UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Climate Action Partnership Moving UBC Beyond Climate Neutral

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Climate Action Partnership

Moving UBC *Beyond* Climate Neutral

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Table of Contents

Part I: General Overview

1.1 Abstract

Working in conjunction with the UBC Food System Project, we, group 3, have conducted research to determine whether rooftop gardens at UBC would decrease greenhouse gas emission, help with climate change, and move UBC beyond carbon neutral. In the project, interviews with highly respectable and professional individuals, such as Ted Cathcart and Tara Moreau, were conducted and calculations were done to evaluate the carbon emission associated with the transportation of food. This allowed the group to determine if having edible landscapes at UBC would truly move UBC beyond climate neutral. It was found that edible landscapes could potentially assist with these goals; however, factors such as appropriate crops, suitable buildings and available resources would need to be carefully chosen and assessed in order to successfully include edible landscapes on UBC campus. Furthermore, preliminary calculations reveal that rooftop gardens, community gardens alike, will do very little to reduce the campus' dependency on imported food. This report includes useful information regarding the building of edible landscapes and the carbon emission caused by transportation; furthermore, it also contains recommendations that promote further research, initiate sustainable practices, and include more local food sources. These proposals and recommendation set forth will help future AGSC 450 to effectively move UBC beyond carbon neutral.

1.2 Introduction

The impact of climate change has already dramatically affected the ecosystem and its population. Documentation reveals that excess greenhouse gas emissions have adverse effects on human health, loss of wildlife habitats, and failure of agricultural crops (Environmental Issues, 2009). Due to these negative events, many countries, institutions, and even individuals are implementing various methods and programs that will help decrease the amount of greenhouse gas emissions caused by humans. The University of British Columbia has gained a well-known reputation as being the first university in North America to successfully implement a variety of sustainability strategies, such as the "Inspiration & Aspiration" plan that promotes sustainability targets in UBC's operations, programs, research and teaching, the opening of the first Sustainability Office in Canada, and the execution of Canada's largest energy and water retrofit (UBCFSP). In order for UBC to effectively move beyond climate neutral, it has launched a partnership, the "Climate Action Partnership" (CAP), that initiated the Integrated Climate Action Framework, which utilizes a collaborative approach by including the ideas and participation of faculty, staff, students, technical experts and community members in order to come up with new and beneficial ways in becoming more sustainable (UBCFSP).

This report works in collaboration with the UBC Food System Project (UBCFSP), with its primary focus on the UBC food system and its linkages between greenhouse gas emission and climate change. This project aims to assist UBC in moving beyond climate neutrality. The target of edible landscapes has been suggested in the "Climate Action Partnership" as a possible approach to climate actions. As such, it has been thoroughly analyzed and researched in order to determine whether rooftop gardens are beneficial to the UBC food system and if they can play a role in rectifying the problems of climate change. Ideally, the results will provide assistance to both the UBC Food System Project and UBC's Climate Action Partnership, and become a stepping-stone for moving UBC beyond climate neutral.

1.3 Vision Statement & Value Assumption

In general, the majority of our group agrees that these vision statements are ideal, but we have come to the conclusion that it is virtually impossible or not feasible to put them all into action. Statement 1, which suggests, "food should be locally grown, produced, and processed", is the focus of our group discussion. We are aware of the benefits of local food production, such as the increase in food sustainability, and the decrease in food miles and transportation. However, we question its feasibility in a real life situation. We currently grow our food at the cheapest cost in areas with comparative advantages. These advantages include climate, geographic or labour. If we assume consumers will continue to demand the foods they are having now, switching to local production may require unsustainable practices, such as using heat to imitate hot weather. In turn, this may be harmful to the ecosystem, the social-economic welfare and the environment. Some regions have a very limited choice of crops they can grow due to soil quality, geographic and economic barriers. Without food imports, they may be unable to obtain all their nutrient needs, including essential micronutrients.

Statement 1 also contradicts statement 3. To obtain culturally sensitive foods, in many cases such food must be imported. With swelling immigration and a national policy emphasis on multiculturalism, it may not be possible to sustainably grow all unique cultural foods locally. In turn, the crops we do grow locally may be unacceptable for these new immigrants. While we can synthetically produce these non-local foods, many factors have to be taken into consideration, such as farming techniques, education, or pest control. Restricting all food production to the local region will mean sacrificing certain foods we want but cannot grow. We believe it is impossible for immigrants to give up on the cultural foods they have been eating for many years.

If statement 1 is put into action where all foods are produced locally, then statement 7, that states all providers and growers pay and receive fair prices, will likely not be feasible. Growing non-local foods in a non-native environment requires extra input and resources, making them more expensive for consumers to purchase. Also, when all foods are produced locally, there is competition between local farmers, as this is the only source of these non-local foods. Local farmers will then be able to control the market prices of these products.

The idea of growing all foods locally is only possible if everyone is willing to give up their non-local produces. This includes giving up on cultural foods and shifting towards a diet consisting of similar food items. Widespread education and promotion is needed to educate the population of the benefits of local food production. A large majority is still unaware of food sustainability issues and lack simples knowledge of how the overall food system operates.

Social equity should not be a local concept, but be spread throughout the global food system. Western-centric view emphasizes our capability to change our food system. Since the majority fo these countries are at the centre of the world trading system, it is inevitable that changes in the food system will result in changes in the international trading patterns, and may then consequentially affect third world exporters. All in all, the statements made seem western-centric, idealistic and sometimes unsustainable.

