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Water use characterization during crop processing at UBC Farm

ENGL301 – FINAL REPORT

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Introduction

A. Water use in agriculture

According to the United Nations World Water Development Report in 2015, The agricultural sector accounts for 70% of all freshwater withdrawals globally. Sustainable and efficient water use strategies are becoming an increasingly demanding research topic, attempting to limit agriculture's water footprint. To observe the effect of water use reduction strategies, a water innovations node for UBC's Campus as a Living Laboratory initiative is set up at UBC Farm.

B. UBC Campus Living Laboratory Initiative

Living laboratory is a term first coined by researcher at MIT that emphasized place-based research which integrates innovation and co-production of knowledge into the local public-private-people partnership ("MIT Living Labs", n.d.). UBC will be an unique campus to employ this research methodology as UBC maintain full control of its utility, heating, and waste infrastructure ("CAMPUS AS A LIVING LABORATORY" , n.d.). For this project, UBC the advantage of an on campus 24-hectare production farm known as UBC Centre for Sustainable Food Systems (CSFS). This will be the platform on which research will be carried out by cooperating with farm managers, fieldwork farmers and research students.

C. UBC Farm water innovation node process update

UBC Farm water innovation node is installed and has been running since June 2019. This node consists of a continuously expanding network of sensors measuring climate, canopy microclimate, soil water content, irrigation water use, and finally, water use at the Harvest Hut where all the crop processing happens. 2019 is the pilot year of the project, so there are many problems needed to be addressed. Resolving these problems will be essential in ensuring the node is providing accurate data that reflect the complex dynamics of water demand and supply at UBC Farm. This project is recently featured by UBC CSFS and can be accessed via https://ubcfarm.ubc.ca/csfs-research/living-laboratory-for-water-sustainability-at-ubc-farm/.

D. Current challenges addressed in this report

The biggest problem thus far is the inability to characterize water use during the crop processing phase. Crop processing is a significant black box process for the sensors network as farm operation in washing crops is highly variable. A black box process is a term used to identify systems where its input and output are known, but the system's internal structure is unknown. Crop processing is a black box process because water flow sensors can identify how much water is being used, but exactly what crop it is used for is unknown to the network. This problem is highly variable because the crop being washed at a station depends on the bi-weekly harvest.

Multiple solutions are needed to address the two-part problem. The first part of the problem is understanding the usage of the water after leaving the tap. This help answer questions such as "what is the water used for?". A possible solution for this is to understand the washing processes at the farm. To do this, I would investigate by volunteering to be a part of the washing team to familiarize myself with their operation.

The second part of the problem is addressing the variability in the washing process. This help answer questions such as "is there a pattern in how farmers wash their crops?". I propose to solve this problem by having multiple meetings with the farm's processing manager Matt Delumpa. By talking to Mr. Delumpa, I will look into a systematic approach in identifying where crops are normally washed. Then arrive at a possible that works for both the researcher and the farmer.

E. Scope of this report

The purpose of this study is to arrive at a sampling methodology that can accurately reflect the water used in the processing stage for each crop being harvested at UBC Farm. To arrive at this conclusion, I will follow the questions outlined below.

1. (First problem) What is Mr. Delumpa's workflow during each harvest from receiving the crop to finished processing? How is water being used in each stage?
2. (First problem) Is the current data coverage sufficient to observe water being used in each of these stages or does it need to be expanded?
3. (Second problem) What are the current measurement variabilities?

4. (Second problem) How do washing procedure differ between harvests? Are washing procedure consistent with each crop?

The following two result sections will explore each problem in detail and state findings gathered. The third section will propose solutions to overcome the two challenges in discussion. This report will then be concluded by stating current system limitations and future's work.

First problem: what is the water used for?

A. Restate problem

The first problem focusses on identifying the usage of the water after leaving the tap in the harvesting hut, where crop processing takes place. In general, water could be used for many purposes such as cleaning equipment (i.e. crates, tools), washing crops, and personal use by the farmers. I participated in three harvesting days where I helped washed salad greens, lettuces and observed how root vegetables were processed.

B. Summary of findings

After various interviews with Mr. Delumpa, UBC Farm's processing manager, the flow of different crops can be generalized as the following:

1. All washing tanks are filled up in the morning in preparation for crop processing.
2. As crops are harvested from the field, they will be dropped off and get pre-rinsed with a hose (Hose 1, flow meter serial number: 0124). The water will wash off soil and give a general rinse before being sorted by farm staff. Pre-rinsing will also cool down the crops and prevent heat damage. Especially in the summer months the crops are quite warm coming off the field.

Figure 1. Loading area where crops are unloaded from the field and pre-rinsed.

3. Root vegetables (i.e. beets, potatoes, carrots, etc.) will be loaded into the barrel washer (flow meter serial number: 0123) to be machine washed.

Figure 2. Barrel washer where root vegetables are washed

4. Leafy vegetables (i.e. leeks, lettuce), Onions and scallions will be loaded into the two blue tubs (Tank 1, flow meter serial number: 0125; Tank 2, flow meter serial number: 0126) to be hand washed.

Figure 3. Tank 1 and 2 where leafy vegetables are washed.

