UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

Business Proposal for the New SUB Rooftop Garden

Benjamin Amundson

Janbaaz Ghani

Patricia Szeto

Joseph Shen

Nanette Ho

XiaoLin Shi

Xiu-Ming Tang

Leslie Brugger

Tracy Burnett

Hilda Wang

University of British Columbia

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LFS 450

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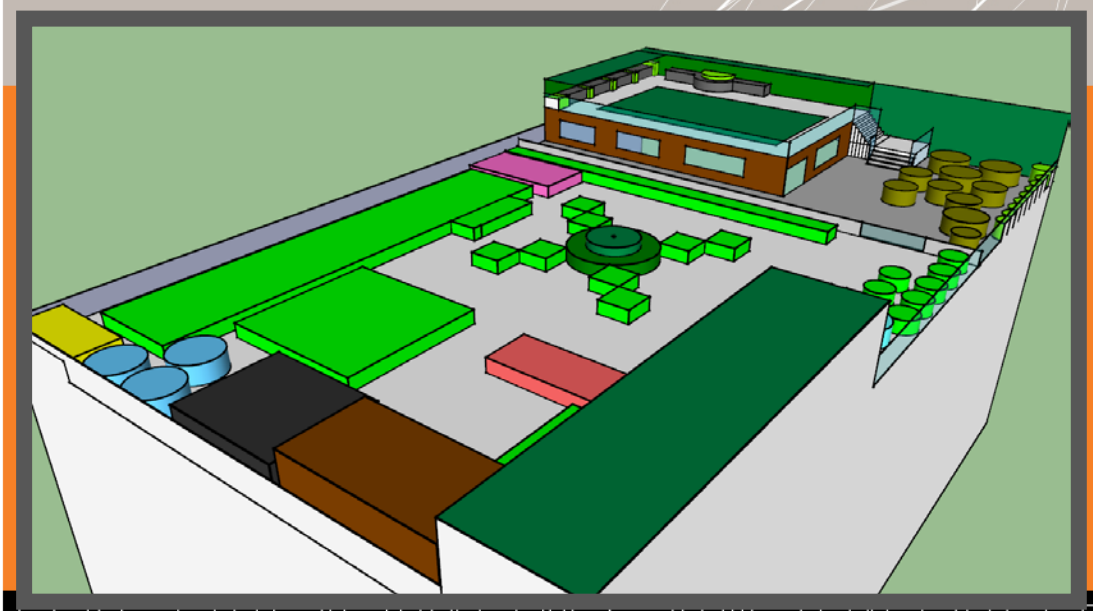

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1.0 Overview

1.1 Introduction

A New Student Union Building (SUB) is scheduled for completion in 2014, with construction starting in the fall/winter of 2011. The New SUB design phase will be taking place between January 2010 and 2011. This will involve creating a design that is innovative and incorporates sustainable practices. Consultations with UBC faculty, staff, and students have been collected regarding the needs and requests in the New SUB. Based upon these surveys, it was found that the primary concern was that the New SUB should be economically, socially, and ecologically sustainable. Furthermore, there was overwhelming response for a rooftop garden being the most preferred location for a student lounge.

The New SUB has designated a total of 30,000 square feet of roof space to be made into green space. The design of this 30,000 square feet rooftop has been assigned as a project scenario for LFS 450. The tasks for LFS 450 students are to design and create a business proposal for a rooftop garden on the New SUB.

1.2 Intent of the Guidelines

The intent of these guidelines is to incorporate the AMS goals and translate them into an environmental and financially sustainable rooftop garden model. The guidelines are based on UBC's building design guidelines, feedback from UBC students and stakeholders, research of existing university rooftop gardens, and AMS mission statements.

A study at the University of McGill found that the transportation of raw and processed foods accounts for 1.4 quadrillion BTU/year of energy, this translates to about 14% of the total energy that is used in food production (Making Rooftops Bloom). A rooftop garden at UBC would not only reduce energy to transport and process food, but also promote local eating, reduce chemicals and pesticide used, and make an otherwise unproductive rooftop to one that nourishes the university and its community members.

A rooftop garden has many beneficiaries including, the University establishment, UBC students and faculty members, the surrounding communities and schools, and the environment. As a consequence, the guidelines are focused on:

1. Creating a financially sustainable rooftop garden;
2. Providing student, faculty, and community members a place to relax, study, enjoy, and eat;
3. Providing a space that promotes sustainability and general health and wellness;
4. Providing a space that allows for educational opportunities;
5. Providing food that is ethnically diverse, affordable, safe, and nutritious;
6. Providing food that not only nourishes but also enhances the community; and
7. Raising awareness on consuming responsibly.

1.3 Background:

Alma Mater Society (AMS) is the student government in charge of guiding the design and management of the New SUB project. AMS has been given the duty of creating a SUB that will exemplify sustainability.

1.3.1 Summary of Rooftop Garden Benefits:

Economic Benefits	Public Benefits
- Garden can serve as venue that promotes sustainability for student, faculty and community members.	- Promotes community self-reliance and sustainability
- Distribution of crops grown on rooftop to UBC and other organizations.	- Increasing capacity for local food source
- Reduces energy needed to cool the building in the summer and heat the building in the winter	- Reduce carbon footprint by reduction of fossil fuels
- Protects rooftop from damage and extending the life of rooftop.	- Improve air, reduce pollution, and enhance biodiversity by providing habitat for wildlife and insects.
- Production of marketable crops to public, such as herbal teas and honey).	- Promotes foods security
- Help gain possible funding for green initiatives.	- Educational opportunities for research, teaching and learning
- Provides sound insulation for the building.	- Urban heat island effect
	- Storm water retention
	- Aesthetically pleasing

Table 1: Summary of Rooftop Garden Benefits

1.3.2 Reduce Storm Water Runoff

A rooftop itself, beyond the garden, can help retain the rainwater and the rainwater can be either used as a water supply for the rooftop garden and green walls or be returned to the atmosphere via evaporation and transpiration. There is a reduction in runoff and the stress on the sewage system is significantly improved. Excess water can eventually go into the main system but that can also be prevented by collecting and storing the water for ground level irrigation. A study at BCIT found that a green roof could reduce the storm water runoff and save money in the long run.

1.3.3 Rooftop Gardens are Energy Efficient

Rooftop gardens can reduce the energy needed for cooling or heating the building. In the summer, a green rooftop shades the outer surface of the building from direct solar heat and in the winter it provides added insulation that reduces heat lost through the roof.

In a larger scope, reduced energy to heat and cool the building means a decrease in greenhouse gas emissions.

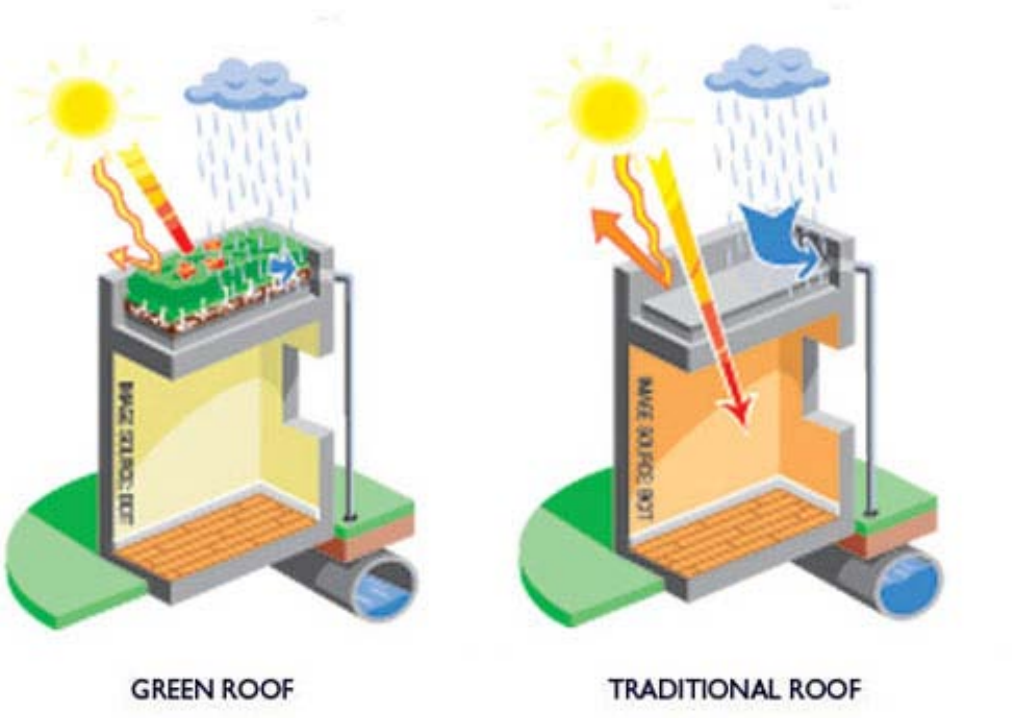

Figure 1: Rooftop Gardens can reduce the energy needed for cooling or heating the building. Source: BCIT Green Roof Research Program

1.3.4 Improves Air Quality

The plant leaves can trap dust and pollutants from the air leading to improved air quality. Also green rooftops ability to return moisture back in the atmosphere via evaporation and transpiration (evapotranspiration) aids in cooling the ambient temperatures, thus reducing Urban Heat Island prolife.

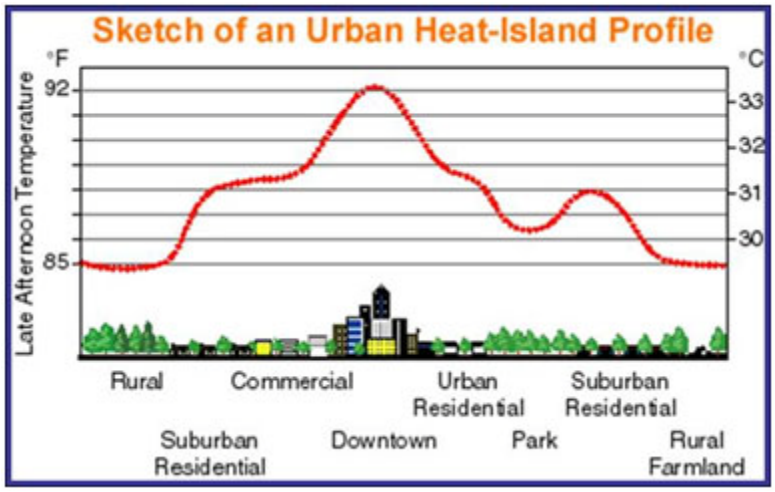

Figure 2: Temperatures in the urban core can be 3^{o}-5^{o} C warmer than rural and suburban areas. Source: BCIT Green Roof Research Program

1.3.5 Rooftop Gardens Enhance Biodiversity

A rooftop garden can serve as habitat for both plant, animal, and insect species which would encourage biodiversity in the urban areas. BCIT Green Roof studies have stated that, "Ground-nesting birds, such as Killdeer, use green roofs for nesting and raising their young."

1.3.6 Rooftop Gardens Extends the Life of Roofing

A rooftop garden provides protection from the rain as well as UV rays from the sun. It can also protect the building from any extreme fluctuations in temperatures which extends the life of the roof. BCIT Green Roof projects have stated that a green roof can extend the life of the waterproofing membrane on the roof by two times, when compared with conventional rooftops. The extended life of the roofing translated to less costs over time in re-roofing and less waste caused by re-roofing.