Part II: Climate Change and the Food Systems

2.1 Background Information

2.1.1. Problem Statement

Climate change has become a widely accepted reality and its effects are also roaring to the front page. In February of 2009, hundreds of Australians died after wild fires spread through neighbourhoods and burnt houses to the ground. Although there is no direct connection between global warmth and these incidents, scientists make it clear that we should expect drier summers and less predictable weather patterns (IPCC, 2007). In 2007, Al Gore and the Intergovernmental Panel on Climate Change, a collaborative body of academics, UN committees, and intergovernmental councils, won the 2007 Nobel Peace Prize. In effect, they won the prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change" (IPCC, 2007). Evidently, climate change is no longer an academic myth – it is real and it is happening.

Climate change, which is caused by excessive greenhouse gas emissions, is an increasing concern to the population and the environment. Many of the harmful gases that are released into the atmosphere are caused by human activities, such as the carbon dioxide and nitrous oxide that are produced from burning solid waste and fossil fuels, and the methane that is emitted from organic waste decomposition (Environmental Issues, 2009). This overabundant amount of gases results in infrared radiation being trapped and withheld in the outer atmosphere, which consequently leads to the rising of temperature (Environmental Issues, 2009). Due to the population's increasing demand for generating the most products in the least amount of time, advanced technologies and quicker methods of transportation, such as production companies and automobiles that burn fossil fuels, have increased greenhouse gas emissions by 70%;120% of the total gas increase has been directly from transportation between 1970 and 2004, and it is estimated that the amount of carbon dioxide emission will increase by 75 – 350% by the end of the 21st century (NOAA, 2008). One of the main contributors towards climate change is the often overlooked food system. Many of the greenhouse gases are emitted throughout the process of food production, such as methane during agriculture decomposition and carbon dioxide from the transportation of food products to consumers (Richer *et al*. 2009).

The drastic increase in greenhouse gas emissions is resulting in rising global temperatures, which affects population health, living wildlife habitats, and agriculture productivity (Environmental Issues, 2009). The issue of climate change greatly affects the living conditions of the population because warmer temperature increases the chance of vector-borne diseases to become more widespread (Environmental Issues, 2009). Climate change affects wildlife because animals and plants need to adapt to the changes within their ecosystems, such as rising sea levels, which reduces the land available to living organisms and destroys the vegetations needed for food and habitats (BBC Home, 2009). With warming temperatures, it is inevitable that agriculture will suffer from droughts, increasing the number of problems for farmers, such as pest management, crop variety choices, and seeding dates, due to the uncertain and constantly changing temperature (Alberta Agriculture and Rural Development, 2007).

At UBC, issues concerning climate change have recently been taken to centre stage. In March 2008, President Toope signed the *Canadian University and College President's Statement of Climate Action*, a mandating document which formalized our drive to solve climate problems and commits the university to setting specific scientific targets towards the participatory reduction of greenhouse gas emissions. This mandate will be met via the Integrated Climate Action Framework, which will effectively produce the climate action plan for our campus. The framework is a roundtable of community stakeholders which will outline how UBC can move towards and beyond carbon neutrality. Roundtables bring together sectors such as transportation, energy, food, education and building policy, and they consist of students, faculty, staff, technical experts and the wider community. The roundtables will produce a series of discussion papers that will morph into a climate action vision statement; this in turn will be adopted by the UBC community. This grass-roots approach attempts to bring together all stakeholders into a consultative and collaborative initiative.

UBC makes the claims to produce "exceptional global citizens [and] promote the values of a civil and sustainable society" (UBC Trek, 2009). This mission statement is effectively embroidered in the climate action plan, which moves to solve problems of climate change that will affect the world. If UBC wants to be a leading global partner towards carbon neutrality, this project plays an important role in starting the discussions and recommendations that may allow our school to lead the field. The recommendations and results obtained from the collective studies in the UBCFSP project will undoubtedly allow UBC to assess its environmental impact; more importantly, the results may very well lead to further implementations and actions at other universities and communities.

2.1.2. Linkages between Climate Change and the Global & National Food Systems

Food systems have a major impact on GHG emissions; mainly from agriculture, cattle grazing, energy use, transportation, processing and packaging, and waste management. Crop production requires a lot of resources and inputs. Fertilizers are often used, overused in some cases, and their synthesis involves the burning of fossil fuels (AGSC 450, Group 12, 2007). Fossil fuel use causes carbon dioxide emissions, and this is one of the primary sources for global anthropogenic GHG emissions (IPCC, 2007). The second major carbon dioxide contributor is land clearing and deforestation (IPCC, 2007). Not only does this result in gas emissions, the lack of forests to take in carbon dioxide means the loss of important carbon sinks (Bentley & Barker, 2005). Because of the high demands for animals and crops in today's market, many farms are operated intensively at the industrial size. Wastes from livestock are a major emission source, contributing as much as 16% to the annual global production of methane (Nierenberg, 2005). Of the animal products, beef and lamb are found to contribute the most to greenhouse gases (Bentley & Barker, 2005). Aside from meats, rice and soy are two of the GHG-intensive crops (AGSC 450, Group 12, 2007). Nitrous oxide emissions are also a consequence of agriculture (IPCC, 2007). Food miles, the distance the food has traveled, is a common concern, as it should be. However, the means of transportation also plays a major role. Due to the high efficiency necessary in today's food market, producers rely on airfreights and trucks instead of cargo ships to transport their products, and these methods are highly polluting (Richer *et al*. 2009).

