Water Demand for Vertical Farming –

Advantages and Challenges

A Major Project

By

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Acknowledgements

During the process of accomplishing this project, I would like to thank my supervisor Dr. Les Lavkulich. With his help, I could collect the data of local vertical farming and be encouraged to consider the meaning, value, and functions of green infrastructure. I really appreciate that he could answer all my questions and provide information to inspire my ideas. Under his guidance, I finished my project successfully and contacted Cagla Buzluk.

I also would like to thank Cagla Buzluk, who has provided lots of help in my major project. She supplies some details of local vertical farming she works in to assist me in accomplishing my project. Also, I would like to thank Ms. Julie Wilson for her advice and suggestions for this project.

My special thanks are also extended to my family members and friends who supported me through this unexpected time during COVID-19. They give me spiritual support, encouragement and motivation to successfully complete my Master's degree.

Executive summary

Due to the drastic growth of the world population, the food demand for supporting survival has been intensified. Based on many scientists' assumptions and estimations, food production of traditional farming methods can hardly satisfy peoples' requirements because of the fast speed of population growth. The creative methodology should be suggested to improve food production.

The concept of vertical farming has been introduced to improve food safety and production, as well as using less water, land, and other natural resources. This project aims to explore the differences between water demand per unit of production of vertical farming and traditional farming, especially for lettuce. Besides, the various sources of water supply for vertical farming will be listed to see the costs for irrigation in these ways. The approach for the study is based on the BC water calculator and data analysis of local vertical farming lettuce production. Based on conclusions from the research above, advantages, limitations, and challenges of vertical farming can be shown through comparisons with traditional farming.

In the end, available suggestions and recommendations will be provided to show the value and development space of vertical farming in various aspects such as saving natural resources, resolving food shortage, and alleviating the negative impacts of climate change. Also, this project can assist to promote target audiences to install vertical farming infrastructure in future agricultural production.

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Introduction

1. Population growth and natural resources scarcity

According to official data released by the United Nations, the global population is predicted to reach 9.7 billion in 2050 and include 70% of people living in urban areas (United Nations, 2015). More population requires greater food demand. The demand for food and agricultural products is estimated to increase by 50% between 2013 and 2050 (Vos & Bellu, 2019). However, the increase in the food supply is not expected to reach the level that will satisfy human needs. Currently, it’s hard to feed the world population. Not only does the increase in population causes food shortage, but urbanization deepens the gap between food demand and food supply. However, because of the urban expansion of cities, infrastructure development, and urbanization, undesirable pollution and erosion have caused serious loss of arable land. The fast growth of the population requires more land resources, which will directly lead to intensifying the demand for available agricultural land. Scientists have warned that the world has lost a third of its arable land in the past 40 years (Milman, 2015). With traditional farming methods, it’s hard to supply enough land resources for cultivating crops. Planting crops is limited by space. The size of the field, which allows for growing crops, determines overall output and makes it difficult to expand and produce more food (Farming Solutions, 2016). To meet the demand, the output should be expanded, but it still faces huge difficulties due to natural resources limitations. Thus, increasing food demand poses one of the greatest problems for society.

2. Climate change: another threat

Climate change is another major challenge that currently impacts natural resource productivity, as it can seriously affect the yield of crops. It is likely that the adverse influences of climate change will outweigh the benefits until 2030 (Vos & Bellu, 2019). Crop production has been affected by increasing temperature and changing precipitation frequency and amount.

Except for land limitations and shortage, water, which is essential for cultivation, also faces a crisis (Fig. 1). From Figure 1, we can see that many places have undergone different levels of water scarcity. Water and nutrients are key points in food production.

Globally, water consumption of planting crops ups to 9% of freshwater (FAO, 2012), which is approximately 70% of total global water withdrawals (Johnson et al, 2001). With the appearance of climate change, concerns of freshwater availability have risen specifically for vulnerable regions that have undergone droughts and water shortage (Neilsen et al, 2018). The worst impact that climate change has brought to agricultural production is the decrease in the reliability of water resources. It's estimated that a decrease of annual river water runoff of 10% to 30% for dry regions by 2050 (Wegehenkel, 2013). Future trends for water availability also show the water usage stress will not only appear in arid and semi-arid areas.