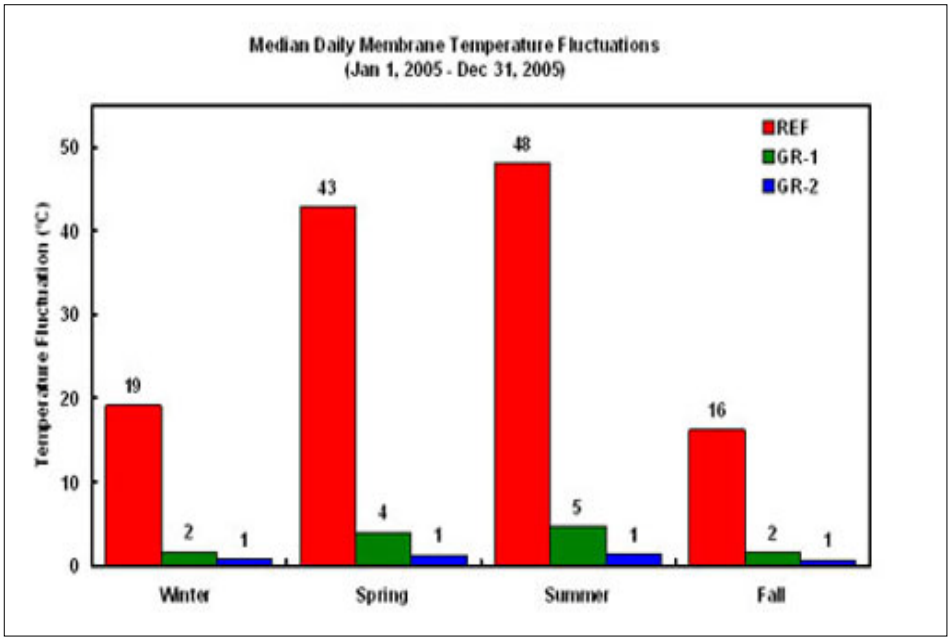

Figure 3:
REF: Reference Roof (without rooftop garden)
GR-1 and GR-2: Green roofs

Median daily temperature fluctuation experienced by roof membrane of the three sections (REF, GR-1 and GR- 2)
Source:
BCIT Green Roof Research Program

1.3.7 Possible Confounding Factors for a Rooftop Garden

If plants get dry, it could be a fire hazard and so "fire breaks" should be considered where there are regular spaces around the roofs. The spaces should be made from non-combustible material like gravel or concrete pavers (about 60 cm wide) and located every 40 meters in all directions. Another option would be to use fire retardant plants (like sedums) or installing a sprinkler system connected to the irrigation.

1.3.8 Partners and Contacts

Partners

- ❖ Alma Mater Society (AMS)
  - ♦ Jensen Metchie, Coordinator for New SUB Project
  - ♦ Liska Richer, Coordinator for SEEDS Program, UBC Sustainability Office
- ❖ AMS New SUB Project Design Team
  - ♦ Guillaume Savard, MHPM, New SUB Project Manager and Client Advisor

Contacts

- ❖ AMS Food and Beverages
  - ♦ Nancy Toogood, Manager
- ❖ AMS/UBC Clubs
  - ♦ Caitlin Dorward, Co-President of Sprouts Club.

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www.rooftopgardens.ca/files/Making_Rooftops_Bloom_Final_Draft.pdf
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2.0 Site Description and Plans

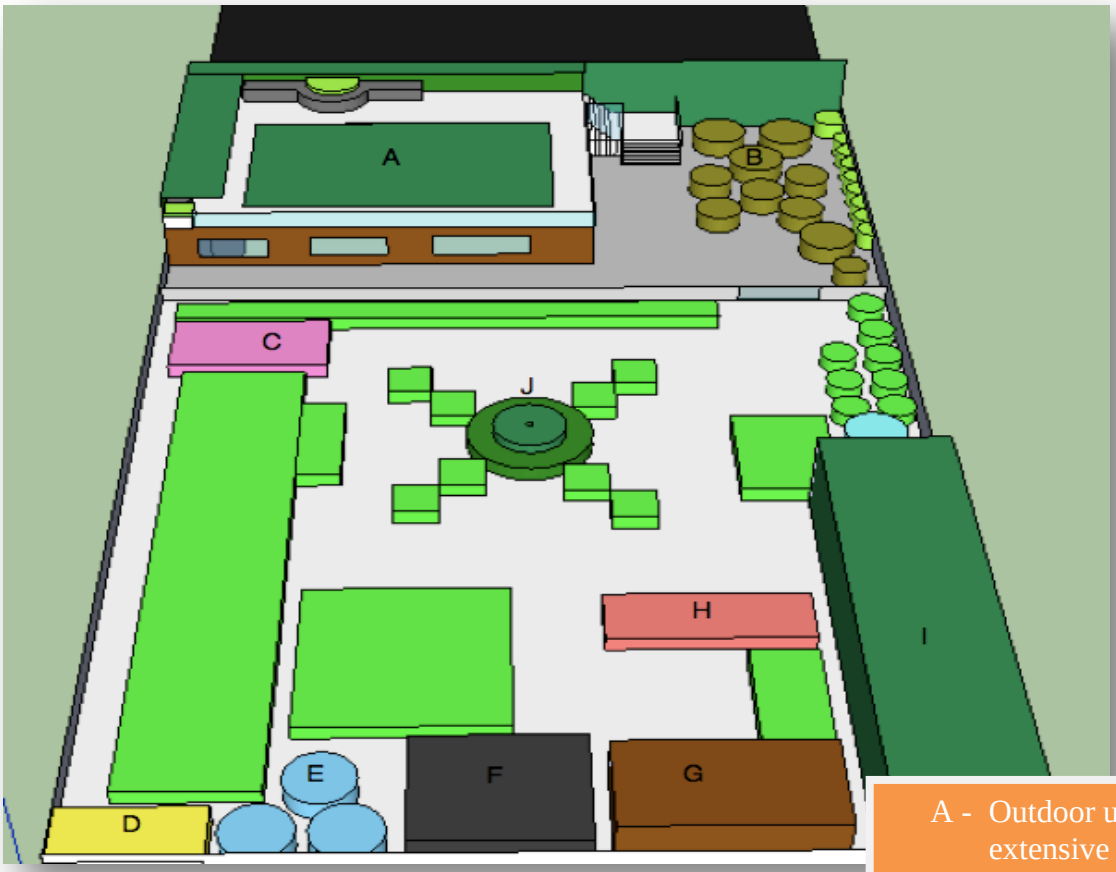
2.1 General Layout Guidelines

The garden design and layout is based on survey results polled from UBC students. The garden will feature: indoor and outdoor student lounge areas, small food outlet, community kitchen, greenhouse, water reservoir system, composting system, garden research area, indoor and outdoor green walls, 2 beehives, and crop areas. Rooftop layout focuses on the demands of students and the necessity for the garden to be sustainable.

The layout includes a tiered outdoor lounge area. An approximately 4000 square feet extensive lounge area will be on the top tier and on the lower level will be a community kitchen space, food outlet, restrooms, elevator, and more indoor lounge area. An indoor green wall is

proposed in the lounge (working aesthetically and as an air filtration system). The remaining rooftop will be inaccessible to the public and is designated for crop production. The crop area includes a greenhouse, water reservoir system, composting system, garden research area, and 2 beehives. The remaining area in the crop space allows for at least 6500 square feet of farming.

Outdoor Layout View

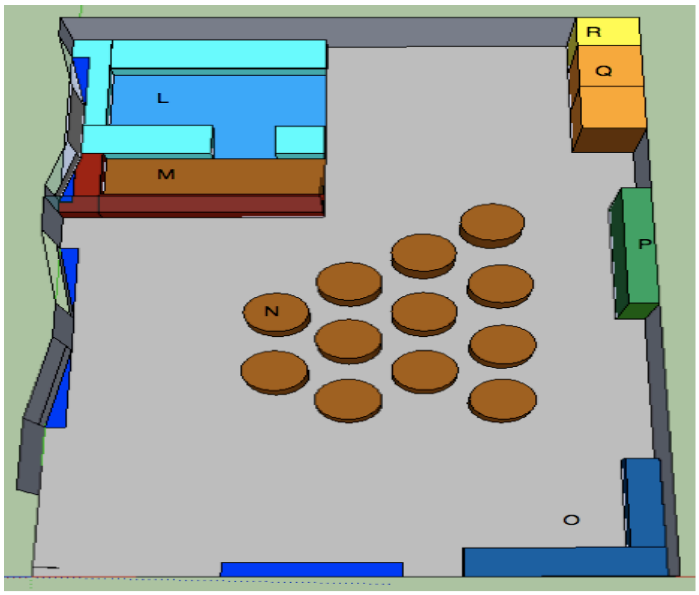


A - Outdoor upper lounge with extensive garden floor
B - Outdoor lounge seating area
C - Research garden
D - Beehives
E - Water barrels
F - Compost/waste area
G - Shed
H - Resting area
I - Greenhouse
J - Central green art display
K - Outdoor green wall with trellis shading

Figure 4: Above; Figure 5: Below

Bottom Indoor Lounge Layout View

Figure: 6



L - Community kitchen area
M - Food outlet
N - Indoor lounge seating area
O - Indoor lounging/study area
P - Indoor green wall
Q - Restrooms
R - Elevator

2.1.1 Details to Layout

Features	Location/Area	Why it's proposed
LOUNGE AREA		
Lounge (upper floor, outdoor)	- North side - 80’ x 50’ = about 4000 sq ft	- Building guidelines (blooming rooftop) - Outdoor lounge space
Green wall (outdoor)	(see 2.2.2 for more detail)	
Marketplace (indoor)	- 25’ x 10’ = 250 sq ft	- Possible area for people to purchase refreshments and sell/feature crops from the rooftop garden
Community Kitchen (indoor)	- 25’ x 20’ = 500 sq ft	
Green Wall (indoor)	Bottom indoor lounge (see 2.2.1 for more detail)	- Built in fan to circulate air, better air quality
Bathrooms (indoor)	- 7’ x 6’ (x2 for gendered rooms)	- Standard sized bathrooms.
Elevator (indoor)	- 5’ x 6’	- Canadian standard sized elevator (small) for handicap accessibility (optional)

OUTDOOR CROP AREA		
Garden Research Area	- 24’ x 20’ = 480 sq ft	- Allotted for faculty, student and community use. Used to study new methods of rooftop gardening/agriculture practices
Compost (vermicomposting)	- 30 x 40 cm minimum bin size. - Allotted 24 x 20’ = 480 sq ft	- Odourless and worms grow to reach capacity (how to setup rooftop article)
Water System Area	- Permeable paving, - Capture, filter, reuse, the rain barrels hooked onto growing containers (self-watering system)	- For every 1 cm, 10.7 sq ft of collection surface = 10 L (1 barrel = 200 L) - Rain barrels connected to growers, 5 L for each additional autonomy per fruiting plant/day
Apiculture Area	- 10’ x 20’ = 200 sq ft - 2x beehive boxes located at furthest point from lounge area	- Bees promote pollination and health of crops - Honey production could generate revenue
Crop Area	- Several crop areas of differing sizes; total of at least 6500 sq ft of crop space - Proposed methods of polytunnel and container gardening	- Container farming allows for ease of maintenance and flexibility (esp. for volunteers) -Allows for more varied selection of crops - Polytunnel usage increases farming capabilities of year-round production.
Shed	- 16’ x 30’ = 480 sq ft	- For storage of materials and tools.
Greenhouse	- 80’ x 20’ = 1600 sq ft - Southeast side	- Location based on maximum amount of sunlight exposure during winter hours. - Also proposed as it could be area for seeding tables.
Full/shaded crop	- Full sun in the east wall - Shaded along west wall	- Accommodates the requirements of more diverse plants.