Food processing is an essential step in today's food production. The purpose may be to create new forms of unique food products, or simply to preserve food products during long travels to international markets. Regardless, these processing operations, including dehydration and freezing, depend heavily on energy use, which contributes to the overall GHG emissions (Adams *et al*., 2008). In addition to processing, product packaging has increased significantly (AGSC 450, Group 12, 2007). This entails the use of energy and inputs to produce a variety of materials; while efforts have been made, there are still many types of packages that are not degradable or recyclable, which adds to the waste and pollution.

As a whole food system from production to consumption, all the above factors act to intensify GHG emissions, increase the society's dependency on finite natural resources, lower the air quality, and contribute to numerous health concerns (Richer *et al*. 2009).

Since the interaction between climate change and food systems works both ways, the increase in global average temperature will in turn affect the food systems. While warmer temperatures may be beneficial to crop yields, it can cause heat stress and potential droughts, which poses a significant threat to agriculture (AGSC 450, Group 12, 2007). The lost of soil moisture due to a higher rate of evaporation degrades soil quality and makes it less feasible to produce quality crops (IPCC, 2007). The overall decrease in crop productivity is especially severe at lower attitudes, in tropical and dry regions.

The change in rainfall patterns also affects soil moisture level, as well as its erosion rate. The actual amount of change in precipitation varies between regions; areas at higher altitudes suffer from precipitation increases, while subtropical regions experience a decrease, causing possible droughts (IPCC, 2007). However, the overall events of extreme rainfalls tend to rise globally. Accelerated soil erosion lowers soil fertility, causing a decrease in agricultural potential.

Tremendous increases of atmospheric CO2 level due to emissions, combined with water, may enhance crop growth and productivity by acting as a fertilizer; however, the trade off for such increased yield is the nutritional value of crops (AGSC 450, Group 12, 2007). The amount of protein in crops has been found to decrease as a result of the accelerated growth rate, giving it less time to accumulate nutrients; key minerals such as zinc and iron are also lost.

The warmer climate is generally beneficial for food production. However, such effect will vary regionally. Some regions may suffer agriculture loss while other regions experience positive effects (IPCC, 2007). Areas with high fluctuation of weather conditions are more vulnerable due to the amount of stress the crops have to adapt to.

2.1.3. Linkages between Climate Change and the UBC Campus

Greenhouse gas emissions have wreaked havoc upon Mother Nature and caused climate change. In 1997, UBC took the initiative as the first university in Canada to adopt a sustainable development policy in order to promote a community-integrated sustainable agriculture system with an aim to reduce impacts on climate change (UBCSH). With that mission in mind, UBC Farm is moulded as a model farm that focuses on the urban agro-ecosystem that explores the possibility of an enhanced future for urban communities through its linkage to the ecological, economic, and social health of surrounding communities (UBC Farm). Since the UBC Farm functions as a catalyst for change through research, alternative methods in agriculture that improves the health of urban communities is instigated

(UBC Farm). UBC strives to establish healthy habitats with sustainable farming techniques, and its feasibility is validated with the UBC Farm land being over twice as productive as farmland in Northern BC (FOTF). The main culprit behind climate change, being the rapid growth of human population and industrialization, has led to competition for limited land (APP). UBC is no exception to these changes where significant surge of students from outside British Columbia has expanded the UBC community each year, requiring more campus residence space (APP). Consequently, the competition for the limited land at UBC is stiff, and UBC farm is tagged as "future housing reserve" (Walker). With UBC's sustainability pledge, it encourages the campus community to eat locally by providing West Side Vancouver residents with organic fresh produce and eggs on a Ten Mile Diet (FOTF). This demonstrates the impact of individual food choices on climate change. However, climatic shock can result in food insecurity and possible vulnerability of food production at the UBC farm. Since the farm embraces ecological and bio-diverse farming practices, it gives us an edge to hedge against the uncertainties of weather and climate change; for example, the winter cold weather in March may decrease crop yields (FOTF). However, due to various farming techniques and the large range and variety of crops being planted, UBC Farm is doing its best to combat against climate change (FOTF).

2.1.4. Summary of Climate Neutral Action by Campuses

UBC is not alone in its climate change actions. The University of Florida has a set of plans in reducing its greenhouse gas emissions to the point where it has no net impact on climate change. Their approaches, for example, include appropriately scheduled infrastructure renovations, equipment upgrades and new energy management such as enhancing carbon sinks on the university land. (CNAP, 2004) They believe the majority of GHG emissions are from energy consumption from building and gas emissions from vehicle, so by reducing electrical demand of buildings and making a change to hybrid or other powered vehicles, GHG emissions can be lowered. (CNAP, 2004) In order to achieve those targets, their university has conducted several studies, and they have all indicated that it is possible to achieve climate neutrality with no net cost within twenty years. (CNAP, 2004) One study shows that for every dollar invested in energy saving programs, two dollars or more can be saved and 40% of energy reduction can be achieved. However, the success of this target is reliant on the execution of the plan, so having an independent budget for energy-saving is the key. (CNAP, 2004)

