How Might the Evolution of Urban Agriculture Advance Sustainable Agriculture in the Future?

(A foresight study looking at food security through the lens of urban rooftop agriculture and sustainable water management.)

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Major Research Paper

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Abstract

In order to feed the ever increasing global population without further degrading the natural environment we need to create a more sustainable food system utilizing small scale intensive (SPIN) methods of urban agricultural production.

This paper looks at the history of agriculture and the current food system as a basis for understanding its future and investigates the need and conditions to create a resilient food system. Viewed through a Toronto-centric lens to better understand how implications may affect urban rooftop agriculture, this paper presents arguments for the intensification of rooftop agriculture and the decentralization of the food system. Strategic foresight is engaged to understand not only the ecological and environmental impact of the agricultural system, but also the importance of food security itself.

Rooftop agriculture has the potential to add resilience to our food system while providing social, economic and environmental benefits for all Torontonians.

Search Words: Rooftop Agriculture, Food Security, Urban Farming, and Resilience

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1.0 Introduction

This paper utilizes a Toronto-centric lens to focus on sustainable urban agriculture in the context of rooftop agriculture and water usage to identify areas for improving its efficiency and expansion with a view to creating a more resilient food system for the city of Toronto. The intention is to investigate new ways of thinking about how we grow food; to consider a number of alternatives and perspectives that look at the social, economic, political and environmental impact of sustainable agricultural production while adding to the growing body of evidence supporting rooftop agriculture.

The current local food system is inextricably linked to the global system. To understand urban agriculture and the phenomenon of rooftop farming one must first understand what drives the food system from a global perspective. This is especially important with regard to the current overconsumption and unsustainable use of our natural resources in the current food system.

> "As food shortages loom around the world, many believe the next wars will be fought over food and water. The best protection against world food conflicts is local, regional and national food self-sufficiency."
>
> (Ladner, 243)

2.0 Background

2.1 Framing the Problem

The driving question behind this paper is how to feed the ever increasing global population without further destruction or depletion of our increasingly fragile planet? This paper proposes rooftop urban agriculture as a catalyst for more resilient and decentralized food systems. The current food system is a major contributor to many of the most pressing issues we face today, including global hunger and environmental crises such as natural resource depletion, water pollution and climate change. The current global supply system of importing products from around the world has a direct impact on the country of origin's water though the agricultural pollution of watersheds, and the exportation of virtual water. As the global population increases and crop yields decline due to environmental factors, the availability of imported food in the future becomes uncertain. According to the Food and Agriculture Organization of the United Nations (FAO) by 2050 the global population will reach 9.1 billion and they estimate that food production will need to increase by as much as 70% based on population and improved standards of living. (Ladner, 5) This raises a number of questions.

How are we going to feed our growing population?
Why transition from a global to a local food system?

As a country's population increases it will require more food, leaving less for export. Toronto currently relies heavily on imported food. We need to find a way to increase our food production without encroaching further into the hinterland to protect the ecosystem services we rely on for our survival.

As we move into the 21st Century, resilience will become critical in order to deal with any possible future disruptions in the global food system. Addressing issues of urban food production and distribution, water management and sustainability are important aspects of a resilient food system. A robust local food system including urban agriculture and rooftop farming has the capacity to decentralize the current food system while adding diversity and resilience to better absorb shocks from unforeseen disruptions in the global food supply chain. The investigation of local rooftop agriculture and water management and its impacts on the food supply and demand system will reveal opportunities for increasing resilience and food security.

What would it take to increase rooftop food production in the city of Toronto?

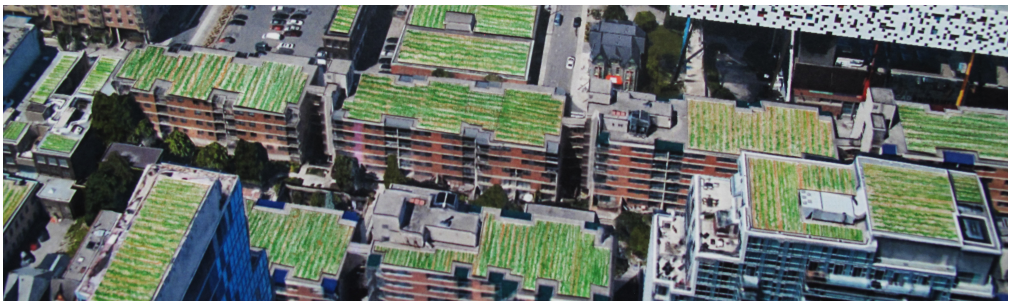


Image 1: Proposed Rooftop Farms. Source: Google Earth modified by Robert Mitchell.

2.2 Assumptions and Biases

In writing this paper I realize that I have a clear bias toward local sustainable environmentally friendly food production based on an eco-centric point of view. This paper makes the assumption that rooftop urban agriculture would be predisposed to small human scale production predicated on benign organic farming principles used to produce food for the local market. The paper focuses on the potential for rooftop production of fruit,

vegetables and herbs in the city of Toronto and does not consider livestock or aquatics as part of this study.

There is an assumption that an increase in local food production will increase equitable access to healthy nutritious food while implementing water saving strategies for production, a key factor in the paper.

2.3 Research methodology

This paper is based on a comprehensive understanding of the current food system and how water is currently used in agriculture from a social, economic, political and environmental perspective, along with the emerging trend of urban rooftop farming and its contribution to a resilient food system. Understanding an urban farmer's perspective, and identifying opportunities to improve the efficient use of water, and what is required to develop them are important aspects of this paper. (Emergent trends that maximize the efficient use of water or production while protecting environmental water flows are also important.) Several methodologies were employed in the research for this paper.

Literature Review: Through an extensive literature review, I investigated key concepts and challenges of sustainable agriculture regarding water usage and identified leaders in the domains of agricultural practice, water conservation, water policy and environmental impact. I also investigated other industries dealing with issues of water sustainability and possible mechanisms that could be exploited and leveraged to increase water efficiency in the agricultural sector. The literature review helped to identify possible candidates for expert interviews.

Expert and Semi-structures Interviews:

Interviews offered additional information, clarification and new directions of investigation. I interviewed different stakeholder groups to get a variety of perspectives in hopes of better understanding concepts and challenges related to the overall system and the impact or acceptance of proposed alternatives.

Interviews were restricted to experts in the fields of agriculture and water issues including authors, farmers, policy makers, water management experts, architects or social scientists. Research Ethics Board (REB) approval was necessary to enquire about personal opinion or in the event that I wished to pursue a question further during an

interview. Interviews were also taped for clarification of details and transcribed. All material and data was handled according to the REB's specifications.

Horizon Scan: Investigating alternatives to current agricultural practices and the efficient use of water, not restricted to the agricultural sector are also important aspects of the paper. Looking at best practices from a sustainability or regenerative perspective that could be leveraged to improve agricultural irrigation practices.

Case Studies: A number of case studies dealing with alternative agricultural practices based on either increasing water efficiency or yield per unit of water are included to support the viability of rooftop farming. Also included are a number of other areas that are dealing with water conservation or reclamation issues to leverage some of their findings to benefit the agricultural sector.

Sense-making: Sense-making conducted using a number of methodologies including, systems mapping, stakeholder analysis, and scenario building.

2.4 Stakeholder Analysis

Our agricultural food system whether global or local is complex and involves a large number of stakeholders. During the research for this paper I identified over thirty individual stakeholders that fall into the flowing ten categories.