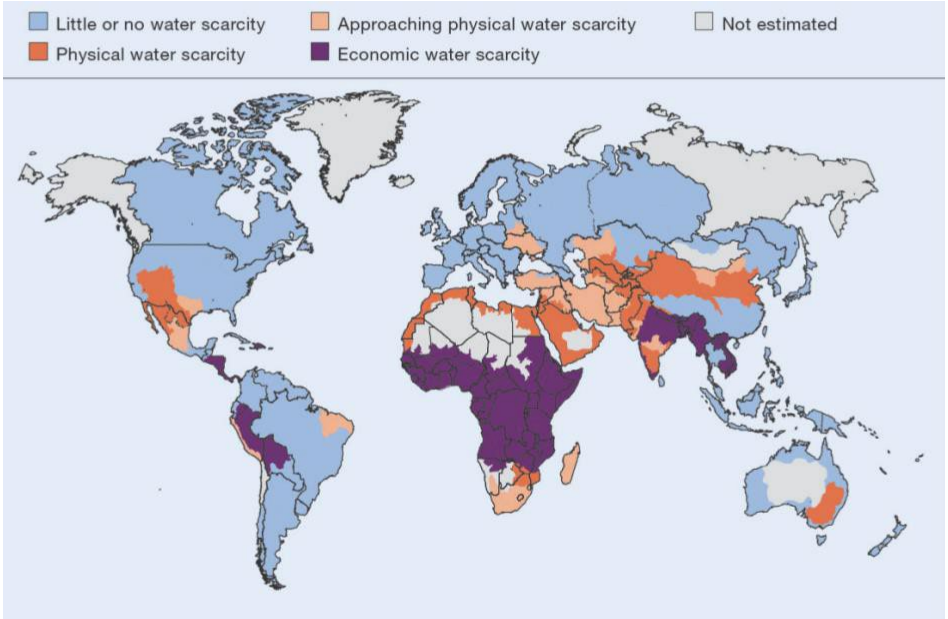

Figure 1. Areas of physical and economic water scarcity at the basin level in 2007. Definitions and indicators: (1) Physical water scarcity: water resource development is approaching or has exceeded sustainable limits; (2) Approaching physical water scarcity: more than 60% of river flows are withdrawn.; (3) Economic water scarcity: human, institutional and financial capital limit access to water, even though the water in nature is available locally to meet human demands (Adapted from "Water scarcity and future challenges for food production", N, Mancosu, R. L. Synder, G. Kyriakakis, & D. Spano, 2015, *Water, 7,* p. 975-992)

According to recent reports in British Columbia, prolonged dry weather is capable of causing crop damage (B.C. Government, 2020). This warning for people raises awareness that climate change has brought unfavourable impacts on available water resources.

3. Vertical farming: technology in solving food shortage and water scarcity

Vertical farming is one of the new ideas to boost feasibility for extra food production with constrained natural resources. This concept is relatively novel and is especially popular in Europe. Vertical farming to save water is relatively effective, it allows people to cultivate crops with 70-95 percent less water compared to normal farming method. The food demand of a huge population has put unprecedented pressure on land and water resources. The imbalance between water demand and water availability has reached a critical level in many areas. According to the challenges and dilemmas for food production mentioned above, some innovative and sustainable methods should be created to solve those problems.

4. Objectives

This project explores the difference between two methods: traditional farming and vertical farming per unit production of lettuce as a case study. Through the case study of local vertical farming, data of the water consumption of lettuce production will be collected to assess how much water vertical farming can save. The comparison of the water uses of two farming strategies can illustrate the advantages, meanings, and functions of this new technology in saving water. In addition, various water sources for vertical farming will be provided to assess the cost of irrigation. Results aim to explain the contributions of vertical farming in saving water. Based on the benefits and costs of vertical farming, further suggestions on the future construction of vertical farms will be given for the development, improvement, and promotion of vertical farming. More importantly, this project will show how operating vertical farming can resolve the negative impacts that climate change brings to natural resources. Additionally, the benefits of this novel technology are capable of persuading target audiences to familiarize their functions in sustainable development.

To achieve the goals mentioned above, this project will consider as:

1. List the advantages and disadvantages of vertical farming,
2. Explore the water amount that vertical farming can save in a measurable way,
3. How vertical farming can assist to solve current issues such as saving natural resources, resolving food shortage and alleviating impacts of climate change, and
4. Suggest how vertical farming may be more acceptable and widespread for future agricultural production

Methods

1. Study area

The research is based on a case study in a local vertical farm – "Cubicfarms" (Fig 2). "Cubicfarms" is capable of producing over 1.25 million heads of lettuce for commercial sales each year. It also produces basil, microgreens, and combinations (Cubicfarms, 2020). The production is supported by a twelve-machine configuration. The system is easily expandable without disrupting the present production. The location for the production system is a custom-built stainless-steel growing chamber. The walls of the chamber are used as the exoskeleton. There are up to at least 240 trays in this machine containing plants to move back and forward so that light can reach each tray. The cycle for each tray returning to the front is 90 minutes. Water and nutrients are distributed evenly through a simple watering system. The special character of this system is that it doesn't clog or jam up like many fine misters or sprayers. In terms of the germination machine, there's a tray holding water on the bottom for watering. Each time the tray containing seeds reaches above, the watering tray will lift up and water the underside. Under the help of this type of irrigation system, the germination rate can reach one hundred percent.