The University of Tennessee, Knoxville, has a different approach to GHG reduction for the campus. This university is one of the pioneers who have signed up for LEED, or Leadership in Energy and Environmental Design. It is a program administered by the U.S. Green Building Council to create a set of standards for ecological friendly buildings. (The Charter-human-responsibilities, 2007) All new buildings constructed at this campus that cost more than $5 million, and any major building renovations, will be required to follow LEED standards; this ensures that new buildings are more energy and water efficient compared to the previous structures, so they will not negatively impact the global climate. (The Charter-human-responsibilities, 2007) Furthermore, the University of Tennessee has committed to limiting its GHG emissions by signing two other policies, one of which being the Tallories Declaration; this declaration consists of ten environmental principles that incorporate sustainability into teaching, research, and operations, so the campus can be more environmental friendly. (Tallories Declaration, 1990)

A group has published a progress report that recognizes the path to a carbon neutral community involves collaboration with an “interdisciplinary perspective” of “civic leaders, businesspeople and the broader public” (Adams *et al*., 2008). Its authors describe carbon neutrality as “measuring emissions, reducing them, and then purchasing offsets to cover the rest.” In order to achieve this goal, UBC has put forth a “Community Energy Plan (CEP)” to categorize areas that need improvement (Adams *et al*., 2008). The plan is described as “[having] six plan goal areas: improve the energy efficiency of buildings, increase transportation efficiency, encourage energy efficient land use planning, diversity the power production portfolio, educate and engage residents and businesses, and to demonstrate local government leadership.” (Adams *et al*., 2008). However, the authors realize some aspects are not covered, “in particular, the CO_2 inventory does not count the impacts of the energy used to produce and transport the goods that we consume on in the region." (Adams *et al*., 2008). The plan also fails to take into account the externalities, like the way tourism will affect the carbon footprint elsewhere. In achieving carbon neutrality, UBC has established multiple working groups and trusts to develop the concept.

The first group is dedicated to business and the economy. Section one is described as the entity that deals with purchasing and investment where, "by leveraging this purchasing power, UVic can support the development of green businesses in the region." (Adams *et al*., 2008). Modifying and implementing policies that support climate-friendly businesses accomplish this. The second section basically aims to re-localize the economy to eliminate food miles. This is accomplished through the actions of the third section, as described by "clustering geographically, businesses offering similar products and services." (Adams *et al*., 2008).

The second group, labelled "Civic Engagement and Governance", aims to establish communication networks between stakeholders and the general public (Adams *et al*., 2008). This is accomplished in two steps. The first is to increase awareness "through holding public information meetings, addressing local city council meetings, educating the board of governors at UVic about the CE project, and coordinating public events in conjunction with local municipalities"; while the second section involves the actual decision-making of policies that affect action (Adams *et al*., 2008).

The third group, which deals with the concept of energy usage in the university, is first broken down into 6 categories: heating and electricity, water, transportation, waste streams, other material streams, and deliverables (Adams *et al*., 2008). These categories are first measured to assess their impact on climate change. Then, projects and proposals are put forward, such as the use of carbon credits, to mitigate their effects.

The fourth group assesses the transportation issue at the university. Some of the proposed ideas that the university has put forth to limit transportation include implementing bike kiosks, and reengineering roads to be more efficient (Adams *et al*., 2008). A rail system has also been suggested as a way to reduce reliance on automobiles.

Food, the fifth section, is the most difficult aspect to measure, and the most sensitive to change. The University of Victoria has begun building edible gardens as a model and educational tool to raise awareness (Adams *et al*., 2008). Through this garden, "pocket markets" have been established to market this sustainable source of food and to re-localize the food system through advertising. Finally, composting and waste management has been made aware to the general population of the school through workshops (Adams *et al*., 2008).

Finally, the sixth and last group, "buildings, infrastructure, and ecology", aims to raise awareness in the attempt to change behaviour among the institution's population. This is achieved through outside visitation to the campus' green buildings, and the creation of healthy competition between stakeholders for rewards. This section also attempts to retrofit existing buildings on campus to become more climate-friendly, such as the use of videoconferencing (Adams *et al*., 2008). The last step in this group is to re-establish the campus' ecology through introducing native vegetation and harnessing the Georgia Strait to reduce dependence on artificial water supplies, which results in a decrease of energy consumption and land erosion.

The University of Victoria understands that the road to carbon neutrality requires action from a vast network of entities. Adams and colleagues (2008) makes the following analogy:

> *The best approaches to the mitigation of climate change will look like a beehive swarming with experimentation, communication, and action, rather than a mighty slugger stepping up to the plate to deliver a grand-slam home run.*

2.2 Climate Action Paper Target: Edible Landscapes

From the various suggestions that the UBC Climate Action Partnership has proposed, the idea of edible landscapes has been chosen as the main research subject for this paper. Edible landscapes help climate change in many ways, such as dramatically decreasing the amount of fossil fuel input into the food system and significantly reducing the amount of greenhouse gas and carbon dioxide emitted into the atmosphere (The Urban Farmer, 2005). These could be achieved because local edible landscapes and rooftop gardens do not require the large amount of fossil fuel that many conventional farming uses for fertilizers, pesticides, herbicides and machineries (The Urban Farmer, 2005). Furthermore, the easily accessible and local rooftop gardens eliminate the need to transport food products to distant locations, which would consequently decrease carbon dioxide emission caused by transportation devices (The Urban Famer, 2005).

2.3 Methodology

Edible landscapes, rooftop gardens in particular, will be evaluated to determine their effectiveness and relationship as a solution for carbon neutrality. We will determine whether rooftop gardens will be helpful to the UBC food system and how they may contribute to the push to get UBC beyond climate neutral. Three specific steps will be conducted: (1) investigate, through interviews with experts on the matter, how to create rooftop gardens, (2) determine the feasibility of rooftop gardening at UBC, and (3) evaluate and calculate the relationship between food miles, carbon emissions and local gardens.