Producers Growers & Processors	**Consumers**	**Distributors**	**Government** Policy Makers	**Non-Profits**	**Environment**	**Building Owners**	**Healthcare** Providers	**Green Tech** R&D	**Education**

3.0 Setting the Stage

The following pages set the stage for understand the current global agricultural system from a historical perspective. It also looks at the local system and where our food comes from as well as defines what sustainable, urban agriculture is. This section also investigates what is needed to build a resilient local food system.

3.1 A Brief History of Agriculture (Era Analysis)

The following graphic illustrates a timeline of the history of agriculture.
(Graphics by Lotus Yu)

Agricultural Era Analysis High Level Events with Major Impact on Agricultural Society

Hunting and Gathering Era 0-10,00 BC
Prior to 10,000 BC society was based on small social groups of nomadic people moving in search of food.
- Society - based on resource-population balance
- Energy - production based on human activity
- Population - limited due to minimal availability of resources, accumulation of goods, capital or surplus
- Technology - limited specialization or trade

The Agricultural Era 10,000 BC-
Widespread transition from nomadic hunter-gatherers to agrarian societies based on sedentary settlements established through the domestication of plants and animals, irrigation and deforestation, often referred to as the Agricultural Revolution or the Neolithic Revolution.
- Society - based on the domestication of food production (food becomes the basis for economy)
- Energy - domesticated animals, wind and water are utilized to increase energy output, cultivation and transportation
- Population -increases substantially due to improved access to food

Surplus accumulation allows for specialized skill, increased trade and the development of the first civilizations including recorded writing, historical record keeping and the development of class structure
- Technology - innovation includes advances in metallurgy and tool development

The Columbian Exchange 1492 –
With the discovery of the New World, Christopher Columbus began exchange between East and West (One of the most significant events in the history of world ecology, agriculture and cultural exchange)
- Society – large scale contact between the Old and New World expands global exchange
- Energy – consistent with the Agricultural Era - Introduction of crops and animals from the West to the East
- Population – continues to rise in the East - responsible for depopulating the West due to disease
- Technology – introduction of trans Atlantic transport

The Industrial Era
Beginning in 17th Century innovative agricultural techniques generate massive increases in agricultural productivity driven by technological advance, mechanization, large-scale production and increased livestock husbandry. Fertilizer increases yield per acre supporting unprecedented population growth and helps to drive the Industrial Revolution.
- Society – increased food supply and health allow more people to engage in other activities, high reliance on trade and commercialization result in unprecedented accumulation of wealth. Wide acceptance of scientific perspectives and investigations facilitate new agricultural innovations.
- Energy - development of the steam engine allows for the pumping of water for irrigation and efficient transportation
- Population – unprecedented growth with a high degree of specialization
- Technology – improvements provide labour savings and increased productivity, surplus and trade

Timeline of Agricultural events Affecting Agricultural Innovations

9,500 BC
1st evidence of planned cultivation and domestication of crops

6,000 BC
- Rice farming begins in China and East Asia
- Earliest evidence of irrigation

5,500 BC
Organized agriculture begins in Samaria including large-scale cultivation, mono-cropping, and organized irrigation

600 BC
Earliest rooftop gardens

500 BC
Row cultivation begins in China reducing seed loss and allowing intensive hoeing and weeding

1599
1st practical green house (greenhouses 1st appear in Italy in the 13th Century)

1700
Charles Townshend popularizes crop rotation (practiced by ancient Roman, African and Asian cultures)

1800
Introduction of chemical fertilizers

1830
Swing Riots, an Agricultural Rebellion In England, protesting the introduction of the Threshing Machine and the replacement of ¼ of the agriculture workforce during the previous 15 years

1837
John Deere develops the 1st commercially successful steel plow

1850-1930
Potato Patches, (Detroit) an urban agriculture program during the depression offering hope, self-respect, independence and self-reliance to the poor and unemployed

1860
Refrigerated cars move more meat across the USA

1860's – 70's
Introduction of mechanized hay cutting, stationary bailer was invented in the 1850's but didn't gain popularity until the 1870's

1879
Anna Baldwin patents milking machine replacing hand milking

1892
John Froelich builds the 1st practical gasoline powered tractor

1900-1950
Birth of industrial agriculture

1900's
The Organic Movement begins in response to the move toward synthetic nitrogen fertilizers and pesticides

1917
War gardens are established on public and private land to support the troops during WWI

1929-39
Depression Relief Gardens in the US, urban gardens used during the depression to combat hunger, poverty and emotional stress

1930
Henry F Rosenberg patents the 1st plant, a rose

1939
DDT introduced as a pesticide beginning the heavy use of chemicals and pesticides in developing countries (Now banned in 86 countries)

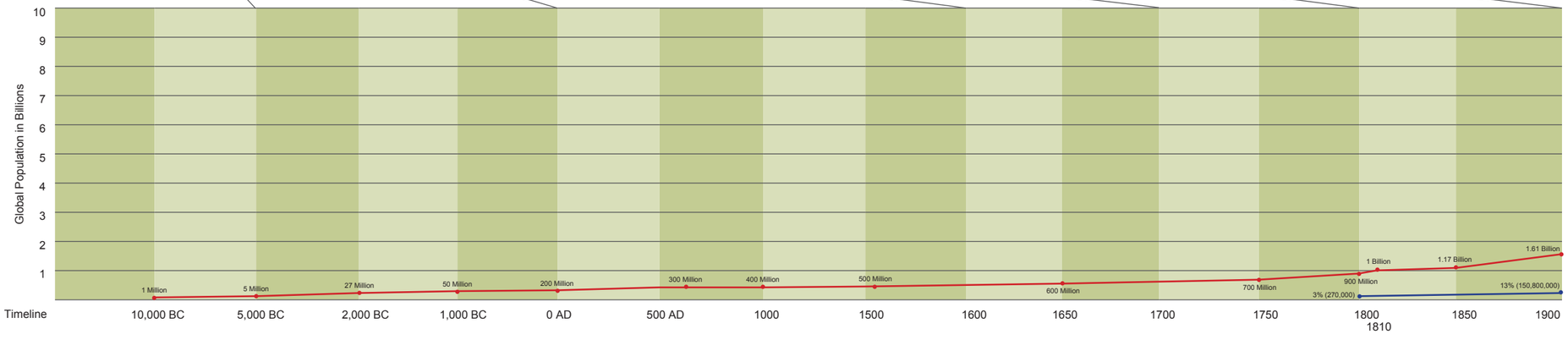
1940's – 50's
Start of the 'Pesticide Era', the Green Revolution begins in 1943-1984; chemicals developed for WWII are redirected to civilian use

1940 – 45
Victory Gardens of WWII account for 40% of the US vegetable production

1943
Canadian cities produce 115 million pounds of food for the war effort

1950's
Focus on decentralized mass production and specialization of the factory is applied to agriculture substantially increasing productivity; driven by cheap fossil fuel high chemical use is standard practice. The term, agri-business is coined and long distance shipping becomes feasible expanding global trade.

Global Population



Global Population

Global Urban Population

The Fossil Fuel Era
Beginning in the 18th Century coal, oil and gas allow for vast increases in energy supply contributing to unparalleled production increases culminating in the Green Revolution of the mid 20th Century.

- Society – expands to include more specialization, similar to Industrial Era; however, industrialization and mechanization reduce the number of people working in agriculture
- Energy- high reliance on fossil fuel increase energy and chemical production resulting in unprecedented increase in agricultural production and wider transportation
- Population - increases as a result of food access
- Technology – improved management techniques and scientific advances in chemical pesticides and fertilizers increase use of fossil fuel in agriculture

Modern Era (The next era)
We are about to enter a paradigm shift in food production however, what exactly it will be has yet to reveal itself. There are a number of movements underway to try and discover how we can feed the world based on a search for alternative, renewable energy and healthier living.

