CivE 230 Assignment 5

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Assignment 5

Question 1

In 2010, wine packaging was analyzed with a LCA to minimize impacts. While glass is the historically conventional option, it wasn't clear if it was the most environmentally conscious option. 0.75 L PET bottles, glass bottles, bag-in-box, stand up pouch, and beverage cartons were all compared. Beverage cartons were found to have the lowest impact on the environment. This knowledge can help wineries be more sustainable with their packaging and give consumers the ability to choose a better alternative to glass bottles.

<https://assets.tetrapak.com/static/documents/sustainability/lca-nordic-wine-comparative-2010.pdf>

Question 2

Based on Lansink's Ladder, I find the Polystyrene cup to be largely more advantageous.

Figure 1: Lansink's Ladder

For part **A**, material usage is prevented by switching to the polystyrene instead of the paper. Polystyrene also requires less electricity to be produced. This

makes the production process more efficient. For **B** and **C**, the polystyrene cup is far superior to the paper cup. The paper cup is difficult to reuse due to its poor structural composition, and is tricky to recycle because of the hot melt adhesive used. On the other hand, polystyrene cups are excellent for reusing and recycling. For **D** and **E**, both options can be cleanly incinerated. However, the polyfoam cup has a better mass-energy ratio. The 8.3g cup provides heat recovery of 170 MJ, while the 1.9g polyfoam cup provides 80 MJ of recovery. Now, for the last component **F**, paper cups appear more ideal. Both take up a similar volume, but the polyfoam does not biodegrade while the paper does. However, I do not think this is as important because as the Lansink's ladder suggests, landfilling should be last-resort.

Question 3

Planetary boundaries are like the asymptotes on a graph that humankind is unable to cross due to the constraints of land, energy, population, and an abundance of others. This means that growth of different industries is unsustainable over time large assuming "business as usual". Some of the most notable sectors include industrial output, food per capita, global services, and human population growth. Donella Meadows, Dennis Meadows, Jørgen Randers, and William Behrens are credited with sparking interest into this concept through the publishing of *The Limits to Growth.*

Question 4

Scopes 1, 2, and 3 all contribute to the overall emissions caused by a product or service. **Scope 1** refers to all direct emissions caused by the activities of the company such that the company has control over the amount of emissions. **Scope 2** refers to all indirect emissions caused by outside electricity production that is purchased and used by a company. **Scope 3** refers to all other indirect emissions caused by the activities of the company such that the company has no control over the amount of emissions.

Question 5

Study: Eriksson, O., Hadin, A., Hennessy, J., & Jonsson, D. (November 2016). Life Cycle Assessment of Horse Manure Treatment. *Energies, 9*(12), 19. https://doi.org/10.3390/en9121011

The **goal** of this study is to explore how horse manure can shift from contributing waste to providing renewable energy and nutrient recycling. It accomplishes this by analyzing the environmental impacts of anaerobic digestion, unmanaged composting, managed composting, large-scale incineration, and small-scale incineration of manure.

LCA Framework

Boundaries: Starts with manure and woodchip collection, ends with disposal options

Goal: To determine the environmental performance of manure when used for renewable energy

Inventory

Parameter	Unmanaged	Managed	Small Scale	Large Scale
10000 tonnes horse dung				
5000 tonnes woodchips				
Composting input				
Input Oil (L/tonne)	0	3.3		
Air emissions %				
NO_2	0.25	0.27		
NH_3	10	2.78		
CH_4	2	0.86		
Water emissions %				
N	0.3	0.01		
NH_4	0.004	0.01		
NO_3	0.033	0		
P	0.07	0		
Heat (MWh)	2.0	2.0	1.6	0
Electricity (MHh)	0.25	0.4	0	0.25
Incineration emissions				
CO			1.1281 kg/tonne	1.42E-5 kg/MJ
Dioxin			0	2.57E-15 kg/MJ
NH_3			0	1.39E-6 kg/MJ
NO_x			0.8179 kg/tonne	1.1E-5 kg/MJ
N_2O				2.18E-7 kg/MJ
Dust				0.66 mg/MJ
HCl				2.12E-6 kg Cl/kg CO_2