Table 2: Details of the layout

2.1.2 New SUB survey

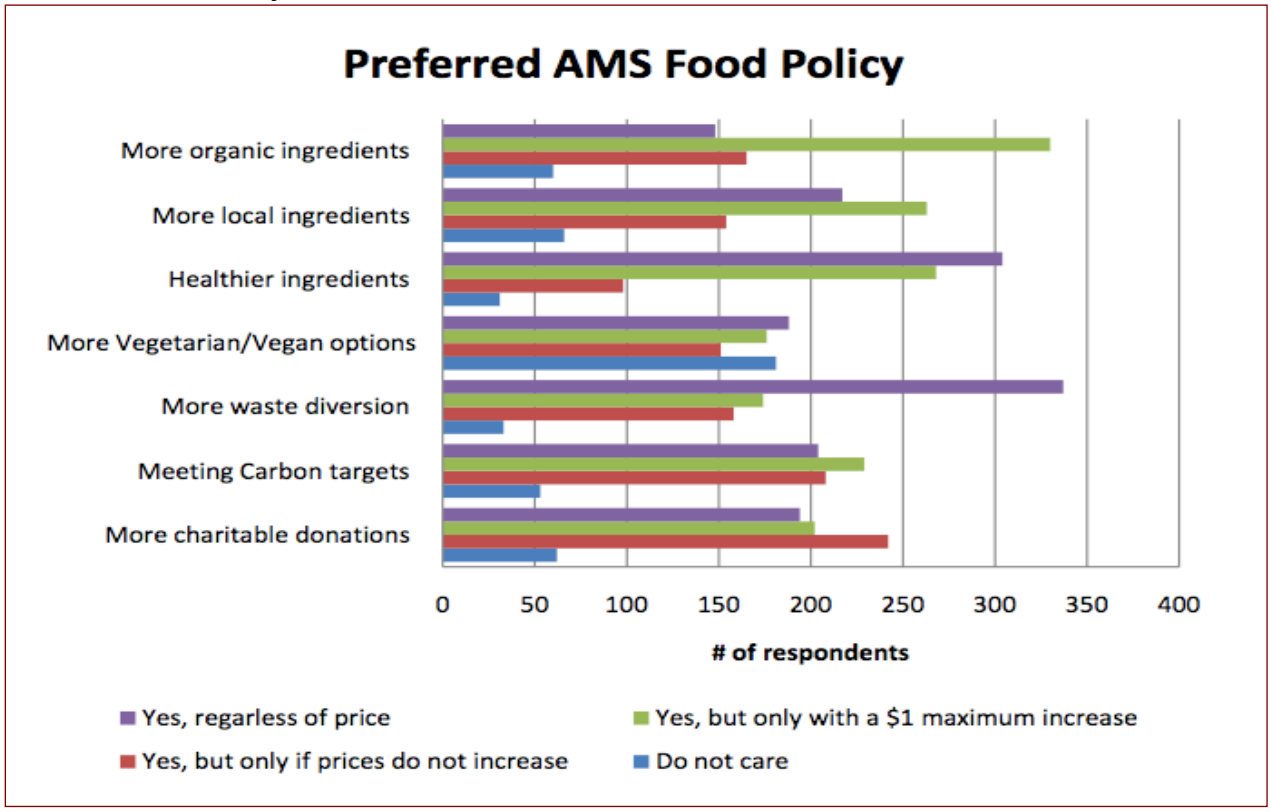


Figure 7: Results of New SUB Program Survey showing Students' preferred AMS Food policy
Source: New SUB Program Survey Summary

2.2 Green Wall Features

There are two types of green walls; ornamental (fascade) and living walls. Ornamental/fascade walls are composed of climbing plants that grow directly onto the wall or on supported structures. The plants are planted on the sides of the building; the roots are rooted into the ground while the plant shoots crawl up the side of the building. In a living wall, the wall is usually made of polypropylene plastic containers, geotextiles, irrigation systems, growing medium and appropriate vegetation.

Living walls can be further categorized into passive and active systems. Active living walls are based on a bio-filtration system in which the air is routed through the root system of the wall so that beneficial microbes can degrade the pollutants in the air and mechanically return the filtered air back into the space. It has been studied by the University of Waterloo and has been said that, "Living walls with biofilters increase the capacity of air filtration." Passive living walls do not move air into the roots where degradation of pollutants can occur thus the effects of passive living green walls on air quality is not clear.

2.2.1 Indoor Green Wall

An indoor green wall feature not only makes a space feel more comfortable and relaxing but also has the potential to clean the air and has been associated to reduce the stress levels and increase productivity of the occupants. There are several types of green walls. Some which are mainly ornamental (and tend to be low maintenance and low cost) and others that are more productive (which tend to need a little more maintenance and installation). The proposed is a more productive green wall. They require more maintenance and installation than an ornamental green wall but they are actively cleaning the air. Thus, Naturaire Biofilter has been proposed for the indoor lounge space in the New SUB.

The Naturaire Biofilter has been well researched at the University of Guelph. The biofilter consists of a hydroponic green wall. The wall contains a water pump and fan that is integrated into the building structure. The air goes through the wall of plants and the pollutants (such as formaldehyde and benzene in the air) are degraded into benign counterparts of water and carbon dioxide. The filtered air is then redistributed back into the space mechanistically. In general, all green walls have the capacity to clean the air but often the air/pollutant do not get through the foliage layers of the plants to be filtered. This active living wall system ensures that the air penetrate that wall to enhance air filtration.

It has also been done in several other green walls that the water is directly connected to the irrigation and rain water runoff system from the rooftop. According to Nedlaw Living Walls, a company that uses the Naturaire system, the plants have a 90% survival rate each year and would require general maintenance once a month. Also, normally 1 square meter or green wall would be sufficient for 100 square meters for floor space.

"A single pass through the **Living Wall** removed up to 80% of the formaldehyde, 50% of the toluene and 10% of TCE. These numbers are incredibly impressive; particularly when you consider that the filter is only 5 cm thick. Concentrations of toluene and formaldehyde in the aquatic system did not increase during the four-week experiment, suggesting that these materials were readily metabolized. TCE levels in the aquatic system initially did increase slightly, but then plateaued, suggesting a possible capability to degrade this compound. Even before the challenge, we knew that two to three percent of the bacteria present had the ability to break down VOCs (Volatile Organic Compounds)."

A confounding factor with an indoor green wall is the research to find the optimal plant species that would thrive in the space and the availability of sunlight; this will play a big part in plant health.

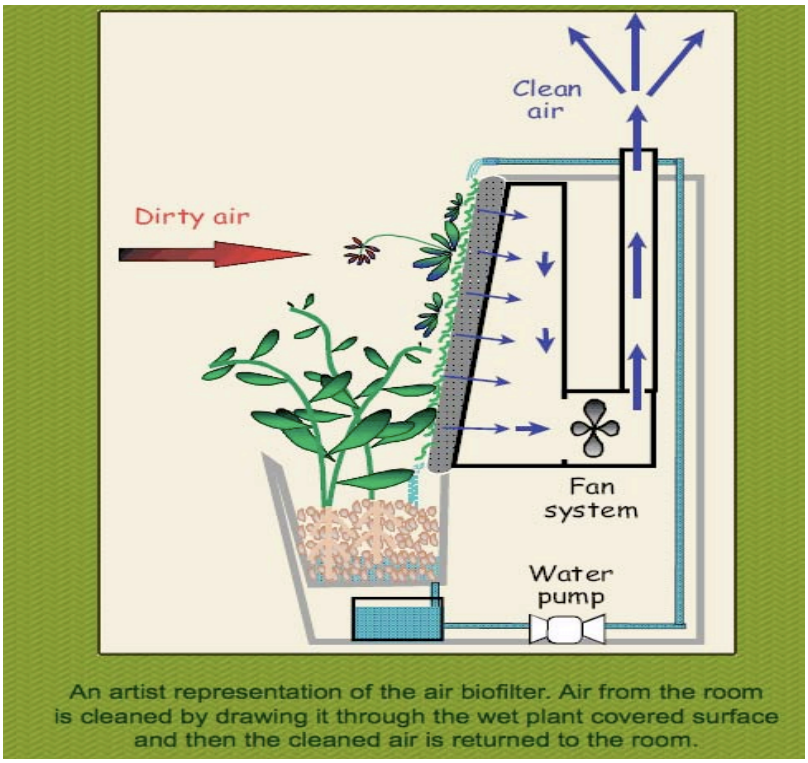


Figure 8: Indoor green wall air filtration

2.2.2 Outdoor Green Wall

An outdoor green wall is both aesthetically and practically beneficial in the rooftop garden. A green wall can provide shading for the outdoor lounge area and also help reduce the overall temperature of the building which can consequently save energy cooling the building. Green walls can also reuse rainwater and may have the capacity to filter slightly polluted water (such as grey water). Due to the vertical structure of a green wall, there is less evaporation and this may enhance plant viability.

There are several different green wall systems available, the wall mounting system has been proposed due to its ability for the plant panels to be easily removed or replaced if necessary. The removable panel feature allows for the changing of green wall art (please see photo below). Also, this system has a built-in irrigation system that uses recaptured water from drainage.

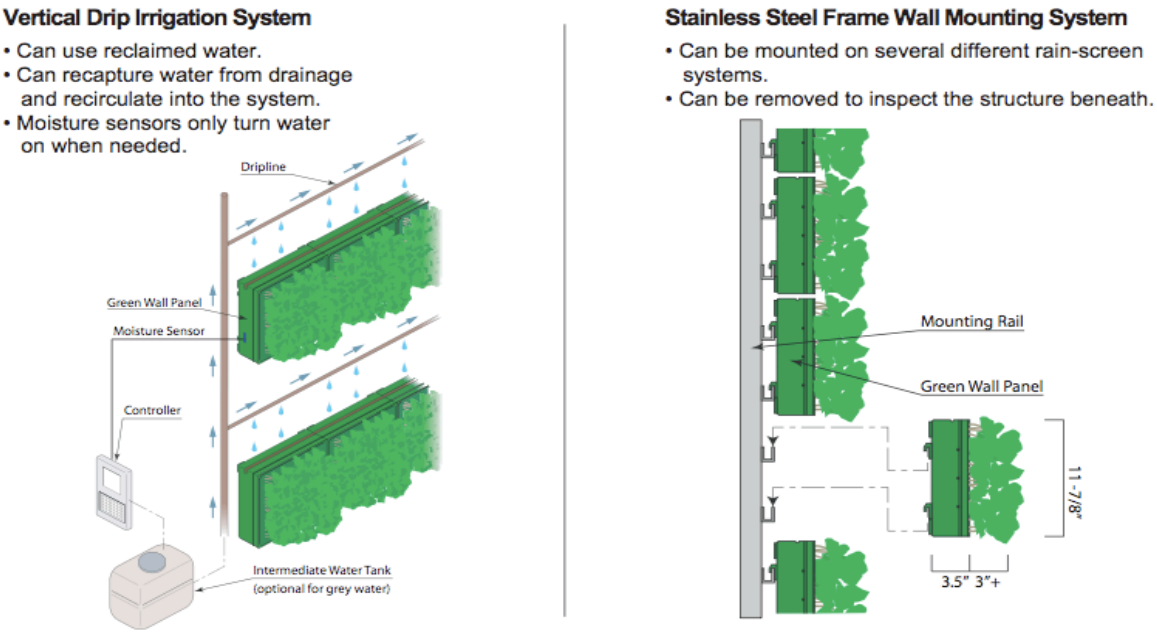


Figure 9: Outdoor green wall system

2.4 Greenhouse

A greenhouse can help supply certain crops in seasons where it would not be possible to grow them outside. The changing climate and conditions of the roof (increased wind) can also make it difficult for new, more sensitive plants to thrive. Once these plants have established themselves, they can be transferred outside if needed. Temperature, humidity, light, and water control can all be monitored to ensure an optimal environment for the plants being grown in the greenhouse.