Figure 2. "Cubicfarms" production machine chamber inside (Adapted from

“Cubicfarms”)

The headquarter of “Cubicfarms” is located in Pitt Meadows, a city located 35 km east of Vancouver in southwestern British Columbia. Pitt Meadows is situated in Lower Fraser Valley and also a member municipality of Metro Vancouver (Fig 3). The city of Pitt Meadows is bordered by Maple Ridge to the east, the Fraser River to the south, and the Pitt River to the west (BC Ministry of Agriculture, 2011). It’s a primary agriculture region, situated on the north side of the Fraser River at its junction with the Pitt River. As reported by the City of Pitt Meadows, seventy-eight percent of the landmass in Pitt Meadows is under the control of the BC Agricultural Land Reserve (City of Pitt Meadows, 2020). Therefore, the importance of agriculture can be appreciated by regulations and illustrates that agriculture is the main industry in Pitt Meadows.

The dominant soil type in Pitt Meadows is the “Pitt soil” series. “Pitt soil” occurs mainly in Pitt Meadows and with other soil complexes with Alouette and Katie soils. Typically, the Pitt soil is gently undulating to undulating, with slopes less than 4 percent. Compared with adjacent soils, it is situated on higher landscape and positions and often appears as slightly raised sinuous and discontinuous ridges. Parent materials of the Pitt soil are moderately fine-textured, stone-free, mixed floodplain deposits of the Fraser, Alouette and Pitt Rivers. According to the soil type, irrigation type and crop type, the amount of water used for conventional farming can be calculated by the BC Agriculture Water Calculator (The British Columbia groundwater association, 2016). In this project, the goal was to compare the water consumption of traditional farming in Pitt Meadows with “Cubicfarms”.

Figure 3. Location of Pitt Meadows in Lower Mainland Map. (Adapted from City of Pitt Meadows, 2020)

2. Lettuce: target plant

When choosing the crop type in this analysis, it’s necessary to examine factors such as economic viability, timing and liability. Considering the perspectives mentioned above, lettuce was selected. According to the 2016 State of Indoor farming report, lettuce can be grown about 4 to 5 times indoors for one year, compared to outdoor cultivation (Agrilyst, 2016). Besides, lettuce and other leafy greens are the largest productions by far for indoor farming (Crumpacker, 2018). Lettuce is popular among customers. In addition, lettuce is one crop that can be cultivated in vertical farming on a commercial scale. The cost of production for planting lettuce is relatively low. Thus, lettuce was chosen to be the representative crop for this research.

3. Methodology

In this project, the research was completed in three parts: 1) A literature review and calculation of the traditional farming water consumption, 2) To explore vertical farming water demand, and 3) determination of the costs of water supplies for vertical farming. During the research, the BC Agriculture Water Calculator was applied to measure the water demand of traditional farming methods in the location of local vertical farming – “Cubicfarms” (The British Columbia Groundwater Association, 2016). Through the literature review, the soil type can be learnt. In terms of irrigation type, the project adopted drip irrigation for the analysis of field agriculture. By setting up soil type and irrigation types in this tool, water consumption in this region for cultivating lettuce was determined. Comparisons between field agriculture and vertical farming were displayed by the water use difference. Finally, the cost of vertical farming irrigation was determined. In addition, based on the research above, the contribution of water use efficiency by vertical farming to sustainable development was assessed. Considering all the benefits and challenges, recommendations, and suggestions are given for the future promotion of vertical farming.

Results and Discussion

1. Traditional farming method

For the BC Agriculture Water Calculator, Pitt Meadows was chosen as a conventional farming irrigation region. Irrigation water for Pitt Meadows for conventional farming originates from groundwater. With the help of the BC Agriculture Water Calculator, the annual amount of irrigation water demand is presented in Figure 4. Since the lettuce is a target plant, in the item of "crop" the vegetable was chosen. The typical soil type in the Pitt Meadows area is silty clay loam. The irrigation type for conventional farming is usually drip irrigation. From the result, 20 acres (8 ha) in Pitt Meadows vegetable irrigation water demand per year is 16,530,800 L.