- Society – looking for solutions for the social environmental and economic conditions created by the current food system
- Energy – still reliant on fossil fuel but trying to transition to green energy and sustainability in light of global warming
- Population – continues to increase, but slowing
- Technology – advances in green technology, innovative growing techniques

1960's – 70's
Grocery stores abandon the North American inner city for the suburbs, due in part to the proliferation of the automobile

1970's
The Organic Movement begins in North America (formal guidelines are not established in the US until the 1990's)

1972
- US and Canada ban DDT due to negative impacts
- Organic Movement takes hold, a reaction against the external effects of the industrial food system

1973-79
Energy Crisis demonstrates the extent to which the global community relies on no-renewable energy

1978
American Community Garden Association is established, reinvigorating the Community Garden Movement in the US and Canada

1988
USDA Sustainable Agriculture Research and Education (SARE) program is established

1990's
- 'Convenience Foods' fill supermarket shelves
- Companies go Global, farmers and producers become suppliers for the global food chain rather than local communities

1991
Toronto Food Policy Council is established

1993
US launches task force on sustainable agriculture

1996
- 1st commercial genetically modified crop
- 1st cloned animal using adult cells (Dolly, the sheep)
- Development of the Community Food Coalition and the Farm to School Program
- Mike Schreiner, starts Toronto's 1st commercial organic food box program
- Toronto's 1st rooftop farm, Annex Organics is founded

1997 – 98
USDA proposes standards for organic production

1997
US food Quality Protection Act is passed

2000
- GMO's are cultivated around the world
- Toronto adopts the city's 1st Environmental Plan

2001
Toronto adopts the Toronto Food Charter

2002
Toronto's Official Plan establishes policy for the built environment

2003
The Buy Fresh Buy Local (BFBL) movement starts in the US

2005
- The 100 Mile Food Diet made us aware of just how far our food travels (Locavorism is coined in California)
- 4 grocery retailers control 78% of the Canadian market

2008
- Rising food prices cause riots around the world due to rising fuel and fertilizer costs, climate change, drought, bio-fuel production and changing global diets
- Toronto adopts the Local Food Procurement Policy

2009
Toronto implements the Green Roof Bylaw

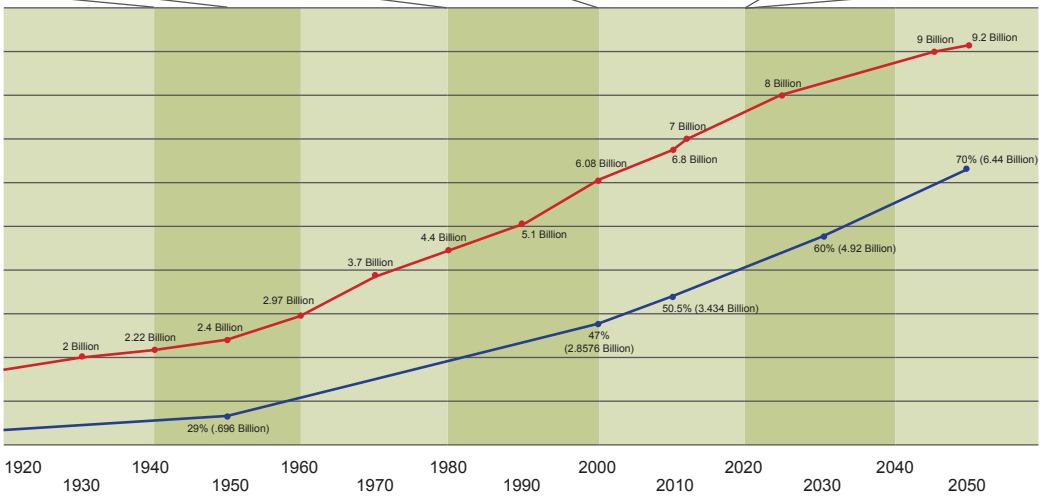
2010
Toronto's Food Strategy is established through Toronto Public Health

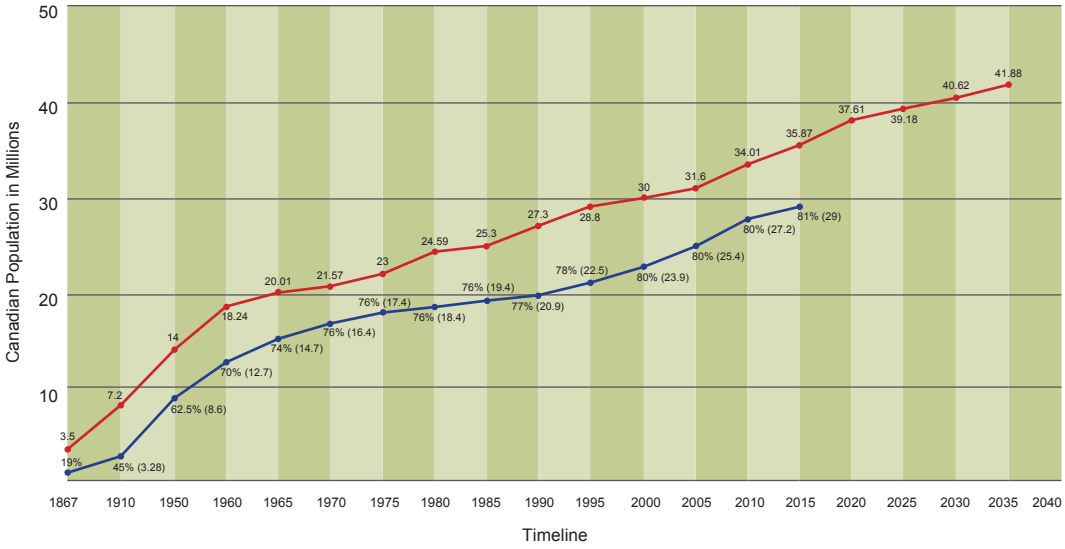
2012
Toronto City Council endorsed the Greater Golden Horseshoe Action Plan preserving farm land in Ontario

2010
The Modern Urban Agriculture Movement begins to take hold

2011
Lufa Farms installs a commercial hydroponic rooftop garden in Montreal

2015
According to the UN, climate change, global warming and excessive irrigation threaten water security in 36 countries





Total Population of Canada

Population Living in Urban Areas
(defined by Statistics Canada as a community with 1,000 residents or more)

3.2 Understanding The Current Food System

> "After an era of human agricultural history focused on the domination of nature, reductionist logic, short term high yields, and dependence on technological solutions, 20th century food systems are rapidly becoming a thing of the past, and symptoms of an unhealthy food system may no longer be ignored."
>
> (De la Salle et al, 21)

Image 2: Modern Industrial Agriculture: Photo by Soja Colheita.
Source: AFNEWS Agricola http://www.afnews.com.br/economia/departamento-de-agricultura-americano-reduz-estimativas-para-safra-de-soja-e-milho.html

The current agricultural system is a product of the industrialization of the twentieth century and a shift to a fossil-fuel-based food system devoid of human or animal energy inputs

Graphic

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The current agricultural system is a product of the industrialization of the twentieth century and a shift to a fossil-fuel-based food system devoid of human or animal energy inputs

reliant on monoculture, mechanization, chemical pesticides and fertilizers, biotechnology and government subsidies. This shift has resulted in fewer people growing food and larger amounts of embodied energy in the food produced. According to the Reference for Business, Encyclopaedia of Business, the term Agri-business was first coined in the 1950's to describe the shift to large-scale corporate farming. The focus of agri-business is to grow as much food as possible resulting in the high external input dependant model of industrial agriculture including production, storage, manufacturing, packaging and transportation all of which significantly contribute to global energy consumption, green house gas (GHG) and the depletion and pollution of natural resources.

