THE UNIVERSITY OF BRITISH COLUMBIA OKANAGAN CAMPUS

FACULTY OF APPLIED SCIENCE, SCHOOL OF ENGINEERING

APSC 169

Fundamentals of SUSTAINABLE ENGINEERING DESIGN

LABORATORY REPORT 5 – Smart Moisture Sensor

LAB SECTION L2I APSC169 GROUP I1

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Executive Summary:

Water scarcity is becoming common within the Okanagan region as most of the potable water is obtained from lakes and watersheds. In fact, over half the population of Kelowna uses water obtained from the Okanagan Lake (City of Kelowna, 2019). With an increasing amount of population and the need for potable water in the Okanagan region is also increasing exponentially. Acknowledging the scarcity of water available, responsible utilization of water resources has become imperative. Some of the tasks that require high water usage include agriculture, domestic demands such as residential lawns and gardens, cooking, cleaning and industries. According to Okanagan WaterWise, 24% of the water in Okanagan is allocated towards outdoor lawn use (Okanagan WaterWise, n.d). With a lack of knowledge or attention in gardening, overuse of water is very common. Even though most of the rules set by the City of Kelowna and products that assist homeowners with gardening help restrict how often water is used, preventing overuse of water is overlooked. Overwatering plants not only use an excessive amount of water, but also limit the amount of oxygen the roots receive; eventually resulting in the death of the roots and the plant. Therefore, a number of combinations of methods and products were tested to determine the best ways of limiting residential outdoor water usage to prevent overuse.

The goal was to build a product that must reduce the amount of water wasted while watering outdoor plant life, results in better plant growth, and be easier to implement than other products in the industry. We also wanted to have it be affordable for low-income communities in the Okanagan therefore resulting with a bigger impact on the stoppage of water wastage. The team came up with a novel solution that is easy to implement as it is plug and play straight off the shelves. The product has two kits, starter kit and Add-on kit. Starter kit comes in three pieces, two soil sensors and a motherboard and the add-on kit is just extra soil sensors for a bigger garden. The soil sensor needs two AA batteries and the motherboard can be connected straight to an AC power source and your irrigation system box. Once both have been turned on, you may plant the soil sensor in your garden in the driest area. Once they both have connected (blue signal light stops blinking), the motherboard will start recording the soil moisture level every three hours and also the temperature and humidity outside. Using this data, the motherboard will decide when to start the water pump and the waterflow sensor inside the motherboard will decide the flow of the water going out so that the plants get the maximum amount of water needed while making sure that there is no wastage or overwatering. Future plans are to have an app that shows all data to homeowners and also gives owners the choice of setting a benchmark soil moisture level and also choose an interval of data collection, providing more user control.

City of Kelowna: "Water restrictions". (2019, September 12). Retrieved April 6, 2020, from https://www.kelowna.ca/city-services/water-wastewater/water-restrictions
Okanagan WaterWise. (n.d.). Retrieved April 6, 2020, from https://okwaterwise.ca/waterwise-in-the-yard.html

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Background:

There have been numerous ecological charity groups created world-wide attempting to solve a particular universal issue: water consumption. The Earth may appear to be a bottomless wellspring of water, yet in truth, 99% of the water is not accessible for human use (United States Environmental Protection Agency, 2018). The expanding unlimited demand for freshwater is constrained by the scarcity of the resources the world can supply. Furthermore, despite the fact that the hydrological cycle confirms that the water cycle persistently returns water to Earth, it isn't constantly coming back to a similar spot, or in a similar amount and quality (Government of Canada, 2013). Some of the higher areas of water usage in the world include agriculture and even household lawns and gardens. According to the AquaHacking website, in the Okanagan, residential outdoor watering is the second-most elevated use after agriculture, fundamentally on lawns and gardens (AquaHacking - Source of Solutions, 2019). This is a serious concern considering the region's primary potable water sources- the lakes and watersheds- are close to being over-allocated. Furthermore, considering Okanagan's dry climate, these resources can be stretched very thin.

According to the Okanagan Water Board, the average Okanagan resident uses upwards of 675 litres of water per day, making that the highest number in all of Canada. (Okanagan Basin Water Board, n.d.). Regardless of where people live, it is crucial to think about outdoor water conservation, especially in lawn care. Most technological solutions have focused on reducing indoor water use and outdoor water usage has been neglected. If unattended, the ecological system could be disrupted. Groundwater depletion could result in a shortage of water for not only us but also the animals in the Okanagan. Therefore, technology to reduce outdoor water use should be widely used through the Okanagan.

Need Statement:

A way to address the wastage of water while taking care of outdoor plant life in the Okanagan that results in less water wasted but with maximum plant growth.

Justification of Scope:

The initial need statement developed based on the requirements of the AquaHackers Challenge, "A way to address the wastage of water while taking care of outdoor plant life in the Okanagan that results in less water wasted but with maximum plant growth" was broadened with respect to both the problem and population. Based on research it was found that this problem is very applicable to all of British Columbia not just the Okanagan, by broadening the population we are ensuring that we have a bigger market size. It was also found that the problem was not only in residential but a   lso commercial areas such as agriculture, by broadening the area of problem we ensure to not only have a bigger market size but also help reduce a much larger environmental footprint.

Project Requirements:

Functions

- Must reduce the amount of water wasted while watering outdoor plant life- measured in litres
- Must result in better plant growth - measured in quality of plantlife
- Must be easier to implement than other products in the industry - measured with surveys regarding the ease of installation
- Must be affordable for low-income communities in the Okanagan - measured in dollars
- Must be able to adapt to commercial users such as agriculture, resorts, hotels and golf courses

Objectives

- To minimize the amount of water wasted in overwatering- measured in litres
- To maximize consumer satisfaction with the product- measured in customer response to surveys
- To minimize overall cost- measured in dollars
- To maximize plant growth- measured by plant size and yield
- To maximize ease of use- measured in the number of steps and consumer response to surveys

Constraints

- Must obey the City of Kelowna’s water act
- Must meet the provincial groundwater protection regulations
- Must meet the provincial environmental regulations
- The prototype must be under $100 - measured in Canadian dollars
- Must be completed by April 8, 2020.
- Must meet the federal agriculture regulations

Stakeholder analysis:

Shareholders/ investors(Candian Tire, Home Depot and Lowe's)- Organizations and individuals with an interest in reducing water usage would be the first to come to mind when thinking on who may be interested in investing. These investors would primarily need to have an affinity for the environment and reducing the impact people have on the world. Must maintain financial support from investors, they are potentially one of the most important factors when starting a business.

Consumer(Homeowners and Farmers)- The consumers would be anyone with a yard that is interested in or required to monitor their water usage. These could be front yards or even golf courses. They are the primary target we want to sell our product too, and their opinions and view of the design could either get new customers or keep potential new ones away.

