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# Final Project Report

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## Abstract

The world is running out of the materials vital to societies' operation in its current state. People need to change the way that they live to become more sustainable. The approach in the Netherlands that is continuously being applied is circular economy. Circular economies focus on designing and using products in a way that eliminates waste, preserving the value of resource inputs and extending products lifespans. Implementing a solution that involves diverting waste streams such as food to a path that reuses the nutrients, instead of incineration or landfills is sustainable economically, environmentally, and socially. The implementation of these strategies into Spokane's society is pertinent to preserving resources for the future.

**Sustainable Cities Introduction**

Over the past decades societies have increased the amount of waste they are producing and the amount of material they are consuming, with no end in sight (Lee, 2016). As GDP in countries rises, the amount of Municipal Solid Waste (MSW) produced increases as well (Daskalopoulos, 1998). Parts of the world have begun considering the effects they have on the future generations and have come up with a model, sustainable cities. A sustainable city is a place that has been established in a way where it can provide for its residents indefinitely. The city has to be able to provide human necessities in an environmentally, economically, and socially beneficial way (Odegard, 2022). The development of a sustainable city is constructed in a way that allows it to be repaired indefinitely or deconstructed and reused. Throughout production and use, resources are used in a way that allows them to be reused. When a recyclable material like cardboard is infused with plastic or painted with toxic paint it becomes harder to recycle or reuse. When it comes to resources like water, sustainable cities need to use the resource in a way that does not cause downstream affects. The Wastewater Treatment Plant (WWTP) needs to have effluent water released into the river that does not pollute the water source. When it comes to energy, sustainable cities need to have a renewable source. Many considerations need to be taken into account when looking into renewable energy production. Considerations include, natural resources needed to start producing energy, the effect of production on ecosystems, and the lifespan of the energy collecting device. With all of these factors, a sustainable city is quite a complicated system to construct.

Systems that provide human necessities like water, waste cleanup, and food need to be running at peak efficiency especially in larger cities. New York for instance has millions of tons of waste that need to be picked up and taken out of the city. The systems in place to remove the garbage are planned in a way that has garbage truck drivers on the optimal route to provide services to the city equitably. The dump that receives the trash also must be designed so that it won't ever leach pollutants into the environment and cause harm to the surrounding ecosystems. Many dumps are designed in a way that allows them to be encapsulated and used later on as viable land for construction. A dump near the city of Denver was converted into a large park, covering up past waste with something vibrant for the future. The park provided social benefit providing an area

for citizens to exercise and converse with neighbors. The park also increased the property value of the surrounding land as it was no longer neighboring a dump, providing an economic gain.

**Social**

Allowing for social interaction is one of the main components of a city that allows the city to run smoothly. Parks, walking and biking paths, and cafes/restaurants allow people to interact with one another throughout the day. Both social interaction and time spent by yourself in these areas allows people to recuperate and keep themselves mentally and physically healthy. Farmers markets and other thrift pop up shops allow people to connect with their communities and buy goods produced from the surrounding areas. Thrift markets allow for unused goods to be recirculated into society decreasing waste and sparking conversation about past fashion. Older clothing also reminds modern society about how poor-quality fast fashion products really are. Fast fashion clothing is bad for the planet, harms less fortunate communities, and promotes consumption-based society.

**Environmental**

Getting food for a city is a challenge especially when trying to locally source from the surrounding areas. Many times, the surrounding area does not produce the quantity, nor the variety wanted within a city. Transporting goods to cities can be harmful to the environment but often times there is not another option as certain areas are not producing food during parts of the year when people still need sustenance. Water can be of similar concern as water flows at different rates throughout the year and people consume water at different rates as well. During summer months people are watering lawns and plants, while during winter months the largest water demand is most likely long showers. In snow melt areas, rivers run rampant during the spring and taper off over the summer, having the least flow during the fall and winter. Many rivers are dammed, and the flows are controlled, allowing for a steadier river year-round. Although, putting a dam on a river has other affects as well, commonly changing upstream water levels and disrupting ecosystems. All solutions in turn have consequences, finding the most effective option is what is needed to continue societies path toward a sustainable future.