"The energy it takes to produce, distribute, store, and sell food is now far greater than ever before" (De la Salle et al, 24) It is estimated that it takes 9 units of energy to produce every unit of energy in the food we consume.

Agricultural practices have changed dramatically since World War II resulting in souring productivity due to "technologies, mechanization, increased chemical use, specialization and government policies that favoured maximizing productivity" (Feenstra et al) over everything else. Global food production has increased to unprecedented levels unseen in history; however the current industrial system is based on the mass production of cheap food, and generally considered unsustainable by most experts. The system has created an export-based agricultural economy that has more to do with the bottom line than food security or sovereignty. I am not suggesting that exporting agricultural products is wrong, as it has many significant benefits to our economic health as a nation and in some cases imports can be more economically and environmentally sustainable than local growing depending on the methods of production and delivery. However it should not be the only option practiced when you consider the social and ecological impact of local vs. imported food.

During the Green Revolution, food production worldwide increased considerably with the caloric intake in the developing world increasing by 38% between 1961 and 1998. (Harrison, 55) During roughly the same time the production of rice, maize and wheat increased by as much as 88% in Asia and Latin America while the global average meat consumption rose by 50%. (Sanchez) According to the World Bank, 70-90% of these increases were due to innovations in conventional agriculture, not to increases in acreage under development. Conventional agriculture refers to the rapid advances in agricultural practices since the 1950's characterized by rapid technological innovations, large capital

investments; large increases in farm size and the adoption of large-scale monoculture farming practices using uniform high-yield hybrid crops under continuous cultivation. The Green Revolution also relied on the extensive use of chemical pesticides, fertilizers, and external energy inputs along with high labour efficiency and an increased dependence on big agri-business. (Chemical use in agriculture is discussed in more detail under Environmental Concerns on page 53) Although outside the scope of this paper I feel that it is important to acknowledge that in terms of livestock most production comes from confined concentrated systems reliant on antibiotics to maintain livestock health.

“In considering an alternative or more sustainable model, it is important to note that the global industrial market and regulatory system are all structured to perpetuate the current unsustainable system.” (De la Salle et al, 31)

The current conventional system has had a number of positive effects, most notably the increase in production however these benefits have come at a significant cost to the ecological environment. Negative environmental, social and economic consequences include: “erosion, depletion and contamination of soil and water resources, loss of biodiversity, deforestation, labour abuse and the decline of the family farm.” (Sustainable Agriculture. National Geographic.com) The system is also responsible for the disintegrating economic and social conditions in rural communities, having a profound effect on the viability of small scale farming in rural areas resulting in “Rural Flight”. The costs of these externalities rarely reflected in the price of the product in the marketplace. (Harrison, 67)

A strong Canadian dollar has a negative impact on export products making it hard to compete in global markets where labour costs are a fraction of those in Canada. Globalization and international trade have resulted in cities dependent on the global market rather than local food sheds. Removing the consumer connection from food in favor of large centralized processing and distribution facilities filled with food from around the world has created a highly dysfunctional system. The globalization of the 20th Century has resulted in city building and planning that until recently ignored the need for agricultural space. Most of these urban areas have been established on prime agricultural land and therefore urban sprawl directly consumes fertile agricultural land.

The move toward sustainable agriculture provides opportunity for stakeholder

engagement and education, addressing many of the environmental and social concerns stemming from the agricultural practices that contribute to the negative impacts of the current food system.

> According to Karl N. Stauber et al, there are several philosophical underpinnings of industrial agriculture based on the following assumptions:
>
> a) Nature is a competitor to be overcome
> b) Progress requires the unending evolution of larger farms and the depopulation of farm communities
> c) Progress is measured primarily by increased material consumption
> d) Efficiency is measured by looking at the bottom line
> e) Science is an unbiased enterprise driven by natural forces to produce social good
>
> (Stauber et al, 13)

The global food system faces a number of challenges today: first we need to feed the current 7 billion people on the planet equitably without depleting the natural resources required for future generations to feed themselves; second, we need to increase production to feed our growing population; and thirdly, we need to do it while becoming environmentally sustainable.

> According to Foley and a team of international experts five steps pursued together could be the solution:
>
> 1. Stop agriculture from consuming more tropical land
> 2. Boost the productivity of farms that have the lowest yields
> 3. Raise the efficiency of water and fertilizer use worldwide
> 4. Reduce per capita meat consumption
> 5. Reduce waste in food production and distribution

I would argue that urban agriculture has the potential to impact all of these issues while including economic and social benefits not offered by Foley's solutions. Although not able to increase the productivity of low yield farms it could have the potential to minimize the need for increased production in these cases.

Foley and his research team argue that improving productivity and closing the "yield gap" on the world's least productive farms offers the world the largest gain in food production. Their analysis suggests, "That closing the yield gap for the world's top 16 crops could increase total food production by 50-60 percent, with little environmental damage." (Foley, 64) The team envisions the "next generation system as a network of local agricultural systems that are sensitive to nearby climate, water resources, ecosystems and culture

and that are connected through efficient means of global trade and transportation. Such a system could be resilient and also pay farmers a living wage." (Foley, 65)

In the past 20 years global crop yields have only increased about 20% (Foley, 62) while the global population increased from 5.1 billion in 1990 to over 7 billion in 2011, representing an increase of 37%. The food industry has continued to provide for our needs through efficiencies, however as our population continues to rise and crop yields decrease due to environmental impacts or stress, I do not believe that the current system alone can fulfill our future food needs. According to many experts, drought and soil degradation are expected to undermine growing conditions around the world in the near future. The World Resource Institute estimates that nearly 40% of the world's agricultural land is already depleted in some way due to a number of causes. (See fig. 1)

"Even moderately degraded soil will hold less than half of the water than healthy soil in the same location" and excess irrigation can cause soil salination. (Crawford, Gold) According to a 2006 comprehensive study by David Pimental, published in the Journal of the Environment, "Soil is being washed away 10 to 40 times faster than it is being replenished." (The study draws on statistics from 125 sources) As a result the United States is losing soil 10 times faster than replacement rates and in China and India it's as high as 40%. About 60% of the eroded soil ends up in the watershed, increasing risks of flooding and water contamination due to fertilizer and pesticide runoff. (Pimental) Over 18% of the formerly productive land in China is now desert resulting from the unsustainable over use of water in that country. "The Chinese Research Department for Industry, Transportation and Trade estimates that desertification directly causes $7.89 billion in losses each year due to the health, economic and environmental effects of sandstorms and water shortages." (Patel, 47) The World Bank estimates that the cost could be as high as $31 billion.