Environment(Ministry of Environment BC)- an important part of designing the product is making sure that it will not harm or change the environment in a negative way. To ensure this the products and materials used in manufacturing are non toxic after the product is ready. Main goal of reducing water usage is to improve ecosystems as well as keeping yards green.

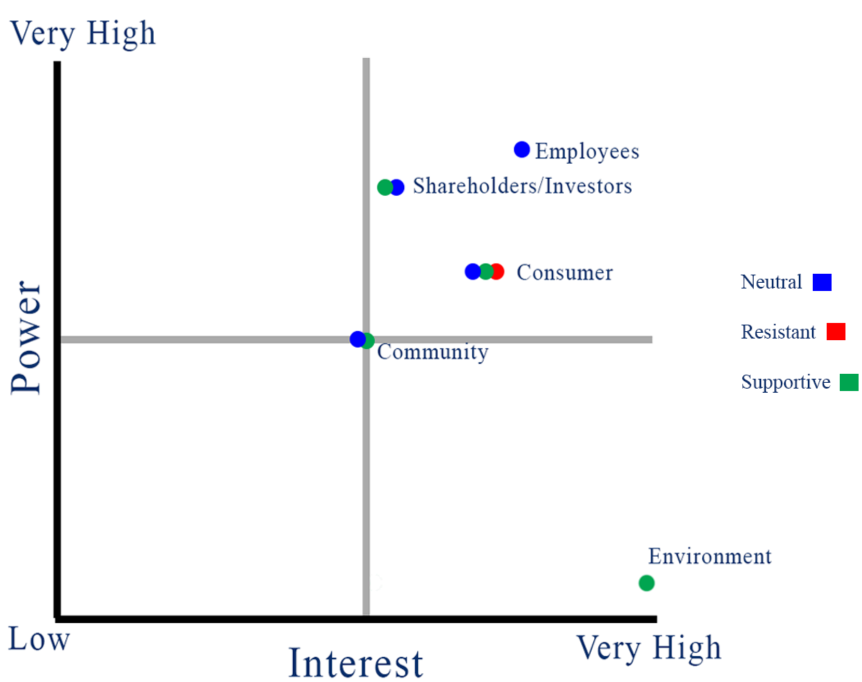
Employees(Landscapers/ Gardeners)- They are responsible for distributing the product to customers as well as having the knowledge to operate and use it. Important to the everyday operation and distribution of the product, and aiding customers.

Community(Okanagan residents)-to ensure positive feedback on the product it is imperative to make sure that it does not affect surrounding yards and grounds in a negative or unwanted way. With the support of the community the business could more easily advertise to new customers unimpeded by negative views of the product.

Stakeholder Plot of Impact:

Stakeholders	Power	Interest	Impact
Shareholders/ investors	Very high	high	Neutral/Supportive
Consumers	high	high	Resistant/neutral/supportive
Environment	low	Very high	Supportive
community	medium	medium	Neutral/Supportive
employees	high	high	Neutral

*Consumers could be resistant as they might not accept new technologies coming in and trying to replace what they already have; consumers could be neutral and their opinion might change as they find out more about the product and the ideas associated with it while considering the price range as well and they could also be supportive if they don't mind a change and also want to make the environment cleaner and safer in addition to saving water.



All Solutions Table:

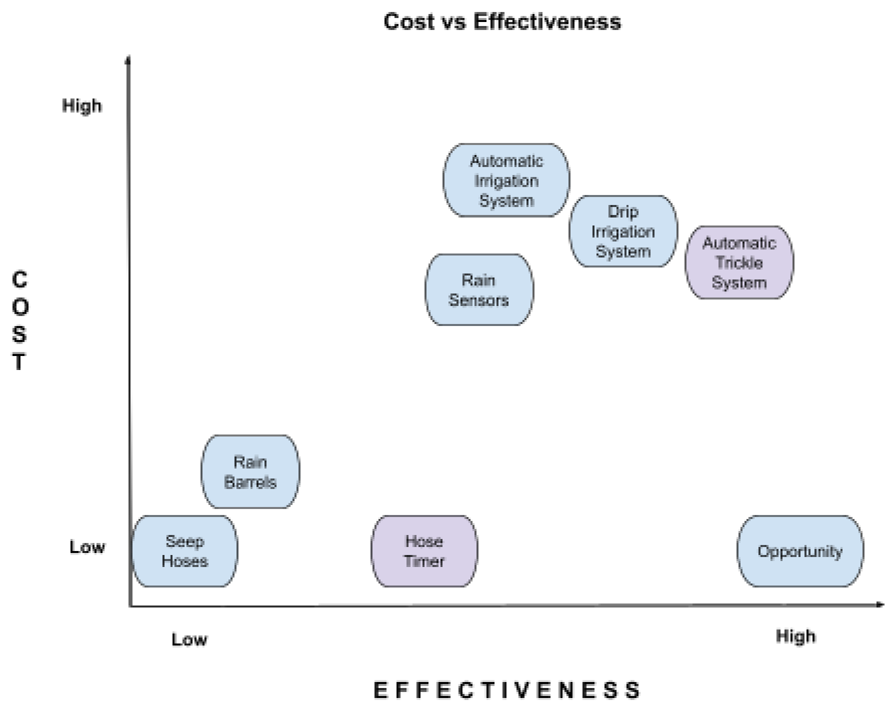
The “All Solutions Table” lays out all solutions already available in the market to cut down on water usage in residential areas. It shows the cost of each solution as well as how effective it actually is as well as the life expectancy and social impact of each solution. In addition, we also compared each solution to see if it matched our project objectives.

Solutions	Cost	Effectiveness/ Efficiency (Benefit)	Environmental Impact/ Manufacturing/ Life Cycle/ Disposal	Social Impact/ Utilization Profile	Maximize Ease of Use- measured in the number of steps and average consumer ratings.	Maximize plant growth- measured by plant size and yield
Rain sensors	Medium	Medium	Medium	Medium	Low	Low-Medium
Automatic irrigation system	High	High-Medium	High	Medium-High	High	High-Medium
Drip irrigation systems	High	High	High	High-Medium	High-Medium	High
Rain Barrels	Low	Low	High	Medium-High	High	Low
Seep hoses	Low	Low	Low	Low	Medium-High	Low-Medium
Novel 1: Automatic trickle irrigation system	High	High	High - Medium	High	Medium	High
Novel 2: Hose timers	Low	Medium	Medium	Medium-High	Medium	Medium

The following data has been compiled from multiple sources like (Cullen A, 2017), (Swett J, 2019), (Aquasense,2017), (HSOTR, 2013), (“LoveYourLandscape”, 2017), (Wedner, D,2008), & (“RoyalBCMuseum”,2013) and is intuitively placed under 3 categories of high, medium or low.