5. Salad greens (arugula, mizuna, mustard, spinach and scarlet frill) will be double washed with the two adjacent silver and blue tub (Tank 3, flow meter serial number: 0121; Tank 4, flow meter serial number: 0120).
6. Eggs, radishes and beets that are sold in the weekly farmer's market are washed and processed in the front of the harvest hut outside of the area monitored.

In conclusion, the question of "what is the water being used for?" can be confidently addressed based on the findings from interviews. Furthermore, Mr. Delumpa and I concluded that the current monitoring system is not sufficient in covering all washing areas that receives crops.

Second problem: variability in the crop washing process

A. Restate problem

The second problem focusses on identifying the systematic and human variability in the washing process. Systematic variability can be understood as variability in the sensors being used for each harvest. For example, sensor 1 is used to fill up the two blue tubs last week but sensor 2 is used this week.

Human variability can be understood as human interference to the measurement system. For example, lettuce could be washed with sensor 1 last week but it was washed with sensor 2 this week to improve washing efficiency at the time.

B. Summary of findings

One challenge is identified in addressing systematic variability. The challenge is that Mr. Delumpa fills up all the tank (1 to 4) in the morning with the hose 3. He is doing this because hose 3 has a Hudson valve attached. Hudson valve is a float valve that turns off the water when water level reaches the valve, this can be visualized in Figure 4. This attachment significantly improves his efficiency in preparation for a long day of processing.

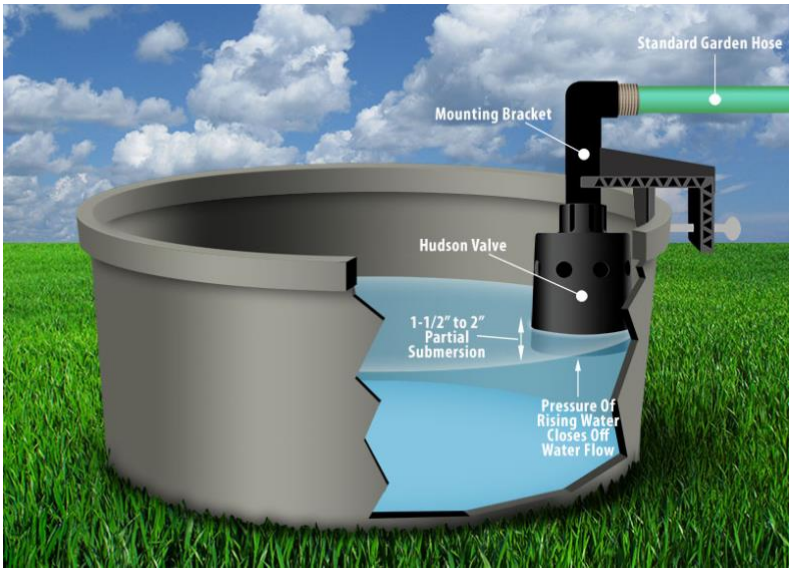

Figure 4. Diagram showing how Hudson valve works. Retrieved from PlumbingSupply.com

No instances of human variability were identified during the three harvesting days where I was present. However, this does not mean that a situation described above will not occur. Meeting with Mr. Delumpa concluded that washing crops with different is a possibility that could be triggered by a faulty hose or there is empty available hose to be used to help with the wash.

In conclusion, a high priority challenge is to fill all tanks with different sensors instead of just hose 3. This is high priority because all water use for different crops are aggregated into one sensor which makes it impossible to separate water use for each crop. A lesser priority challenge will be the human variability issue that could arise but occurs at a lower probability.

Proposed solution: zone division and expansion

A. First problem solution: Zone division and expansion

The idea of dividing washing area into separate zones can overcome the first problem, "what is the water used for?". The sensor in a given zone can record how much water are being used. Correlating that with what crops are usually washed there can allow researchers to assign the recorded volume of water to that specific crop. The post expansion zone layout map is shown in figure 5.