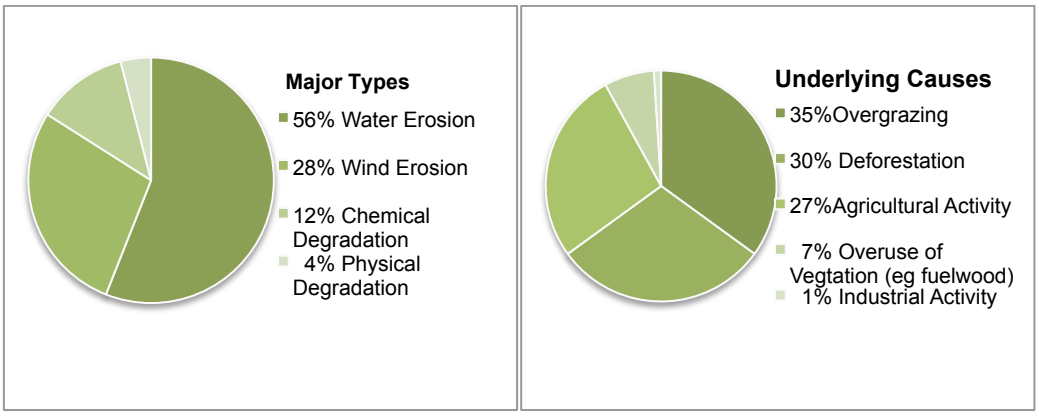


Figure 1: Major types and causes of soil degradation. Source: FAO/UNEP

Breakdown of global agriculture

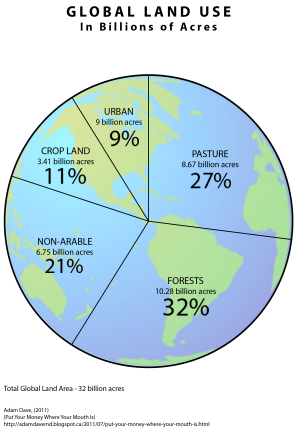


Figure 2: Total Global Land Use

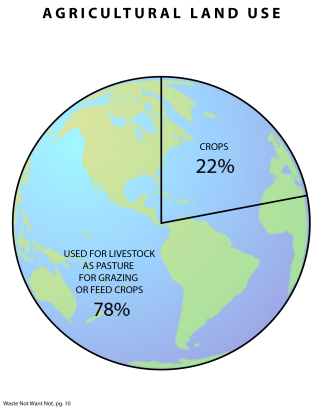


Figure 3: Agricultural Land Use

> "A doubling in global food demand projected for the next 50 years poses huge challenges for the sustainability both of food production and of terrestrial and aquatic ecosystems and those services they provide to society. Agriculturalists are the principle managers of global usable lands and will shape irreversibly the surface of the earth in the coming decades. New incentives and policies for ensuring the sustainability of agriculture and ecosystem services will be crucial if we are to meet the demands of improving yields without compromising environmental integrity or public health." (Tilman, 671)

We need to envision an alternative inclusive model that includes agricultural production from within the city itself as well as sustainable local, regional, national and international imports if we are to have a truly resilient and secure food system.

History of the Supermarket / Corporate Interests

> According to British Architect and Historian, Carolyn Steel “Never in the field of human consumption has so much been fed to so many by so few”
>
> (Ladner, 2)

Image 3: Supermarket Vegetables: Image by Robert Mitchell.

In the past, the family unit was responsible for maintaining its own food stock, today this responsibility has been largely offloaded to the industrial food chain and the grocery store creating a disconnect between the consumer and food production and processing. This has dramatically altered the 20th century city in terms of land use, transportation needs, growth management, building type and open space design. It has also greatly affected the local agricultural economy where more of our food is imported from the global market and less comes from our own back yard or local food shed. Facilities dealing with the growing, processing and storing of food have been forced from city centers and relegated to outer industrial or rural zones or other countries altogether. Today grocery stores and supermarkets function more like mega warehouses for over processed foods imported from around the world, replacing the small local markets of the past.

Supermarkets came into being in the 1920’s as a result of the rise of the suburb and the proliferation of the automobile “Grocery stores abandoned the North American inner-cities in the 1960’s and 1970’s, following their more lucrative customers out into higher-income neighbourhoods” (Ladner, 221) Today they are the antithesis of local food systems; driven by price it is often economically cheaper to import food from large distant producers than to buy local. The challenge for urban farmers is to differentiate

themselves in the marketplace through education geared toward changing consumer behaviour or the creation of high value niche market products to avoid the battle of pricing pressures as a marketing tool. Niche is becoming mainstream. (This will be discussed in detail later in the paper)

The scope of the global food market is represented by large-scale transnational agri-business, a system controlled primarily by large supermarkets and lobbyists. The top five food retailers in Canada account for approximately 80% of all food sales and include three Canadian companies, Loblaws, Sobeys and Metro, and two American, Walmart and Costco. These large-scale retailers benefit from the economy of scale that enables them to maintain aggressive pricing schemes. According to Sarah Elton, author of Locavore, the average Canadian grocery store stocks between 30 and 40 thousand products based primarily on food lobbyists who get products on the shelves, and Ladner estimates that in the USA the average is as high as 50 thousand. Urban agriculture has the potential to create stronger relationships with these institutions in order to increase the local market share within these organizations (even a small share could have a big impact for local producers) or change social behaviour to value purchasing from small-scale local producers over the mega chain.

"The grocery store is the most common gateway to access food". (Tilley et al, 5)

Top three food retailers in Canada: Sales in 2010 ($millions)

Loblaws Co. Ltd (Operating under 22 different banners)	-	$31,603
Sobeys Inc. (Operating under 7 different banners)	-	$15,723
Metro Inc. (ON and QU: Operating under 5 different banners)	-	$11,408

Source: CIBC World Markets, Estimated (Roukhkian, 17)

The key to increase the market share for locally grown and processed food is to create a robust urban agricultural sector that can provide a reliable supply to these retailers. This could have a major impact on the local food system and add resilience to the uncertainty of the future reliability of the global food chain by focussing on import replacement crops rather than those already harvested from local sources.

> "There are only three days' worth of fresh food in the city at any time." (The State of Toronto's Food) This is an estimate based on the "just in time "strategy used by major food retailers to limit inventory costs "in the grocery world it is called just-in-time-replenishment." (Elton, 147)

> According to Elton most chains keep a safety stock in distribution centers to mitigate any disruption in the delivery chain consisting of “three days’ worth of perishable produce, 8-9 days of frozen food and 14 days’ worth of dry goods.” (Elton, 147)

The logistical challenges of urban agriculture supplying the supermarkets of the world are daunting. Shoppers at farmers markets are willing to pay a premium but supermarket shoppers are driven primarily by price, therefore better education on the benefits of local production must be used as a mechanism to influence purchase behaviour.

Conflicts between global and local food systems are becoming prevalent in Canada, however the ability of a local food system to feed the masses has yet to emerge. This does not need to be an all or nothing scenario but rather involves making informed choices that reduce our personal impact on the planet. The idea is not to eliminate rural farming, but to stop its further expansion into what remains of the natural environment. The expansion of food production to feed our increasing population should come from the city itself.

Where does our food come from?

According to The Canadian Food Guide recommendations the average Canadian 14 years of age or older requires 7-10 servings for fruit and vegetables a day to maintain optimal health yet according to data from Statistics Canada 2007, “Canada’s farmers only grow enough to provide each Canadian with 1.27 daily servings of vegetables and 0.42 servings of fruit. (Based on 125g serving size.)” (The State of Toronto’s Food 2008, 6) As a result, “Canada imports food from 190 countries.” (Ladner, 236) This provides an opportunity for rooftop agriculture to increase the production of local fruit and vegetables to meet demand without negatively impacting local farmers by focusing on import replacement crops.

According to Elton, more than fifty percent of the fruit and vegetables grown on the planet come from China and a rapidly expanding export industry. More than 60% of the fresh produce consumed in Toronto comes from the United States alone, and a third of it arrived during Ontario’s growing season. (Ladner, 104) Cheaper imports are causing stress on the local food system and as a result local food procurement policies are being implemented across the country. Contrary to the negative issues around protectionism, procurement of local food adds to local food self-sufficiency and security by adding

resiliency to a region or community protecting against breakdowns and disruptions in an increasingly centralized global supply chain.