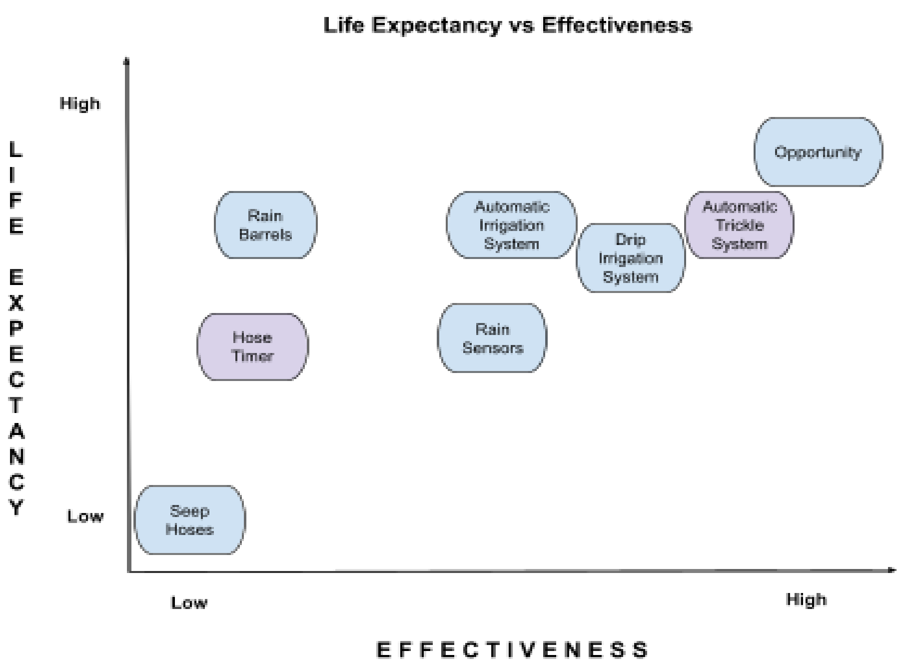
Solution Landscapes:

1. Cost Vs Effectiveness



Novel solutions coloured in purple

2. Life Expectancy vs Effectiveness

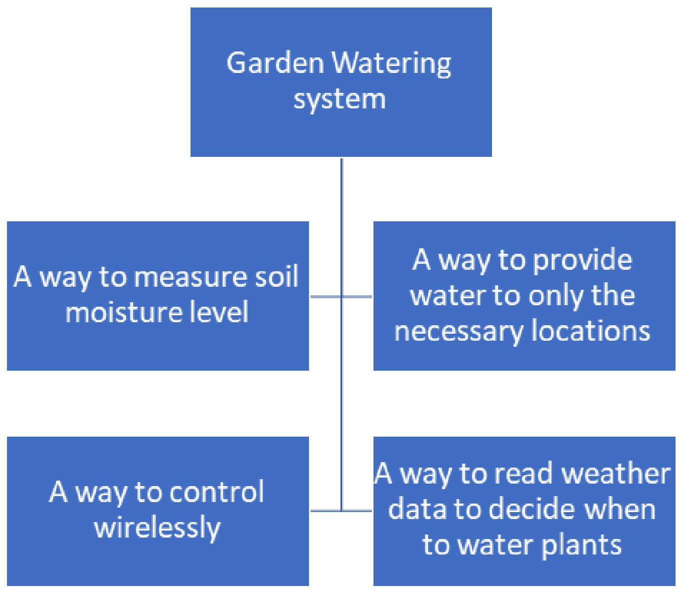


Novel solutions coloured in purple

Solution Selection:

To start the selection of our solution, a Functional Decomposition of the product was made. Then to generate ideas for each function, Brainstorming and SCAMPER techniques were used. Since we have to make a product, it was much easier to break down the functions of the product rather than the structure.

Functional Decomposition:



Ideation Selection using brainstorming:

We chose SCAMPER and Brainstorming as our ideation selection process. For brainstorming we had each member come up with at least two ideas that fall into one of the functions that we chose in Lab 1.

Function:	
A way to measure the soil moisture level	Soil moisture sensor (SparkFun, Vernier) hose timers
A way to provide water to only the necessary locations	Automatic Irrigation System Smart Controllers
A way to limit the amount of water used	Add a shut-off nozzle to garden hoses Hose Timers water-efficient emitters
A way to read weather data to decide when to water plants	Smart Controllers automatic-rain-shutoff device
Miscellaneous ideas	Rain barrels to collect water

SCAMPER technique:
Using the automatic irrigation system as the product to improve on. While using this technique not all steps were needed to be done as the product has some systems that do not need to be improved.

Substitute the water sprinklers with a drip irrigation system. Therefore helping reduce water wastage
Combined with rain sensors and soil sensors around the garden, this will help the system know when to water the gardens.
Adapt residential areas by making the system more affordable. This can be achieved by having two models, one more advanced for Commercial use and one for just residential areas.
Modify the software to be able to read weather data from online sources to choose the best times to turn the irrigation system on.
~~**Put** to another use~~
Eliminate the self-installation process, have professionals install the systems as they will install in the most efficient places, therefore, minimizing water loss.
~~**Reverse**~~

Solution matrices:

To select the most appropriate solution to continue researching, it is important to analyse the many factors involved when considering the best option. For this purpose, summation solution matrices will be used to relate all the factors in consideration. Furthermore, a weighted summation matrix will be conducted to relate the factors based on our perspective of their significance. In the following matrices, effectiveness, cost, maintenance cost, and life expectancy will be the factors considered weighted by their importance

The effectiveness of our product is our main purpose when planning the target problem. Currently, there are no shortages in ideas and creations that tackle the problem regarding outdoor water usage. Which is why our ideation is focused less on a product that can accumulate a large amount of revenue but a product that will be helpful and fully accomplish its purpose. Therefore, the factor to maximize effectiveness takes up 35% of the weight when making our decision. In addition social impact will be allocated with 15% weight.

The consideration of the production cost is crucial for any decision made by companies when analysing a solution. However, its importance is lowered when considering the objective of our product. Initially, we aim to maximize the effectiveness of our product at the sacrifice of the production efficiency and cost. After the completion of a prototype, we can then work to improve the model to further minimize the cost of production. Nevertheless, the production cost must be minimized enough so it will not cause any financial issues which is why it is assigned a weight of 15%.

When considering outdoor water usage, it must be understood that the product will be used everyday. Such a device will become used like a vacuum cleaner for a routine where its necessity is not usually subject to change. For this purpose, the life expectancy of our solution is important so as to reduce the hassle of constantly replacing a routine assistance tool. Furthermore, the product must be easy to use and is not a strenuous chore that must be conducted. However, while we do want a product that is durable, its accessibility is not our largest concern since we are prioritizing efficiency. Therefore, we will assign 20% of the weight to maximize life expectancy and only 10% weight to maximize ease of use.
Lastly, the effect of the solution onto plant growth will be mainly ignored. While we do not want the plants and grass to deteriorate, we are not focused on accelerating its growth. Therefore, we give plant growth the lowest amount of weighting in our decision with an allocation of 5%.