Assessment

Global Warming Potential impacted by

- Manure collection
- composting
- heat, fuel, electricity

Acidification impacted by

- incineration
- composting

- heat, fuel, electricity

Air Eutrophication impacted by

- arable land
- composting
- heat, electricity, fuel

Water Eutrophication impacted by

- arable land
- landfill disposal

The **interpretation** that can be drawn is that no clear conclusion can be made towards treatment methods. Further research is required.
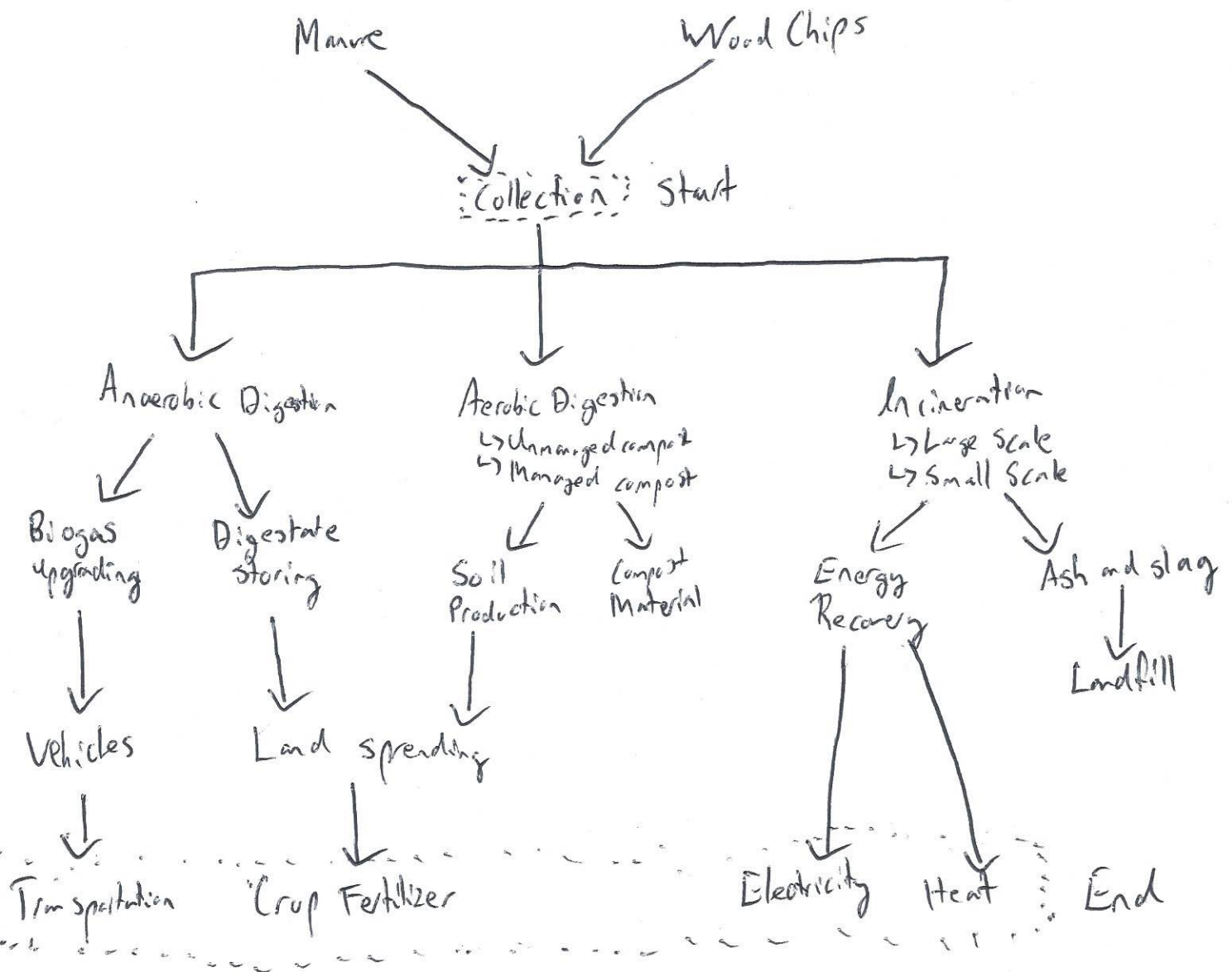
Question 6