**Economical**

Having work for all the citizens in a city has ebbs and flows. As the world continues to evolve some jobs get replaced by machines and algorithms, but where one job is taken away another job replaces it. Industrial factories use to be operated by human workforces constructing all products used by the society. As those factories started to incorporate machines in their place, jobs opened up overviewing the factories, as well as in other fields, relieving people from having to do hard manual labor. Allowing citizens to have fulfilling work that keeps them economically stable is an important consideration for any city planner. Keeping people working allows them to have an income that is taxed, providing money to the government, as well as being dispersed back into the community through local businesses. Having a continuous flow of money is vital to a city to keep up with maintenance and future projects. It is very difficult to predict the future of economies, thus keeping unemployment relatively low is often the main goal.

**Civil Engineering Contribution**

Civil engineering as a discipline can play a vital role in making sustainable cities for the future. As engineers design buildings and roads, they can promote sustainable ways of life. Creating more bike and walking paths with vegetation can create a pleasant way to traverse a city that is environmentally friendly. Walking and biking as ways of transportation also encourages physical and mental health into design considerations (Peng, 2021). Walking around Amsterdam, you can tell that the city was designed for biking and walking more than it was for cars. Having people walk and bike around allows them to explore all aspects of a city and really connect with the people who live there. Also, designing buildings to be as energy efficient as possible with work, shops, and parks all nearby can incentivize less driving. The design of cities and neighborhoods is very important in that respect because if all essentials are not within walking distance people will tend to drive on a daily basis clogging roadways. Decisions that civil engineers make as they design cities and buildings can have lasting effects on how sustainably citizens choose to live. The way that materials are used and disposed of is also vital in the future as some materials are running low in the natural environment.

The following report focuses on the way industries can function to conserve material and divert waste. The conservation of material occurs on both ends of industry, producers have to make products that are meant to last, and consumers have to use products to their full extent. Waste has many products held within that are currently being sent to landfills or incinerated that can instead

be collected and used to replenish supplies within industries. The rest of the report will start off with a look into how the Netherlands is tackling sustainability and then funnel into some of Spokane's concepts. Then, it will look into a strategy that began in the Netherlands that can possibly be implemented into Spokane's Sustainable Action Plan (SAP).

**Areas of Action**

Sustainable city plans generally have four main areas of focus/action that need to be addressed moving forward. The main area of focus in this report is waste diversion and material conservation, which aims to decrease the amount of material being thrown away (SAS, 2021). Waste diversion and material conservation plays a role in sustainability by encouraging better usage of materials in economic industries, allowing materials to be used by future generations. Waste diversion contributes to environmental sustainability by polluting less waste, and suggesting the three R's reducing, reusing, and recycling. Material conservation and waste diversion also contributes to social sustainability by creating better relationships between producers and consumers as products are constructed to last.

**Netherlands Circular Mindset**

Within the Netherlands waste conservation and material conservation can be summed up by the implementation of a circular economy. Circular economies design products intentionally to eliminate waste by keeping products and materials in use and preserving the value of resource inputs in perpetuity (SAS, 2021). The Netherland looks for solutions that decrease the harmful effect on the environment as well as provide an economic gain to the community. If a solution does not provide economic opportunity either through jobs, product, or the ability to get to work they don't pursue the solution. Along with following guidelines of a circular economies, the Netherlands has the key principles for projects of sustainability, flexibility, and solidarity (Bloeman, 2014). The Netherlands also has begun constructing buildings with the ability to deconstruct and rebuild a different structure in the future, reducing waste from past projects and conserving material. Building out of common materials like concrete slabs or transport containers formed together allows projects to have a second life when they become insignificant. This design and construction process is especially helpful when used in industries that are constantly being revamped and processes are constantly being phased out. A figure describing the circular economy model can be seen in Figure 1.