Currently, greenhouse crop production in the lower mainland is high in tomatoes, peppers, cucumber and lettuce but the production can be catered to the demands of stakeholders.

Crop Production Cycle

Crop	Seeding Time	Harvest Time	Number Of Crops Per Year
Sweet Peppers	October/early November	March to November	1
Tomatoes	November	March to November/December	1
English Cucumbers	December & July	February to November	1 – 3
Butter Lettuce	Throughout year	All year	8 – 10

Figure: 10 Crop production cycle
Source: An Overview of the BC Greenhouse Vegetable Industry

A greenhouse 1600 square ft. with the dimension 20 feet by 80 feet is proposed for the rooftop garden (see figure 11). The floor will consist of compartments enclosed in areas similar to the growing method outside the greenhouse. The frame of the greenhouse can be made from the trees that will be cut down during the construction of the New SUB to maximize sustainability. Covering material should be made from fiberglass reinforced panels because they are cheaper, long lasting, and more functional than some of the alternatives. See Appendix A for possible materials and suggestions made by the LFS team.

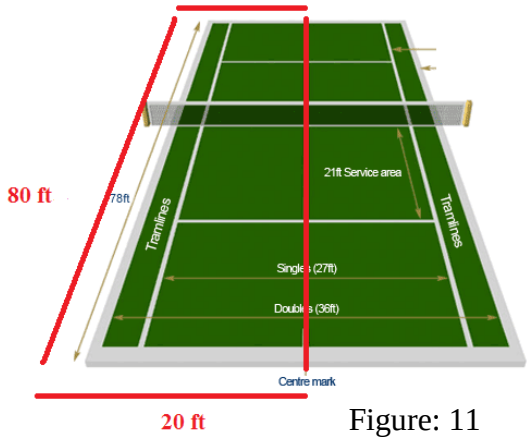


Figure: 11

The greenhouse should be placed where there is maximum amount of sunlight, especially during the winter. According to the sunrise and sunset positions in Vancouver, it should be set up near the East side of the roof because there are less buildings and more exposure to the sun.

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http://www.timeanddate.com/worldclock/astronomy.html?n=256&month=4&year=2010&obj=sun&afl=-1&day=1

3.0 Production Plan

3.1 Growing Methods

After reviewing all the above methods of growing management we recommend the following and the layout of the garden was mainly based on these decisions:

Container Gardening

As highlighted in Appendix B, containers allow portability and provide flexibility, which is ideal for the number of different uses of the garden we have proposed. Soil content in each container can be separately controlled to provide optimal conditions for different crops (Novak, 2004) and the containers allow for easy vertical gardening
http://www.youtube.com/watch?v=RlQaOsDZuBQ&feature=channel
http://www.youtube.com/watch?v=YHOPg5hDvsA&feature=fvw
http://www.youtube.com/watch?v=BbIipA86uek&feature=fvw).

Use of Mobile Polytunnels

Polytunnels can be used during harsh weather to protect crops and maintain an optimal climate. Portable polytunnels allow for removal during good weather and can transport from plot to plot depending on the different needs of each plot (Growing Raw Health, 2009).

Drip Irrigation

Can be easily installed with container gardening as this type of gardening can lead to moisture loss due to lower soil mass and the materials of the container. Drip irrigation can save water and allow for optimal control over the water distribution and usage. Fertilizer solution can also be distributed using the drip irrigation system.
http://www.youtube.com/watch?v=RS2QqR3JBi4

Vermicomposting

This is an easy form of composting that can be done at a small scale (for rooftop gardens) and allows for good crop growth. It works at moderate temperatures and thus does not take as much energy than systems that require heating to reach high temperatures. It is also a relatively rapid form of composting so soil can be replenished relatively quickly if need be. This form of composting also uniquely allows for the maintenance of an optimal bacterial balance for ideal crop growth and disease minimization

Greywater treatment

During drier seasons, greywater treatment can be used for irrigation in the garden and as stated in the above table, helps to reduce stain on the sewage system. This system also needs to be well installed and allow for good filtration to reduce undesirable health and environmental effects from contaminated water

3.2 Plan of Production

When selecting crops for the rooftop garden, we wanted to make our decisions based on the three pillars of sustainability: ecological, economic, and social sustainability. As a result, we compared crops that are currently grown on the UBC Farm and vegetables that are currently purchased by AMS outlets and considered the capabilities and limitations of container gardening. By doing so, we created a primary and secondary list of crops to be grown on the rooftop garden. Ecologically, we have chosen plants that can be grown successfully and in large quantities for our climate range and proposed growing methods. Refer to Figure 12 for the growing season of common BC crops. In addition to this we are proposing the production of honey to serve as an ecological service. To maintain economic sustainability we analyzed data given to us on crops purchased by each of the eight AMS outlets, which include: The Moon, Pi R Squared, The Pendulum, The Pit Burger Bar, Bernoulli's Bagels, The Honor Roll, Blue Chip, as well as the Wednesday Night LFS BBQ. From this, we calculated which crops were in highest demand (in quantity) and which crops would yield the most profits. This also reduces the ecological footprint of some of these outlets as these ingredients can be obtained straight from the building. Social sustainability was considered in respect to ambiance in the lounge area for visitors. We have included ornamentals as a primary crop, as well as different berries and fruit trees to attract visitors and make their stay more enjoyable.

In discussion with Nancy Toogood, the AMS Food and Beverage Manager, she suggested that we also look into growing more unique crops like multi-coloured carrots, beets (golden and candy cane), daikon, chayote, heirloom tomatoes, mushrooms and unique varieties of potatoes like purple potatoes etc.

Through researching vertical gardening we also found that vining crops like cucumbers, watermelons and pumpkins are also a possibility. Vertical gardening is also needed for heirloom tomatoes as listed above (http://www.youtube.com/watch?v=RlQaOsDZuBQ&feature=channel). In addition, Bee pollination is a key component of successful crop production. As well, bee hives can benefit the rooftop garden by yielding honey. When a bee lands on a plant, it transfers pollen stuck on its legs from the previous plant. This cross pollination helps the reproduction cycle of plants, which ultimately benefits crop production. In addition, the populations of bees have been on a decline and having green spaces such as rooftop gardens can help preserve the bee population (World Focus, 2009).

Due to the recent infection of clubroot at the UBC Farm, we would like to stress the important role the rooftop garden could take in filling the void of certain crops which will no longer be able to be grown. Clubroot is a fungal disease that effects the growth of plants in the Brassica family (Meyers, 2008). This would include such vegetables as: cabbages, cauliflower,

radish, Bok Choy, broccoli, and rutabaga, which also encompass UBC's popular salad greens mixture.

3.2.1 Crop types

Primary crops: Basil, parsley, cilantro, tomatoes, broccoli, lettuce (romaine, iceberg, and salad mixed greens), potatoes, red pepper, green onion, cauliflower, green pepper, onions, cucumber, spinach, carrots, apples, garlic, yams, raspberries, blueberries, fennel, strawberries, teas, kale, chard, honey and ornamentals

Secondary crops: ginger, zucchini, eggplant, red onion, red cabbage, jalapeño, green cabbage, Bok Choy, celery, beets, rosemary, oregano, savory, leeks, thyme, radish, squash, pumpkin, peas, and beans (green, pole, bush)

Another option: Meyer lemons, key limes, dwarf oranges, kumquats, avocado, papaya, guava, blackberry, dwarf grapefruit, blueberry and fig dwarf trees can be grown in containers and put in green house during freezing months (need to stay above -7 degrees Celsius)

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Mysterious decline in bee population creates worry.
http://worldfocus.org/blog/2009/08/20/mysterious-decline-in-bee-population-creates-worry/6892/

For more in-depth information on how to grow each of these crops listed above, these are very useful websites:

- http://www.howtogardenadvice.com/
- http://www.saltspringseeds.com/
- http://www.westcoastseeds.com/gardenresources/