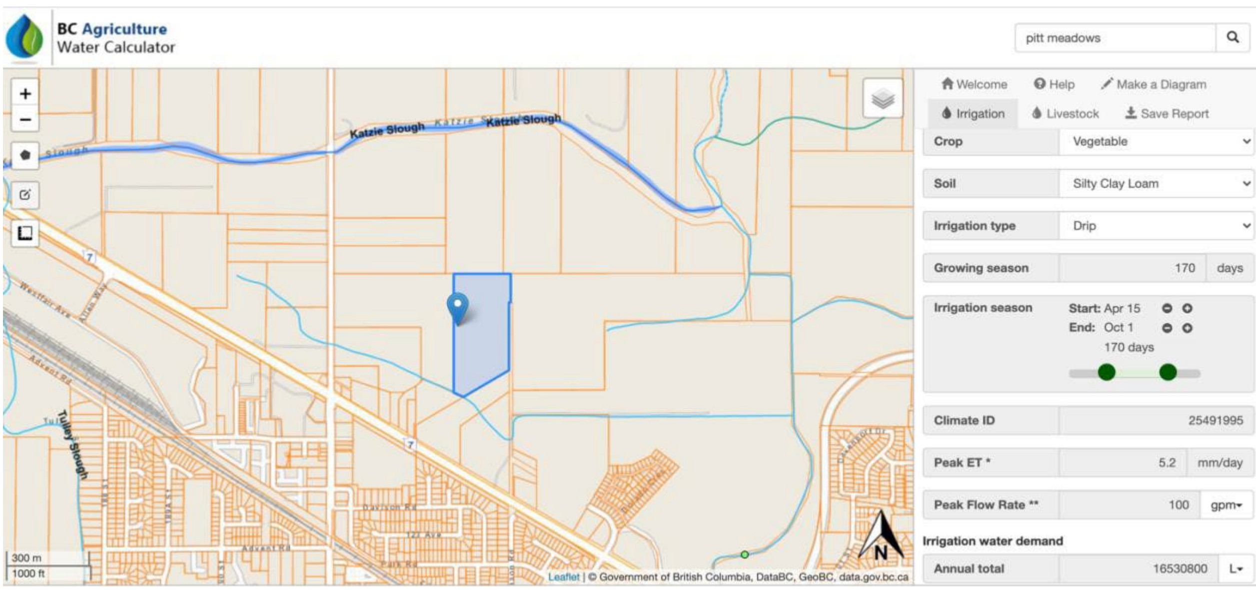

Figure 4. Annual Water demand for traditional farming irrigation.

According to an overview of the BC field vegetable industry, leafy lettuce is one of the main vegetable crops which is grown over a wide range (Ministry of Agriculture, Fisheries and Food Industry Competitiveness Branch, 2003). The total production of lettuce (all types) is 17,438 lbs (8,000 kg) (Table 1). The size of field lettuce growth is 750 acres (300 ha). Therefore, the estimation of the quantity of lettuce for 20 acres (8 ha) is 465 lbs (200 kg) per year.

Commodity	Acres	TOTAL SALES	
		Quantity 000 lb	Value $'000
Potatoes	6,002	113,924	28,526
Carrots	796	20,693	7,162
Corn	3,052	30,426	5,296
Lettuce (all types) (field)	750	17,438	4,750

Table 1. Summary of BC field vegetable industry, 2001 (Adapted from An Overview of the BC Field Vegetable Industry, 2003)

2. Vertical farming method

Generally, many hydroponic farms claim that about ninety-five percent of the water has been saved by recycling with the help of vertical farming (Jurgens, 2020). In the case study of "Cuicfarms," the system is able to grow two heads of lettuce for every litre of water consumed, on average, growing two heads of lettuce applying conventional method requires twenty-four litres of water, according to Water Education Foundation (Cubicfarms, 2020). A single head of lettuce from seed to finish used less than a litre of water in "Cubicfarms," while the general field growing lettuce used around sixteen litres per head. The introduction video of "Cubicfarms," provided information that the production system that consisted of twelve machines configuration which is capable of supplying over 1.25 million heads of lettuce per year for markets (Cubicfarms, 2020). Based on the water consumption of "Cubicfarms." The annual total water demand for lettuce is about 0.625 million litres.

Butter Lettuce:

PRODUCT	SERVINGS / BOX	GROSS WEIGHT	YIELD	NET WEIGHT	LABOR
24ct Butter Lettuce	76/3oz Servings	22 lbs	65%	14.3 lbs	40 minutes

Table 2. Weight of lettuce (Adapted from Taylor Farms Foodservice, 2020)

Based on local market data, the weight of 24 heads of lettuce is 14.3 lbs (6 kg). The total production per year is 1.25 million heads in "Cubicfarms." Thus, the weight of annual production is 744,792 lbs (338,000 kg). If the assumption is based on growing two heads of lettuce requires one litre of water. The total water consumption of vertical farming per year is 372,396 litres.

	Water demand (litres/ year)	**Production (lbs/ year)**
Vertical farming ("Cubicfarms")	372,396	744,792
Conventional farming	16,530,800	465

Table 3. Comparisons of total water demand and production of lettuce with two methods

3. Discussions

From the data of production and water use per year, it is possible to see that the water efficiency and production for vertical farming are much higher (Table 3). There are huge data gaps for both production and water consumption. It is indeed that vertical farming is valuable in conserving freshwater in agriculture production. It is predicted that by 2050, about 80 percent of people will live in urban areas and accordingly food demand will increase as well (Geronimo, 2018). Considering the issues mentioned in the introduction, the conventional farming method cannot effectively improve the total food production and has many variables that come to play. Therefore, new technology will need to play a significant role in solving food shortages. As the data and many types of researches have shown, vertical farming can save about 70 to 90 percent of water (Geronimo, 2018). A vertical farm is capable of providing amble food in a smaller space. Roughly calculated, the annual production of lettuce in "Cubicfarms" is about 1,601 times comparing to field agriculture. The improvement that vertical farming can create on production is considerably large. In addition, the controlled environment can allow crops to be produced year-round. Without the limitation of natural factors, production is significantly improved.