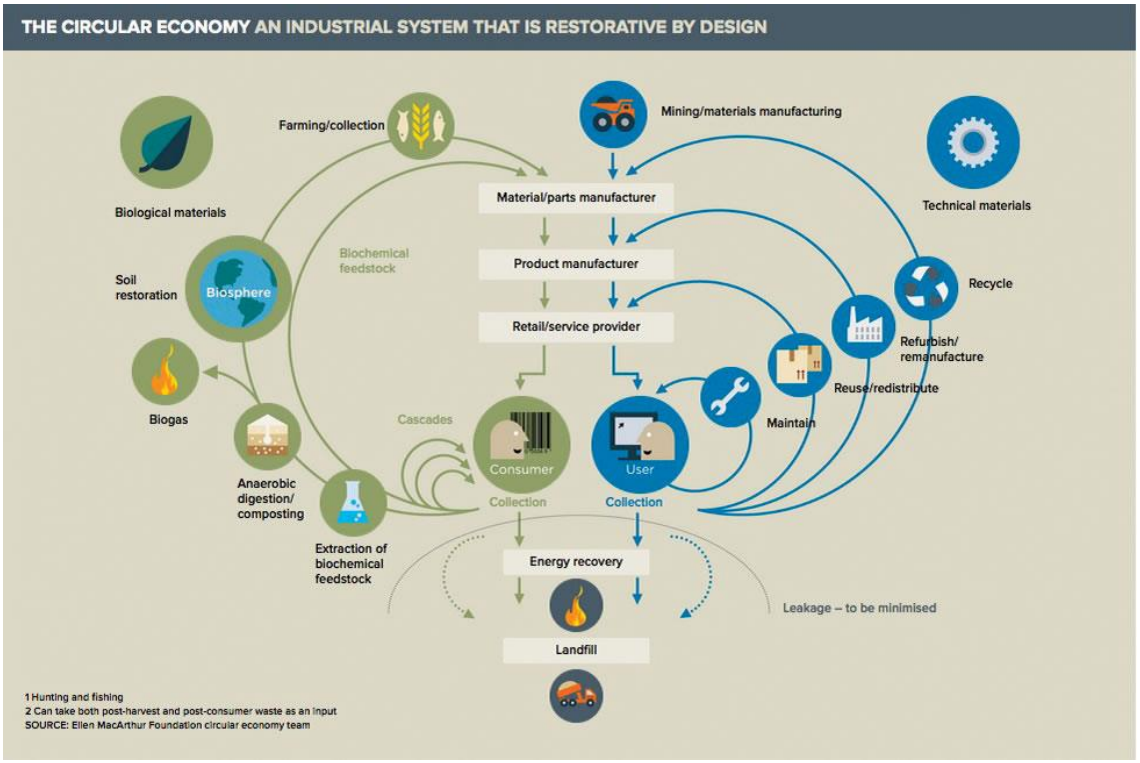


**Figure 1.** Circular economy figure seen in a Netherlands WWTP

Managing waste diversion and material conservation in a sustainable way has the potential to provide utilities to citizens for cheaper, reduce the amount of waste being permanently stored in the environment, and provide jobs and products improving the economy. Following through on the SAP is the difficult part now as some changes citizens won't like in the beginning as it will need additional funding to get infrastructure in place. Getting people on board from the start is quite possibly the only way the action plan will come to fruition.

**Spokane Sustainable Mindset**

Spokane's SAP has two main goals, reducing Municipal Solid Waste (MSW) and boosting economic opportunity by promoting circular waste. Circular waste involves using waste products to generate future commodities for society. The city intends to engage in efforts to change habits of consumption and promote conservation of food, materials, and products. In 2018 Spokane produced 310,677 tons of trash, all of which being burned at the Waste to Energy (WTE) plant or placed into a land fill (SAS, 2021). The WTE plant in Spokane is one of the top greenhouse gas emitters in the state of Washington, but the process produces less greenhouse gas then if the waste was placed into a landfill. Dealing with waste is far less efficient than reducing, reusing, or

recycling the material to begin with. An action in the SAP is to start a composting system for inedible food and yard waste as well as to promote compostable packaging. The compost will divert all organic waste back into the ecosystem in an environmentally friendly way, producing fertile soil for agriculture. Spokane also hopes to put systems in place that will divert edible food to community members in need as well as informing citizens on ways to reduce food waste on a daily basis.

The SAP intends to incentivize the production of durable goods that use compostable or recyclable packaging. The recycling system in current times is not effective at receiving multiple types of material intended to be input back into the economy. Spokane would like to transform recycling infrastructure to maximize material separation and recovery, reducing contamination between materials. Also, they would like to conduct a community that supports sharing and exchange within the economy. An example of this being tool sharing systems that allow residents to rent or share nicer tools when needed instead of everyone owning their own cheaper, less durable tools. The SAP intends to have an industrial symbiosis program to create circularity in manufacturing, having producers become responsible for what happens to the material used in a product when it is being disposed of. A statewide waste management solution in Washington intends to reduce waste including an extended producer responsibility policy. The next section of the paper will include a strategy that communities in the Netherlands have focused on, finding solutions to directly use organic waste.