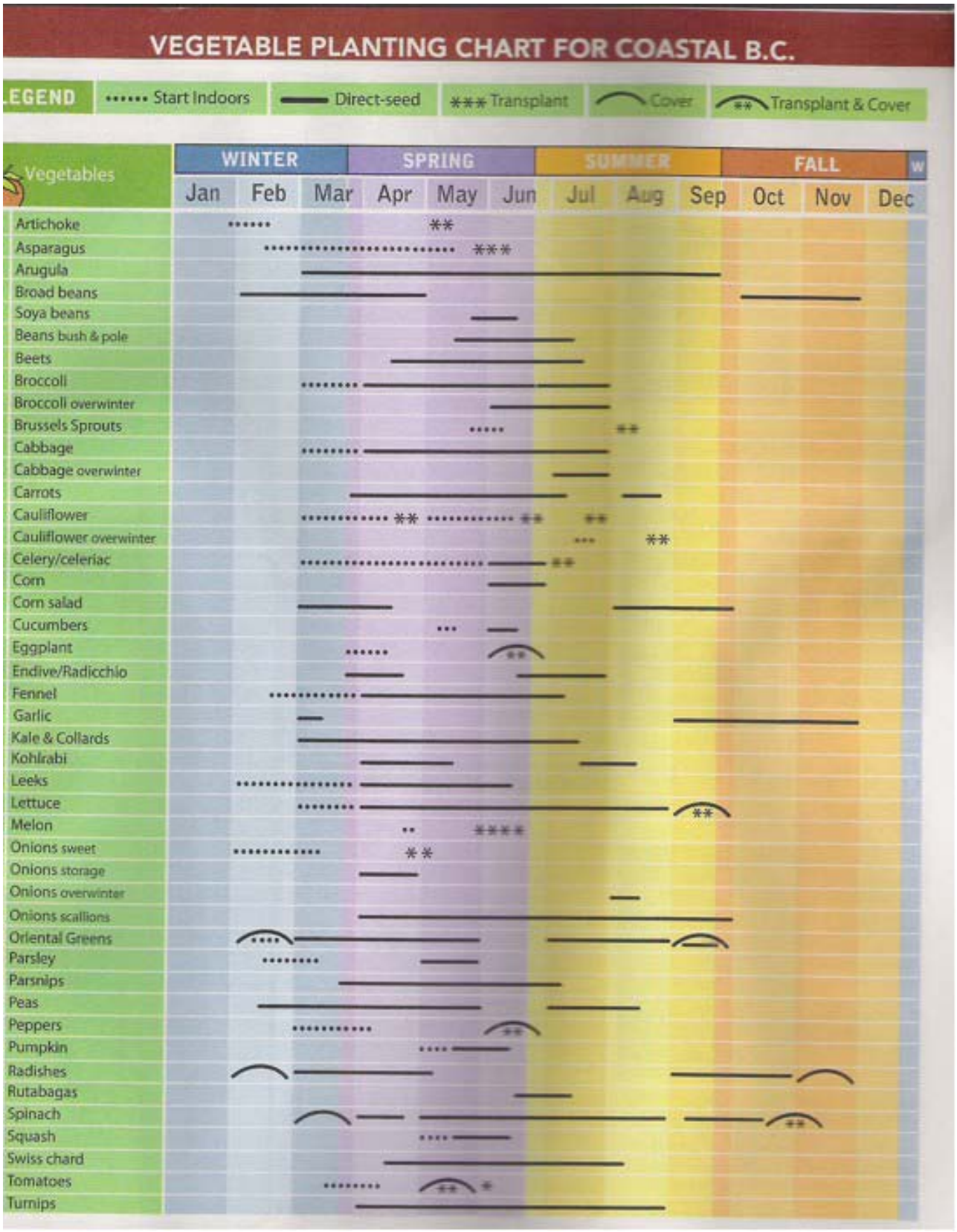


Figure 12: Vegetable planting chart for coastal BC
Source: West Coast Seeds

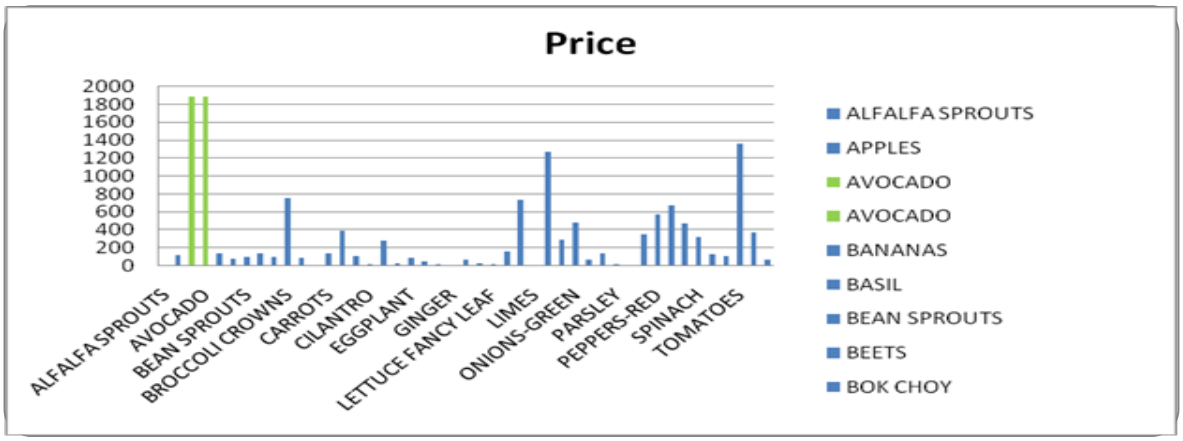


Figure 12.1: Toogood, N. AMSFB Monthly Purchasing Data, 2010.

References

—3.2—

West Coast Seeds-Gardening Guide.
http://www.westcoastseeds.com/admin/product/item/catalogue/2009-catalogue-west-coast-seeds.pdf

4.0 Distribution Plan

4.1 Allocation of Produce

Our group would like to be able to provide the AMS food outlets in the new SUB with the greatest amount of our crops as possible. This will reduce travel costs and promote the garden through advertising sustainability and "where your food comes from" in these outlets. We would like to have a kiosk in the new sub where promotions for the garden can take place and crops can be sold to foot traffic. This kiosk will also be used to educate the student population on the importance of buying local and organic foods, and tips for reducing your carbon footprint. The sprouts club has expressed a lot of interest in participating with the garden. They have student workshops and a campus grocery store that would be able to utilize some of the garden crops as well. The grocery store's first priory is promoting sustainability and would be a great program to collaborate with who shares the same sustainable values with the garden. The manager of the grocery store was especially interested in getting a variety of herbal teas from the garden. They also have a community supported agriculture (CSA) program called "Sprouts boxes" which distributes fresh produce throughout the UBC campus that the garden would be able to contribute to as well. Building a strong relationship with sprouts would also help with the organization of volunteers needed for growth and maintenance of the garden. The Land and Food systems (LFS) faculty puts on a student barbecue every Wednesday night. They currently get a lot of their crops from the UBC farm; this would be another great place for some garden crops to go. Volunteers from the garden would be able to participate in the Saturday farmers markets at the UBC farm in order to sell the remaining crops and help spread awareness of the new garden to community members. While production is high during the summer months, crops can be preserved for sales during the school year via pickling, canning, and jamming methods. Any

extra crops that are not utilized can be donated to local food banks or composted. Our group came up with a list of crops that would be best suited to grow in the garden and our climate.

5.0 Management Plan

5.1 Potential Management of the Rooftop Garden

At first, the prospect of inventing an AMS Rooftop Garden Club was an attractive alternative to an AMS regulatory body managing the rooftop garden operations. Since the space belongs to AMS, it was deemed appropriate for an AMS body to govern and allocate the rooftop garden space once the rooftop is completed in 2014. Subsequently, after discussing with AMS stakeholders on forming a Rooftop Garden Club, it was soon discovered to be an unnecessary option, so the issue was disregarded. At the moment, various groups such as UBC Sprouts Club and UBC Friends of the Farm have shown genuine interest about participating in the rooftop garden's operations.

The lounge space will be open to the public. It will include both an indoor and outdoor seating area and a community kitchen. The crop area will not be publicly accessible outside of certain hours or unless there is supervision. We want to minimize the risk of pollutants, contaminations, and safety hazards. The design of the building allows for an elevator to open on to the rooftop. The advantages of this feature can be fully exploited by the rooftop gardeners and the functional operations of the garden.

5.2 Operations of Rooftop Garden

Our recommendation for the rooftop space (given 30,000 sq ft) is based upon the allocation of 75% crop area and 25% lounge area. The actual space used for crop production will be less than 22,500 sq ft (1/2 an acre) due to open spaces and other features (see layout section for details). As a result, the time requirement for cultivating crops is highly dependent on knowing the actual design of the rooftop. Some other factors that influence the rooftop garden operations are the crops being produced, the time of year, the skills of the workers, and the number of volunteers. Once a rooftop design is adopted, we recommend following up with the LFS Orchard Garden, UBC Spouts, and UBC Farm to obtain information regarding their capacity to participate in the rooftop garden operations. In any situation, our recommendation would still require an experienced gardener to oversee the rooftop garden year-round.

Summer is the best time for crop production; therefore, the food grown in the summer could be stored, preserved, or sold at a later date. An example would be to make tomato, raspberry, and blueberry jams. The year-round gardener's duties will include summer maintenance when students are away. Depending on the season and the amount of produce being grown, the hours can range from casual maintenance during the winter months to full-time hours during the summer months.

Half an acre of year-round vegetable production requires about one to one and half full-time staff. Food and Beverage Department (FBD) Manager, Nancy Toogood, plans on opening a

position for a staff person to maintain the rooftop garden. Both FBD and Sprouts envision their collaboration on managing the rooftop garden to be split seasonally. During the summer months, FBD will take on a greater role, while in the winter months, Sprouts will mainly be in charge. In theory, AMS only needs to hire one gardener because any extra labour hours can be supplied by Sprouts. Students were also keen to volunteer for the rooftop garden according to the AMS survey.

5.3 Management Team

The management for the rooftop garden would be undertaken by a sub-division of the AMS Food and Beverage Department or even a separate entity within the AMS. Since survey results and many UBC students felt strongly about the implementation of a rooftop garden, we suggest keeping the ownership within the student body; hence, our proposal does not explore the possibility of hiring independent contractors to maintain the rooftop garden. Even though the rooftop garden would be officially owned and operated by the AMS FBD, stakeholders such as Sprouts would be of key importance throughout the annual maintenance of the rooftop garden. Of course, our suggestions for the management plan are solely at AMS Counsel's discretion.

The advantage of having a paid coordinator supervising as the AMS liaison is that it would help streamline the flow of information between the AMS FBD and the AMS Counsel. Also, the AMS liaison would be responsible in co-managing the rooftop garden operations on behalf of the AMS.

<u>Partners of the Management Team</u>

The Sprouts plans on designating a volunteer coordinator. These will be semester-to-year-long positions that require a fair amount of responsibility for such a sensitive crop production area. They will be trusted individuals who will ensure the safety of the crops. Sprouts will be the main gateway through which volunteers gain access to the garden.

The 'what if's' are important when reducing the risk of internal conflict. Should another organization wish to directly partake in the decision-making process, the group can put forth a proposal through the AMS counsel. For example, should Food and Beverage have a problem with Sprouts they can file a complaint with the Counsel and vice versa. However, there should be a sense of ownership over the garden. It cannot be subject to the yearly whims of fickle political parties. Sprouts and AMS Beverage should be seen as the key collaborators and owners of the roof-top garden. Management conflicts will be dealt with through the AMS counsel.

To ensure that Sprouts participates in the planning process, it is recommended that they request to join the Sustainability Advisory Committee (SAC). This can be done through contacting Jensen of the SUB Renewal Committee. The SAC will be responsible for developing and administering overall sustainability objectives for the new SUB.

5.4 Bridging the Rooftop with Learning Opportunities

In terms of academic opportunities, the New SUB project outlines a need for a Professional Advisory Component (PAC). In order to manage the garden proficiently it is recommended that the LFS Teaching Team helps create the PAC to advise SAC. It has not yet been established and may require the collaboration of different faculties. Some professors and groups have already expressed interest in studying the roof-top, however small the plot scale.

6.0 RESOURCES

6.1 Resources Needed for Rooftop Foundation

It is important to make sure that the rooftop has a suitable foundation before a rooftop garden can be implemented. There are few to no modifications to the roof needed for container gardening as long as the roof already takes into account added snow load. The weight of a container garden can be comparable to a snow load.

An extensive green roof (in relation to the grass area on the outdoor lounge) requires the structural loading of roof to be between 10 and 35 pounds/sq ft (72.6-169.4 kg/sq m). The soil depth for an extensive garden is usually 2-6" (5-10 cm) in depth (Design Guidelines for Green Roof).

6.2 Maintenance Needed for Container Gardens

For harsh winters, terracotta pots can crack, thus wood, plastic or metal containers generally survive winter better and can hold more moisture so moisture loss should be regularly monitored for each container. Extreme hot weather and the smaller soil volume can cause soil dry-out and may need daily watering. A mulch cover like straw, wood chips or a sub-soil layer of newspapers and compost can help slow evaporation and shade soil. See more information in 6.3.

6.3 Resources and Maintenance of Garden Features

Rooftop Garden Feature	**Resources Needed**	**Maintenance Required**
LOUNGE AREA		
Indoor Lounge Area	- Seating and tables - Restroom (toilet, sink, paper, lighting) - Elevator - Lighting - Windows	- Daily maintenance (cleaning/repairs)
Indoor Green Wall (Naturaire Indoor	- Hydroponic growing medium - Water pump	- Pruning and trimming of plant (weekly).