A local food system has the capacity to build community and provides environmental benefits by reducing GHG emissions from transportation while increasing the nutritional and economic health of a community through the provisioning of fresh nutritionally rich produce and jobs.

Urban agriculture can be used to minimize the lack of access to healthy food in food deserts in large city centers.

The Ontario Food Terminal

The Ontario Food Terminal is "the epicenter of the food system for Canada's largest city," Toronto. (Elton, 139) Opened in 1954 by the provincial government as a symbol of the modern economy and efficiency, more than 2.2 million kilograms of fruit and vegetables from around the world pass through the terminal every day, facilitating the long-distance trade in food. The terminal ensures an uninterrupted flow of affordable fresh food and an opportunity for direct access for local farmers to buyers removing the middleman and making local produce competitive with foreign markets.

The terminal only produces 10 million kilograms of waste a year representing about 1.2% of the overall volume. This is due to a stringent recycling program that recycles all plastic and cardboard and reuses virtually all waste. Food waste is converted into hog feed for local farmers. This is only one of the channels used to get food into the city; supermarkets often have their own networks for food procurement. (Elton, 140)

Going Local

As of May 10, 2013 the Canadian Food Inspection Agency (CFIA) expanded its definition of local food in a new interim policy from food produced within 50 kilometers of where it's sold to include all food produced within the province it's sold in or within 50 km of the province of origin. This change has been received with mixed reactions. (Landry, June 27, 2013)

As more consumers are demanding local products education and demand are changing the system, and mainstream grocery stores are beginning to brand local food separately.

As a result Loblaws introduced “grown close to home” in 2008 and produce sales increased 12%. (Elton, 148) According to an Elvironics Analytics study, “79% of Central Ontarians prefer to buy locally grown food, 71% are willing to pay more, 91% would buy more local food if it was made more convenient, and 55% seek out and buy local food at least once a week.” (Schreiner)

> “In July 2009, ten Ontario Grocers abandoned their Sobeys affiliation so they could meet their customer demand for local meats. Sobeys company policy, which stated that all meat sold in their stores be processed at a federally (vs provincially) inspected processor, had prevented the grocers from buying meat from nearby farms.” (Elton, 148)

Local Food Plus is striving to create supply chains to connect local farmers with the people of Toronto creating a local food system by linking farmers with institutions that buy local food. In Toronto they work closely with the Local Food Procurement Policy. The organization has created a certification brand for local and sustainable food (LFP) and defined ‘local’ as products that have been produced, processed, and distributed within the province in which they are consumed. (http://www.localfoodplus.ca) Products can be purchased in Toronto with the LFP Logo on the label making it easy to identify local products. The criteria for the label are based on local production using ecologically sustainable methods of production as standards. To date, over 200 local farmers and processors, together with almost half as many “retailers, restaurants, caterers, distributors, and institutions” have been certified by LFP. (http://www.localfoodplus.ca) In 2009 LFP received funding from World Wildlife Fund to test the program in other provinces.

According to Elton, critics argue that a local food system in Toronto is a fiction that cannot be realized due to the cost, making local or regional food difficult for all income groups to access. The main argument is that without the cheap imports of the current system, not everyone will be able to eat. Critics cite local labor and the cost of inputs as a major barrier with Canadian labourers making significantly more than their American or Mexican counterparts. As global wealth increases the gap in labour cost will be reduced.

In the case of Organic or LFP certified products the additional costs associated with compliance to produce food using environmentally sustainable methods are also a factor affecting price with certified products tending to be 10% more expensive. According to

Toronto grocer Dale Knopf, “the majority of consumers still look at the price first” (Ladner, 23) when making purchasing decisions and that local food “appeals to the minority of buyers who put quality first, price second.” (Ladner, 23) This brings up the need for better information regarding the cost of a product including social and environmental impacts to better inform the public that the true costs are not always measured simply by economics.

Changing demographics, including high immigrant populations and the need for international foods and flavours not traditionally possible in our climate are also an issue. According to The Vineland Research and Innovation Centre, in 2011, “residents in the Greater Toronto Area (GTA) purchased $61 million each month of Chinese, South Asian and African-Caribbean fruits and vegetables. Few of these crops are currently being grown commercially in Ontario and demographics in the GTA will continue to diversify. By 2017, immigrants will represent half the population in the GTA, 63% by 2031.” (vinelandresearch.com) I would argue that even in diverse ethnic dishes, many if not all components could be grown and sourced locally; it’s about purchasing locally what we can and not importing economically cheap but environmentally expensive alternatives. There will always be certain products that are imported because we can’t grow them and in some cases sustainably grown produce from other countries can be more environmentally friendly depending on production inputs and transportation methods.

> 79% of the Torontonians surveyed in a telephone survey agreed with the statement, “I prefer to buy locally grown fruits, vegetables and meats.”
> The majority of respondents agreed that the distance food products travel is a concern and “almost everyone, 97% - agree that supermarkets should create dedicated and visible sections to make it more convenient to buy locally grown food.”
>
> (Lander, 23)

One of the best examples of the potential of locally grown food can be seen in our past. The Victory Gardens of World War II produced large quantities of food to support the allies during the war effort with citizens around the world growing food in their front and backyards as well as public spaces. In 1943 alone, Canadian cities produced 115 million pounds of food from Victory Gardens. (Johnson)

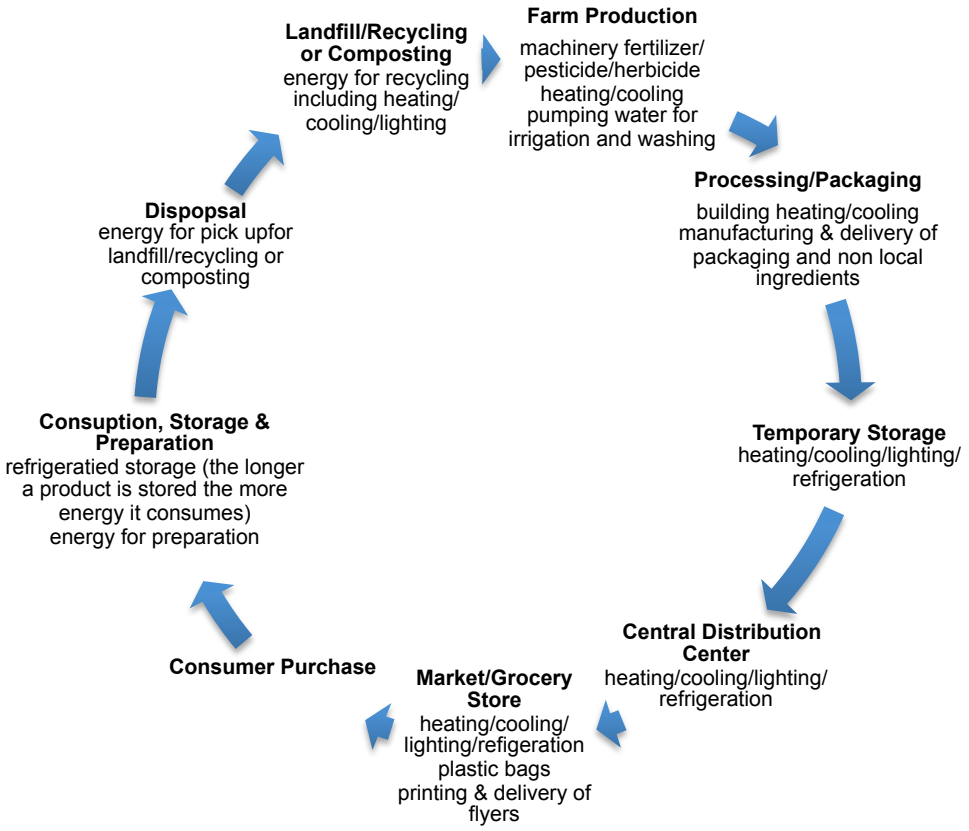
Benefits of going local:

- Local food = local economy (Importing food sends jobs and grocery dollars to other countries)

- Local support for farmers
- Fresher, tastier and more nutritious local food can be picked at its peak nutritional value unlike produce that is picked early and ripened during long distance shipping– in most cases the nutritional value of produce begins to degrade once harvested
- Increased resilience in the food system to minimize the effects of disruptions in the distribution system
- Consumers feel that local food is safer citing that it is easier to trace food related illness due to contamination
- Local food has the potential to reduce food waste as a result of damage or bruising as well as decreasing the amount of packaging used to protect produce during long distance travel

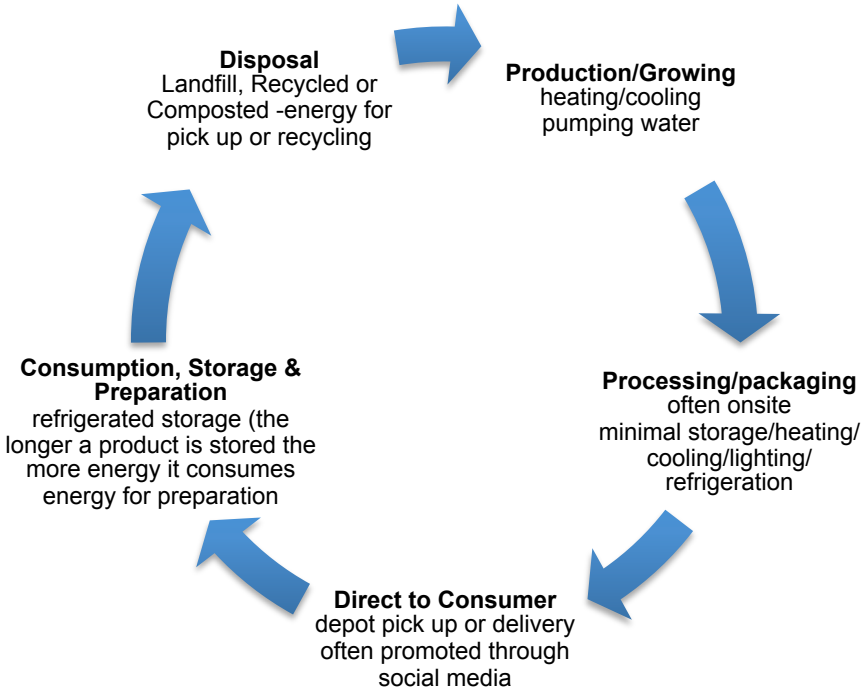
Food Miles

According to a 2005 study by FoodShare in Toronto the average distance traveled in a sample basket of groceries is over 5,000 km. Food miles are not the only way to measure sustainability however they are embedded with fossil fuel consumption and a major contributor to GHG emissions. (See fig. 4)



(Arrows represent transportation)

Figure 4: Fossil Fuel Energy Consumption in Conventional Agriculture.



(Arrows Represent Transportation)

Figure 5: Fossil Fuel Energy Consumption in Urban Agriculture

Several US studies indicate that transporting local and regional goods is far less harmful to the environment than importing them. According to a study in Iowa, purchasing local and regional produce reduces the environmental cost of transportation, consuming as much as 17 times less fuel. (Ladner, 15) Lettuce from California "shipped to Toronto requires about 35 times as much fossil fuel energy in transportation as it provides in food energy when it arrives." (Seccombe, 16)

San Francisco California to Toronto	-	4242 km	-	72 hrs by truck
Orlando Florida to Toronto	-	2062 km	-	24 hrs by truck
Dallas Texas to Toronto	-	2348 km	-	28 hrs by truck

Based on a Waterloo Public Health Study on the food miles of 58 commonly eaten foods and extrapolating the data to Toronto "if we grew foods locally that could be grown here, the city would reduce greenhouse gas emissions by about 500,000 tons per year. This is the equivalent of removing 162,000 cars from Toronto streets!" (Seccombe, 16)

Ladner argues that food miles are an “unfortunate distraction” from other unsustainable aspects of the food production system. Although I agree that there is more to sustainability than simply the distance that our food travels, I believe it to be an accessible entry point for people interested in a more sustainable food system. To be truly sustainable we need to look at all aspects of the system from production to distribution to consumption to waste management as there are many contributing factors that determine a product’s sustainability. Food miles also distract from the GHG emissions inherent in various types of food; for example, more GHG emissions are created in livestock production. If North Americans reduced their meat intake 10-20% they would reduce GHG emissions more than if they shifted all their food to local sources. Seeking out local beef as a means of reducing GHG emissions is pure fiction. Even then, how the meat is raised dramatically changes the GHG emissions, and other environmental impacts. (Weber and Matthews)

A National Resource Defense Council study in California studied six of the top imported products into California (table grapes, navel oranges, wine, garlic, rice and fresh tomatoes). “The study tracked GHG emissions, pollution, air quality and health impacts based on the number of miles traveled and the means of transportation from the originating country”. The study concluded that “harmful air pollution from these food imports was 45 times the pollution caused by local or regional transportation” (The study also indicated that the GHG emissions were up to 500 times higher for imports transported by plane when compared to locally sourced products. (Ladner, 16) (National Resources Defense Council, “Foodmiles: How far your food travels has serious consequences for your health and the climate” nrdc.org/policy, Nov.2007)

Studies in the United States found that food miles account for up to 20% of the total GHG emissions from food production. (Ladner, 15) Studies also illustrate that to cover the true cost of food miles associated with environmental and social factors, the current market cost of food in the US should be about 12% higher. (Ladner, 102) This is a conservative estimate, in my opinion.

> “Agriculture is far too complex to boil local food’s virtues down to a simple matter of a few miles traveled to get to the market. When local food is only available at a farmers market 15 miles down the road and accessed in a single occupancy SUV on a single purpose trip, or when it comes from a fossil fuel warmed greenhouse, its economic and environmental benefits wither” (Ladner, 17)

Many argue that the majority of GHG emissions and fossil fuel use in the current food system occurs on the farm during production, and not during transportation. This may be true however the environmental impact of long distance shipping is undeniable. Small Plot Intensive (SPIN) urban agriculture including rooftop production has the capacity to minimise GHG emissions through closer proximity to the end consumer by reducing food miles and the energy consumption required for processing, packaging and refrigeration necessary for the long distance shipping of perishable goods. Local production can also reduce waste due to shipping delays and product spoilage.

> According to David Van Seters, former CEO of Sustainable Produce Urban Delivery (SPUD) a Vancouver based company that sources local food for home delivery. "When you add up the carbon footprint of trips to the store, the heating, lighting, and refrigeration in grocery stores, the plastic bags, the hundreds of thousands of advertising flyers they mail out our energy use per unit of sale is half that of a grocery store. As prices of fuel go up and carbon footprint becomes more a factor, we benefit."
>
> (Ladner, 129)

Shortening our supply lines and reducing our reliance on long distance food imports is a prudent move to ensure food security in the future.