<u>Initial Solution Matrix:</u>

Solutions	Maximize Effectiveness	Minimize Cost to produce ($)	Maximize Life Expectancy (years)	Maximize Social Impact	Maximize ease of use (Rated out of 5)	Maximize plant growth
Seep Hose	0.1	50	2.2	0.25	3.3	0.4
Rain Sensor	0.45	165	11	0.5	1.3	0.4
Automatic Irrigation System	0.5	2600	20	0.7	4.7	0.8
Drip Irrigation System	0.65	2000	18	0.8	3.9	1
Rain Barrel	0.2	225	20	0.7	4.6	0.25
Hose Timer	0.2	50	11	0.7	3.0	0.5
Automatic Trickle System	0.9	700	18	1	3.4	1

The data for cost and life expectancy has been compiled from multiple sources like (Cullen A, 2017), (Swett J, 2019), (Aquasense,2017), (HSOTR, 2013), ("LoveYourLandscape", 2017), (Wedner,D ,2008), ("RoyalBCMuseum",2013), & (Environmental Services, City of Portland, 2006)

Normalized Summation Solution Matrix:

Solutions	Maximize Effectiveness	Minimize Cost to produce ($)	Maximize Life Expectancy	Maximize Social Impact	Maximize ease of use (Rated out of 5)	Maximize plant growth
Weight	0.35	0.20	0.15	0.15	0.1	0.05
Seep Hose	0.11	0.02	0.11	0.25	0.70	0.40
Rain Sensor	0.50	0.06	0.55	0.50	0.28	0.40
Automatic Irrigation System	0.55	1	1	0.70	1	0.80
Drip Irrigation System	0.72	0.77	0.90	0.80	0.83	1
Rain Barrel	0.22	0.09	1	0.70	0.97	0.25
Hose Timer	0.22	0.02	0.55	0.70	0.64	0.50
Automatic Trickle System	1	0.27	0.90	1	0.72	1

Summation evaluation:

Solutions	Non -weighted score	Weighted score
Seep Hose	2.55	0.378
Rain Sensor	3.17	0.568
Automatic Irrigation System	4.05	0.587
Drip Irrigation System	4.48	0.686
Rain Barrel	4.05	0.623
Hose Timer	3.59	0.549
Automatic Trickle System	5.35	0.903

Sample calculation of non-weighted summation solution score of Seep Hose:

$0.11 + (1 - 0.02) + 0.11 + 0.25 + 0.7 + 0.4 = 2.55$

Sample calculation of weighted summation solution score of Seep Hose:

$0.11 * 0.35 + (1 - 0.02) * 0.2 + 0.11 * 0.15 + 0.25 * 0.15 + 0.7 * 0.1 + 0.05 * 0.4 =$ 0.378

<u>Solution Selection:</u>
After evaluating the scores of the factors within the summation solution matrix, the best solution purely based on the theoretical values in each category is the rain barrel with a score of 5.35. Indeed, the automatic trickle system is a product that can last a long time with a high social impact as well as effectiveness. However, when considering the best solution, the factors are not used equally and adjusted and the best solutions are chosen based uniquely on the weighted matrix.

Using a weighted evaluating system, the resulting top 3 solutions is the automatic trickle system with a score of 0.0.903; the drip irrigation system with a score of 0.686; and the rain barrel with a score of 0.623. When choosing which of the top 3 options to further pursue, the decision comes to which solution is more preferable with more interest than the others. However, during this evaluation, the automatic trickle system stands far above the other options with a gap of at least 0.2 in score when evaluated based on the weight preferences set beforehand. Therefore, the best solution to continue researching is the automatic trickle system.

Proposed Solution:

Riskiest Assumptions Prototyped:

1. Risk of it being ineffective
2. Risk of having an unsafe design
3. Risk of poor performance in sales
4. Risk of insufficient funds

<u>Solution Prototype:</u>

A Soil Moisture based Smart Irrigation System

This prototype was idealized to counteract the riskiest assumption of many irrigation systems being ineffective. This prototype was designed to work like a model with medium fidelity and consisted of an Arduino Nano BLE and Arduino Nano Sense BLE, a Breadboard, jumper cables, LEDs, a 3 point relay, and sensors such as soil moisture sensor and flow sensor, and batteries. The prototype comes in two parts, the soil moisture sensor and a motherboard. The soil moisture sensor has probes that work like resistors that have varying resistances according to water content in the soil. This resistance is inversely proportional to the soil moisture. The resistance produces an output voltage which can determine the soil moisture level ("Last Minute Engineers", 2018). This sensor was connected to the Arduino Nano BLE 3.0. Although adding a power adapter would provide uninterrupted usage all day, to make the smart system wireless and easier to handle, batteries were added. This part records the soil moisture level and sends it to the Motherboard via bluetooth. The motherboard consists of an Arduino Nano BLE Sense, a 3-point relay that is connected to the water pump and an AC power source, and a water flow sensor. The flow sensor which in accordance with Faraday's Law, uses a magnetic field to produce and channel the liquid flow ("Omega", 2018) while outputting an electrical pulse with every rotation. For this flow meter/pump, with a high power circuit, to be controlled by a small power circuit like an Arduino, the relay was added. The arduino has an inbuilt temperature and humidity sensor therefore the motherboard would have to be installed outside but in a dry area. The motherboard receives the data from the soil moisture sensor and also records the temperature and humidity in an interval of however long homeowners choose. Using all the data, the motherboard then decides when is the best time to start the water pump and using the water flow sensor, it also chooses the best rate of flow for the plants. The LED's in each of the parts display the following:

- Blinking red is low battery level
- Solid red is no sensor input
- Solid green is all systems are good
- Blinking blue means pairing
- Solid blue means bluetooth is connected