2.4 Research Findings & Discussion

2.4.1. How to Build a Rooftop Garden?

To initiate the research on rooftop gardens, member of the group conducted an interview with Ted Cathcart, manager and master gardener of YWCA's rooftop garden. We find that rooftop gardens do not require significant special maintenance compared to regular farms. The main issues to be considered when operating a sustainable rooftop garden, like regular farms, include accessibility, nutrient management, irrigation and crop zones & crop rotations. However, some differences between rooftop and ground level gardening exist, which mainly influence the type of crop that should be grown, and include size restrictions, weight restrictions, and the need for a more complex irrigation system. The interview highlights and addresses all of these points with respect to bringing the idea of edible landscapes to UBC, which uses the YWCA rooftop garden as a model that is easily transposable to the rooftops of UBC's buildings.

According to Ted Cathcart, one of the most important attributes of rooftop gardening is human resource (personal communication, Ted Cathcart, 2009). For any edible landscape to be sustainable, volunteers are preferred because the products of edible landscape do not yield enough profit for hired help. Volunteers must have basic knowledge in agriculture. In the past case of YWCA's rooftop garden, Ted has usually been the one to extend his knowledge to new volunteers (personal communication, Ted Cathcart, 2009). For popularity of edible landscapes to spread, the garden should be located in a place where it is highly accessible. Accessibility promotes ideas, concepts and awareness. It may also increase volunteer applications. In the case of UBC, an accessible location provides a dynamic learning tool for all faculties.

To construct edible landscapes on top of buildings, the first issue that needs to be addressed is the structural integrity of the building. For YWCA's rooftop garden, Ted comments that modern rooftops are usually built stronger than they need to be. Such determinants include building the roof to be able to hold the weight of snow saturated with rainwater, in the event of a catastrophic blizzard preceding a heavy rainfall (personal communication, Ted Cathcart, 2009). When planning a rooftop garden, the blueprints of the building's roof should be analyzed to figure out how the weight of the planters can be most effectively distributed (personal communication, Ted Cathcart, 2009). Ideally, the rooftop should have some sort of drainage system that can be retrofitted with a low energy pump to be used as a means for localized irrigation. Harnessing the storm water collected on a roof means less carbon emissions will be produced as a result of transporting water to the garden. Using storm water as irrigation also improves sustainability in which storm water will no longer be sent to suburban water treatment facilities, thus limiting carbon emissions from transportation and operation of such facility (personal communication, Ted Cathcart, 2009).

The steps in raising crops on edible landscapes take time, and do not have a universal formula to accomplish the goal of feeding students on campus. As Ted (2009) comments on the developmental stages of YWCA's rooftop garden, prototypes will be needed to evaluate the growing conditions on the roofs; YWCA has done this by planting ornamental and low-maintenance vegetation to assess the ability for plants to grow in such an environment. Ideally, these plants will have to be localized in planters that can house as much soil with a high nutrient retention per weight ratio as possible (personal communication, Ted Cathcart, 2009). A synthetic membrane sheet will also be needed to line the bottom of each planter to act as a sieve or a filter should the need to drain excess water from rainfall be needed (personal communication, Ted Cathcart, 2009). Along with rainwater, artificial irrigation, preferably from a local storm water collection unit, should be used. Using volunteers or equipment, soil moisture should be monitored as closely as possible, for plant growth may be severely affected to the point of plant death (personal communication, Ted Cathcart, 2009). After the prototype planters have shown to be successful, increasing the scale of the project will be possible, given the capital to expand the operation and resources such as volunteers are readily available.

The mechanics of maintaining an edible landscape on top of a roof is not very different from a regular farm. For sustainability, and perhaps organic, purposes, fertilizers should be derived from organic wastes produced on campus. Such wastes like left-over food from the major food outlets, "grey-water" obtained from washrooms and sinks scattered throughout campus, and the inedible parts of harvested foods should all be composted back into the soil (personal communication, Ted Cathcart, 2009). To address the need to feed students on a daily basis, crops should be planted in succession to ensure a daily harvest schedule. Food diversity can be accomplished through the rotation of different crop types (personal communication, Ted Cathcart, 2009). Greenhouses may also be used to extend the growing season. However, the YWCA model garden has just recently implemented this idea and there is insufficient evidence regarding the success of using greenhouses (personal communication, Ted Cathcart, 2009).