**Action Plan Strategy**

Within the Netherlands citizens are focused on altering the way that their society operates. One organization in particular, within Rotterdam, called Blue City operates as a start up haven for circular economy entrepreneurs. Only businesses that have a model of transforming waste into a commodity are accepted into the “city” (Schellekens, 2022). As the business ideas plan to change the industry they are entering, they need backing to stay afloat as they convince people to switch to the sustainable option. One company that in some ways laid the foundation for future entrepreneurs was RotterZwam. RotterZwam is a company that collected coffee grounds that were traditionally being thrown away and stated using the grounds to grow Oyster mushrooms to sell back to the community. In recent years they have determined that a majority of coffee is

consumed at home. Therefore, they have begun selling grow kits to allow residents to grow the mushrooms from their own coffee waste stream, shown in Figure 2.


**Figure 2.** Home grow kit produced by RotterZwam

RotterZwam, as well as taking a portion of the organic waste from the waste stream, produces a fertile material from the waste material of the mushroom production as the mushroom substrate is full of nutrients. Lastly, the mushrooms provided to the community are grown regionally cutting down on transportation, providing the commodity for cheaper to the surrounding citizens.

Taking coffee grounds out of the waste stream, as well other forms of food waste, will reduce the amount of energy consumed by the waste energy plant. The food waste is saturated with water and is uneconomical to burn for energy. The energy plant will be more efficient, and businesses will have the opportunity to grow produce using resources from the waste stream, a cheap resource. All waste that is processed through the waste energy plant produces ash waste that is sent to a land fill. Removing food waste from the stream reduces the amount of material being put into landfills by roughly 30% (Buzby et al, 2014). Dealing with the waste stream in the US takes millions of tax dollars and creates millions of tons of greenhouse gas emissions. Having a source of fertile soil and having to deal with less waste can reduce the cost of living for citizens. Lower cost of living allows citizens to spend more of their income on things that make life more

enjoyable. Removing organic waste from the waste stream is an economic, environmental, and social benefit to society.

Specifically within the Spokane SAP, supporting businesses that are based on using waste streams to create products meets both goals within the material conservation and waste reduction section. The first goal involves investing to reduce the volume of MSW that needs to be processed and sent to landfills (SAS, 2021). Having businesses step in and take portions of the organic waste out of the stream would assist the waste management system. The city is planning on implementing a composting system supplying bins to households to cut organic waste out of the waste stream. The additional infrastructure and labor needed to process the waste would be an economic burden on the state, at least to begin with. Providing subsidies or some other kind of support to circular waste business models could be a cheaper option that is an economic benefit to both parties. The implementation of compost will divert all organic waste back into the ecosystem in an environmentally friendly way, producing fertile soil for agriculture. The second goal of the material conservation and waste reduction section is to boost regional economic opportunity by promoting circular waste programs (SAS, 2021). This goal goes hand in hand with the strategy of promoting startups with similar ideas to the Netherlands company, RotterSwam. Spokane also hopes to put systems in place that will divert edible food to community members in need as well as informing citizens on ways to reduce food waste on a daily basis. In the US it was calculated that 167K tons of produce could be diverted from waste to discounted use. The diversion of edible food would save consumers a total of 37 million dollars annually (ReFED, 2016). All solutions will help lessen the amount of resources needed to deal with the waste stream produced by the city.

In the US there are definitely those who try to eat sustainably produced products and support businesses that are environmentally friendly. Although, from the small time that I spent in the Netherlands I feel that they are more unified in sustainable practices compared to the US. The Netherlands tends to still think economically as well, making sure that a strategy will provide to the three pillars of sustainability. In the US finding businesses that are not strictly economically driven is harder to come by, which I think may be a challenge when translating the strategy to Spokane. One of the other problems with implementing the strategy is organic waste cannot be combined for some business models, such as mushrooms grown on coffee grounds. Therefore,

once a composting system is implemented, that waste will be too contaminated to be used for any other purpose. In conclusion, the strategy may be slightly idealized and a mass collection system like compost is the smarter plan.

**Conclusion**

Getting people to think with circular processes in mind is important moving forward if the societies are ever going to become sustainable. Focusing on cities in particular is vital as every place has different requirements that need to be met and thus different solutions are necessary. Civil engineers have influence over how a city will operate and how sustainable it will be. Having a waste management system that disposes of organic waste in other ways, rather than incineration or directly into the land fill, will be important to increase the efficiency of the waste to energy plant. Any reduction in the waste stream that can be made is a step in the right direction. Looking for companies that are converting waste into commodities to support in the community is the most direct way to reduce waste. Getting the compost system implemented into the community is vital to keep nutrients of the waste from being incapsulated into landfills and lost forever.

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