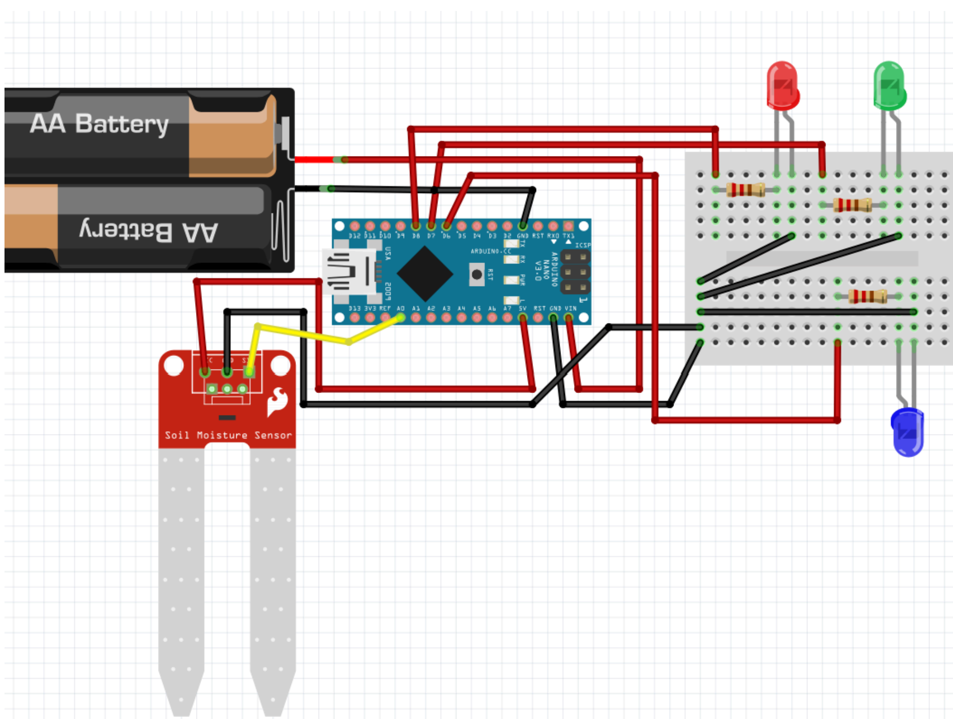


Figure 1: Schematic Diagram of soil sensor connected with batteries

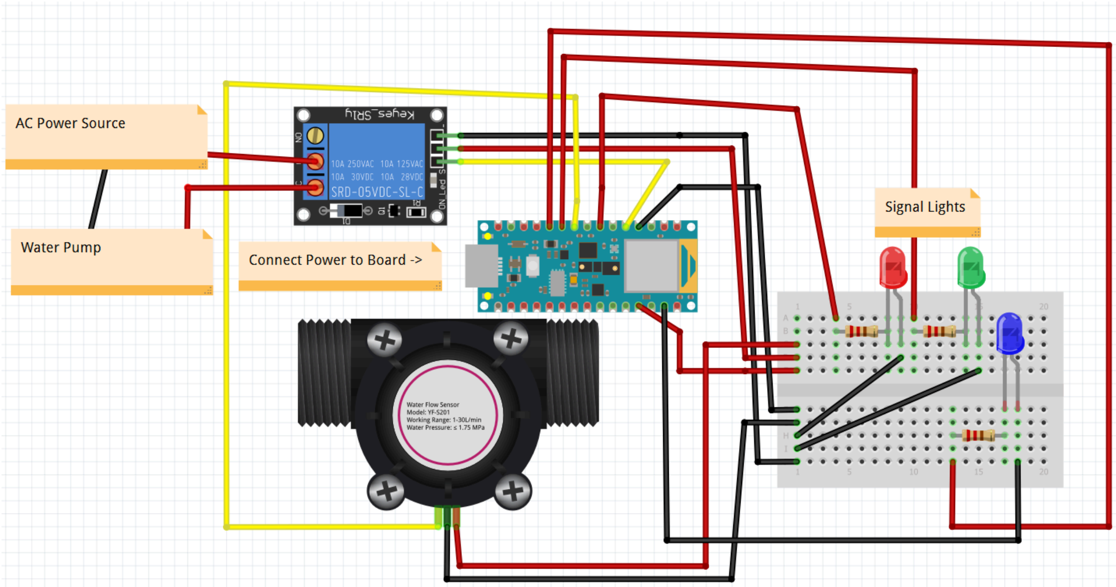


Figure 2: Schematic Design of motherboard with flow sensor connected with AC power source

Due to recent Covid-19 situations, testing the prototype could not be finished as many parts were not delivered. In theory, this setup would be able to account for the risk assumptions as it considers the soil moisture in order to control the amount of flow of water provided to the plants as well as the temperature and humidity levels while considering not an excessive amount of water would be dispensed either. Since most of the electrical components will be provided in a safe casing box, the possibility of getting a shock or the system short-circuiting is very minimal as the only open electrical part would be the battery casing which is only opened to replace batteries. The simplistic design also suggests that it is easy and accessible to many which was measured by a survey done amongst some known family members and friends who are homeowners. This same survey also hinted that many homeowners who do not have much time to pay attention to their garden or are beginning to learn gardening would find this product extremely helpful. Since this prototype was built with components easily available over the internet or stores like Home Depot and Canadian Tire and were fairly cheap to purchase, the risk of having insufficient funds is also minimal.

<u>Cost-Benefit Analysis:</u>

To determine whether our product will be profitable, an analysis of both the future and the present value of the costs and benefits will be calculated over a 5-year economic timeline. Furthermore, an average interest rate of 20% will be used and we will assume that our sales will increase by 15% every year.

Cost/Benefit Matrix

Cost (+)/Benefit (-)	**Future Value**	**Present Value**
Initial Cost	N/A	+ 100
Material costs Year 1 Year 2 Year 3 Year 4 Year 5	 + 6000 + 6900 + 7935 + 9125 + 10494	+ 23002
Rent for manufacturing building (5 years)	+ 60000	+ 35887
Advertisement (5 years)	+ 20000	+ 11962
Maintenance service provided for customers (e=0.05) Year 1 Year 2 Year 3 Year 4 Year 5	 + 800 + 840 + 882 + 926 + 972	+ 2598
Sales Profit Year 1 Year 2 Year 3 Year 4 Year 5	 - 16000 - 18400 - 21160 - 24334 - 27984	- 61338

