity to respond to the emergency needs of individuals and families with housing, utility and health assistance. These grants give agencies the ability to respond quickly in situations requiring emergency funding.

In addition to the grant support, AATS also provides vouchers to social service agencies. Vouchers can be distributed by agencies to clients who have needs that can be found in the retail space. The vouchers are for \$50 or less in shop merchandise. This allows clients to shop without the stigma of being a "social service client". The AATS has developed a special partnership with the J. Jill Compassion Fund. J. Jill chose AATS to be the recipient of all donations made to their local store during their clothing trade-in program.

Summary of CE Opportunities

By virtue of its meticulously curated merchandise and thoughtful design of its display floor, the Ann Arbor Thrift Shop is an excellent example of an "on-ramp" to the Circular Economy: it provides customers with a department store-like environment for resale shopping. Making resale shopping attractive and fun draws a broad clientele into the CE. By donating used goods instead of throwing

them away, AATS plays a role in reducing greenhouse gas emissions that result from waste and new production. When customers shop at AATS, they save money, give used items new life, and prevent the purchase and production of new products by reducing demand.

In addition, at the organizational level, AATS completely embodies the socially resilient and equitable aspects of what a circular economy can be. They, as an organization, prevent as much waste as possible by rerouting goods that they cannot sell to other local organizations or selling them for more money through online retailers. In addition to this, they donate the large majority of their revenue not needed for operating costs to social service agencies and community members in need. An operation like AATS is rare given their charity model. The strength and value of this system can be seen in the fact that AATS is celebrating its 90th anniversary this year (2022). For 90 years, AATS has been run by faithful volunteers (currently over 300 people) who dedicate their free time to serving the community and foster a circular economy through AATS. We also want to recognize that they were able to share their data and we are able to tell their CE story is because they made got a new digital cash register and started accounting more precisely and itemizing.





Pilot Project 2: Ann Arbor District Library

The AADL workgroup includes Brooke Troxell, Tariku Negassa, John Callewaert, Cat Diggs, and Jenny Petoskey. Sincere thanks to Eli Neiburger, AADL Library Director, for meeting with us several times and providing helpful information to our process. This report will provide:

- I. An overview of AADL
- II. Information on AADL operations that support project metrics: decarbonization, resiliency, and equity.
- III. A summary of AADL operations and CE opportunities

Overview

The Ann Arbor District Library (AADL) is a public library that was established to serve the city of Ann Arbor and parts of seven surrounding townships with five public locations: Downtown (Central Branch), Malletts Creek Branch, Pittsfield Branch, Traverwood Branch, and Westgate Branch. It is supported in part with public funds.

AADL has almost 600,000 physical and electronic units in its collection. There were a total of 375,000+ physical library visits and over 3 million visits to the library's website visits in the fiscal year. AADL also provides Wi-Fi internet access indoors and outside the building which were utilized 512,000+ times this year. Other services AADL provides include releasing online educational content and renting out meeting space for community groups.

Metrics

Decarbonization

AADL efforts to promote decarbonization through their CE initiatives include circulating books and materials therefore preventing purchases; forming reuse partnerships with entities like RAA, Friends of District Library, and Better World Books; and sustainable event planning. All the above initiatives and the circulation of non-media items such as thermal cameras, sewing machines, synthesizers, and pedals contribute to decarbonization through reducing resource consumption, saving materials, and reducing waste.

- number of shared non-media items,
- number of media items in circulation and/or circulation rates,
- number of digital resources/eBooks,
- weight of recycled materials,
- number or weight of compostable items on sustainable events/number of sustainable events,
- number of repaired tools and number of seedlings for green initiatives.

Resiliency

Resiliency in the context of the circular economy that the City of Ann Arbor is trying to foster means complex networks of connections between people, organizations, businesses, and the environment

where knowledge and resources can be shared in order to build community and reduce consumerism and waste. The AADL is an integral part of the free circulation of both knowledge and resources.

Some great examples of initiatives in pursuit of resilience where we could measure both the scale of the project and the impact on community circularity are:

- seed distributions (sharing resources to foster connections between people and the environment),
- DIY videos and in-person events (sharing of knowledge that can help reduce consumerism and waste because consumers will understand their impact),
- tool rental programs (sharing of resources that can help reduce consumerism and waste),
- idle/unused item sales (reduced-cost access to resources that helps reduce waste),
- space rentals by community organizations (fostering connections and knowledge-sharing between people).

Equity

Equity for AADL is also described through recognizing and repairing harms of the past, making sure people have present needs met, and creating the pathways for a diverse, intercultural, and interdisciplinary future. Assessing how often community members access resources without cost barriers like computers, printing, Wi-Fi, meeting spaces, and tax filing services is a great way to measure how current needs are being met. AADL does not collect fines for overdue materials and also provides services at no charge to all residents living within the Ann Arbor District Library's service area.

Summary of CE opportunities

While there is so much that AADL is doing to contribute to sustainability and the CE (most of which is inherent to AADL's mission) there may be an opportunity to directly promote these activities. Here are a few examples of how other library systems are integrating sustainability into their activities.

- The [Sustainable Libraries Initiative](#) (SLI) (Home, n.d.) provides library leaders with a proven path forward to co-create libraries and communities that will thrive in the coming years. The Sustainable Library Certification Program and the SLI community of practice focuses leadership to enable a library, and ultimately a community, to become more environmentally sound, socially equitable and economically feasible.
- [Green Libraries: Sustainable Libraries, resource list](#) (LibGuides, n.d.). This section of the [Green Libraries LibGuide](#) focuses on sustainability resources specifically designed for libraries.
- The paper, "Sustainability Metrics in Library and Information Services: A Quality Management Framework" (LIS, 2014) discusses the role of sustainability metrics in quality management in Library and Information Services (LIS) and provides an integrated framework to measure sustainability value, influence and meaning of information services.

Finally, a recent [media story](#) (Rivenburg, 2022) on alternative lending programs of libraries provides helpful insight on AADL's leadership in this area with loaning non-traditional items since 1969 (starting with artwork) and opportunities for the future as captured in this quote from Sacramento library Justin Azevedo:

"After Sacramento unveiled its initial batch of things in 2015, nominations poured in for future items – many of which sounded unworkable, he says. When people asked for weed whackers and cake pans, he recalls, "I said, 'No way.'" But now the library carries both, he notes. "I'm curious to see what we'll have in three years that seems impractical now."

Pilot Project 3: Recycle Ann Arbor



Abstract

This case study of the City of Ann Arbor’s contracted non-profit partner Recycle Ann Arbor (RAA) measured the value created by the zero-waste organization’s operation of municipal recycling collection and processing, including monetary benefits, environmental impacts, and job creation. We examined the merit of having on-site processing with a local material recovery facility (MRF) using Life Cycle Thinking. This study evaluated diversion rate (tons diverted from the landfill) and the residual rate (percentage of unrecyclable content sent to landfills) of the single-stream recycling as a reflection of recycling practice quality. This case study was conducted with available data through the monthly summary report provided to the city that contains the composition for each material. This data was used in EPA Waste Reduction Model (WARM) to get a life-cycle impact result.

Background

Recycle Ann Arbor’s recycling practice

Recycle Ann Arbor (RAA), is one of only four zero-waste mission-driven organizations nationwide that is dedicated to delivering recycling services that put materials to their highest and best use as locally as possible and uses best practice environmental and social strategies including maintaining an ethical workplace. A recipient of the prestigious Tim McClure Award for outstanding environmental and community leadership, RAA created Michigan’s first curbside recycling program in 1978, which was one of the first in the nation. (RAA, 2005) RAA demonstrates its “highest value, best use” philosophy, in its “Bottle to Bottle” recycling which partners with a glass manufacturing company to process and recycle glass bottles into bottles again rather than downcycling into uses such as road resurfacing.

Historically, Ann Arbor transported their recyclable waste to Ohio. After RAA opened as a local MRF, it has been processing materials locally, on-site. Table 1 shows the costs for on-site processing and compares it with historical transfer or shipping costs, making an economic case for a local MRF such as RAA. More impacts of a local facility on emissions are given in the Recycling Impact Report section under Decarbonization metric below.

RAA PHASES	Historic Transfer Costs	MRF Development Transload Phase	RAA Onsite Processing in Ann Arbor
Dates	July 2017 - Sept. 2020	Oct. 2020 - Nov. 2021	Dec. 2021 - Sept. 2022
Total tons recycled	43,391	15,818	10,942.56
Total cost for recycling processing	\$5,521,044	\$1,399,499	\$631,073.29
avg. cost/ton	\$127	\$88	\$57.67
% savings over transfer			55%
Estimated number of Tons Recycled/Year	13,500	13,500	13,500
Total Estimated Cost	\$1,717,722	\$1,194,383	\$778,565
Annual projected savings over Transfer			\$939,157

Table 1. RAA practices and MRF stages information (RAA)

Ann Arbor's New Local Material Recovery Facility (MRF)

RAA is already revitalizing recycling in Southeast Michigan with a new materials recovery facility (MRF) that ensures recyclable materials are sorted and sold to manufacturers for use in new products.

The MRF reopened Dec. 1, 2021, at 4150 Platt Road in Ann Arbor, after 12 months of construction to complete a \$7.25 million overhaul of the facility, which had been defunct since 2016. Its physical redesign and operating strategy are both driven by a zero-waste ethic with the aim of supporting an effective, sustainable recycling system (ClickOnDetroit, 2022).

Metrics

Corona et al., (2019) indicated that a good metric for a MRF should clearly indicate how the benefits of recycling are allocated to the recyclers and the users of recycled materials and should measure the increased value through increased product utility and economic value-added measurements. Notable examples of economic indicators are the cost associated with reverse supply chain activities, the profits associated with recovery activities (Baptista et al, 2019; Jin et al 2019) including remanufacturing, recycling, and the quality of recovered products.