I chose to use the website footprintcalculator.org. Here are my exact results:

1. *How often do you eat animal-based products?* Daily
2. *How much of the food that you eat is unprocessed, unpackaged or locally grown?* 20%
3. *What material is your house constructed with?* Wood
4. *How many people live in your home, and how large is your home?* 4 people, 1900 ft^2
5. *Do you have electricity, and how efficient is it?* Yes, average efficiency
6. *What percentage of your home's electricity comes from renewable sources?* 100% (Hydro)
7. *Compared to your neighbours, how much trash do you generate?* Same amount
8. *How far do you travel by car each week?* 50 kms
9. *How fuel efficient is your vehicle?* 11 litres/100 km
10. *When you travel by car, how often do you carpool?* Never

Overall results:

My highest contribution to carbon footprint is through the food I eat (3.3 gha). Here are some solutions I could implement to reduce my footprint:

1. Eat more local. Much of the emissions from food intake are from transportation. By buying all of my food from the farmer's market, I could increase my local percentage from 20% to 100%. This would eliminate most of the emissions due to food transportation.
2. Eat meat with a lower carbon footprint. I have discovered that each serving of beef releases 7.5 lbs of CO_2 into the atmosphere. In comparison, each serving of chicken releases less than 1 lb of CO_2 into the atmosphere. While going vegan might be a stretch, removing beef from my diet might be positive for the climate.

Manure   Wood Chips

```
  Manure              Wood Chips
      \                  /
       \                /
      [Collection]   Start
            |
   _____|_____
  |                |                    |
  v                v                    v
Anaerobic Digestion   Aerobic Digestion      Incineration
                      ⤷ Unmanaged compost    ⤷ Large Scale
                      ⤷ Managed compost      ⤷ Small Scale
```

Anaerobic Digestion
- Biogas Upgrading
- Digestate Storing

Aerobic Digestion
⤷ Unmanaged compost
⤷ Managed compost
- Soil Production
- Compost Material

Incineration
⤷ Large Scale
⤷ Small Scale
- Energy Recovery
- Ash and slag → Landfill

Biogas Upgrading → Vehicles → Transportation

Digestate Storing → Land spreading → Crop Fertilizer

Soil Production → Land spreading

Energy Recovery → Electricity , Heat

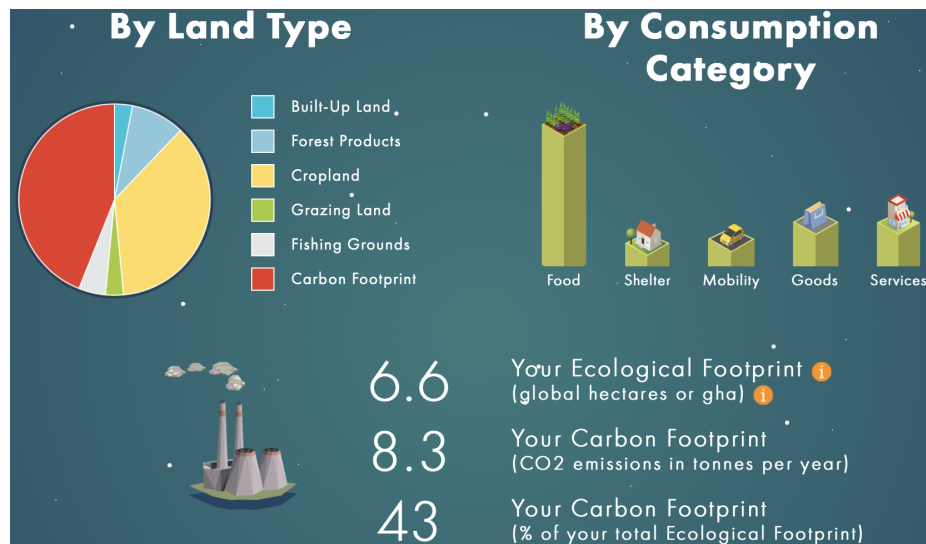Transportation   Crop Fertilizer   Electricity   Heat   End