Air Biofilter or "living walls")	- Fan system - Crawling medium for plants Source: Manhattan Plant Experts	- Maintenance of plant health and replanting if necessary - Checking proper function of fan and water pump
Outdoor Green Wall (Living Wall Panels)	- Plants: dicentra formosa (Pacific bleeding heart), Dryopteris expansa (spiny wood fern), Fragaria vesca (woodland strawberry), Gaultheria procumbens (wintergreen), Polypodium glycyrrhiza (licorice fern), Tellima grandiflora (fringecup), Tiarella trifoliata (foamflower) and Vaccinium ovatum (evergreen huckleberry). - Drip irrigation system connected to rainwater runoff. Randy Sparks Stainless steel panels Source: Gsky and True Arts	- Pruning and trimming plants. - Check irrigation system for clogs weekly.
Outdoor Lounge Area (extensive)	- Specialized growth medium, filter or cloth to contain roots and medium but allow water penetration, specialized drainage layer with reservoir, waterproof membrane, strong roof structure and specially selected plants appropriate to climate and design. Source: Design Guidelines for Green Roof	- Pruning and trimming of plants - Maintain health of plants with weekly weeding. - Keeping doorways clear from obstruction - Plants may initially need fertilization and watering until greenery established. - After the first year, weed for invasive species twice a year. Source Green Roof Proposal and Guide
Community Kitchen and Market Area	- Kitchen utensils - Stovetop - Fridge - Cabinets - Table tops - Range hood - Fire extinguisher - Dishwasher - Large kitchen sink	- Daily maintenance (cleaning/repairs)
ROOFTOP GARDEN AREA		

Composting Area	- Vermicomposting (about 1 sf each pound of waste generated each week). - Requires special earthworms (e.g. -Tiger Worms, Red Wrigglers, and Indian Blues) and other decomposer organisms and grey water system	- Keep vermicomposting bins at temps between 55 and 77 F (13-25°C) - Provide a bedding mix that is not as fresh as the main food source to ensure worm breeding and check pH (acidity) 2 times/week
Beehives	-Adequate housing for bees	-Maintained by the bee keeper
Greenhouse	- Construction materials (wood, nails, etc) - Fiberglass reinforced panels - Ducts, tubes for channeling building heat - Fans - Proper lighting - Dainage, filter, root-resistant layer - Drip irrigation equipment - Nets	- See maintenance required for crop area - Cleaning of cover material when needed temperature, humidity, and general climate check (3 times/week)
Garden Research Area	- Dependent on researcher and study	- Dependent on researcher and study
Water Reservoir System - Drip irrigation for green walls - Rain water reservoirs - Rain barrels		
Crop Space - Container Garden - Drip Irrigation System	- Container gardening - Drip irrigation system that contains a filter and allows for fertilizer solution attachment to distribute the water to each container	Gardener care - Post planting (immediate watering after planting for first growing season and then 3 times/week for 13 weeks) - Weeding (3 times/wk after planting for 3 wks and then once a week for rest of season) - Maintain health and grooming of plants - Erosion control (check areas susceptible to wind and water monthly) Long term care - Biweekly monitoring program assessing condition of garden and plants - Supplemental planting - Perennial division program (perennials need to be divided for better growth—opportunity for flower sale) - Pruning and trimming - Tree root pruning

		- Pest control - Mechanical equipment safety checks - Drainage (monthly checking for overflows, keeping drains clear from obstruction) - Check and maintain irrigation system Source: City of Chicago
Extensive Garden	- Specialized growth medium, filter or cloth to contain roots and medium but allow water penetration, specialized drainage layer with reservoir, waterproof membrane, strong roof structure and specially selected plants appropriate to climate and design. Likely need irrigation system.	- low maintenance
Shed	- Construction materials (wood, roofing, nails)	Daily maintenance (cleaning/repairs)
Other Miscellaneous Materials	- Garden tools (i.e. hose, equipment, shovel)	Daily maintenance (cleaning/repairs)

Table 3**:** Resource and maintenance needs of each garden feature.

References

—6.3—
City of Chicago. www.cityofchicago.org
Design Guidelines for Green Roof.
http://www.cmhcschl.gc.ca/en/inpr/bude/himu/coedar/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=70146
Green Roof Proposal and Guide.
http://www.rivercenter.uga.edu/education/upper_altamaha/pdf/greenroof_acc_spring2007.pdf
Green Wall Panels (Gsky). http://www.greenrooftops.com/GreenWallPanels.aspx
Green Wall Panels (True Art). http://www.livingwallart.com/living-walls/green-wall-panels/
Manhattan Plant Experts Inc. http://www.manhattanplant.com/livingwall.htm
Urban agriculture on the rooftop. Cornell University.
Ublvd Design Guidelines.
http://www.planning.ubc.ca/campus_design__public_places/current_projects/amenities/articles281.php

7.0 Organic Discards

7.1 Waste Management

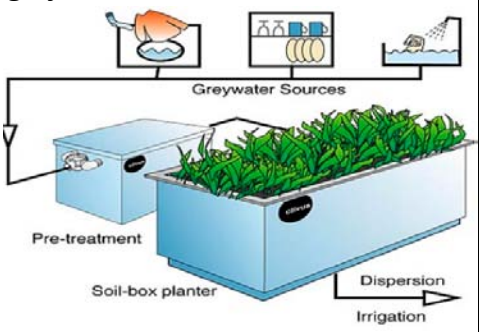
Types of Waste Management	Advantages	Disadvantages	Suggestions
<u>Vermicomposting (composting with worms)</u>  - Is a form of composting which uses worms to break down organic waste in a container.	- Grows better vegetables - Works at moderate/ambient temperatures; rapids composting (ready in one month) - Requires special earthworms (e.g. -Tiger Worms, Red Wrigglers, and Indian Blues) and other decomposer organisms - Aids soil aeration and drainage; develops and maintains a culture of effective aerobic bacteria by culling pathogens, fungi and anaerobic bacteria	- Worms apparently do not breed in organic waste and will move away from the food to breed (therefore, it is important to provide a bedding mix that is not as fresh as the main food source) - Requires lime to stabilize the pH (acidity) - Worms need consistent care, food, heat and moisture	- Keep vermicomposting bins at temperatures between 55 and 77 F (13-25°C) - Vermicomposting bin size depends on the amount of organic waste produced by garden. The general rule of thumb is one square foot of surface area for each pound of waste generated per week.
<u>Greywater treatment:</u> - Constructed wetland can be used for greywater treatment (floating aquatic plant system) - Constructed reed beds as an example are used as a method of removing pollutants from greywater.  	- Reduce the need for fresh water – indoor greywater can be used for toilet, or exterior washing - Reduce strain on sewers system – greywater makes up the majority of the household wastewater stream, so diverting it from the sewers extends the life and capacity of the system - Groundwater recharge – greywater treatment for garden irrigation replenishes groundwater - Maintain soil fertility – the nutrients in the greywater are broken down by bacteria in the soil and made available to plants.	- The potential for pollution and undesirable health and environmental effects; cost of a greywater system and plumbing requirements; ongoing maintenance.	

Table 4: Recommended types of Waste Management

References
—7.1—
Composting Techniques.
http://www.compostsantacruzcounty.org/Home_Composting/Backyard_Composting/by_techniques.htm
Greywater. http://www.greywater.com/
Home Gardening. http://www.calrecycle.ca.gov/organics/gardening/
Wastewater Gardens. http://www.carpathians.pl/gardens/budowa.html
Wastewater Re-use. http://www.yourhome.gov.au/technical/fs74.html
Waste Water.
http://www.waitakere.govt.nz/AbtCit/ec/bldsus/pdf/water/wastewtr.pdfhttp://www.recycle.ubc.ca/

8.0 Budget[1]

8.1 Estimated UBC Rooftop Garden

An exact budget for the rooftop garden is not given due to the high probability of inaccurate calculations. However, some references and case studies of existing rooftop gardens in North America and their budgets have been provided. The following are estimated costs of a rooftop garden for the New SUB rooftop garden project. Values were derived from the Design Guidelines for Green Roofs. In addition, a USD price chart is included in Figure 14 because the scales of those projects reflect the same magnitude as that desired for the New SUB rooftop garden. As a result, a more accurate estimate of costs and price fluctuations can be determined. Below is an estimate for the proposed rooftop garden.

8.1.1 Estimated Cost for Extensive Garden (Upper Lounge Area)

The upper tier of the lounge area has been proposed to be an extensive rooftop garden and the estimate is based on the approximate 4000 sq ft area.

Component	Estimated Cost
Design and Specification	5 - 10% of total roofing
Project Administration and Site Review	2.5-5% of total roofing project cost
Re-roofing with root-repelling membrane	~$50, 000
Green Roof System (curbing, drainage layer, filter cloth, and growing medium)	~$30, 000
Plants	~$6, 000
Installation / Labour	~$22, 000
Maintenance (for first 2 years)	~$6, 000
Irrigation System	~$12, 000
TOTAL	~$126,000 minimum (does not include design/specification or project administration)

[1] An exact budget was not analyzed due to the complexity of such calculations. Thus we have provided some references and case studies of existing rooftop garden budgets in North America.

Table 5: Estimated costs for outdoor lounge components.
(The table where the values were derived from to estimate the budget for the UBC rooftop garden can be found in Appendix C)

8.1.2 Estimated Cost for Container Rooftop Gardening

The lounge area takes up less than 1/3 of the rooftop space, the remaining area has been proposed as green/rooftop garden space. There is approximately at least 6500 sq ft of space proposed for container gardening, this area excludes the greenhouse, shed, beehives, composting, and other non-vegetative areas. There is estimate for this container garden since the pricing can be very variable. Containers can be purchased or even be homemade and the type of container that will be ideal for our use needs to be further researched.

A general estimated has been provided is based on the case study at the University of Toronto (U of T). The numbers is derived from the idea that the UBC rooftop garden is approximate 15 times larger than the U of T rooftop.

Component	Estimated Cost
Containers (materials and maintenance)	~$25, 500
Drip Lines	~$2, 750
Timer	~$ 15, 000
Pump	~$ 150
Garden Hose	~$ 150
Fertilizer/soil (material and maintenance)	~$ 33, 750
Seeds	~$ 6750
Tools	~$ 4, 500
Pest Control	~$ 2,700
TOTAL	~$ 91, 250 minimum estimated cost

Table 6: Estimated Costs for Container Gardening.

8.2 Other Estimated Budget According to University of Toronto Case Study

This case study is based on the proposed rooftop garden on the U of T (downtown) campus. It has been included in the proposal because it was an extensive garden with containers, which is similar to the rooftop garden proposed here. The plot was estimated to be about 431 sq ft.

Capital Costs			
Item	**Unit Cost**	**Quantity**	**Total Cost**
Materials – Start up			
Containers[5]	$65	25	$1,625
Drip lines	$10	25	$250
Timer	$100	1	$100
Pump	$75	1	$75
Garden hose	3	$50	$150
Fertilizer/soil	$75	25	$1,875
Seeds	$15	30	$450
Tools	$300	1	$300
Shed	$400	2[6]	$800
Fencing	$300	2	$600
Informational signs	$100	4	$400
Transportation	$500	1	$500
Cold frames[7]	$175	4	700
Materials - Maintenance			
Container	$65	1	$65
Fertilizer	$25	15	$375
Pest control	$30	6	$180
Materials - Outreach			
Workshop material	$300	6	$1,900
Public relations, advertising, and volunteer recruitment[8]	$1,200	1	$1,200
Human Resource Costs			
Stipend for staff[9]	$3,200	3	$9,600
TOTAL			$21,145

Figure 13: Estimated costs for other things according to the U of T case study.