Decarbonization

2021 RAA's Recycling Impact Report

Before the MRF was reopened, the city's recyclables were being trucked to Columbus, OH. Local processing now significantly reduces these transportation-related emissions and costs (2021 Recycling Impact Report | Recycle Ann Arbor, 2021). From RAA's website, 15,699 tons of materials were diverted from landfill in 2021, of which 82.7% were collected curbside through a single-stream recycling collection system, 6.6% were picked up at drop-off stations, and others were construction and debris recycling. Through material diversion from landfill, 32,757 MT CO₂ eq was prevented and an equivalent of 40,700 barrels of oil was conserved.

In RAA's Recycling Impact Report, there are three decarbonization indicators that RAA is currently tracking and reporting: diversion rate, GHG emissions prevented, and energy use conserved equivalent. From the monthly recycling report, other metrics include: AA residual rate, facility-wide residual rate, and material processed off-site rate.

End Market for Processed Material

The processed materials are sold to end markets. The following list shows markets representing over 90% of commodities shipped from RAA.

- Cardboard and Mix Paper: 20 tons per load, shipped 137 miles.
- HDPE Plastic: 20 tons per load, shipped 21 miles.
- PET Plastic: 20 tons per load, shipped 269 miles.
- Glass: 35 tons per load, shipped 192 miles.
- The metals (aluminum and steel) go to various regional markets through brokers.

Resiliency & Equity

Job Creation

RAA employs 24 individuals – 17 sorters and 7 administrative and operational staff at the MRF. As of August 2022, they had employed 4 returning citizens (formerly incarcerated individuals) to provide job training, a living wage, and assistance with food and housing security. Although the number of returning citizens employed varies on a monthly basis, all of these positions pay at least the Michigan living wage (\$16.36/hour) and include a benefits package.

Material Revenue Share Credit

Figure 4 shows a detailed situation for RAA in April 2022. RAA received the “City of Ann Arbor Processing Fees” from the City, paid the “Host Fees” to the City for 3rd party material processed on-site, and finally gave the “Commodity Rebate” to the City by selling materials, while in the end saving the “Net Invoice” for daily operation.

Thanks to the expense offset by the revenue share that the City is receiving from the MRF, this helps reduce actual processing cost (Figure 5).

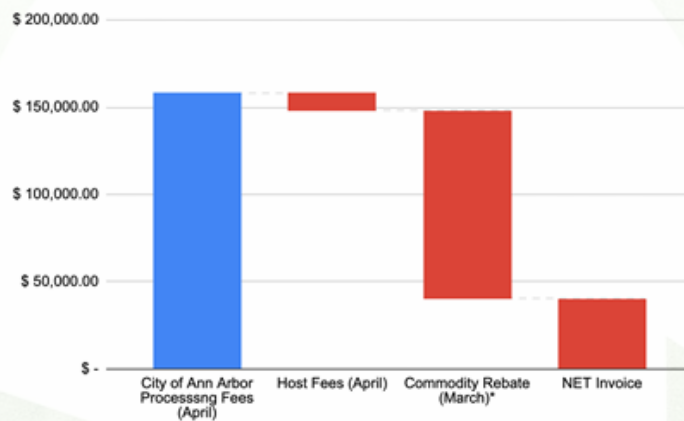


Figure 4. Detailed Value Creation in Apr 2022 (unit:\$)

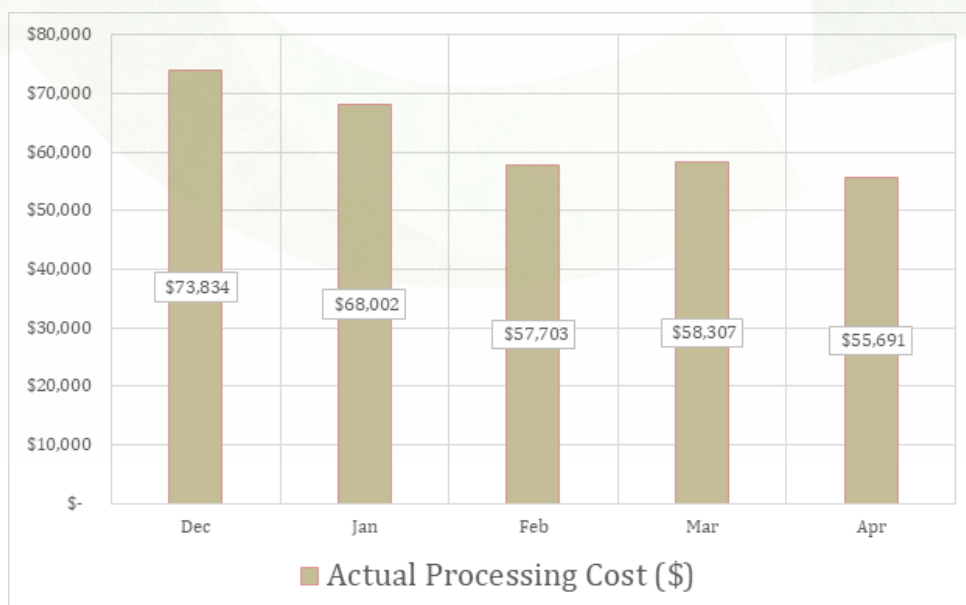


Figure 5. City of Ann Arbor Actual Processing Cost per month, from Dec 2021 to Apr 2022 (unit: \$)

End-of-life Multi-commodity Emissions Analysis

Summary of data

For this analysis, we used RAA's monthly recycling reports. We defined the temporal scope of this analysis for this case study as December 2021 – April 2022. Although they have a single stream of input waste, RAA has robust data on the composition of their waste by category using a composition analysis. Using the data on percentages of the categories of waste presented in the monthly summary report, a multi-commodity analysis using EPA's WARM Model Version 15 was done. All final results in MT CO₂e are for an aggregate of 5 months. Among the metrics defined above, this study falls under Decarbonization.

Methods

Determining Total Tonnage by Material Type

The data that we obtained from the monthly summary report was used to estimate the emissions for recycling and landfilling scenarios of the different categories of waste collected. The composition mix is shown in Figure 6. End-of-life emissions from only transportation and recycling processing are calculated. They do not account for emissions associated with transportation to end-markets neither for the virgin material or new material use avoided. Our analysis differs from the 2021 RAA Recycling Impact Report in the sense that RAA's considers emissions for disposal of single-stream of waste whereas our analysis considers emissions from disposal of different categories of commodities, hence, providing a more accurate account of total emissions and a comparative study of landfilling versus recycling scenarios.

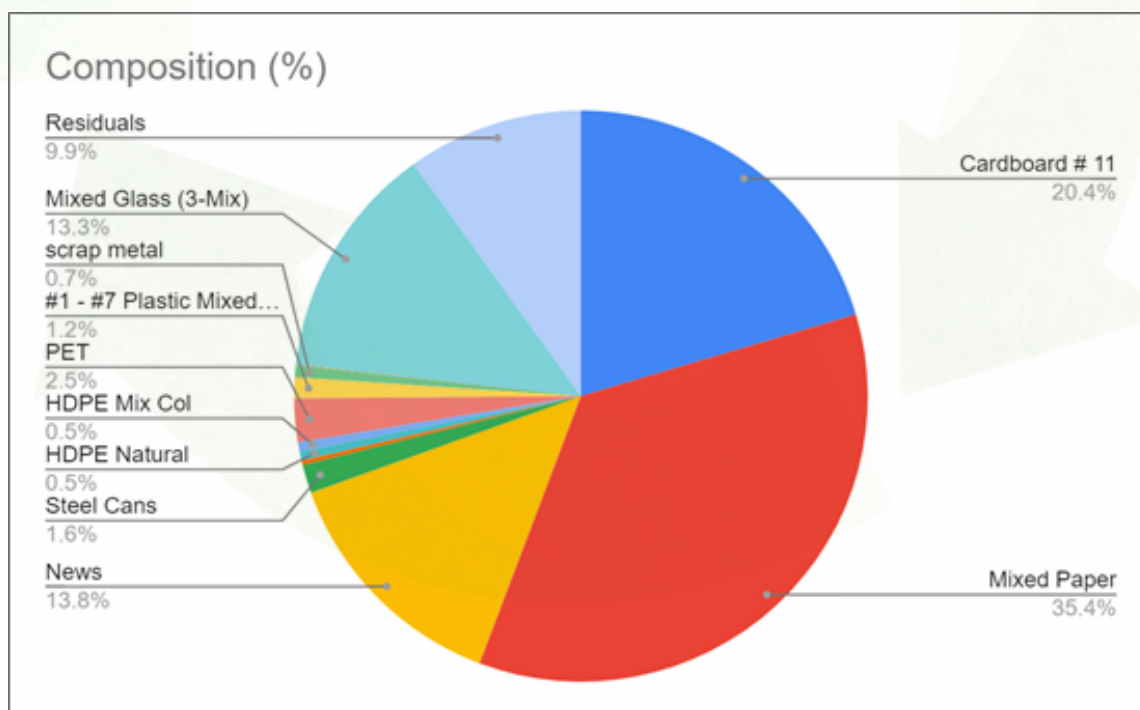


Figure 6. Waste type classification by percentage in total single-stream recycling

For each category, tonnage was calculated from each month's total tons (Dec 2021 – Apr 2022). Total tonnage for each category was calculated by summing up tons from every month.