Figure 2: Result 1

Figure 3: Result 2

3. Start carpooling. Carpooling to school with friends would completely eliminate the emissions that would have come from one vehicle. This is both economical and environmentally conscious.
4. Use public transportation more often. Since I have a car, I rarely consider using public transportation. However, if I start using this locally, the CO_2 emissions that would have been emitted from my car would be negated.
5. Produce less garbage. I enjoy at least 1 or 2 sparkling waters each day. I normally buy them in a can, which requires electricity to produce. In order to eliminate this from the equation, I could purchase a *SodaStream*.
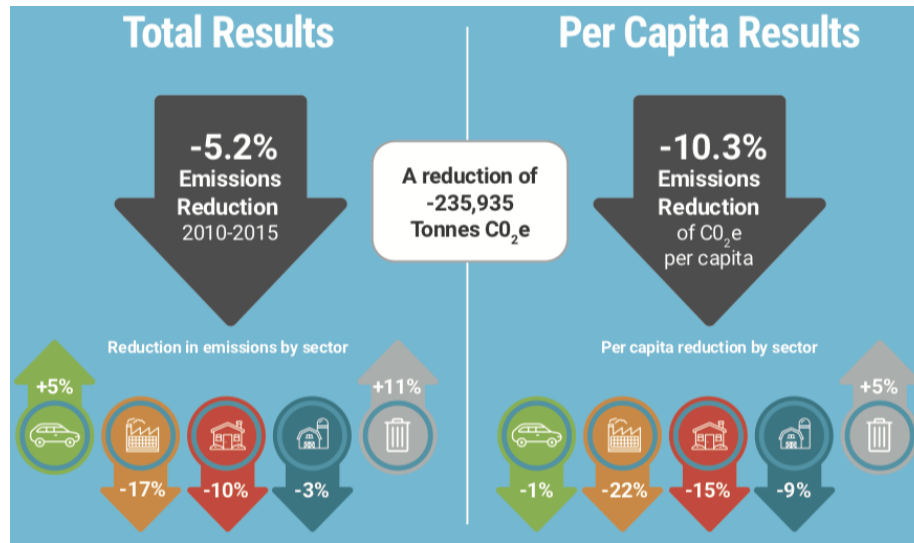
Question 7


Figure 4: Waterloo Results

Workplace emissions (orange) fell by 17%. This is largely due to the removal of coal power plants from Ontario's electricity sourcing. Local energy distributors like Energy+ and Waterloo North Hydro also provided around $ 50 000 000 of incentives towards energy conservation for local businesses. Local initialives like the Regional Sustainability Initiative have also actively helped organizations become more sustainable over this time period.

Transportation emissions (green) saw a 5% rise. While the per capita percentage is lower, it is only due to improved vehicle efficiency. The amount of vehicles owned increased by more than twice the population growth of the region, with 78% being attributed to personal vehicles. These large changes lead to the 5% rise. However, the region has implemented an ION light rail transit system. This will hopefully lower the vehicle purchase rate for years to come by shifting transportation usage from car to public transit. There is also an

ongoing initiative of placing electric vehicle charging ports. This will help make emission-free driving feasible. Other companies, like Carsharing and TravelWise, are also providing economical alternatives to driving through car-sharing.