2.4.2 The Feasibility and the Creation of Rooftop Gardens at UBC

In an effort to determine whether rooftop gardens are feasible at UBC, members of the group interviewed Tara Moreau, director of Society Promoting Environmental Conservation (SPEC), and a UBC PhD candidate in the Faculty of Land and Food Systems. Tara is the manager and coordinator of the SPEC rooftop container gardening at 2150 Maple Street, and has hands-on experience with an extensive knowledge on rooftop gardening. There are no rooftop gardens with edible food plantations at UBC, but there are green rooftops (personal communication, Tara Moreau, 2009; personal communication, Joe Stott, 2009). Tara believes that rooftop gardening at UBC is definitely feasible. The essentials for growing food, such as vegetables, include soil (temperature, aeration, organic matter, nutrition, pH, moisture), climate (temperature, humidity, atmospheric gases, wind), water, sun, plant selection, and plant and insect diversity are all present at our campus (personal communication, Tara Moreau, 2009). Tara believes that it is vital to understand the soil and its microclimate in order for plants to grow well (personal communication, Tara Moreau, 2009). It is also fundamental and necessary to research the rooftop microclimate, as many plants will be exposed to harsh weather conditions to begin with; thus, the location of rooftop gardens is essential on whether plants can survive the severe environment (personal communication, Tara Moreau, 2009). Tara also explains that plants on a rooftop experience extreme heat and wind, hence it will be necessary to water frequently, insert wooden planks beneath plants to provide ventilation and air circulation, and incorporate palettes or decks to maintain plant temperature are important for plant survival (personal communication, Tara Moreau, 2009). Growing plants on a building with a centre exit to the rooftop could also prove beneficial, since the taller structure offers the plants on the rooftop a shaded area, and acts as a wind breaker (personal communication, Tara Moreau, 2009). Other than that, constructing fences around the area where the plants are grown, or planting high vegetables such as corn, would serve as windbreakers as well (personal communication, Tara Moreau, 2009). An optimal row orientation for maximum sun exposure, including rooftop gardens in British Columbia, is from East to West (personal communication, Tara Moreau, 2009). The soil pH determines the optimal environment for specific vegetables and fruits; for example, broccoli needs pH 6.0 – 6.8 (a slightly acidic pH), whereas okras require soil pH of approximately 5.5 – 6.0 (a more acidic pH compared to broccoli) (personal communication, Tara Moreau, 2009). Tara also pointed out that Vancouver has the lengthiest growing season compared to Abbotsford, Chilliwack, Dawson Creek, Kamloops, Kelowna, Nanaimo, Nelson, Port Alberni, Prince George, Prince Rupert, and Victoria at 221 days (personal communication, Tara Moreau, 2009). Harvesting the most out of Vancouver climate's growing season knows no boundaries, be it rooftop gardens, or community gardens. The type of mulches used as a coating above the soil utilizes the short sun rays that is present here in Vancouver to keep soil temperature constant (either raises or lowers soil temperature), and promote optimal plant growth, and is especially valuable to rooftop gardening (personal communication, Tara Moreau, 2009). With plants being on rooftops, it is definitely an advantage for the vegetables and fruits to receive sufficient sunlight exposure for satisfactory growth (personal communication, Tara Moreau, 2009). Even though all plants have different sun, water and food requirements, they also have many diverse cultivars (varieties) of each species so that crop yields are maximized under varying conditions (personal communication, Tara Moreau, 2009). The most important task is to carry out crop rotation, every three years, because it helps minimize build-up of soil-borne insects and diseases, and prevents nutrient depletion of the soil (personal communication, Tara Moreau, 2009). To maintain a stable ecosystem for rooftop gardens, increased biodiversity of plants is vital (personal communication, Tara Moreau, 2009). Companion plantations should also be looked into, because they enhance the diversity by providing alternate food and shelter sources for insects, birds and animals (personal communication, Tara Moreau, 2009). Square foot gardening (SFG) can be adapted for rooftop gardening purposes, as well as gardening in confined and small spaces on rooftops (personal communication, Tara Moreau, 2009). Square foot gardening is based on a series of 12 inches by 12 inches squares, for a total area of 1 square foot; each square can hold a different type of vegetable or herb (personal communication, Tara Moreau, 2009).

The feasibility of rooftop gardens does not depend solely on the crops, its ecosystem, and farming methods, but also on the infrastructure of the buildings. Realizing this crucial factor, an interview with Joe Stott, director of the UBC Campus and Community Planning, has also been conducted. He emphasizes the importance of the building's infrastructure because that determines whether or not the rooftops can support the load of soil, plants, and the amount of water the plants and soil holds. Rooftop gardens also strike him as a feasible notion, because the Rose Garden at UBC is built on top of a parking lot (personal communication, Joe Stott, 2009). However, approximately 437 buildings at UBC have been built in the 1920s, and they are not constructed to support rain or snow load (personal communication, Joe Stott, 2009). Furthermore, these buildings have not been built according to safety guidelines and building codes that allow public occupancy on rooftops (personal communication, Joe Stott, 2009). There are also no emergency exit plans or maps from the rooftop to a safe location for these buildings, and hence it is not reasonable to retro-fit old buildings (personal communication, Joe Stott, 2009). Therefore, if rooftop gardens are to be built, it is appropriate to propose the idea to new building constructions such as the new Student Union Building (SUB). A rooftop garden at the centre of the current SUB (patio-like space on second floor with greens and fountain) can be considered for modifications to support a rooftop garden. It is also a great space for increasing awareness about rooftop gardens, and serves as a demonstration for educational purposes as well (personal communication, Tara Moreau, 2009). The one major objection rooftop gardens face is the budget set for a building (personal communication, Joe Stott, 2009). Architects begin with concepts, and their concepts are realized by contractors who refine their drawings. Then, engineers incorporate electrical features and evaluate the safety of the building for public occupancy (personal communication, Joe Stott, 2009). Through each stage, as the concept of a building becomes a tangible infrastructure, costs increase greatly (personal communication, Joe Stott, 2009). Due to limited funding, even if there is any money left over, they will be spent on indoor structures, like improving classrooms, labs and offices (personal communication, Joe Stott, 2009). In spite of that, there are always different methods to account for funding, such as students raising funds to permit landscaping on arable land next to the building, and for rooftop gardening.

2.4.3. Appropriateness: calculating and offsetting the food miles

While evidence seems to show it is possible to construct rooftop gardens at UBC to increase local food production, research has also been conducted to determine whether these actions will help lower GHG emissions. We have chosen one crop, potato, as a model to evaluate the emissions that are associated with its transportation to campus for consumption.