Multi-commodity analysis using EPA WARM Model v. 15:

Each category in the RAA recycling data was mapped to the categories available in the WARM tool for which emission factors available and put into the *Analysis Input* tab of the Excel tool in the EPA WARM Model version 15.

RAA Waste Category	Selection of WARM Category
Cardboard #11	This category's tonnage was plugged into the model under the Corrugated containers category for landfilling and recycling scenarios.
Mixed Paper and News	Both of these tonnages were summed and the total was used in the model under the Mixed Paper (general) category for landfilling and recycling scenarios.
Steel Cans	Tonnage was inputted and the emissions were calculated using the MT CO _{2e} / ton factor for the steel cans category for both recycling emissions and landfilling emissions.
Aluminum Cans	This category's tonnage was plugged into the model under the Aluminum Cans category for landfilling and recycling scenarios.
HDPE Natural and Mix Color	Both of these tonnages were summed and the total was plugged into the model under the HDPE category for landfilling and recycling scenarios.
PET	This category's tonnage was plugged into the model under the PET category for landfilling and recycling scenarios.
#5 Plastic Mixed (with rigid)	This category's tonnage was plugged into the model under the Mixed Plastics category for landfilling and recycling scenarios.
Scrap Metal	This category was excluded from the emissions' calculation since scrap metal constitutes less than 1% of total Municipal Solid Waste.
Aseptic Carton	Aseptic carton's composition is as follows- 74% paper, 22% Polyethylene and 4% Aluminum (About Cartons, 2022). Hence, the emissions estimation for this category was calculated for each category separately and then summed to determine the total emissions for the landfilling in both the traditional landfilling and recycling scenarios since we assume that it is difficult to separate these constituent materials. The calculation for this category is shown in a table in the appendix. Even though recycling emissions are available, due to lack of sufficient data from RAA, aseptic cartons are considered landfilled in both the landfilling and recycling scenarios. Calculations given in the Appendix 2.

<p>Mixed Glass (3-Mix)</p>	<p>This category's tonnage was used in the model under the Glass category for landfilling and recycling scenarios. Since RAA transports the glass to be recycled at a facility in Columbus Ohio, the transportation emissions were also calculated and added to the total glass emissions using the emissions factor (Green Freight Math How to Calculate Emissions for a Truck Move, 2021) from the Environmental Defense Fund. The method to calculate the glass emissions used is therefore a drawback of the modeling method as it does not account for the fact that RAA which uses "highest value, best use" practice to do bottle-to-bottle recycling has a lower CO2 emissions and energy impact than recycling at RAA's facility.</p>
<p>Residuals</p>	<p>This category's tonnage was plugged into the model under the Mixed MSW category as landfill for both landfilling and recycling scenarios.</p>

Table 2. Methodology to calculate emissions for each category of waste

Results

The results showing absolute emissions and differences between the landfilling and local recycling scenario can be found in Figure 7.

For the landfilling scenario, the total amount of emissions equals 575 MT CO2 eq. For the recycling scenario, the total amount of emissions equal -13,536 MT CO2 eq. A negative value for emissions in a WARM model indicates that those emissions have been avoided during the management of specific materials in a scenario. This is a result of the amount of virgin material production avoided as stated by the [WARM model handbook](#) (USEPA, 2019). Hence, a net negative value means that an aggregate of 13,536 MT CO2e have been avoided over a period of five months as a result of using recycling, compared to landfilling. Overall, there is a difference of 14,076 metric tons of CO2 equivalent.

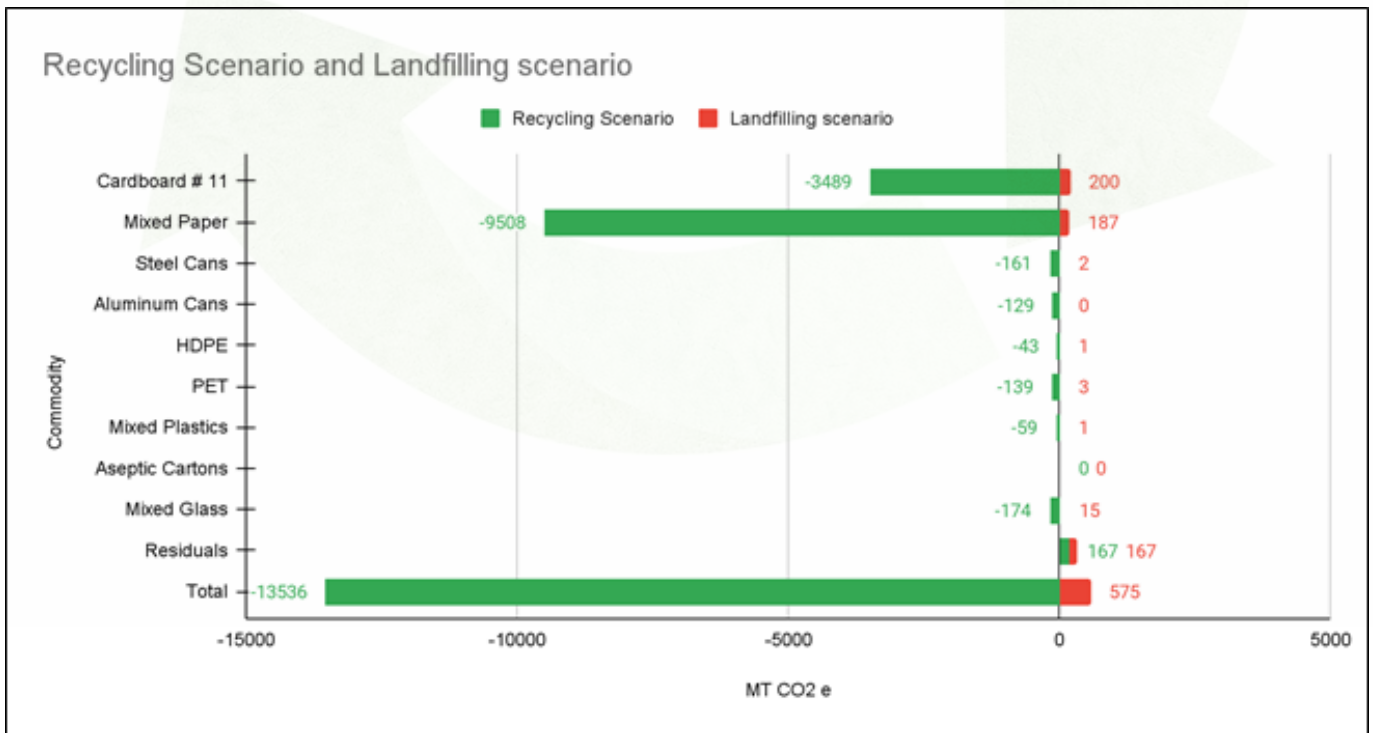


Figure 7. Results from end-of-life multi-commodity emissions analysis

Remarkable Aspects of a Zero-waste MRF

RAA is employing best practices to help ensure they receive the cleanest end materials possible. For example, they utilize the new 'Samurai sorting robot', which will not replace jobs but will help sort out contamination from the facility's paper and add the health-related equity benefits as working in a MRF can be hazardous. As a result, the material sorted is cleaner and advances RAA's highest and best use objective by getting higher prices for the material that they sell as well as making their facility safer and more efficient. Another example of the highest and best use recycling is that they send glass to Columbus, OH with a cost to be reprocessed into bottles again rather than downcycling.

Future Use and Implications

The results we obtained from this pilot study were used to understand and calculate the emissions avoided by on-site recycling the recyclable materials of the municipal single-stream recycling over a period of five months. The stream of waste, however, and their relative composition mixes, are not identical each month. A similar study could be carried out for different months of the year to analyze the seasonality of waste composition throughout the year. Another consideration for a future refinement would be to include the transportation required for the recycling and to consider less than 100% replacement of virgin materials. Such an analysis would likely make the benefit smaller but more realistic while still beneficial.

Summary of Pilot Case Studies Indicators

Pilot Case Studies	AADL	AATS	RAA
Metrics	Indicators		
Decarbonization	<ul style="list-style-type: none"> • Number of library locations supporting sharing economy, • Number of shared items, • Number of items in circulation and/or circulation rates, • Number of digital resources/eBooks • Weight of recycled materials, • Number or weight of compostable items on sustainable events/number of sustainable events, • Number of repaired tools and number of seedlings for green initiatives 	<ul style="list-style-type: none"> • Monetary value of purchases prevented • GHG-saving-per-dollar 	<ul style="list-style-type: none"> • Diversion rate • GHG-prevented perweight • Energy use conserved equivalent • AA residual rate • Facilitywide residual rate • Material processed off-site rate
Equity	<ul style="list-style-type: none"> • No fines collected for overdue materials. • Services provided at no charge to all residents living within AADL's service area. • Resource access without cost barriers: computers, printing, Wi-Fi, meeting spaces, and tax filing services 	<ul style="list-style-type: none"> • Broad clientele brought into the CE 	<ul style="list-style-type: none"> • Residual Rate • Job creation • End market for processed material sale • Material revenue share credit

<p>Resilience</p>	<ul style="list-style-type: none"> • Seed distributions (sharing resources to foster connections between people and the environment), • DIY videos and in-person events like sharing of knowledge that can help reduce consumerism and waste because consumers will understand their impact), • Tool rental programs (sharing of resources that can help reduce consumerism and waste), • Idle/unused item sales (reduced - barrier access to resources that helps reduce waste), • Space rentals by community organizations (fostering connections and knowledge- sharing between people). 	<ul style="list-style-type: none"> • Number of volunteers • Amount of charitable giving 	
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Table 3. Summary of indicators used in pilot projects



Inventory Survey

Introduction

The purpose of the pilot case studies in the previous section was to determine the information that some CE activities organizations are currently tracking and the relevant indicators. After that information was gathered, we selected indicators that were in alignment with the City's overall metrics of decarbonization, resiliency, and equity (Table 9). We then compared the information gathered from the pilot studies and the indicator framework (Table 1) to develop a survey (Appendix 1) to send out to CE organizations across Ann Arbor that the City has been working on building relationships with. In the future, the City hopes to round out this inventory with additional types of circular economy businesses.