Although traditional farming has approved initiative methods such as drip irrigation, rotational grazing and crop cover, the results have not been adopted favourable. The water amount it can save is far from effective contrast to the vertical farm. There is one example of vertical farming is a company called Plenty. Plenty has claimed they are able to produce 350 times greater crops than conventional farming with merely using 1 percent water and little to no soil (Geronimo, 2018). Similarly, "Cubicfarms" also has shown the ability to adequately conserve water. The water supply system that supports water and nutrients recycle inside the system without clogging compared to traditional sprayers (Figure 5). The central irrigation reservoir recirculates and reuses the majority of freshwater that the cubic farm applies. As an automated system, it can reduce human error and labour. In the progress of each cycle, unused water is filtered and recycled back to the system. This operation drastically minimizes water consumption versus traditional farming. Since the growth of error is dependent on machines, the whole environment inside is individually climate-controlled. According to the "Cubicfarms" CEO's introduction, the system allows the environment close to perfect for each crop or even the stage of those crops' life (Cubicfarms 2020). It is impossible to achieve this in a traditional open warehouse-style rack and stack system. Staff can operate and set up on crop-based on using an app on mobile devices. The watering system is also controlled. Monitor and alarms are triggered if something is not quite right (Cubicfarms, 2020).

Figure 5. Irrigation system inside the machine for harvesting lettuce in "Cubicfarms" (Adapted from "Cubicfarms". 2020)

Compared to the conventional farming method, from the data of the "Cubicfarms" company, vertical farming is twenty-four times more efficient in growing lettuce in terms of water consumption. The main reason for that water use efficiency is that vertical farming has less evapotranspiration during irrigation. Because the whole harvest environment for plants is able to be controlled. The impacts of several climate characters are not that serious for production. For example, inside the vertical farm, irrigation is not affected by evaporation. The environment is controlled at constant high humidity. There is also no wind. In "Cubicfarms," water is recycled to obtain higher water efficiency. Conventional farming methods always have unnecessary water waste due to unpredicted climate factors and inefficient irrigation methods.

Figures 6 and 7 are visual overviews below of differences in water consumption and production between vertical farming and field agriculture. The figures vividly illustrate the differences between the two methods. For local farmers, high production means huge economic benefits. From the aspect of human needs, it greatly satisfies food demand for the whole world's population. More importantly, the transportation distance has been sharply decreased. The carbon footprint also has been positively impacted. Shorter travel distance brings two main advantages. One is that farmers are able to grow vegetables in local farms rather than paying for importing crops from distant places, another is the lifespan and freshness of products can be enhanced. Some fragile crops that cannot survive long can cause waste if they are bruised in the progress of transportation. However, this does not happen in local vertical farms.

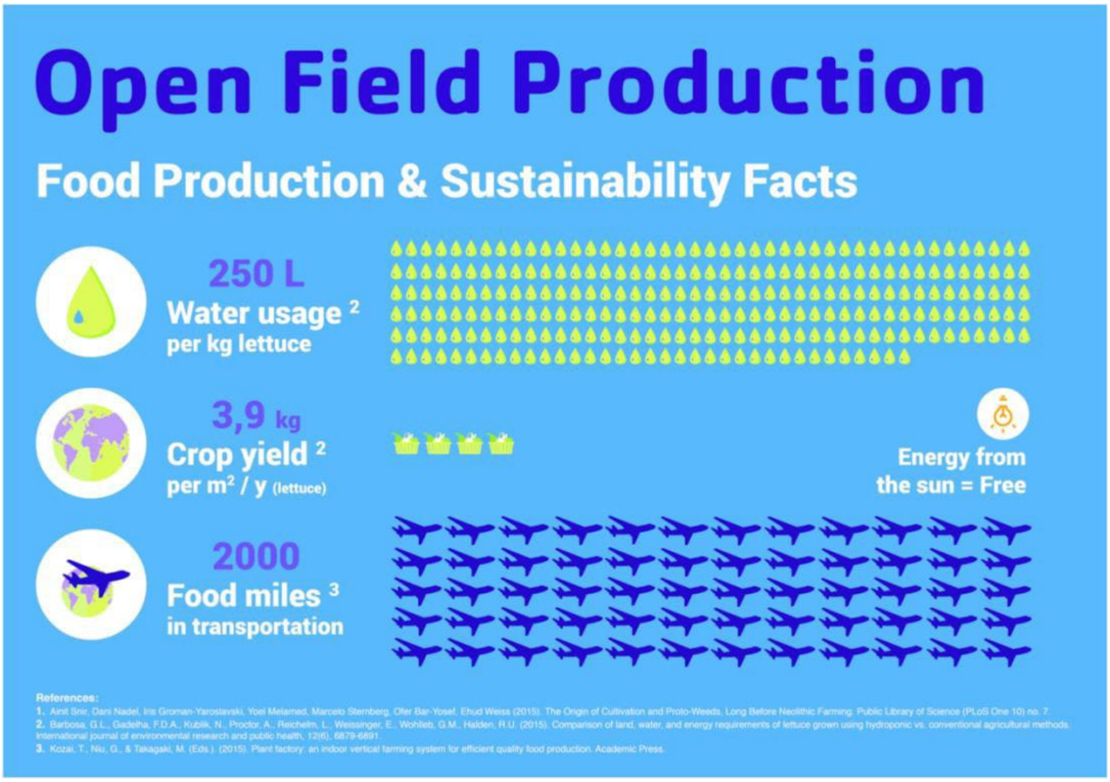

Figure 6. Water consumption and production of field agriculture (Adapted from Tessa Naus, PlantLab, 2018)