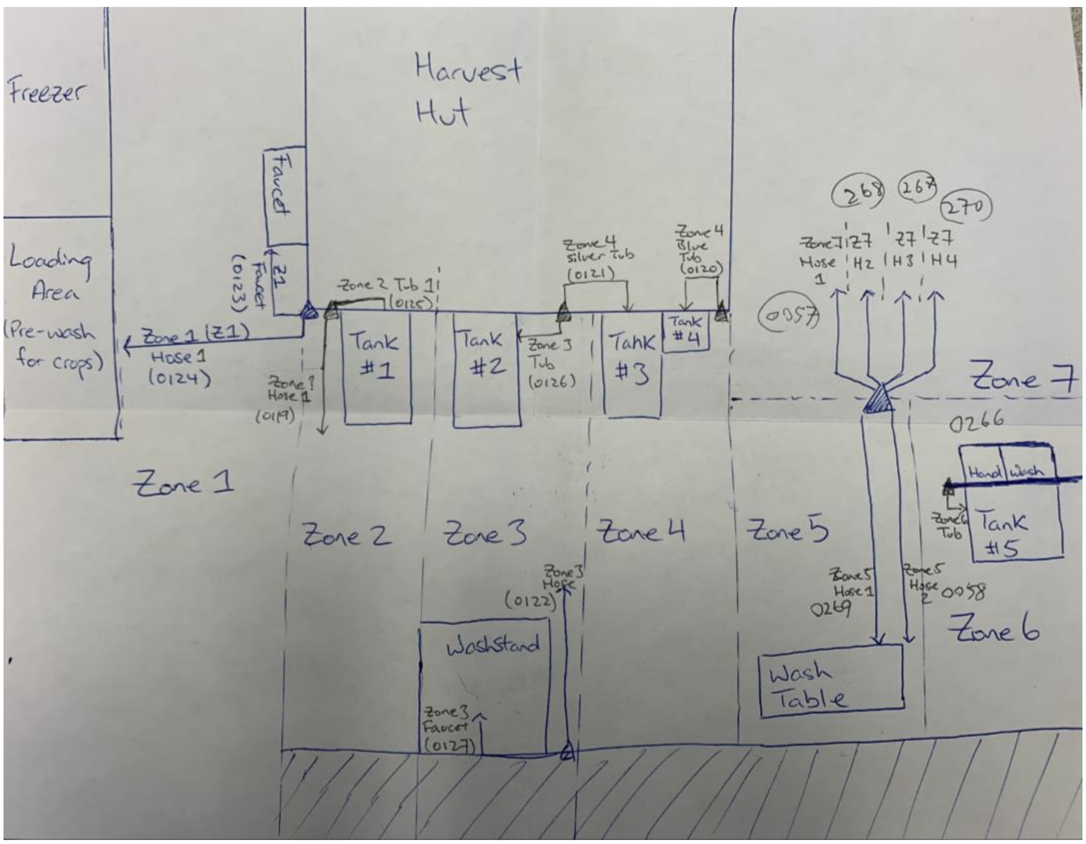

Figure 5. Post expansion zone layout map with sensor names and serial numbers shown.

For example, salad greens (arugula, mizuna, mustard, spinach and scarlet frill) are double washed in tank 3 and 4. By grouping tank 3 and 4 into a collective zone 4 allows the total water use in that zone to be divided by the five crops that makes up salad greens. The method of division will be weighted by the proportion of the harvested crops relative to the total weight of crop harvested. This information is updated daily on the harvest spreadsheet on the cloud which can be made assessable to researchers. For example, 100L of water is used in zone 4 that washed salad greens consisted of 10kg (50% of harvested weight) of spinach, 5kg (25% of harvested weight) of mustard and 5kg (25% of harvested weight) of arugula. Resulting water use will be 50L (50% of 100L) for spinach and 25L for both mustard and arugula.

This method of zone division is conformed to the habit of the farm staff and can also indirectly limit human variability in the second problem. By letting farm staff and Matt know the this is how water use is recorded, it will encourage them to stick to their usual washing routine. A follow up meeting with Mr. Delumpa provided me with an excel sheet of all harvested crops of the 2019 season and their defaulted zones where they are washed. This will be extremely useful in assigning crops into their separate zones

Monitoring area are expanded by adding in an additional sensor node (Node 21) to cover zone 6, 7, and 8; totaling seven additional flow sensors are installed. This will extend coverage to the entire harvest hut and allow water use on eggs, beets, and radishes to be reflected in the measurement network. Figure 6 shows the installed Node 21 and its associated sensors located in Zone 7.

Figure 6. Node 21 as seen in the harvest hut that covers zone 5, 6, and 7.

B. Second problem solution: Installation of Hudson valves onto existing tanks

Installing Hudson valves on all tanks will address the systematic variability of the second problem and is beneficial to both the farm staff and the researchers. This installation allows Matt to turn on the water in the morning without returning to switch or turn it off, which simplifies his workflow. This installation also allows the researcher to know precisely how much water goes into each tank. A win-win situation for both parties.

Figure 7. (Left) Hudson valve set up close up. (Right) Hudson valve installed on all four tanks. Tank 1 shows the maximum water level in the tank.

Conclusion

A. Problems addressed and summary of solutions proposed

In conclusion, the first problem, “what is the water used for” is addressed by dividing the washing area into zones. The crop specific water use can then be calculated with the information provided by the sensor (total water use in the zone) and harvest spreadsheet (crop weight percentage of total harvested weight). The second problem of systematic variability due to one sensor filling of all tanks is addressed by constructing Hudson valve attachment to all tanks. This benefit both the farm staff by simplifying their workflow and the researcher by accurately recording water use in each tank/zone.

B. Future challenges

One challenge that have yet to address is the human variability of the crop washing procedure. As Mr. Delumpa indicated, one crop that usually get washed in a specific zone may be moved to improve washing efficiency or overcoming field difficulties such as a busted pipe. Addressing this challenge is problematic as one option is to install cameras connected to the node that records in real time what is being washed. This idea is logistically difficult to implement and might breach privacy issues. Knowing the frequency of this problem occurring is necessary in deciding whether solutions should be implemented. Currently, the benefit of accurately monitoring crops outweigh the logistical difficulty in its implementation.

References

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