Methods

Building trust and relationships with existing CE entities is extremely important for maintaining interest and incentivizing participation as the City continues to develop its CE Strategy. Targeted engagement with a non-probability survey was ideal for the City's goal of collecting baseline quantitative data and engaging stories of circularity in Ann Arbor because this type of survey can collect local knowledge relevant to a problem, collect novel ideas, and categorize stakeholders for further involvement (Mercer et al., 2017). To collect both quantitative and qualitative data, the survey was split up by sector (Appendix 3) and a variety of questions were asked to elicit information such as the amount of waste diverted from landfill and a narrative about challenges and barriers to implementing sustainability practices. We designed the survey and then the City shared it with 18 CE entities in Ann Arbor. Out of these 18 entities, 13 businesses and organizations responded (72% response rate). Participating organizations include:

- Jewish Family Services of Washtenaw County - Rental/ Sharing/ Social Services
- Common Cycle- Repair/ Maintenance
- Buy No Things fb group - Rental/ Sharing/ Social Services
- Milk + Honey - Restaurant/ Food
- Sister Lakes Association - Rental/ Sharing/ Social Services
- All Hands Active - Education
- People's Food Co-op - Restaurant/ Food
- BYOC Co. - Other
- Food Gatherers - Rental/ Sharing/ Social Services
- El Harissa - Restaurant/ Food
- Art on a Journey Gallery/ Studio - Other
- Project Grow - Rental/ Sharing/ Social Services
- Community Action Network - Education

Results

Below in Table 4 are the indicators that we chose to determine a baseline of circular economy activity and elicit qualitative data about the CE in Ann Arbor.

Metric	Goal	Indicator	Current Circular Economy Activity*
Decarbonization	Reduce amount of single-use plastics	\$ saved or spent by CE organizations switching to compostable or recyclable materials	CE organizations spend on average \$1,750 annually to switch to compostable or reusable materials
		Weight of single-use plastic waste prevented by switching to compostable or reusable materials	Total of 1,125 lbs. of single-use plastic waste prevented by CE organizations
		Amount of GHG savings by CE organizations switching to reusable containers	1.09 MT CO ₂ e from reuse***
		% of circular economy organizations offering bulk and/or bring your own (BYO) options	2 of 3 offer bulk and all 3 encourage BYO containers (66.66%)
	Extend the lifespan of products in Ann Arbor	Number of items diverted from landfills Amount of GHG savings by repairing items instead of sending them to landfills	260 bicycles Approximately 24.96 MT CO ₂ e saved by repairing bikes instead of buying new
	Reduce food waste	Amount of GHG savings from food rescue	1.4 -2.91 MT CO ₂ e
Resiliency	Increase access to the circular economy	# of people served by circular economy organizations	610,000+ people****
		% of people served by circular economy organizations that live in Ann Arbor	45% (average)
	Increase re-skilling	# of educational workshops held by CE organizations	284
		# of participants in educational workshops held by CE organizations	1,618

Resiliency	Increase local connections for residents and organizations	# of local (within 250 miles of Ann Arbor) organizational connections/ collaborations	600+
	Increase CE - specific waged jobs	# of paid positions	160+
		No. of volunteers	23,000+
Equity	Increase minority entrepreneurship	% of CE organization leaders who identify as BIPOC ¹ , women, queer, and/or live in Ann Arbor	Current CE organization leaders: 61.5% live in Ann Arbor 38.5% BIPOC 53.8% women 15.4% queer
	Increase minority access to CE opportunities	% of CE organizations that keep systematic demographic records of the people they serve	23.1%
		% of CE participants/consumers who identify as BIPOC, women, and/or low income	62% women 54% BIPOC Majority low-income**
	Improve workforce quality	% of paid CE positions that make at least the Michigan Living Wage (\$16.36/hour)	90%

¹ "BIPOC" is an acronym that stands for "Black, Indigenous, and People of Color".

Equity		% of paid CE positions that are part of a union	0% for most organizations, 90 - 100% of two of the pilot studies' organizations (AADL and RAA)
	Increase food and housing security	% of circular economy organizations that assist residents and/or employees with housing and food security	46%
		No. of people assisted with food and housing security	55,000+ (accumulative)

Table 4. Results from the indicator survey sent out to current CE entities.

*Based on results of our City of Ann Arbor Circular Economy Inventory Survey; numbers are annual sums unless noted otherwise

**All of the organizations who were able to provide us with participant demographic information shared that a majority of their participants are low-income, but they did not provide exact numbers or percentages or what they quantify as low-income

***Calculated it for an average of 8.5 uses from the range 4-13 uses taken from [Hitt et al.,23](#). Using the [WARM's Modeling Reuse Guide](#), emission factor 583 MT CO2e/ 1000 ton of HDPE, calculation was made as follows: 500 lb. = 0.25 ton, so for 500 lb., the emissions would be 0.14575 MT CO2e. Using the reuse model of Emissions = (n-1)*A, n being the number of reuses and A being the emissions per lb.

****Some organizations listed unique participants; others listed total participants in 2022

Discussion

Organizational Leaders

Most CE organization leaders live in Ann Arbor and a wide range of ages are represented. In order to diversify the leadership of CE organizations in Ann Arbor, the City could make efforts to support BIPOC and LGBTQIA+ entrepreneurs.

Current CE Participants

To learn more about who in Ann Arbor is currently accessing CE resources and opportunities, the City could encourage CE entities to keep track of their customers and/or participants. 77% of entities who completed the inventory survey could not provide data about who participated in their services or consumed their products. The organizations who did have information on their participants were social service organizations so women and low-income folks were the majority of their clientele.

Current CE Workforce

One of the biggest opportunities for growth for the current CE in Ann Arbor is to involve more paid labor so the CE becomes a bigger part of the formal economy in Ann Arbor. There are around 160 employees participating in the Ann Arbor CE compared to over 23,000 volunteers. Increasing waged labor is a key way to ensure the resiliency and overall sustainability of the CE. Of the organizations that have paid employees, about 90% of those employees make at least the Michigan living wage (\$16.36/hour). While this is a good start, Ann Arbor has the highest cost of living in Michigan (Lange, 2023) and MIT (Living Wage Calculator, n.d.) calculates that a living wage in Ann Arbor is actually \$18.67-\$83.63 per hour depending on the number of adults working and the number of children in the household. There were also only 2 organizations that had unionized employees.

Challenges & Barriers to CE Participation

The largest challenges organizations face when trying to participate in CE activities are financial ones. Switching to reusable or compostable containers can be a significant cost to a business. The rental prices in populated areas of Ann Arbor are extremely high. Composting and recycling of organizational waste can be a huge time and financial investment that does not currently qualify for many types of funding assistance. The City of Ann Arbor could help CE entities thrive by implementing rent control measures and offering financial or other incentives for switching to reusable and/or compostable goods and for responsibly disposing of waste by recycling and/or composting.

Ann Arbor Circular Economy Locator Map



Geospatial data, technologies, and tools are becoming extremely important in assessing, understanding, and evaluating the current social-environmental crises such as climate change and environmental injustices in order to build a better future. Mapping can make the existing large and complex volumes of sustainability-related data and information intellectually coherent, internally consistent, and easily communicable. Identifying, mapping, and documenting natural resources and social-environmental services that promote equity, resiliency, and emissions-reduction promotes effective analysis and decision making.

In this project all the circular economy related spatial data are identified, analyzed, and mapped using ESRI software products: ArcGIS pro and ArcMaps. Different CE related data are used to produce different map layers that helped to produce mainly the city's [circular economy locator map](#) (Figure 8), [GIS story maps](#), [public transportation accessibility maps](#) against Washtenaw opportunity index and Ann Arbor population density (Figure 9 and 10)

The 2020 Washtenaw Opportunity Index is a tool to benchmark access to different opportunities categorized by census tract (Opportunity Index, n.d.). The goal of this index is to:

- illustrate where there is and isn't access to opportunities.
- inform policymakers, community partners, businesses, and the general public;
- collect and communicate data through an "opportunity lens" - a complement that lens with strategies and tactics that foster human potential; and
- provide the community with a common, understandable framework by which to make policy and resources allocation decisions that can create more equitable opportunity