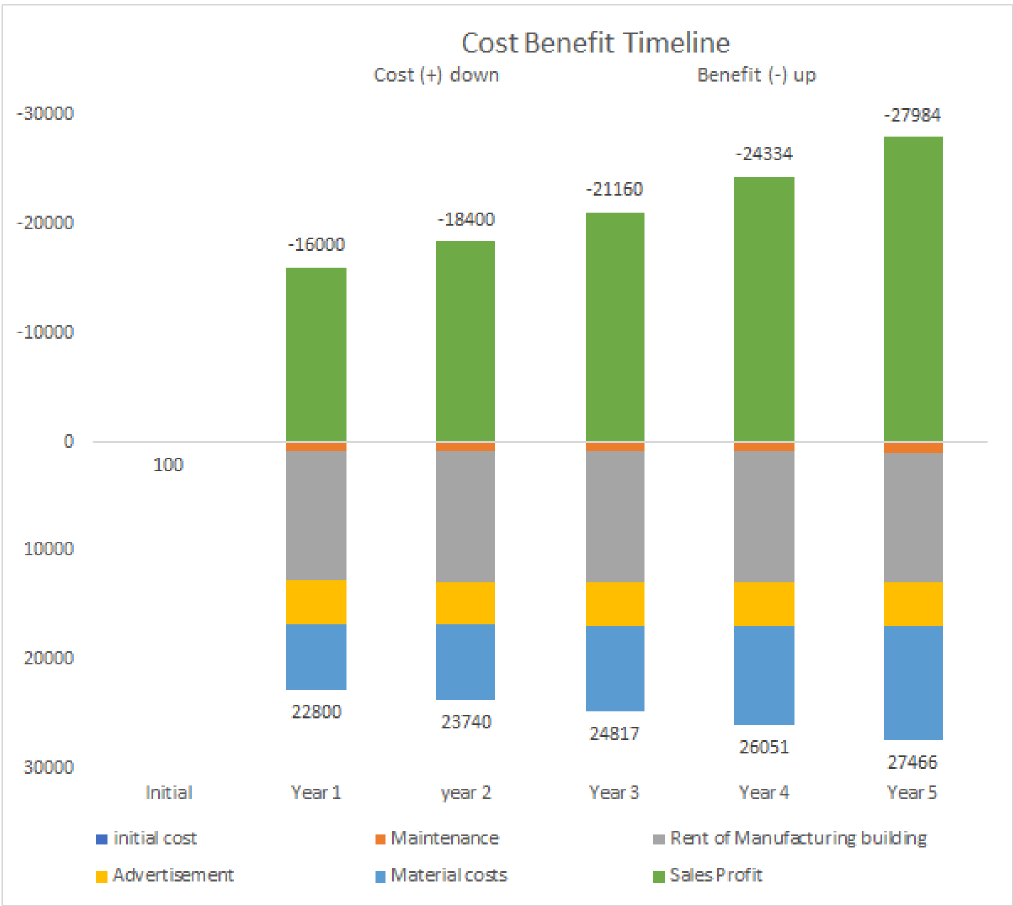
Total Present Cost = $ 12,211.00

Sample calculation for present value of uniform series of future costs:

Present value of advertisement costs= $\frac{20000}{5} * \frac{(1+0.2)^5-1}{0.2*(1+0.2)^5} = 11962.448 \approx 11962$

Sample calculation for present value of a geometric series of future costs:

Present value of material costs (e=0.15) = $6000 * \frac{(1+0.2)^5-(1+0.15)^5}{(0.2-0.15)(1+0.2)^5} = 23001.678 \approx 23002$

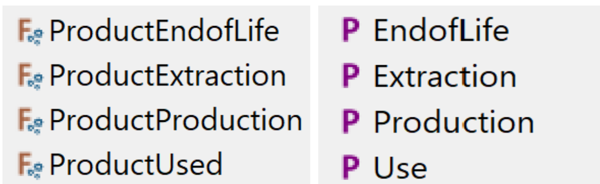


By analyzing the cost-benefit timeline graph and table, the monetary values of the cost will outweigh the benefits at the beginning. However, this should be expected for a newly begun company. Furthermore, when comparing the net loss of each year, a trend becomes noticeable. The rate of increase in the benefits is larger than the increase in costs, therefore, the benefits will outweigh the costs in the future and gradually pay off the cumulated costs.

Life Cycle Analysis:

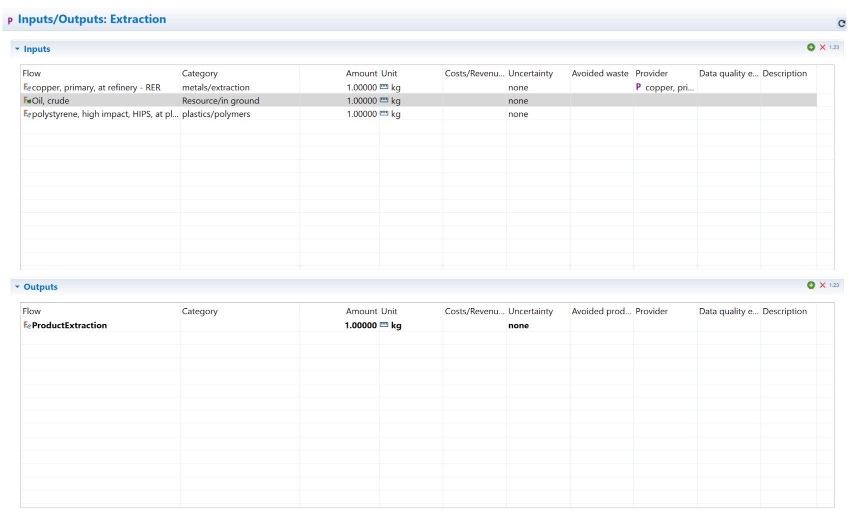
For the life cycle analysis, we chose to analyze only the life cycle of the casing of the product, wiring and packaging as the electronic systems are too complicated to track as each part has multiple components that require extraction, production and end of life analysis.

Flows and Processes:



Extraction Process:

We chose to extract copper for the copper wires used in the electronic systems, crude oil for polyethylene and polystyrene for styrofoam packaging of the product.



Inputs/Outputs: Extraction

Inputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided waste	Provider	Data quality e...	Description
copper, primary, at refinery - RER	metals/extraction	1.00000	kg		none		copper, pri...		
Oil, crude	Resource/in ground	1.00000	kg		none				
polystyrene, high impact, HIPS, at pl...	plastics/polymers	1.00000	kg		none				

Outputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided prod...	Provider	Data quality e...	Description
ProductExtraction		**1.00000**	**kg**		**none**				

Production Process:

Inputs/Outputs: Production

Inputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided waste	Provider	Data quality e...	Description
flat glass, uncoated, at plant - RER	glass/construction	1.00000	kg		none		flat glass, u...		
transport in t*km	Transport services/Other tra...	1.00000	t*km		none		Bulk carrier...		
Copper wire	Metals and semimetals/Met...	1.00000	kg		none		Copper wir...		
Electricity	Energy carriers and technol...	1.00000	MJ		none		Electricity ...		
polycarbonate granulate (PC)	Materials production/Plastics	1.00000	kg		none		Polycarbo...		
polyethylene terephthalate (PET) gr...	Materials production/Plastics	1.00000	kg		none		Polyethyle...		
ProductExtraction		1.00000	kg		none		Extraction		
polystyrene (general purpose) gran...	Materials production/Plastics	1.00000	kg		none		Polystyren...		

Outputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided prod...	Provider	Data quality e...	Description
ProductProduction		**1.00000**	**kg**		**none**				

Use Process:

In the Use process, board boxes and printing ink was added for packaging.