8.3 Other Estimated Budget According to Athens-Clarke County City Hall Case Study

This table is included for the purpose of comparing the USD pricing difference with the pricing table used in section 8.1.1. The Athens-Clarke County City Hall was written with the intentions of development of large scale rooftop gardens (such as UBC rooftop garden). Their prices may be more representative of the true cost, but it should be noted that the prices are in USD and based upon US distributors.

Figure 14:

Table 5.4.1 Green Roof Cost Ranges and Factors*

ELEMENT	PRICE RANGE (USD)	COST FACTORS
GROWING MEDIUM	*Extensive* $2 - $12 / ft^3 *Intensive* $2 - $20 / ft^3	Volume / type of growing medium, shipping distances and method of conveyance to roof (crane, blower truck, manual etc).
VEGETATION	*Extensive* $0.00 - $5.00 / ft^2 *Intensive* $1.25 - $10 / ft^2	May not be required. Type and size of plants, time of year, seeds, cuttings, plugs, mats, pots, shrubs, trees – may require containers and / or anchorage.
INSTALLATION	*Extensive* $2.40 - $6.40 / ft^2 *Intensive* $6.40 – $14.40 / ft^2 (100 to 200 % of material costs)	Size of project, sophistication of design, type of planting approach, nature of access to roof.
MODULAR GREEN ROOF SYSTEM (including vegetation, planting, growing medium & root repellant layer)	*Extensive* $10+ / ft^2 *Intensive* $13+ / ft^2	Sophistication of design, shipping, installation, plant species and density.
STRUCTURAL REINFORCEMENT OF EXISTING ROOF	(cost is highly dependent on existing structure)	May not be necessary. Consult a structural engineer to determine the load carrying capacity of any roof.
EROSION PROTECTION LAYER	$0- 0.30/ ft^2	May not be necessary if growing medium is not left exposed or vegetation is well established.
CURBS / BORDERS	$0 - $20 per linear foot	May not be necessary. Type (pre-cast concrete, aluminum edging, wood, gravel, timber borders, modular systems, recycled products etc.) and length.
WALKWAYS	$0 - $10.20 / ft^2	May not be necessary. Type (pre-cast concrete unit pavers, natural stone, wood decking, recycled products etc) and length.
RAILINGS	$0 - $65.45 per linear foot	May not be necessary. Material (aluminum, brass, wrought iron, welded steel, etc.). Thickness of railing. Number of rails. Roof deck penetration.
MAINTENANCE	*Extensive* $0.25 - $4.10 / ft^2 for the first two years *Intensive* $1.00 - $4.10 / ft^2	Size of roof, types of plants, nature of access.
IRRIGATION SYSTEM	$0 - $5.00 per linear foot	May not be necessary. Type of irrigation system used and size of project.

*Costs may vary significantly due to regional differences
**Based on 2005 National Construction Estimator

References
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Design Guidelines for Green Roof.
http://energy.probeinternational.org/conservation/perversions/design-guidelines-green-roofs
—8.2—
University of Toronto Report on the Environmental Benefits and Costs of Green Roof Technology. www.toronto.ca/greenroofs/pdf/fullreport103105.pdf
University of Toronto Campus Agriculture Report University of Toronto.
www.harthouse.utoronto.ca/.../UofTCampusAgricultureProject2009.pdf
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UGA River Basin Center.
http://www.rivercenter.uga.edu/search/search_results.htm?q=Green+roof+proposal+and+guide&cx=004441298977981780311%3Audoadkygwmq&cof=FORID%3A11&sa.x=0&sa.y=0#802

9.0 Educational Opportunities

9.1 Education Framework

Being one of the leading universities in the world, UBC envisions to “create an exceptional learning environment that fosters global citizenship, advances a civil and sustainable society, and supports outstanding research to serve the people of British Columbia, Canada and the world (UBC Plan, 2010)”. According to UBC mandate, there are nine commitment areas the university as a whole is striving for: student learning, research excellence, community engagement, aboriginal engagement, alumni engagement, intercultural understanding, international engagement, outstanding work environment, and sustainability (UBC Mid-Level Plans, 2010). These areas are not completely distinct and mutually exclusive. Instead, these aspects are interconnected with each other with relationship ranging from simple to complex. One important approach to embody of this ultimate vision is to regard UBC as a community and then to turn the campus itself into a “living laboratory” (UBC Sustainability Academic Strategies, 2010). At UBC, the most updated information and knowledge are disseminated and shared, and UBC is also a place to practice what is taught in lectures

Having UBC Farm, LFS Orchard Garden, and Hawthorn Place Community Garden as successful examples of urban farming, the rooftop garden should incorporate an educational component and contribute towards making UBC campus a living laboratory. According to previous experience of UBC Farm, the involvement of students and faculty members differed, depending on their disciplines and purposes. In 2007/2008, 26 faculties and schools were involved, including Faculty of Applied Science, Faculty of Arts, Faculty of Education, Faculty of Forestry, Faculty of Land and Food Systems, School of Architecture and Landscape Architecture, Sauder School of Business, School of Journalism, and many more (Riseman, A., personal communication, March 16, 2010). There is great potential in using the rooftop garden as a teaching and learning tool is great, and numbers of exciting opportunities are waiting to be explored.

As a research team, we have generated some ideas in terms of incorporating education with the rooftop garden. Several faculty members as well as on-campus/off-campus and student-based/non-student-based initiatives were approached to see if they are interested in the project. However, concrete examples of how and in what form the connection will be are yet to be discussed. The following table is a brief summary, and specifics will be described later.

9.1.1 Educators

Potential Participant	**Work/Field of Relevance/Person Contacted** **(if applicable)**	**Interest and Potential Opportunities**
UBC SEEDS	- Social, ecological, economic, development studies - Liska Richer (program coordinator)	- Liska Richer, the coordinator of SEEDS program has shown interest in giving seminars to students about sustainability once the rooftop garden is completed - Research and studies that are part of SEEDS can be conducted at the garden
Dr. Andrew Riseman	- Professor in Faculty of Land and Food Systems- plant science	- Interested in conducting directed studies project using the rooftop garden as a living laboratory
Dr. James Vercammen	- Professor in Faculty of Commerce and Faculty of Land and Food Systems - Research area: agricultural marketing, agriculture policy analysis agriculture risk and insurance, and environmental markets	- Interested in using real life situations from the garden as case studies and using the garden in directed studies
Dr. Daniel Roehr	- Professor in School of Architecture-landscape architecture - Specialized in green roofs and green buildings	- Interested in incorporating the rooftop garden as an educational tool, but specifics are not yet determined
Allen Garr	- Passionate expert in bee management and its incorporation into urban agriculture setting - Currently manages the bees on the rooftops of Vancouver convention centre and Vancouver Public Library (Central Branch), and bees on the UBC farm.	- Interested in giving seminars to students about bee keeping in an urban setting - Interested in assisting the management of bees if they are incorporated into the rooftop garden
John Terezakis	- Building manager of District	- Interested in giving seminars

	Main which has a operating rooftop garden owned by the residents of the building	to students about how to grow their own food, compost organic waste, and keep a healthy garden.
UBC-Department of Family Practice Research	- Debra Hanberg (research assistant)	- Studies in creating healthy workplace by incorporating rooftop and balcony garden full of medical plants - Interested in incorporating the rooftop garden into this research.
UBC Farm- Urban Aboriginal Community Kitchen Garden Project	- Vancouver Native Health Society - Sandra Bodenhamer (program coordinator/dietician)	- The project currently involves UBC Farm where a plot is allocated for Aboriginal people from downtown east side to grow their own food and cook in the kitchen at UBC Farm - Interested in incorporating the rooftop garden into the project - Foresee this as an opportunity of mutual learning between Aboriginals and UBC students

Table 7: Various Education Opportunities

9.2 Other Suggestions for the Educational Opportunities at the Rooftop Garden:

<u>Rooftop Garden Club</u>

A rooftop garden club could be created by a group of UBC students and faculty members who are interested in urban farming. Regular and occasional events and activities such as lunch/dinner gathering at the rooftop garden, visits to other urban gardens, organizing sustainability workshops, planning special festivals, and promoting the rooftop garden, etc. This is a good opportunity for practicing leadership and teamwork as well as for advocating sustainability on campus.

<u>Integration of Elementary and Secondary Schools in the Community</u>

By collaborating with elementary and secondary schools in the community or in close proximity, field trips could be arranged to the garden. The concept of sustainability could be introduced in earlier stage of education. This might raise the awareness and therefore increase the possibility of these children to live a more sustainable lifestyle in the future. Here is also an opportunity for the involvement of Faculty of Education and Faculty of Land and Food Systems

in terms of delivering mini-classes to the students. Furthermore, volunteering opportunities could be offered to high school students for their community service hours..

The Lounge area

With the frequent usage of the lounge area as expected, it is an ideal location for disseminating information about the rooftop garden and advertising any sustainability related events taking place on campus. Examples of such information tool are posters, pamphlets, and magazines that can only be read at the lounge. Instead of printing out free copies of pamphlets and magazines, it is more sustainable to have the details available on-line that could be readily accessible for anyone interested.

UBC Student Involvement

The garden could be booked and used by UBC students from various faculties as a place to deliver workshops. The workshops should involve both individual and group learning experiences. Students from the LFS series (100, 250, 350 450) can volunteer in the garden as community service.

Collaboration with UBC Sustainability Academic Strategies (SAS)

SAS is a relatively new initiative formed to advocate sustainability learning and research. Two key components of SAS vision are to explore various aspects of sustainability through research, teaching, and leaning in various disciplines and to exemplify sustainability operations. The vision of SAS is in coherence with the creation of the SUB rooftop garden. Therefore, there is a great potential in the collaboration of SAS and the rooftop garden since the garden or even the entire New SUB will be an example of sustainability in practice. Therefore by working with SAS, more educational opportunities could be explored and incorporated into the rooftop garden as research, teaching, and learning.

References

—9.1—
Mid-Level Plans. http://strategicplan.ubc.ca/mid-level-plans/
UBC Plan. http://strategicplan.ubc.ca/the-plan/
UBC Sustainability Academic Strategies. http://www.sas.ubc.ca/themes/caall/

10.0 Conclusion

10.1 Recommendations

Upon completion of the New SUB rooftop garden, a number of exciting and futuristic changes will occur at UBC. The garden will directly support all seven sustainable visions that were collaboratively created by the project partners. The variety of produce, herbs and other plants will enhance diversity and the quality of our unique ecosystem at UBC. Foods from the garden will be incorporated into the vast majority of cultural and ethnic foods available across campus. We will be taking great strides towards lightening UBC and the AMSs' carbon footprint, as well as creating awareness of these pressing issues. At the end of the day, cooking and eating is about health and overall well-being. The garden will serve as a peaceful and relaxing environment for student to gather, socialize, and enjoy the many benefits of urban agriculture. Being able to experience this first hand will hopefully create future movements towards daily green living in students and faculty alike. UBC has always been a leader in innovative ideas for the education community and this will be no exception.

11 Additional Information

11.1 Appendix

Appendix A.