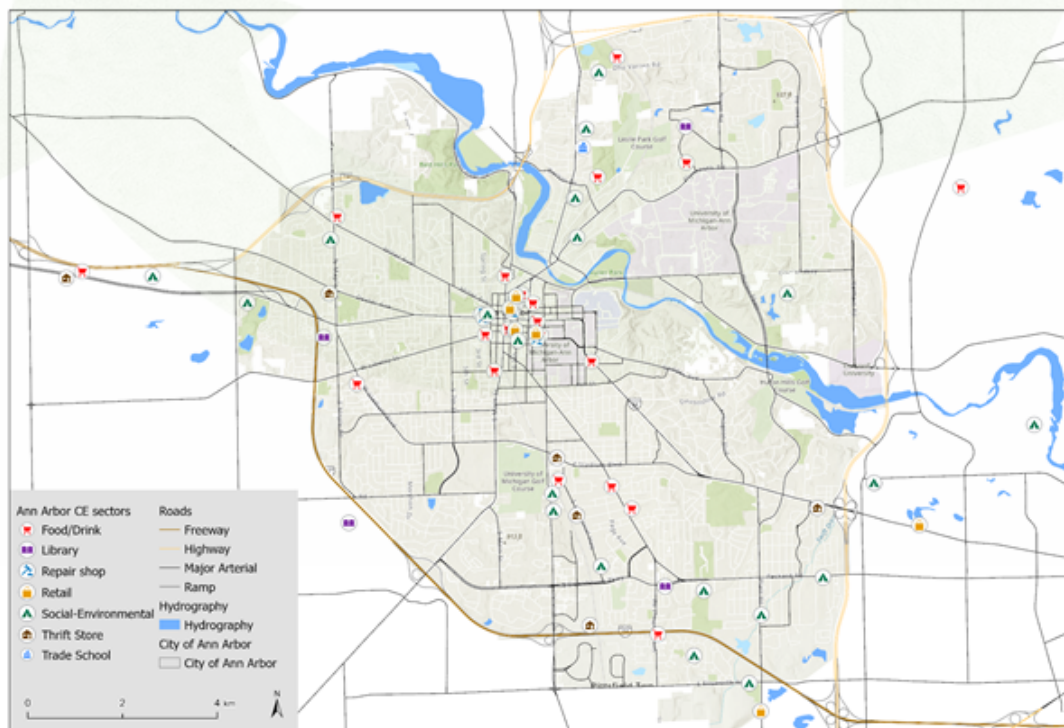


Figure 8. Map layout showing geospatial distributions of Ann Arbor circular economy initiatives compiled from the data from Ann Arbor City: Office of Sustainability and Innovation, Michigan GIS Open Data, US Department of Agriculture, and ESRI Basemaps.

The Circular Economy Locator Map (Figure 8) was created using a list of CE entities created by the City and geocoding the table of them google map addresses. We categorized the sectors based on their services and areas of impacts: Food/Drink, Repair Shop, Library, Retail, Thrift Store, Trade School, and Social-Environmental. The purpose of this map layer is not only to serve as a reference for community members to find businesses involved in circularity but also to identify spatial areas that have potential to expand the circularity in the community. Along with the base map, a layer of access to opportunities using the Washtenaw County's Opportunity Index and another layer with access to transportation were also created (Figure 9 and Figure 10).

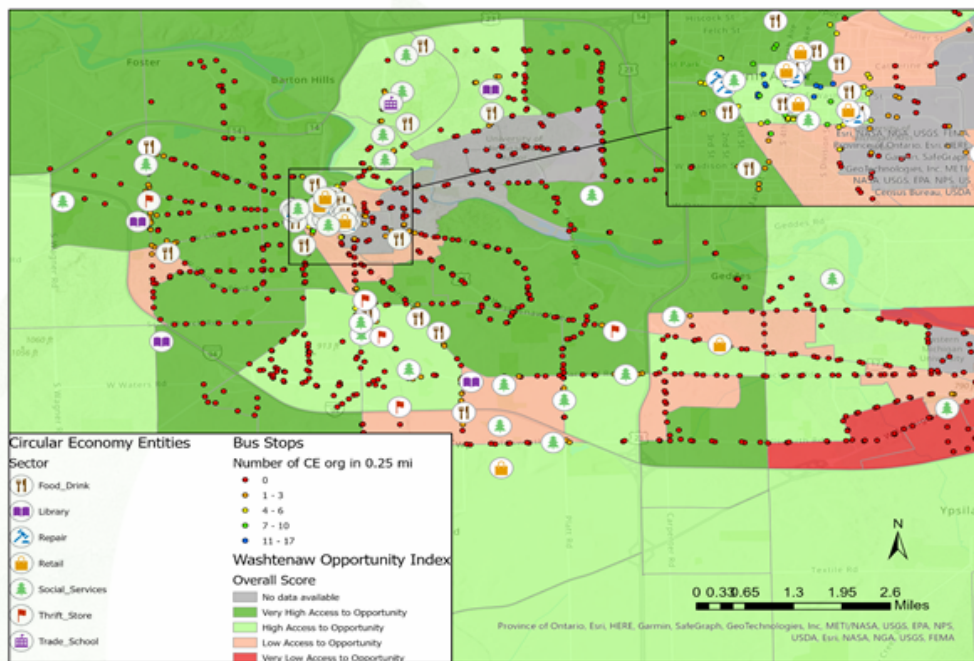


Figure 9. Accessibility analysis: Map showing current CE entities, current AAATA bus stops, with a background of the Washtenaw Opportunity Index ratings of each census tract in Ann Arbor.

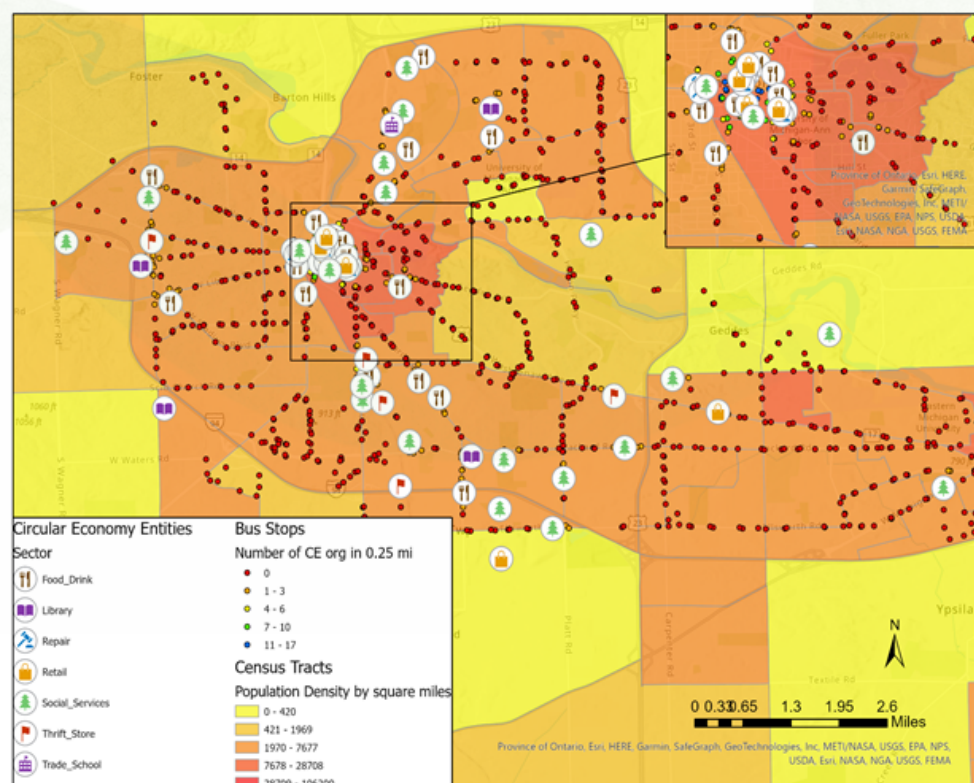


Figure 10. Accessibility analysis: A map showing current CE entities, current AAATA bus stops, with a background of population density (number of people per square mile).

Presenting the city's circular economy in the form of locator map and GIS Story Maps are an effective way to integrate circular economy digital datasets into an accessible framework that is suitable for outreach and interactive public engagement. As a result, the circular economy locator map is currently the most visited (719 times as of October 2022) component of the city's CE website. CE interactive map has been found to be one of the most useful community outreach tools.

These results from the circular economy accessibility analysis (Figures 11 & 12) highlight the importance of city government regularly reviewing how evolving initiatives and plans for the city either compliment or blockade each other. The results show that while Ann Arbor's bus system, TheRide (AAATA) has a robust route structure, zoning regulations prevent the proliferation of CE businesses across and within every neighborhood. This is especially true even in downtown Ann Arbor. When comparing the zoomed-in pop out maps of downtown Ann Arbor in Figures 11 & 12, there is an even distribution of population density across the area, but both CE entities and general access to opportunities are concentrated in 2 census tracts on the west side. One of the City of Ann Arbor's goals for fostering a circular economy is to localize a community's ability to meet everyday needs. If a neighborhood is isolated from both bus stops and businesses, then the CE opportunities of that neighborhood or city will continue to be limited. The findings also show that Ann Arbor's walkability in dense locations such as downtown do not negate the need for access to public transit. Additionally, optimal business locations cannot be determined by proximity to downtown alone, and the need for further analysis determining how many of a particular CE sector exist and where need to be considered in tandem with accessibility to bus stops. For instance, if only 1 route provides access to a CE repair business, finding a direct route on a limited bus schedule could take half a day or more during the weekdays and even longer on the weekend.



Community Outreach

An integral part of the Circular Economy effort in Ann Arbor is community engagement. The goal of this component of the project was to build resilience as a result of increased connections within the community and educational awareness about the concept of circularity. The plan for community outreach involved attending public events and producing a video series, 'Stories of Circularity.'

Key public events attended by the team include the Mayor's Green Fair, Earthfest at the University of Michigan, and a presentation at the Ann Arbor Environmental Commission meeting. Participation at these events and production of video materials served two purposes: highlighting the efforts of local businesses and organizations already spearheading circular economy in the city and serving as a source of education and information about circularity- what it means, where one can find it in the city, and how one can get more involved.