Inputs/Outputs: Use

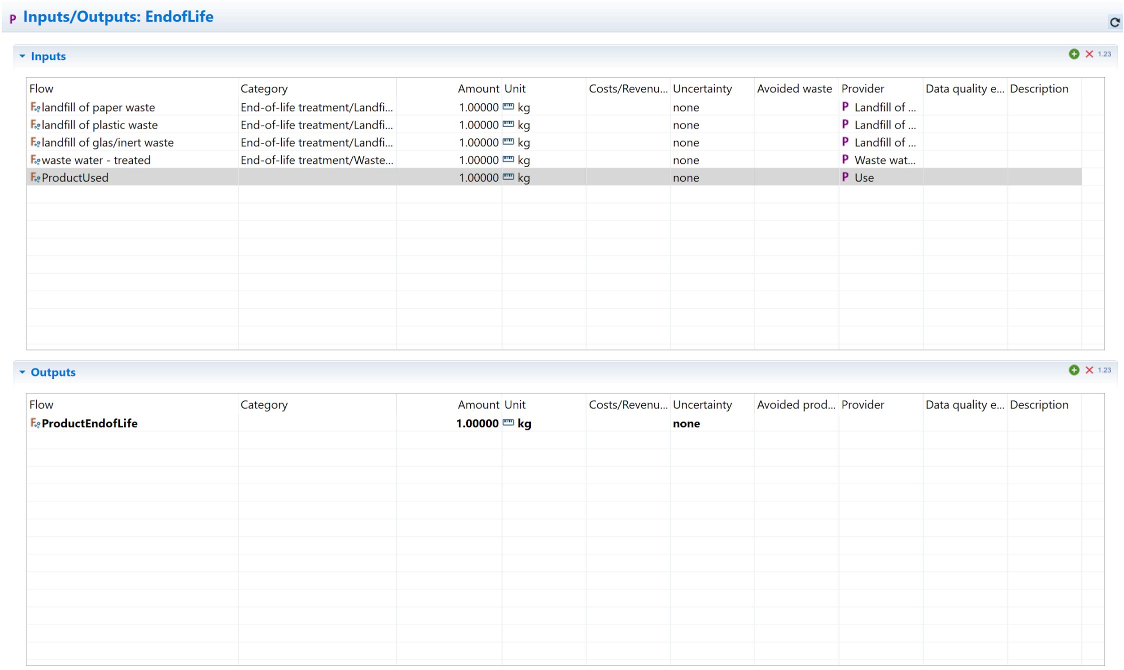
Inputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided waste	Provider	Data quality e...	Description
electricity	Energy carriers and technol...	1.00000	MJ		none		Dummy_el...		
corrugated board boxes	Systems/Packaging	1.00000	kg		none		Corrugate...		
Water	Resource/in water	1.00000	kg		none				
printing ink	Systems/Paints and chemic...	1.00000	kg		none		Dummy_pr...		
ProductProduction		1.00000	kg		none		Production		

Outputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided prod...	Provider	Data quality e...	Description
ProductUsed		**1.00000**	**kg**		**none**				

End of Life Process:



Inputs/Outputs: EndofLife

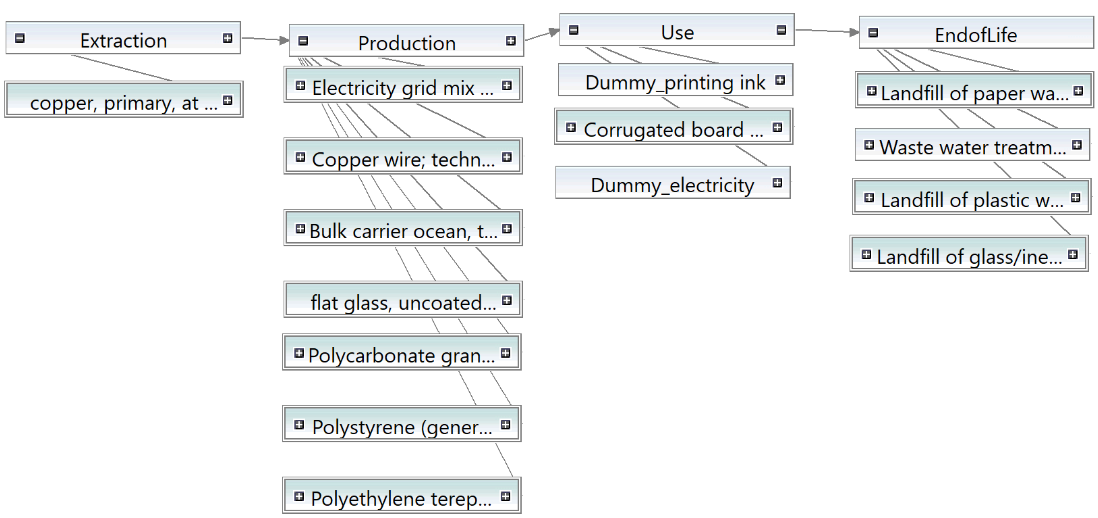
Inputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided waste	Provider	Data quality e...	Description
landfill of paper waste	End-of-life treatment/Landfi...	1.00000	kg		none		Landfill of ...		
landfill of plastic waste	End-of-life treatment/Landfi...	1.00000	kg		none		Landfill of ...		
landfill of glas/inert waste	End-of-life treatment/Landfi...	1.00000	kg		none		Landfill of ...		
waste water - treated	End-of-life treatment/Waste...	1.00000	kg		none		Waste wat...		
ProductUsed		1.00000	kg		none		Use		

Outputs

Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided prod...	Provider	Data quality e...	Description
ProductEndofLife		**1.00000**	**kg**		**none**				

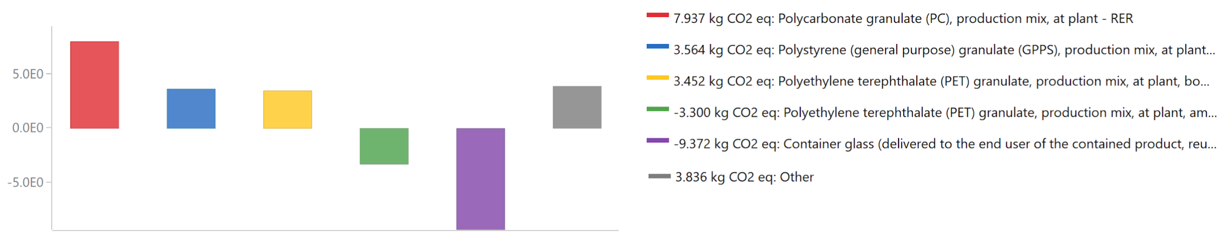
System Process Graph:



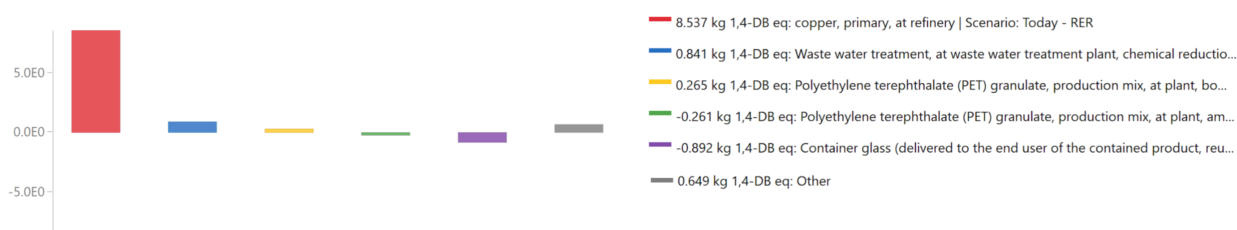
Calculated Impact Graphs:

The graphs are not supposed to have negative points but openLCA would not change even after changing the amounts to “-1.00 kg” in “EndOfLife” Process.