UBC Food Services 2008 Potato Usage[1]
45,371 pounds = 20.58 metric tons
Potatoes are mostly brought from Washington (250 km) on 5 ton diesel trucks and some from the Lower Mainland (25 km). Using the Washington distances and Leopold's center method for calculation, we are able to calculate the amount of CO2, as found in Bentley & Barker's "Fighting Global Warming at the Farmer's Market" (2005).

Weight (in tones) ***** distance traveled (in km) = (Ton-km)
Emission factor for trucks = 207 g of CO_2/ton-km (Bentley & Barker, 2005)
Ton-km ***** Emission factor (g of CO_2/ton-km) = grams of CO_2
20.58 tons * 250 km = 5145 Ton-km
5145 Ton-km *207 (grams of CO_2/Ton-km) = 1065015 grams CO_2 = 1,065.015 kg of CO_2
So, 45,371 pounds of potatoes from Washington, delivered in one trip, emits= <u>1,065.015 kg CO_2</u>

[1]Calculations are done in conjunction with AGSC 450, Group 5, 2009.

Rooftop Garden Potato Production
As provided with the UBC Food Services, the estimated area of the Place Vanier Commonsblock (PVC), where a rooftop garden has once been considered, is roughly 250 m^2.

1. Find the yield from a garden of potatoes of that size, using the average yearly statistics of the YWCA garden by Ted Cathcart:
   250 m^2 of PVC * (0.450 tons of potatoes each year / 650 m^2 of YWCA rooftop area)
   = 0.256 tons of average yield of potatoes at PVC rooftop garden

2. Calculate the amount of CO_2 saved based on the localization of the food source
   0.256 tons * 250 km (distance of closest importer of potatoes) = 64 ton-km
   64 ton-km * 207 g of CO_2/ton-km =<u>0.013 ton of CO_2</u> or <u>1.22% CO_2 saved</u>

Hence, to replace all potato imports at the UBC-Vancouver campus, via rooftop gardening:
100/1.22 = 82 rooftop gardens are needed (at the size of Place Vanier Commonsblock)

Based on the above calculation, it is evident that one rooftop garden will make a very small contribution to saving greenhouse gas emissions from transportation. Furthermore, it is evident that

UBC cannot support 82 rooftop gardens; we doubt there are that many roofs on campus! With that being said, this calculation effectively quantifies the amount of CO_2 that can be saved from localizing the food system. We hope that this may prompt the UBC farm to continue to expand its food production systems and continue to build stronger relationship with UBC food outlets.

Rooftop gardens require a lot of oversight and management, which should not be underestimated. The management of one rooftop garden is very complicated, so the management of multiple gardens will require a lot of collaboration and labour. As the calculation concludes, it is only with 82 fully-functional rooftop gardens of roughly 250 m2 plots that UBC will become potato self-sufficient. It seems almost impossible to introduce that many gardens

The calculations have been calibrated to a one-time, one-way trip by one truck, when that is obviously not the case. Trucks make several trips to and from the exporter's processing plant (Washington, in this case), which increases the amount of greenhouse gas emissions; these trips have not been quantified in our calculations. Therefore, 45, 371 pounds of potatoes to UBC emit more than 1.2 tons of CO2. More calculations and research should be done to realistically quantify

Potatoes were effectively chosen because of their popularity in UBC Food Services kitchens. In fact, UBC Food Services reports that it uses 45,371 pound of potatoes every year (personal communication, UBC Food Services, 2009). Potato was used in these calculations because of (i) its easiness to grow in the Lower Fraser Valley climate, (ii) the widely available literature on its yield and (iii) its ability to grow under a variety of conditions. Meanwhile, the group understands that potatoes are not the only crops imported to our campus. Other crops are probably imported at a larger volume and at greater distance. More research needs to be done to identify those crops and to calculate their food miles.

2.4.4. Potential Barriers, Challenges and Uncertainties

With all the benefits, there are several problems that exist when considering rooftop gardening. The first and foremost is the issue of weight. Rooftops have a weight restriction that severely limits the types of foods that can be feasibly planted. For example, planning heavy, water-dense foods such as potatoes and carrots does not optimize the use of the limited space of rooftop gardens (personal communication, Ted Cathcart, 2009). To maximize sustainability, the types of foods planted on rooftops need to be in sufficient quantity as to replace the food normally transported to the university via trucks. For example, potatoes and common salad greens should not be planted because even if the entire garden space is devoted to growing one such ingredient, it cannot replace the large volume needed in our food system. The same food will still have to be imported at lower quantities, which does not make economic sense considering volume discounted prices (personal communication, Ted Cathcart, 2009). Instead, rooftop garden resources should be devoted to growing foods in low demand, or low consumption, like herbs and spices. These plants are not heavy, are not consumed in high quantities, and the food system will not be threatened in an event of garden failure. The growing of aromatic herbs and spices also has the effect of maximizing food quality. Replacing bulk shipped herbs and spices with fresh variety yields more benefit than doing the same with a staple crop like potatoes.

The second limitation of rooftop gardening is size. Crops chosen for growing on rooftops should take up as less horizontal garden space as possible. Squash may be an ideal food for growing locally because it easily replaces any import of it on campus, but it takes up too much space on the plots to be feasible. To maximize food production, crops should take up less space, such as berries that has vines growing over the planter's edge, or pole beans and tomatoes that grow vertically (personal communication, Ted Cathcart, 2009). Vines can be grown around vertical supports to maximize gardening space (personal communication, Ted Cathcart, 2009).