Figure 7. Water demand and production of vertical farming. (Adapted from Tessa Naus, PlantLab, 2018)

The irrigation system at "Cubicfarms" recycles water to reduce water demand. Water and nutrients are distributed evenly through a simple watering system. The water for irrigation in vertical farms is relatively clean and recyclable. On the contrary, the water for irrigation for traditional farming is often contaminated by fertilizer, pesticides, and other chemicals that will leave farms as runoff (Despommier, 2009). This may lead to pollution of drinking water and other clean water resources, which end up costing more for energy and efforts on water treatment to make it suitable for human use (Sheng, 2018).

Many vertical farms apply creative techniques to boost water efficiency. One technology in particular that raise a vertical farming structure value is atmospheric water generation (AWG) – the production and conservation of water from humidity that is already in the air into the liquid state which can be collected and harvested again (White, 2015). This method is capable of avoiding paying on water waste used in field agriculture irrigation and enables farmers to drastically decrease their water footprint.

In addition, the traditional farming method has potential problems. For example, the soil of Pitt Meadows is not compatible with field agriculture irrigation. Pitt soil is poorly to moderately poorly drained. The permeability is from slow to moderate. Thus, this soil has a high capacity for holding water. During the rainy winter season, the groundwater table is near the surface. It recedes in the growing season. Plants can hardly survive in the poor permeability soil.

The main issue for the Pitt soil in agricultural production is the poor drainage and high water table. If we want desirable irrigation during cultivation programs, artificial drainage is recommended and beneficial for crop production, especially for perennial crops (Luttmerding, 1981). The extreme acidity is a problem for some crops as well. This condition can be alleviated by adequate liming. Additionally, it is difficult to individually manage the Pitt soil since it is always associated with other types of soil. Thus, filed agriculture has many uncontrolled natural impacts that may be costly for people to explore the exact plan to solve.

Further, climate change has seriously disturbed the distribution and availability of natural resources. The shortage of water is assumed to cause food shortage in the future since it is impossible to support enough crop production which will satisfy the food demand (Ranganathan et al, 2018). Especially for freshwater in agriculture, water consumption and waste are the main current issues in crop production. The novel technology of vertical agriculture can assist in saving water resources as well as increasing crop production. Vertical farming uses indoor space to compensate for the lack of land available for farming. It's possible to decrease climate factors, such as water evaporation, inside the closed cultivation chamber. Humidity can be controlled. In conclusion, the whole environment can be regulated to be the most desirable condition for crops. The contribution of vertical farms against challenges brought by climate change is unmeasurable. It contributes to the main idea of sustainable development.

Except for water-saving amount in exploring the effectiveness of vertical farming. The cost of water supplies in vertical farms is also a consideration. According to the staff at "Cubicfarms," the freshwater of this vertical farm is bought from the government (Cubicfarms, 2020). In BC, the price of water is cheap. More importantly, since the amount of water consumption is much lower, the total fee of irrigation for vertical farms can be saved. Compared to traditional farming, where the water supply is from groundwater, the total amount of water use is large. Although the price of water will be the same for both and water is bought from the government, the vertical farming method is more economically efficient.

When considering vertical farms, the cost of energy and labour always is a major consideration. In "Cubicfarms," this worry has been eliminated. The whole growing chamber is highly automated. Everything is controlled on mobile devices. Thus, minor mistakes and errors can be detected by apps at "Cubicfarms" and staff can regulate and correct the apps (Cubicfarms, 2020). The operation is relatively simple and avoids unessential artificial mistakes.

Vertical farming has other advantages besides water conservation and crop production. For example, in terms of the desire to purchase safe crops, the outlook of lettuce cultivated by the vertical farming method is clean and lettuces are easy to package that can be sold in markets. Another benefit is that the lifespan of plants is longer. Since the roots are left in the storage packages and still living, lettuce will last longer, stay healthy, crispy and maintain its nutritional value. Based on the feedback of many customers, they are more willing to purchase products from "Cubicfarms". Right now, increasingly customers and residences are becoming to care more about freshness, healthiness and quality of crops. They prefer to choose products that are provided daily and look fresh and clean (BC Local News, 2019).

In conclusion, vertical farming can improve security by supporting year-round crop production and better use of space. The production won't be affected by adverse weather conditions. Thus, evaporation and other environmental processes that can cause loss of water during irrigation do not occur and conserve water. Vertical farming offers opportunities to completely get rid of using pesticides and other chemicals, which makes the production environmentally friendly. Transportation costs can be saved since people can cultivate crops locally without expensive long-distance travelling. The "Cubicfarms" also owns lower labour costs because the whole system is automated. The energy cost can also be saved, and some vertical farms even may produce energy within the operation (Horti daily, 2020).