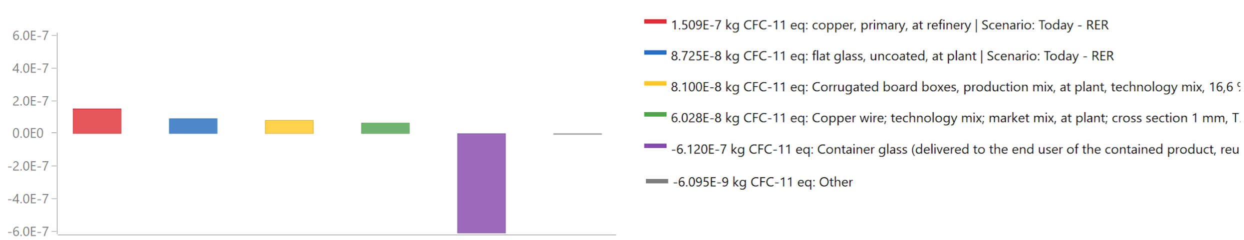
Global Warming Impact



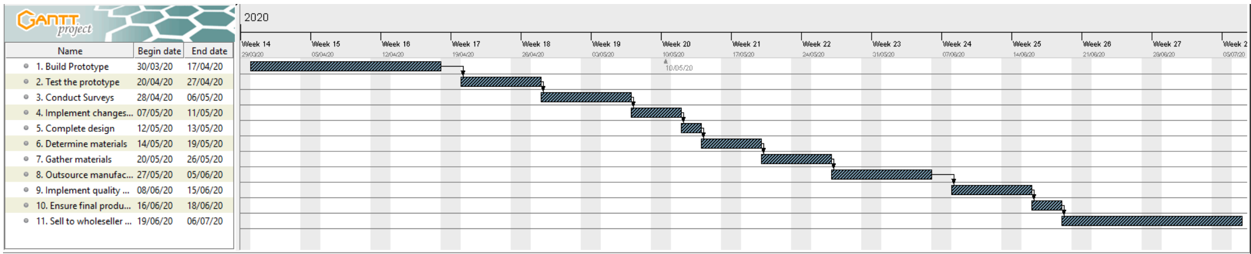
Human Toxicity Impact



Ozone Layer Depletion Impact



<u>Product Implementation Gantt Chart</u>



<u>Risk Assessment of the Solution:</u>

PM: Project management

D: Design

S: Sustainability

Risk	Potential Impact	Likelihood of Occurrence
PM1, Possibility of the wrong scope	5	2
D1. Will the materials be able to withstand weather conditions?	4	4
S1, Will the solution be able to fulfill life expectancy?	4	3
PM2, Is it profitable?	3	2
D2, Can this product perform its function?	4	3

Risk Analysis Plot

		Potential Impact				
Likelihood of Occurrence		Very low	Low	Medium	High	Very high
	Very low					
	Low			PM2		PM1
	Medium				S1, D2	
	High				D2	
	Very high					

<u>List of Mitigation Strategies:</u>

1. Possibility of the wrong scope
    - Conduct surveys among society to gain information on the recurring problems with water usage.
2. Will materials be able to withstand weather conditions?
    - Conduct testing on the casing box every 4-5 months to check durability.
3. Will the solution be able to fulfill life expectancy?
    - Conduct bi-annually inspections/cleaning on the product
4. Is it profitable?
    - Conduct a survey to ensure interest and accessibility to homeowners
5. Can this product perform its function?
    - Conduct testing on the product performance

Project Limitations and Future Plans:

Although our idea does help reduce water usage it does come with its limitations. One of these limitations would be that a single system would not be sufficient for an entire lawn. Since the system only sensors a limited area, it would require more than one in each lawn in order to work at its full potential. Another limitation would be that the system is more specific for gardens with plans and even vegetables growing. Since the system monitors and sensors the moisture of the soil it would be most beneficial for the growth of plants, however most residential areas have lawns with just grass.

Our future plans for our idea would be to eventually lower the manufacturing cost to in turn lower the cost at which it is sold. The lower cost will attract more buyers which will ensure more use of the system and overall lower the numbers of water usage. Another one of our future plans would be to make our solution available worldwide. This will also increase our profits as well as allow us to reach other areas to save more water.

Another future plan is to build an app that connects to the system that displays all the data collected by sensors to the homeowners and also can display battery levels and notify when to change the batteries to maximize the lifespan of the system and also to have the maximum efficiency at all times. In the future we may also be able to substitute batteries to a constant power source therefore reducing maintenance costs for the homeowners.

Conclusion:

To summarize, our solution is an automatic irrigation system that monitors the moisture of the soil and provides adequate amounts of water. The prototype to reach our project goals consists of three main parts. Firstly, a soil moisture sensor will be inserted into the soil as the input for water levels. It will be encased by a shell to protect any wires from water as the data is transmitted to the second component, the arduino uno. The arduino will be the main component that will operate the whole task. To reduce the use of batteries, it will be connected and powered by a common AC power wall plug. Lastly, a water pump will also be connected to the arduino to provide the sprinkle system whenever requested.

The project will decrease the necessary work for customers while minimizing the cost to make it affordable. It will prevent any water flooding or droughts in yards due to improper care and will stabilize water levels that will excel the growth rate and health of the plants. While only consisting of three parts, it will be easier to implement compared to other products in the industry. Furthermore, since the arduino is set to automatically sprinkle water whenever necessary, it becomes very easy to use where the only work necessary shall be turning it on and setting it up.

With a predicted rate of increase in sales annually, the impact of our solution is aimed to be implemented in all the yards of homes in kelowna that do not have an efficient watering system. Over time, a noticeable trend in decrease of outdoor water usage in kelowna should be noticed. Therefore, contributing to decreasing the water deficiency present in the okanagan region. Furthermore, a more consistent and healthy color of grass should become noticeable as water will only be provided when it is necessary while optimizing the health of the plants.

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Meeting Minutes:

Tuesday February 4th, 2020: First meeting at CEO's apartment

- Discussed Lab 1, team contract
- Assigned roles, work for lab 1
- Discussed which of the problems has the most impact on team members and would be the one to write a report on

Tuesday February 11, 2020: Second meeting at a study room in Commons

- Discussed lab 2 requirements, assigned roles
- Started brainstorming possible solutions to problem and what is already there

Tuesday February 25, 2020: Third group meeting at a study room in Purcell

- Discussed existing solutions, ways to improve
- Discussed costs related to project, whether to apply for Aquahackers or not, and whether a prototype must be built upon getting the best solution
- Divided work between members

Tuesday March 2, 2020: Fourth group meeting at a study room in Commons

- Discussed possible prototypes
- Researched numbers for cost analysis
- Brainstormed risks that must be accomplished for the product to be successful
- Divided parts of lab 4 among team members