The final limitation of edible landscapes is that of social problems. The YWCA rooftop gardens have been made as accessible to the public as possible. However, Ted understands the issue of theft and vandalism if edible landscapes are placed in locations that are too public. This issue is easily solved if the gardens are placed on rooftops; they can easily be secured, restricted, and monitored (personal communication, Ted Cathcart, 2009). Ideally, however, edible landscapes should not be limited to only rooftops. Ted Cathcart (2009), a former student of UBC's agricultural sciences faculty, comments that if edible landscapes are to succeed, every moderately sized patch of lawn should be replaced with garden space, starting with the entire median of main mall being converted to edible landscapes.

Part III: Recommendations

3.1 UBC Sustainability Office

- Research and develop literature on carbon sequestration constants for vegetable crops, in an effort to understand how they may play a role in achieving carbon neutrality. During the research and calculations made for this project, it became evident that academic literature was very sparse on the capability of vegetation and soils to sequester carbon. This could play an important role in understanding the relationship of urban gardens and emitted carbon.

3.2 UBC Food Services & AMS Food and Beverage Department

- We urge AMS F&BD and UBC FS to build business connections with community garden. If community and rooftop gardens will make any impact in our fight to reduce food miles, and bring UBC beyond carbon neutral, food will have to be purchased locally –strong local connections will ensure viable and sustainable business.

3.3 UBC Waste Management

- Again, we stress the importance of strong community linkages. Community gardens, especially as they develop, will require plenty of support. We recommend that Waste Management connects with emerging gardens to make its compost and rich soil more available to those who are interested.

3.5 UBC Farm

- UBC farm should also be leading the push for community gardening. With its expertise and ability to acquire farming materials, we recommend that the farm makes itself available to provide fertilizer, workshops and gardening material and expertise to the development of edible landscapes.
- We also recommend that the farm undergo new and enticing projects on community and rooftop gardening, allowing community members to learn from the projects.

3.6 Campus and Community Planning

- Edible landscapes can be included into future planning of the UBC and community. While vast development of campus buildings and housings are happening, gardening sites can be incorporated into these projects. All buildings in the campus could be inspected and scouted for suitable future sites of roof top gardens and container gardens.
- Potential rooftop garden at SUB also serves as an educational tool for those who are unfamiliar with rooftop gardens, since it is more visible to the public and this could minimize vandalism (personal communication, Tara Moreau, 2009).
- Fresh produce booth at the SUB with crops from the potential SUB rooftop garden (personal communication, Tara Moreau, 2009).

3.7 AGSC 450 2010 colleagues

- It is evident that one garden makes very little impact on the climate action plan for UBC, therefore we recommend researching for more wholesome approaches. Whether large-scale expansion of community gardening alongside rooftop gardening or a push for more food production from local agricultural fields, ie. The UBC farm.
- We recommend focusing on crops that sequester high amounts of carbon. During the project, and in coordination with group 5, research was done to attempt to compare crops based on the

amount of carbon they could sequester. Very little academic literature could be found. Meanwhile, this information would be incredibly useful as it could serve to isolate crops for garden-campus use; holding emitted carbon in these gardens.

- We also recommend further research and emphasis be placed towards crops that originate from far distances. Potatoes arrive weekly from Washington state, but we believe that crops commonly imported from Asia or South America could be targeted for sustainable and environmentally-friendly on-campus growth. We do not recommend growing bananas in hot houses at our campus, in an attempt to localize their production. Rather, we recommend researching into the growing patterns and conditions of imported vegetables to see if those could be grown locally, reducing the carbon footprint of these foods and the entire campus food system.
- Clearly, more calculations need to be done. We recognize that these calculations are basic and very inconsequential because of the many inaccuracies. For example, we did not consider the infusion of infrastructure for the building materials and fertilizers for a new rooftop garden, little literature was found concerning the sequestration of carbon by soil and food, and many inaccuracies lie in the average yield of vegetables (potatoes in BC) or the release of carbon from diesel trucks (see emission factor).
- On this note, we recommend research on energy saving thanks to rooftop gardening. Heat rises and will usually exit through rooftops. The presence of a garden may inhibit and trap heat within buildings saving energy bills and GHG emissions due to heating. Future colleagues could implement these results in the aforementioned calculations and encourage the University to fund and support rooftop gardening.

Conclusion

The increasing concern of GHG emissions is prompting Universities across the world to join hands with motivated students, environmental associations and implicated faculty members in an attempt to alleviate the effects of climate change. Universities, like UBC, are to be collective models for our society and at the forefront of the push towards carbon. Although the early research and calculations made in this project are sketchy and somewhat inconclusive, the project concludes the rooftop gardening is an opportunity to give the community an important learning tool, although it may not yet be the most effective means of contributing to UBC's vision of going beyond climate neutral. Conclusively, it was found that the building of edible landscapes at UBC is entirely possible. Meanwhile, buildings would have to be inspected to ensure that they are suitable for edible landscapes, and much time, funding, maintenance and volunteers would have make themselves available. This project has outlined the steps and necessary conditions that would allow a rooftop garden to be created on campus. Again, our early calculations prompt us to think that rooftop (and community) gardening may not be helpful in the push towards carbon neutrality, yet we emphasize that our calculations have evidently left out important factors and conditions and further research needs to be done.

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