Community outreach as a collaborative effort between the SEAS Student team, City of Ann Arbor team and CTN Ann Arbor started with producing a [promotional video](#) for dissemination in the community. "Stories of Circularity" is a series of videos created from the interviews that were conducted with local business owners and organization leaders and footage from the physical locations. The interviews were conducted, in part, to design the metrics and pilot studies that help us identify the nature of data availability to estimate the expanse of circular activity in the City. Over the course of summer 2022, this collaborative team produced a series of videos about local businesses and organizations such as [El Harissa](#) - a restaurant that serves food in returnable containers as a part of the City's A2R3 (Ann Arbor Reduce, Reuse and Return) program and [Just Help Yourself Day](#)- a neighborhood-led effort at swapping things instead of discarding and buying new items. These series of videos comprise the "Stories of Circularity." All of these videos are available for the public on CTN Ann Arbor's YouTube channel.



Discussion

This project was significant in helping the City of Ann Arbor pursue its 2030 carbon neutrality goals. A circular economy moves us away from focusing only on end-of-life resource management strategies to changes in consumer and producer behavior that reduce inputs to the waste stream. Making and using products and services has big GHG burdens. CE allows us to do more with less and avoid making new products. Our project addressed an identified gap in theory and practice by inventorying and promoting the circular economy at the city scale. To achieve a truly sustainable and well-balanced alternative to the current linear economic models, we must examine labor practices, human rights, and community well-being (Mies & Gold, 2021).

Moving ahead, we look forward to seeing how our work shared in a myriad of ways, has some kind of impact with a broader network, namely, the dashboard on the City website, public presentations to businesses, community groups, other groups currently active in the traditional linear waste space (e.g. recyclers) and publications in academic journals and gray literature.

Resiliency via increased connections to recover from an adversity is an integral part of the circular economy in Ann Arbor which, by its definition, is relatively novel in its approach. According to a study by Petit-Boix & Leipold (2018), CE strategy implementations at the city level, when successful, make a case study that can be amplified and implemented at state or national level. As a core metric, this may become a steppingstone towards integrating social aspects into the circular economy of a community.

In summary, the concurrent lack of social and equity metrics and indicators across studies as mentioned in our literature review is clearly addressed in this project with the use of resiliency and equity metrics, their respective indicators, and the community engagement component. We believe that this gives a much more holistic view of the circular economy in a city. In addition to the technicalities of decarbonization, the project introduces the concept of circularity to the community with a human lens by showcasing how the city is already a part of a circular economy and the avenues through which community members can engage in and contribute to expanding the circular economy in Ann Arbor.



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We would like to thank all the people who helped us throughout the project. Firstly, we would like to thank SEAS and our clients, John Callewaert, Jennifer Petoskey, and Lisa Disch for the wonderful opportunity to work on this project with the Office of Sustainability and Innovations at the City of Ann Arbor. We appreciate Dr. Richard Helling for his guidance and supervision which has helped this project reach completion. Secondly, we would like to thank Catherine Diggs and Kira Barsten for their support and background work that initially drove this project forward. We are also thankful to Michal Russo and Kat Cameron for their support.

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We would like to express our special thanks to the classmates of our Circular Economy Theme class for their feedback throughout the course of this project and their help with our final report. We are truly grateful to Dr. Michaela Zint for guiding us through the difficulties and uncertainties that we may have faced. Lastly, we are truly grateful for each other and the opportunities to learn from one another during our contributions to different aspects of the project.



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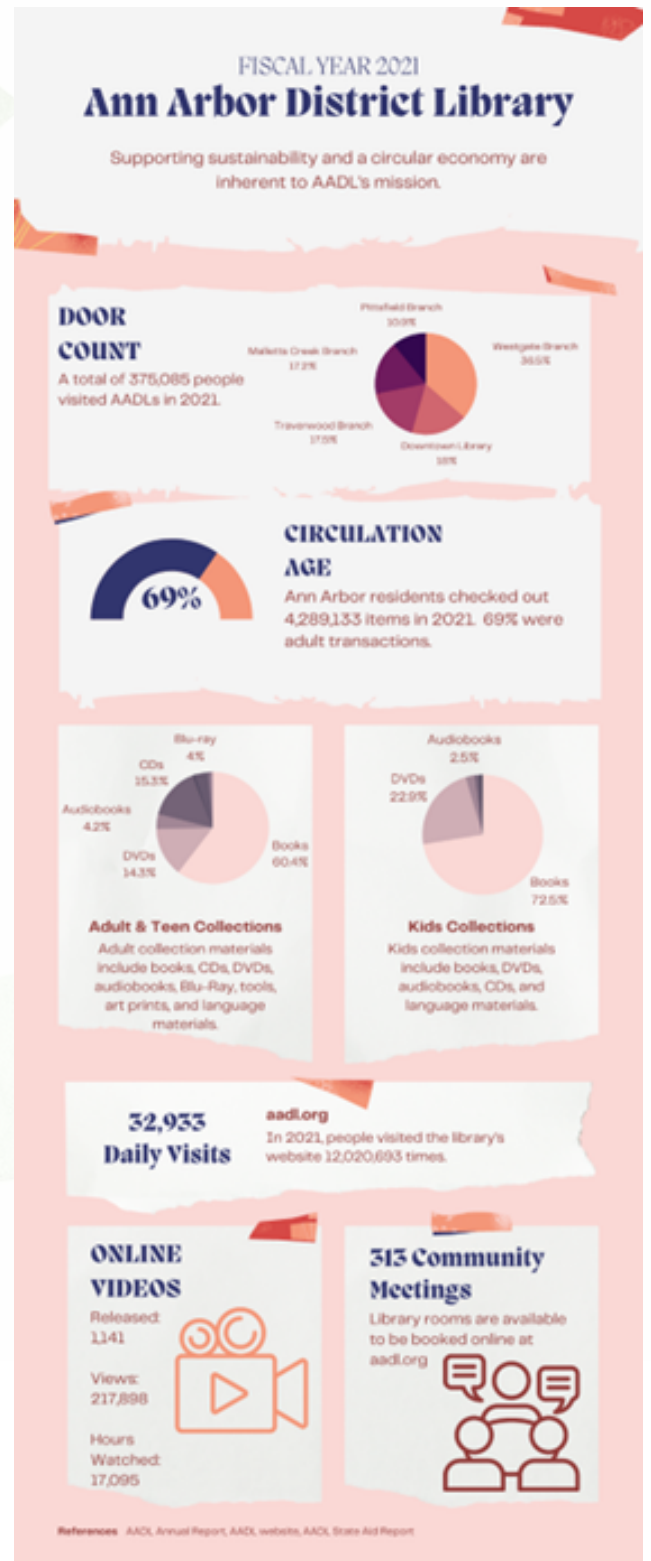
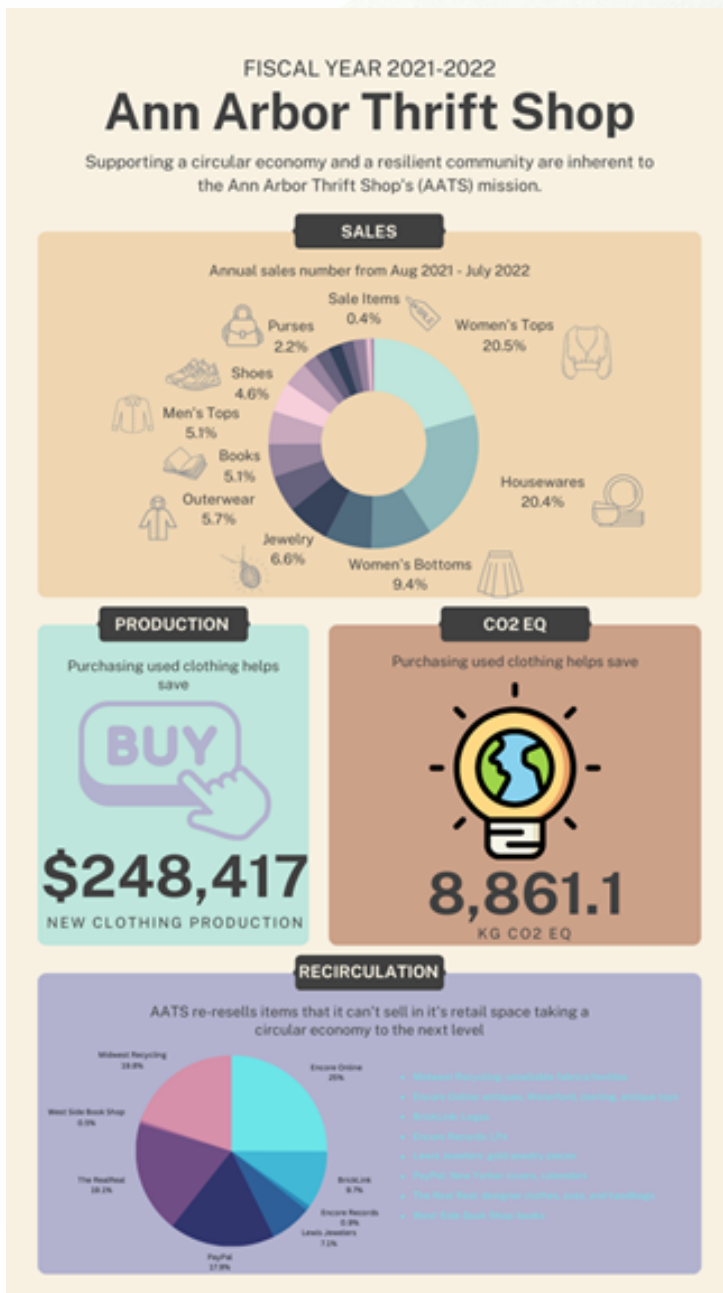
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Appendices

Appendix 1: Pilot Studies Infographics (AATS & AADL)