Question 8

I chose to study Los Angeles, USA. Below are the diagrams:
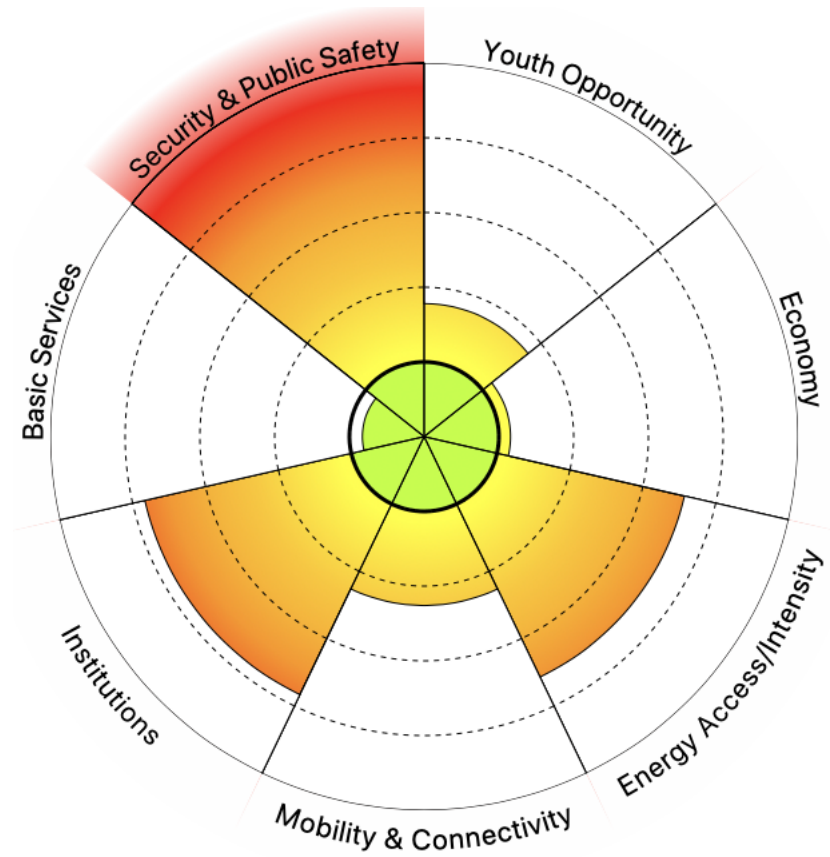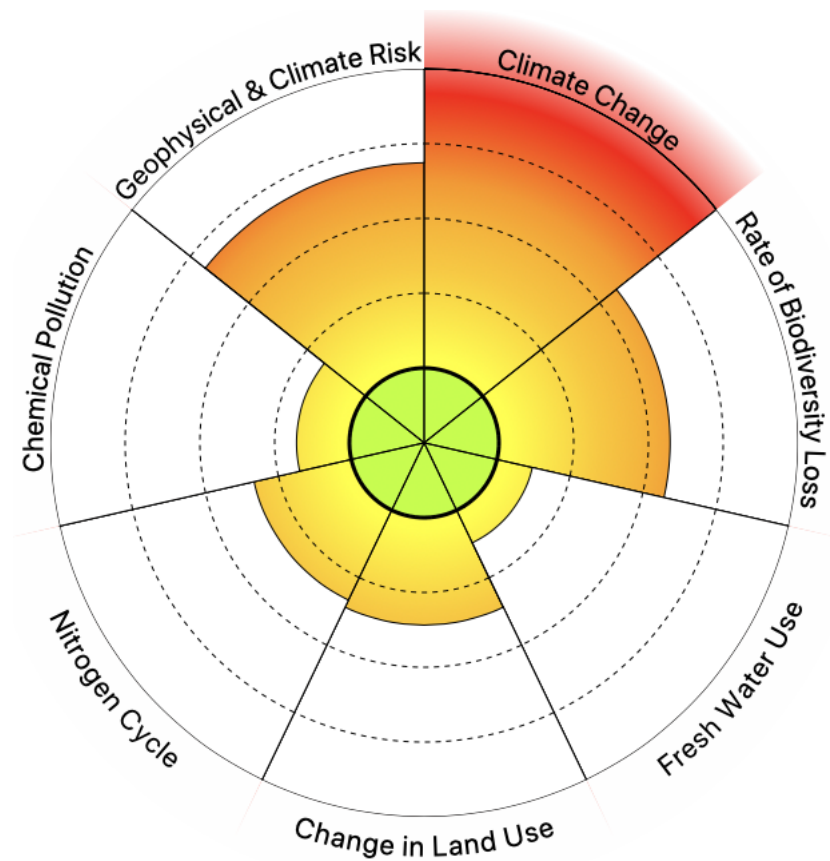
In the bio-physical sphere, climate change has exceeded the safe operating space. The only factor in this category is GHG/capita, which is targeted to be less than $2\ tCO_2$/cap/yr. Los Angeles has a value of 13.

In the socio-economic sphere, security exceeds the safe operating space. This is due to the shocking values below:

Parameter (per 100000/yr)	Target	Actual
Fire-related deaths	<0.5	0.75
Homicides	3	260
Violent Crimes	<500	12996