However, nothing is environmentally perfect. Although vertical farming has improved production and effectively uses the available space and water more efficiently, running machines use considerable energy. Specially designed power and communication technologies are essential in many vertical farming sites. A company in Scotland has claimed that lettuces planted in conventional heated greenhouses in the UK need an estimated 250 kWh (Jenkins, 2018). Increasingly, vertical farms have moved towards renewable energy as alternatives. They could further decrease their carbon footprint by purchasing or producing clean energy (Jenkins, 2018). "Cubicfarms" uses one light for cultivating nine trays of vegetables rather than one light for one tray in normal vertical farms. The creative technology is capable of reducing greenhouse gas emissions and mitigate the carbon footprint. Some vertical farms employ collecting solar energy for running production machines (Roberts, 2018). However, installing solar panels on the rooftop may be expensive. More consideration should be involved in future planning of vertical farming energy supply.

In addition, we cannot feed the whole world with lettuce alone. Lettuce and other leafy greens are easy to be planted in vertical farms. However, other alternative crops and plants are important in people’s diets life. Further, more research and experiments should be done for the future development of vertical farming. This technology is comparatively new. People have a history of planting outdoors for more than ten thousand years, while vertical farming has only been established for about one generation. How to reasonably use hydroponics and saving energy in vertical farming still requires more study. Scientists are still progressing up the technical study curve, to the extent that there exists a shortage of clear data and raising other questions (Solomon, 2019). Considering the benefits and contributions of vertical farms in water conservation and production increase, the promotion of vertical farming is worthy to consider.

Limitations and uncertainty

The data from vertical farming obtained for this case study was from the official website of “Cubicfarms”, and related articles and other sites of vertical farming. Some articles describe that a big proportion of the water can be saved to show how beneficial the vertical farming method. However, the data is very vague and has no origins. They are released by companies or authors themselves. The origins of the data cannot be researched. Also, there exist many factors and processes that impact the water consumption of vertical farming. Nevertheless, what are the effects of those factors and how can those effects be illustrated in numbers to show the total impact are not clear right now.

Additionally, the tool BC Agriculture Water Calculator has some deviations during calculating the water consumption of conventional farming methods. When choosing the target crop type, lettuce was used as the vegetables. However, various vegetable irrigation demands will have differences. The annual production of vertical farming and traditional farming cannot be the same. In addition, the irrigation types for conventional farming is generally drip and flood irrigation. The BC Agriculture Water Calculator only has the choice of drip irrigation. On this point, the water demand for field agriculture is not exact.

Conclusions

Through the comparison of water consumption of vertical farming and conventional farming, it's apparent to see that vertical farming has more efficiency in saving water resources. It contributes to decreasing the water-intensive agriculture process. Vertical farming, a technology that allows farmers to grow crops year-round in a controlled climate, has shown great promise for water conservation (White, 2015).

Since the growing environment can be artificially controlled, the general climate influence of field agriculture is not an issue for vertical farming. This innovation is critical for improving sustainable development. Current conditions and climate change have brought considerable challenges for people's access to freshwater and arable land. Vertical farms manage humidity, water and nutrients recycle which minimize water use for crop cultivation. Farms can be equipped with atmospheric water generation with a closed- recycle structure that can control temperature and humidity within the chamber, while supplying clean water sources for consumption water uses (White, 2015). More importantly, stacked layers adequately use the whole space to solve the problem of low production of horizontal field cultivation.

With the appearance of innovative technology – vertical farming, it's possible to grow crops locally without shipping frequently from so large distances. In addition, customers require crops that are fresh and healthy. Vertical farming enables customers to purchase fresh vegetables daily and curtails the cost of resources of transportation. Current issues of food shortage may be alleviated, as well as the scarcity of water and land resources due to climate change.

Recommendations

The feasibility of vertical farming is decided by several factors, not only increase of food production, but also costs for water, the demand for labour and economic considerations. Based on the analysis in this project, vertical farming is valuable and should be involved in future sustainable agriculture planning. Therefore, if the government would like to promote the construction of vertical farms and promote sustainable vertical agriculture in the future, several items should be involved in the consideration.