	Description	**Advantage**	**Disadvantage**
FRAME	- The "skeleton" of the greenhouse - Foundation and beams		
Wood		- Reused local wood - Low Carbon footprint - Incorporate local waste	- Labour intensive - More expensive (?) - Amount of wood may not be sufficient
Metal		- Long lasting - Sturdy - Preassembled	-High carbon footprint (production, transportation)
COVERING MATERIAL	- The walls of the greenhouse		
Glass		- Can be tempered -Transparent (aesthetically pleasing)	- Expensive - Hard to assemble - Need a sturdier framework
Polycarbonate (plastic)		- Cheap and strong - Easy to assemble	- Decreased light transmission
Fiberglass Reinforced Panels		- Durable - Retains heat better than glass - Lightweight & flexible - Less structural support needed	- Panels need to be customized -Hard to assemble
Polyethylene		- Cheap - Easy to assemble (cover over greenhouse) - Less structure support required	-Chances of tearing -Lasts about 2 years - Algae buildup
HEATING	- Heat loss through the structure is inevitable and a source is needed to maintain temp.		
Building heat waste		- Sustainable use of excess heat - No need for extra equipment - Cost effective	- Setting up through ducts and pipes
Electricity		- Reliable source	- Expensive
VENTILATION	- In addition to windows and natural openings, proper ventilation needed for temperature & humidity control	- Automated for consistent control	- Needs electricity
LIGHTING	- Light needed for photosynthesis during low sunlight	- Adequate growth of plants - Compensation during low sunlight	- More load on the structure - Use of electricity

*signifies suggested recommendations

References

Hobby Greenhouse Construction. http://www.aces.edu/pubs/docs/A/ANR-1105/

Types of Gardening	Advantages	Disadvantages	Suggestions
Container Gardens  Source: JandsRoberts 2004 - Containers can be made from anything: plastic , wood, metal, crates, large sacks, etc. - Growing medium is separated from the roof surface - Type of soil used can be controlled - Container can be covered or uncovered	- Flexible usage; portable - Soil content can be controlled - Can use compost from building and in-vessel composter - Does not interfere with roof surface - Containers can provide large space (depth-wise) for soil and roots, thus extensive or intensive gardening can be used.	- Moving heavy containers can be a great deal of work - Containers can freeze or thaw relatively easily	- For harsh winters, terracotta pots can crack, thus wood, plastic or metal containers generally survive winter better and can hold more moisture - Extreme hot weather, and the smaller soil volume can cause soil dry-out and may need daily watering. A mulch cover like straw, wood ships or a sub-soil later of newspapers and compost can help slow evaporation and shade soil - For low holding capacity rooftops, heaviest containers should be placed at the edge of the root near columns that support much of the structure's weight
Green Roofs  Source: TheSchultzy 2008 - Growing medium in contact with the roof membrane - Constructed using a special root and water-proof membrane for the base layer, then a root barrier, a retention/drainage layer, plus the soil layer, and finally the plants - Alpine plants or desert succulents are often	- Usually built to be inaccessible so need little or no maintenance (only have tree seedlings pulled out periodically) - Protect rooftop surface; in Europe, it has been shown that roof tops can last 2 to 3 times as long as an exposed roof that needs replacing every 10-12 years - Most effective at insulating building and collecting rainwater	- Very costly - Need lots of collaboration with architect and engineers - Green roofs cost roughly ~15-35USD/ sq ft; not including the structural renovation sometimes necessary for green roof projects - Rooftop infrastructure maintenance interrupted by inaccessibility of green roof	- Industry created a modular green roof system, making infrastructure access much easier because parts of the roof can move independently - Example Greenroof Research at Pennsylvania State Uni Centre.

used due to their adaptation to thin, rocky soil and can withstand harsh rooftop conditions - Native plants can also be used because they are adapted to the native climate and soil (at times they may still be unsuitable for rooftop gardening)			
<u>Hydroponics</u>  Source: Choo YutShing 2009 - Means of growing plants with a substrate other than soil: peat, sand, gravel, old rubber tires, rockwool, perlite or vermiculite - The purest form is with water culture: plants supported by a thin later of substrate while roots are immersed in nutrient solutions - pH and nutrient solution strength need to be continually monitored as plants need different levels of nutrients at different stages of growth 2 typical types of hydroponic systems - Passive: simple, cheap and require only a container with drainage, a tray that holds liquid and a growing medium. Plants can be hand-watered with the nutrient solution or the container can be put into tray of nutrient solution - Active: a pump regularly floods the plant tray with nutrient solution, which then drains back into a holding tank	- Containers can be lighter weight than soil filled containers - The system can be quite mobile - Solves the problem of potentially deficient soil - Nutrient solution can be carefully calculated to provide optimum level of nutrients to the plants - Plants may grow faster (up to two to four times) because they have ready access to nutrients and water- putting their energy into growing leaves, fruits and stems instead of roots - Plants are not competing for nutrients - Many systems are automated, don't require labor, and pesticides are usually unnecessary because plants start in a medium that is disease-free - Almost any kind of plant can be grown hydroponically - Water conservation, save money by recycling nutrients	- High set up cost - Require meticulous calculations for optimum growth of the crops we decide to grow - Because each plant is sharing the same nutrient solution, if diseases/pests do arise, they can easily affect all the plants - Plants will react quickly to the environment and if there are bad conditions, signs of deficiency will show quickly - Hot weather and limited oxygenation may limit production and can result in lost crops - Less chance to use compost Source: Hydroponics: Advantages and Disadvantages.	- Good growing media are ones that maintain enough air in the root zone while also holding nutrient solution - Rockwool and expanded clay pellets are widely used. - Rockwool is biodegradable and made almost entirely of recycled materials and can be reused once or twice - Clay pellets can be used for many seasons and provide good root aeration, but hold little water - Perlite and vermiculite made a good combination for a growing medium. Together they hold water and drain well and can be used for hand watering systems

Types of Covered Gardening			
<u>Polytunnels</u> - Large framework of semi-hoops covered in polythene plastic. - The polythene traps the sun's energy creating an increase in temperature. - It is also treated to resist UV damage and can have a thermal, anti-fog cover that prevents moisture . Droplets can block sunlight or drip on the plants. - Structures must be clad in fabric to prevent damage to the plastic when it rubs against the frame. - Covers should last 3-5 years before they need replacing. But some of the latest sheets can last up to 10 years.  Source: Growing a Vegetable Garden in a Polytunnel 	- Retains heat to facilitate plant growth - Protects plants from frost - Protect seedlings and young plants for transplanting and later sowing - Provide ideal growing conditions even in rough weather - Crops can be grown year-round	- Irrigation is required - Pest and disease problems can build up quickly in enclosed space - Some may perceive the polytunnels as visual pollution	- You can optimize polytunnel space using dwarf, miniature or climbing cultivars - Also choose disease-resistant varieties like: tomatoes, capsicums, eggplants, chillies, cabbage, Asian greens, salad greens, snowpeas, potato, radish, silverbeet, carrots, cucumbers, melons, cauliflower, watercress and strawberries. Crops like these bring an early crop or can grow year-round. - Stagger sowings to get a steady supply of fruits and vegetables - Allow space around the bed for you to walk around - Polytunnels should be washed inside and out annually so that sunlight gets in - Use micro-irrigation such as dripping systems to conserve water - Use crop rotation or change your soil frequently to avoid depleted soil, that can make plants vulnerable to disease and pests - Avoid overcrowding plants - Use a thermometer that indicates max. and min. temperature. Ensure doors, windows and vents are open in hotter weather so that the polytunnel interior does not over-heat

For Greenhouse- refer to section 2.4			
Types of Irrigation			
Surface irrigation: - Water is moving over the garden by simple gravity flow in order to infiltrate and wet the soil - It is the most widely utilized	- Conserves water because it applies water only down to the depths required to refill the root zone - It is handy in case where there are water shortages - Cheap to develop - Not affected by climatic and water quality characteristics	- It tends to lead to waterlogging and soil salinity if there are no provisions for adequate drainage - It tends to be labour intensive	
Sprinkler irrigation: - Water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns	- Does not require surface shaping of level - Can be applied to areas of variable topography - Suitable for most crops, not all, and are adaptable to most irrigable soils - Flexibility is possible because sprinkler heads are available in a wide range of discharge capacities	- Water application efficiency is strongly affected by wind - Some crops are particularly sensitive and may suffer leaf scorch because of the salts deposited on the leaves as the intercepted irrigation water evaporates - Falling drops on bare soil causing slaking and surface crusting - High and constant maintenance requirements - High operating pressures	
Drip irrigation: - Water is delivered at the root of the plant, drop by drop	- Conserves water resources - Because the watered zone is shadowed by the plant itself, evaporation is minimal and the consumption is lower - Less energy consumption - The land between the plant rows remain dry and unwanted plant growth is prevented - Leaves remain dry, thus reducing the	- Drippers may get clogged - Initial cost of drip irrigation systems are very high	- Water must be very well filtered and chemicals must be used to clean out the system - Drip irrigation can be a very effective method for areas where a water source is limited, the plant grown is sensitive to soil moisture, vegetable and fruit farms, and growth of decorative plants

	risk of disease - The output of each nozzle can be controlled with great efficiency, high water application efficiency and lower cost to automated system		
Hose Irrigation: - Hose can be used to carry water to irrigate plants	- Always having consistent water supply - Once regular irrigation equipment is not working, hose irrigation can be used as an alternative irrigation method, and also can be used for emergency purpose	- Clean water carried by hose is from the building, natural resource (water) consumption.	

References

Urban agriculture on the rooftop. Cornell University.

Appendix C.

The following is the table where the values were derived from to estimate the budget for the UBC rooftop garden (Design Guidelines for Green Roofs).

(Costs assume an existing building with sufficient loading capacity; roof hatch and ladder access only. The larger the green roof, the cheaper the cost on a square metre basis.)

	Component	Cost	Notes & Variables
a)	Design & Specifications	5% - 10% of total roofing project cost.	The number and type of consultants required depends on the size and complexity of the project.
b)	Project Administration & Site Review	2.5% - 5% of total roofing project cost.	The number and type of consultants required depends on the size and complexity of the project.
c)	Re-roofing with root-repelling membrane	$100.00 - $160.00 per sm. ($10.00 - $15.00 per sf.)	Cost factors include type of existing roofing to be removed, type of new roofing system to be installed, ease of roof access, and nature of flashing required.
d)	Green Roof System (curbing, drainage layer, filter cloth, and growing medium).	$55.00 - $110.00 per sm. ($5.00 - $10.00 per sf.)	Cost factors include type and depth of growing medium, type of curbing, and size of project.
e)	Plants	$11.00 - $32.00 per sm. ($1.00 - $3.00 per sf.)	Cost factors include time of year, type of plant, and size of plant - seed, plug, or pot.
f)	Installation / Labour	$32.00 - $86.00 per sm ($3.00 - $8.00 per sf.)	Cost factors include equipment rental to move materials to and on the roof (rental of a crane could cost as much as $4,000.00 per day), size of project, complexity of design, and planting techniques used.
g)	Maintenance	$13.00 - $21.00 per sm ($1.25 - $2.00 per sf) for the first 2 years only.	Costs factors include size of project, timing of installation, irrigation system, and size and type of plants used.
h)	Irrigation System	$21.00 - $43.00 per sm. ($2.00 - $4.00 per sf).	*Optional, since the roof could be watered by hand. Cost factors include type of system used.

References

Design Guidelines for Green Roof.
http://www.cmhcschl.gc.ca/en/inpr/bude/himu/coedar/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=70146