References: AADL Annual Report, AADL website, AADL State Aid Report

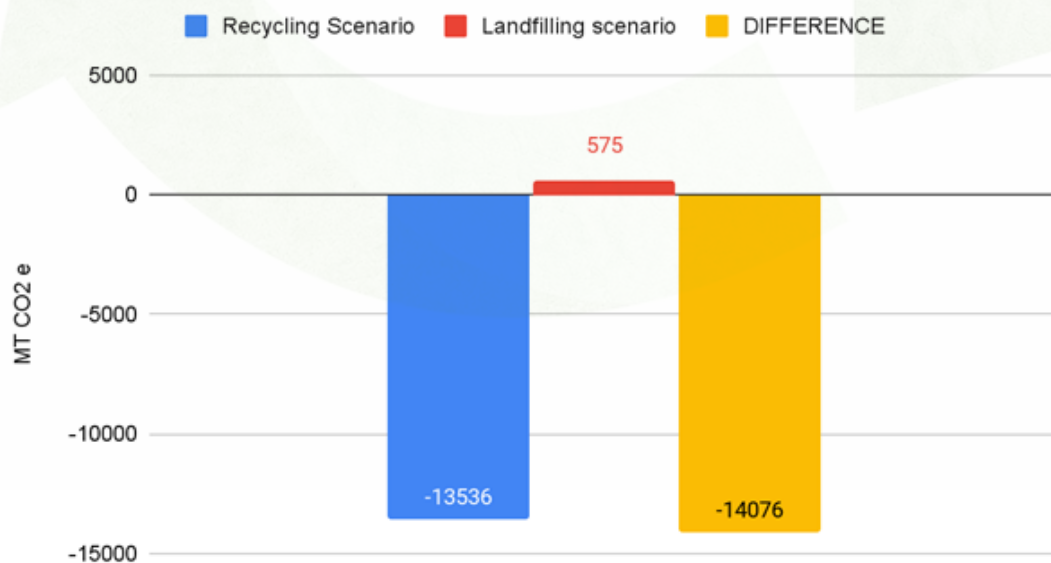
Appendix 2: RAA Pilot Study Tables, Graphs and Calculations

Aseptic Carton Emissions Calculation: Negative values represent virgin material production avoided. All emission factor values in MT CO₂e/ton.

Aseptic Carton Composition		74% paper, 22% polyethylene and 4% aluminum			
		Paper	Polyethylene	Aluminum Cans	Total
	Tons	1.21	0.36	0.07	1.64
	MT CO ₂ e (Recycling)	- 6.07	- 1.04	- 9.13	
	Total Emissions Recycling	- 7.35	- 0.37	- 0.60	- 8.32
	MT CO ₂ e (Landfilling)	0.02	0.02	0.02	
	Total Emissions Landfilling MT CO ₂ e	0.02	0.01	0.00	0.03

*Results take into account landfilling emission values in both cases since there isn't sufficient data available on how RAA recycles Aseptic Carton Emissions (i.e., 0.03 MT CO₂e).

Recycling vs Landfilling (MT CO₂e)



Cumulative results from end-of-life multi-commodity emissions analysis (details in Figure 7)

Results from end-of-life multi-commodity emissions analysis

	Recycling Scenario (From WARM Model V 15)	Landfilling Scenario ((From WARM Model V 15)		
Commodity	Recycling Scenario Emissions	Landfilling scenario Emissions	DIFFERENCE	
Cardboard # 11	- 3489.31	200.02		
Mixed Paper	- 9508.08	187.48		
Steel Cans	-160.65	1.76		
Aluminum Cans	- 129.40	0.29		
HDPE	- 43.01	1.15		
PET	-139.49	2.73		
Mixed Plastics	- 59.04	1.29		
Aseptic Cartons	0.03	0.03		
Mixed Glass	-173.75	14.73		
Residuals	167.09	167.09		
Total	-13535.61	575.43		- 14111.04

Appendix 3: Inventory Survey

City of Ann Arbor Circular Economy Inventory Survey

Thank you for helping us to measure the circular economy, which your organization is a part of, in Ann Arbor. As you may know, 45% of greenhouse gas emissions are from the consumption of products and materials. If we can reduce the consumption of goods, we can reduce greenhouse gas emissions. We also know that resiliency and equity are inherent to and built by the circular economy. These are values that are important to the City of Ann Arbor and the long term health of our community. In order to showcase their importance, we will be asking for metrics that highlight these aspects of the circular economy. We measure resiliency by looking at connections and skills that enable people to thrive as climate change progresses and equity we see as ensuring everyone has access and equal outcomes or the outcomes that they desire. We will also be asking for dollar amounts to determine the economic impact of the circular economy as well as weights to determine the weight of materials that were diverted from the landfill. While it is very challenging to convert these numbers to greenhouse gas emissions, we hope these metrics will help city staff, policy makers, and the public at large understand the value of the vital work that your organization does. Please reach out to the student team (ce-cityofaa@umich.edu) with any questions about the survey.

None of the following questions were required an answer to submit the survey.

Section 1: Organization Information

What is your name? (Short answer text)

What is your email address? (Short answer text)

What organization or business are you representing? (Short answer text)

All survey takers progress to Section 2.

Section 2: Demographic information - Organization

Tell us about the leader(s) of your business/organization. We are collecting this information to measure the existing diversity of business owners and organizational leaders in Ann Arbor.

Do you live in Ann Arbor? (Multiple choice)

- Yes
- No
- Prefer Not to Say

What is your age? (Multiple choice)

- Under 15 years
- 15-19 years
- 20-29 years
- 30-39 years
- 40-49 years
- 50-59 years
- 60-69 years
- 70 years or older
- Prefer Not to Say

Which identifiers would you use to describe yourself? (Checkboxes)

- American Indian or Alaska Native
- Asian
- Asian Indian
- Black or African-American
- Chamorro
- Chinese
- Filipino
- Japanese
- Korean
- Native Hawaiian or Pacific Islander
- Samoan
- White
- Middle Eastern or North African
- Hispanic or Latinx
- Prefer Not to Say
- Other (short answer text)

What is your gender identity? (Checkboxes)

- Woman/girl
- Man/boy
- Transgender Woman/girl
- Transgender Man/boy
- Gender non-conforming or non-binary
- Prefer Not to Say
- Other (short answer text)

How do you identify your sexual orientation? (Checkboxes)

- Asexual
- Bisexual
- Heterosexual or straight
- Homosexual or lesbian or gay
- Pansexual
- Queer
- Same-gender loving
- Prefer Not to Say
- Other (short answer text)

All survey takers progress to Section 3.

Section 3: Demographic Information - Clientele

Tell us about the people you serve. We are collecting this information to see if circular economy opportunities are available and accessible to all residents of Ann Arbor.

What is the approximate total number of people you have served since January 2022? (Short answer text)

Do you keep systematic records of the demographics of the population you serve? (Multiple choice)

- Yes (takes survey taker to Section 4)
- No (takes the survey taker to Section 5)

Section 4: Demographic Information - Clientele cont'd

Tell us about the people you serve. We are collecting this information to see if circular economy opportunities are available and accessible to all residents of Ann Arbor.

What percentage of the people you serve live in Ann Arbor? (Short answer text)

What is the age makeup of your clientele? (Short answer text)

What is the gender makeup of your clientele? (Short answer text)

What is the racial/ethnic makeup of your clientele? (Short answer text)

Is there any other information about your clientele that you would like to share with us? (Long answer text)

Survey takers who complete this section progress to Section 5.

Section 5: Sectors

Which sector best describes your business or organization? (Multiple choice)

- Restaurant/Food (takes survey taker to Section 6)
- Rental/Sharing/Social Services (takes survey taker to Section 7)
- Repair/Maintenance (takes survey taker to Section 8)
- Education (takes survey taker to Section 9)
- Other (short answer text - takes survey taker to Section 10)

Section 6: Restaurant/Food

When you think of the circular economy, think of food redistribution and growing local that build resilience and equity through access to local, healthy food. As you may know, food production, especially at scale, is fossil fuel intensive. Anything that maximizes the use of food reduces greenhouse gas emissions.

Has your business switched from plastic disposable items (cutlery, plates, napkins, to go containers, etc.) to a compostable option? If yes, how much money have you saved (put a negative number if you have incurred a cost) by this switch since January 2022? (Short answer text)

Has your business switched from plastic disposable items (cutlery, plates, napkins, to go containers, etc) to a compostable option? If yes, how much estimated weight (pounds, gallons, etc..) of disposable waste have you prevented by this switch since January 2022? (Short answer text)

Has your business switched from disposable items (cutlery, plates, napkins, to go containers, etc.) to a reusable option? If yes, how much money have you saved (put a negative number if you have incurred a cost) by this switch since January 2022? (Short answer text)

Has your business switched from disposable items (cutlery, plates, napkins, to go containers, etc) to a reusable option? If yes, how much estimated weight (pounds, gallons, etc..) of disposable waste have you prevented by this switch since January 2022? (Short answer text)

If your organization has not made the switch to compostable or reusable items, are you interested in making this switch? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If interested, what challenges or barriers have prevented you from making this switch? (Long answer text)

If interested, what assistance would support you with this switch? (Short answer text)

Do you sell items in bulk? (Multiple choice)

- Yes
- No
- Other (Short answer text)

Do you encourage customers to bring their own containers? (Multiple choice)

- Yes
- No
- Other (Short answer text)

Do you donate any food to local non-profit or food recovery organizations? (Multiple choice)

- Yes
- No
- Other (Short answer text)

Survey takers who complete this section progress to Section 10.

Section 7: Rental/Sharing/Social Services

When you think of the circular economy, think of social services, which employ reused goods to help house and resettle people. Many times, these organizations trade goods amongst each other; a circular economy in miniature. These organizations build equity and resilience in communities.