Improvement of vertical farms construction and suggestions on promoting installing vertical farms:

1. Improve water recycle efficiency, conservation and regulation
2. Produce energy by vertical farms themselves
3. Try to exploit sunshine as energy and balance the cost of collecting sunshine at the same time
4. Using LED as a lighting system to save the cost of energy
5. Holding seminars to introduce value and functions to the local food suppliers to make sure they would like to accept this new technology and purchase products cultivated by this healthy method
6. Establish an official website to convince governors to support vertical farms constructions

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Appendices

Agriculture water demand report of Pitt Meadows

Agriculture Water Demand Report

Generated by: www.bcagriculturewatercalculator.ca (v2.0.2)

Date: Jul. 20, 2020

Property

Property ID (PID): 007561776

Total Area: 20 acres

Irrigation

Irrigated Area: 20 acres

Crop: Vegetable

Soil: Silty Clay Loam

Irrigation Type: Drip

Climate ID: 25491995

Peak Evapotranspiration (ET): 5.2 mm/day

Peak Flow Rate: 100 gpm

Irrigation season: Apr 15 - Oct 1 (170 days)

Irrigation water demand by month:

January -

February -

March -

April 57.4 m3

May 830 m3

June 3,620 m3

July 6,030 m3

August 4,600 m3

September 1,350 m3

October 38.8 m3

November -

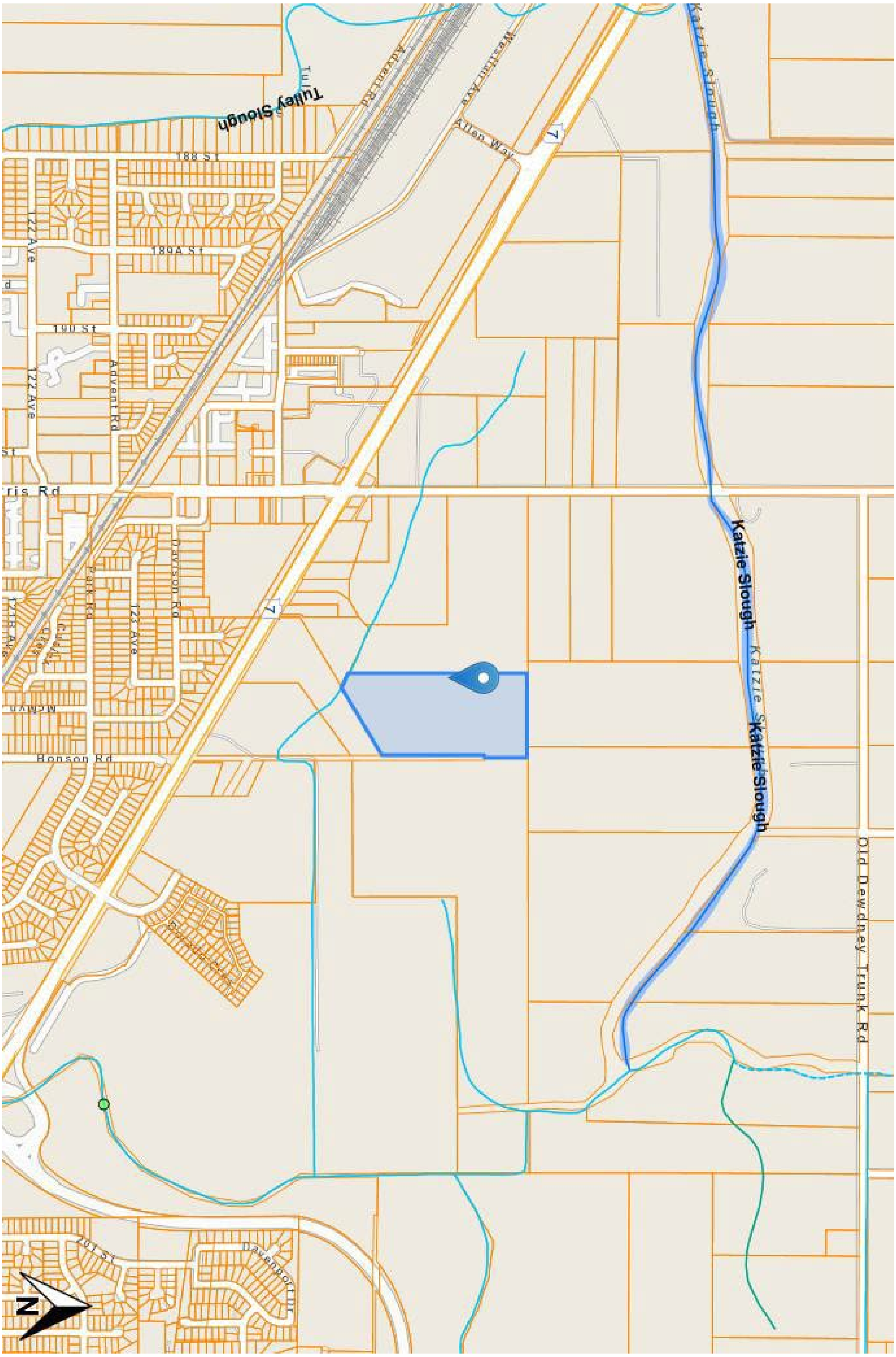
December -

Annual irrigation water demand: 16,526 m3 (16,530,800 L)

Livestock

No Livestock

Total annual water demand: 16,526 m3 (16,530,800 L)



Tulley Slough
Katzie Slough
Katzie Slough
Katzie Slough
188 St
189A St
190 St
122 Ave
122 Ave
Advent Rd
Advent Rd
Allen Way
Davison Rd
Park Rd
123 Ave
Bonson Rd
Old Dewdney Trunk Rd
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