Does your organization facilitate a sharing or rental program? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If yes, how many items have been shared or rented by community members or organizations since January 2022? (Short answer text)

If yes, how many community members or organizations have participated in this program since January 2022? (Short answer text)

Do you keep systematic data of the number and description of items that you rent/share? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If yes, would you be willing to share a description of the items and the number of people who shared/rented them so we can calculate the \$ of purchases avoided by your program? (Can be a spreadsheet, information flier, document, etc.) (File attachment)

What are some barriers and challenges you've faced when implementing and/or running your rental or sharing program? (Long answer text)

What are some things that would help your rental or sharing program? (Short answer text)

Survey takers who complete this section progress to Section 10.

Section 8: Repair/Maintenance

Repair is a critical part of extending the life of goods, reducing the need to purchase new, and thus, reducing greenhouse gas emissions. It also builds local economies and businesses.

How many people or organizations have used your repair service since January 2022? (Short answer text)

How many items has your service repaired since January 2022? (Short answer text)

What types of items do you repair? (Long answer text)

Do you keep systematic data of the number and description of items repaired and/or maintained? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If yes, would you be willing to share with us a description of the items that you have repaired since January 2022 so we can calculate the dollar value of purchases avoided by your service? (File attachment)

Survey takers who complete this section progress to Section 10.

Section 9: Education

Education is an important aspect of the circular economy. Those that are involved with providing people resources to repair their own goods or prolong the life of their resources (like freezing or canning food) are vital to this work.

Does your organization create DIY guides? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If yes, how many different guides do you have? (Short answer text)

If yes, how much has your guide(s) been utilized since January 2022? (How many physical copies do you give away/sell? How many views if on an online platform?) (Short answer text)

If your DIY guides are hosted online and available to the public, please share the link here: (Short answer text)

Does your organization put on learning workshops (virtual or in-person)? (Multiple choice)

- Yes
- No
- Other (Short answer text)

If yes, how many workshops have you hosted since January 2022? (Short answer text)

If yes, how many participants have you had since January 2022? (Short answer text)

Survey takers who complete this section progress to Section 10.

Section 10: All Sectors

How much material would you estimate that you have diverted from disposal in a landfill by implementing sustainable strategies (reuse, repair, redistribute, recycle, compost, etc) in your organization or business since the beginning of January 2022? (can be measured in pounds, yards, gallons, number of items, etc.) (Short answer text)

How many local businesses or organizations does your organization or business interact with in order to complete its normal operations (sourcing local, rerouting unusable goods to different organizations, partners, etc)? Local for us means within 250 miles of Ann Arbor. (Short answer text)

How many full-time employees does your organization or business have? (Short answer text)

How many part-time employees does your organization or business have? (Short answer text)

How many volunteers does your organization or business have? (Short answer text)

What percentage of your paid employees are members of a union? (Short answer text)

What percentage of your paid employees make at or above the Michigan Living Wage (\$16.36/hour)? (Short answer text)

Does your organization or business help secure housing for its employees or community members? If yes, how many people have you helped gain housing security since January 2022? (Short answer text)

Does your organization or business help secure food for its employees or community members? If yes, how many people have you helped gain food security since January 2022? (Short answer text)

Does your organization or business help secure food for its employees or community members? If yes, how much food (can be in weight or # of items, but please indicate the units in your answer) have you supplied since January 2022? (Short answer text)

Is there anything else that you would like to share with us about your organization's contribution to decarbonization, equity, resiliency or the community? (Long answer text)

Any additional comments you would like to share with us? (Long answer text)

Any additional data or materials you would like to share with us? (File attachment)

If you would like to see the compiled results of the survey (with identifying information redacted), please re-enter your email address. (Short answer text)

Appendix 4: BIPOC-Owned Business Inventory

Stakeholder engagement and community outreach is a main part of the City’s CE strategy. Over the summer of 2022, Brooke created a comprehensive inventory of BIPOC-owned businesses in Ann Arbor and surrounding areas. This inventory will help the City center resiliency and equity by intentionally including and supporting minority entrepreneurs. Brooke helped contact and conduct interviews with some of these businesses to learn more about their circular and sustainable business practices.

Appendix 5: Circular Economy Actions Tracker

The CE action tracker is the tool used to track key takeaways from the interviews with organizations including gaps, needs and aspirations for strengthening CE. In addition, the corresponding plans were documented on City helping to reduce barriers to CE, enhancing CE Networks, and potential metrics to measure impact. 30 CE actions have been planned so far, categorized as 7R (Rethink, Regenerate, Recover, Rethink, Reuse, Recycle, and Reduce), also ranked by its influence level (from local to nation, from business to non-profit). Over the course of the project, we helped the City update the tracker with information from interviews and meetings. The City will take over maintenance and implementation of these suggestions.

Action	Which R	Sphere of Influence	Levers of Change 1	Lever of Change 2	Lever of Change 3	Idea Source	Notes
Divest in fossil fuels	Rethink	Local	Policy				Sam F. looks like it was looked at, but maybe not followed up on? https://3rsmiscouncilonline.com/2013/10/22/ann-arbor-circular-economy-checklist/index.html
Make sure our procurement policy is in line with circular practices	Regenerate	Local	Policy				TY: Would like to see our EPP strengthened to require an evaluation (at least)
Training and partnerships with large employers	Recover	City Influencing Community	Capacity Building	Collaboration/Partnerships	Social Equity/Inclusion	AATS Interview takeaway	ZJ: Create mentorship opportunities by connecting people experienced in this industry to people who are aspiring to grow an initiative.
Educational Campaigns/challenges (1.5 degree life case study)	Rethink	City Influencing Community	Outreach/Education				TY: The "flexible sustainable lifestyles" also seems to encompass the 12R3 pitch - making information easy to find and activating, tracking and sharing impacts
Create and support online platforms for reuse and sharing	Reuse	City Influencing Community	Technology				Sam F. says I overlapped this some with row 17, p2p sharing network. Maybe a Q is if this is city-run or just supported
Design for disassembly (city requirements on developers)	Reuse	City Requirement for Community	Law				Sam F. this struck me too. I believe Palo Alto has banned demolition, which IMCO is a better more aggressive step as it covers current structures, not just newly built ones.
dumpsters in neighborhoods that have spots for white green and brown glass as well as paper. Common in Germany	Recover	City Requirement for Community	Policy				Not sure how much this would help our MRF, maybe it's good at it already
E waste recycling pilot	Recover	City Influencing Community	Programs				TY: I'd like to learn more about what isn't working with our current e-waste recycling programs at Best Buy, Recycle Ann Arbor, and the Reuse Center
Eliminate mowing on city land	Regenerate	Local	Policy				
Support Local Producers via marketing and incentives	Reduce	City Influencing Community	Programs				TY: Agree, would love to learn more about what support is needed to activate businesses as well as looking to opportunities to facilitate third-party innovation rather than taking everything on as the City
Design infrastructure and the built environment for resource efficiency	Reduce	City Influencing Community	Technology				Really like the idea of reducing water consumption through gray water and other initiatives like Guelph, Canada
Help residents replace turfgrass lawns	Regenerate	City Requirement for Community	Programs	Infrastructure			Sam F. maybe model on Washenaw County's support for rain gardens - it would be a nice complement to that
Incubate a P2P sharing network	Rethink	Local	Technology	Outreach/Education		Argus Fam Shop's suggestion: Thrift anything- make friends in a thrift shop Partners Meeting - people need an "on ramp" to circular economy activity that mimics how they access resources through the linear economy	Sam F. The "Buy No things" Facebook groups demonstrate the interest but Facebook as the platform limits their efficacy ZW: Potential collaboration with thrift shops/ have the platform info circulated via thrift shops Community Action Network. Things they are doing parallel what AA Thrift Store is doing
Phase out turfgrass management tools (gas-powered lawn equipment, pesticides, fertilizers)	Regenerate	Local	Law				These would be gradual prohibitions on things that lock in consumption of chemicals and fossil fuels. Look to Montgomery County, MD and California among others
Launch a reusable coffee cup program	Rethink	City Influencing Community	Collaboration/Partnerships	Outreach/Education	Capacity Building	Example from Berkeley, CA: https://www.sigate.com/dayana/arnia/berkeley-reusable-coffee-cup-planet-yesssac-streets-14120049.php https://www.nuuniversity.gov/2018/12/12/recycling-events/sale/details.asp	KB: Would want to partner with local coffee shops, could also be piloting with the university. Similar to reusable takeout containers.
Create a citywide Curbside day	Reuse	Local	Law			Outreach/Education	KB: Allow 1-2 days per year where residents can legally leave things out on the curb for free pickup by other residents.
Expand the reusable takeout container program	Rethink	City Influencing Community	Collaboration/Partnerships	Outreach/Education			ZJ: Potential collaboration with local groceries (Argus interested- produce in containers)
Launch Cool Block (or other engagement) program for residents	Regenerate	City Influencing Community	Outreach/Education	Programs			KB: I launched this in Mountain View and it could be helpful for CE activity here
Equity training for residents	Rethink	City Influencing Community	Outreach/Education	Social Equity/Inclusion	Collaboration/Partnerships		CD
Write a grant to increase support to resettlement services with a moving company to provide support for folks relocating							
Cannot Mob - launch map and app, raise money for sustainability grants/BIPOC businesses						Brooke Traxell & Sam Kaiser	
Participate in PR3 standards for reuse	Reuse	Local	Capacity Building			Seattle Reusable Packaging System Design Standard	reusesattle.org
Partner with GAIA or become a member	Rethink	National City Influencing	Collaboration/Partnerships	Social Equity/Inclusion		Cat Diggs	GAIA is a waste justice organization