3.3 Defining Sustainable Agriculture

The current agricultural system has been referred to as "modern agriculture", "industrial farming" or "conventional farming". Sustainable agriculture is a complex global issue even when looking at it from a local context due to our reliance on high amounts of imported food under the current system. At its core agro-ecology is the foundation for sustainable agriculture and is based in part on a rejection of the 20th century approach to the production of food and fibre that favours industrial farming practices over methods that mimic natural ecological systems that have a site-specific application designed to last over the long term.

In the past few decades the term "sustainable agriculture" has become more familiar however it is still not the defacto standard for agricultural practices despite having a significant impact on the agricultural community through policy since the mid 1990's. There is general agreement that sustainable agriculture is the way of the future however there is little agreement as to what is required to make it happen. Although it has provoked dialogue and debate for change while providing a sense of direction and

urgency to the global environmental issues facing today's agricultural systems, the movement is still in its infancy.

According to John M Gerber, a professor of stainable agriculture at the University of Massachusetts, sustainable agriculture should be a societal goal pursued by everyone based on the following general principles: (For more information see appendix C)

> 1. A sustainable agricultural system is based on the prudent use of renewable and/or recyclable resources.
>
> 2. A sustainable agricultural system protects the integrity of natural systems so that natural resources are continually regenerated.
>
> 3. A sustainable agricultural system improves the quality of life of individuals and communities.
>
> 4. A sustainable agricultural system is profitable.
>
> 5. A sustainable agricultural system is guided by a land ethic that considers the long-term good of all members of the land community.
>
> John M. Gerber, 1990
>
> http://www.umass.edu/umext/jgerber/principl.htm

It is my belief that we need to investigate new methods of food production that go beyond sustainability and move toward practices with a regenerative ecological impact following the lead of Leadership in Energy and Environmental Design (LEED) certifications in the architectural industry. We need to think differently about how we use water resources to grow food, maximizing the efficient use of that water while protecting the ecosystem from degraded water quality as the result of runoff and other agricultural outputs.

The idea of sustainable farming is to grow foods where they grow best naturally in order to reduce the addition of artificial inputs of energy, water, chemicals etc. Sometimes it is more sustainable to ship a product over a long distance rather than consume more energy at the source to grow the same product locally. When thinking about sustainability we need to keep in mind the life cycle assessment of a product; this encompasses all environmental costs included in production, distribution, consumption and waste

reclamation. Many of the costs in the food system are external to the agricultural production itself and are not considered or recouped at the point of purchase. We need to recognize the true cost of importing agricultural products in terms of the depletion and pollution of global natural resources such as water, soil and air.

Maximizing under-utilized urban spaces for food production, such as rooftops will increase food security and diminish the environmental impact of cropland expansion and long distance distribution and shipping of agricultural products thus promoting a sustainable, resilient food system. Rooftop agriculture that incorporates food processing strategies in close proximity to the crops enable opportunities to sell the freshest most nutritious product or create value added products with increased nutritional quality and higher value. It has the potential to increase the economic bottom line while reducing losses due to storage, shipping and distribution of perishable products.

This offers a paradigm shift in the way we produce food that includes small-scale high-intensity, high-value, organic and value added practices that move away from the industrial production model that values calories over nutrition in favour of creating local nutrient rich food webs.

3.4 Defining Urban Agriculture

> According to Bailkey and Nasr, "Urban agriculture in simple terms is the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities."
>
> (Nasr, MacRae and Kuhns, 10)

> "Urban agriculture should not be confused with gardening, the main difference is the scale, the plots are larger and the food is sold, not shared among a community or taken home at the end of the day by one gardener."
>
> Debbie Field
> Executive Director of FoodShare
> (Kim, 2008)

Michael Ableman is considered by many the father of the modern urban agriculture movement as the founder the Center for Urban Agriculture at Fairview Gardens, California, Solefood Farms in Vancouver, and the Centre for Arts, Ecology and Agriculture on Salt Spring Island.

Urban agriculture is undoubtedly changing the current agricultural landscape and the public perception of farming and food production. As we fight to feed the populations of our cities the nostalgic visions of row after row of crops in the countryside are changing to include small productive urban spaces and rooftops. Gone as well are a lot of the misconceptions of uneducated labourers of the land trapped in traditional habits and the "hick" persona. These images are being replaced by the biochemist, engineer, entrepreneur and the neighbourhood gardener. In part it has evolved as a form of pushback against the over-chemicalization of the industrial food system and a desire to reconnect to and control the food we consume. Living in the city no longer means we need to be disconnected from our food.

In his 2013 article in the Star.com, "Home-grown Food Part of a New Vision of Urban Development", Mark Cullen states "cities feeding themselves is an idea that is gaining traction". I would argue that this is not a new idea. Until the 20th Century cities were doing just that; however, city planners of the last century, driven in part by entrepreneurial food chains, and urbanization, especially in the west, eliminated agriculture from the city, paving over land and centralizing the distribution of food in large supermarkets stocked with food produced on distant industrial farms.

Urban farmers make use of underutilized or derelict spaces to grow food including front and back yards, vacant lots, parkland, schoolyard, brown fields and rooftops. Many believe that it is smallholder farms like these that will be the most likely to increase global food production.

Currently these farmers cater to the luxury urban market and restaurants as well as supply food access in poor communities and food deserts mainly through community services and non-profits. In Toronto, most urban agriculture provides environmental education and community engagement based on personal provisioning. However, I believe we are in a position to create a robust commercial food system within the city in the near future. Toronto encompasses a number of methodologies for growing and accessing food in urban and semi urban areas including farmers markets, community supported agriculture (CSA) (food box programs), small plot intensive gardens (SPIN) community gardens, community kitchens, school grow programs, back yard YIMBY programs, gleaner programs, container gardens and rooftop gardens.

According to a recent study in Environmental Research Letters, “urban agriculture is playing an increasingly important role in global food security,” and it is much larger than previously thought. (Kinver) The researchers use metrics to quantify the estimated global area of urban and peri-urban irrigated and rainfed cropland concluding that urban irrigated cropland accounts for about 11% of global irrigated agriculture and 4.7% of the rain fed cropland. (Thebo, Drechsel, and Lambin) Lead author, Anne Thebo from the University of California, Berkley, said the study was “an important first step toward better understanding urban crop production at the global and regional scale.” (Kinver)

“In Europe and North America, where people are comparatively well-fed, urban agriculture has been linked to a vibrant spectrum of ecological, social, and economic benefits in addition to those of food security.” (De la Salle et al, 57) Changing the landscape of the city to include growing space and support facilities that are integrated into city planning such as production and storage facilities, distribution centers and markets are key to the success of urban agriculture. Toronto has embraced the need for this infrastructure through policy and programming support for food based organizations.

3.5 Building Resilience Into the System

> “A resilient city is one that has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity”
>
> Craig Applegath
> Resilientcity.org

The need for resilience in regard to sustainable local food systems is key and understanding how resilience affects agriculture is paramount if we are to change the current monoculture approach to industrial agriculture. As a result of its lack of resilience “industrial agriculture and thus the modern food system is highly vulnerable to collapse’ creating an era of uncertainty with regard to food security. (Gerber) The current system has eliminated a lot of the infrastructure supporting small-scale producers in favour of large centralized operations resulting in reduced resiliency. Niche producers have been “pushed aside by the efficiency of economy of scale, cheaper labour elsewhere and safety standards that could only be met by large operations.” (Ladner, 120) One of the benefits of small-scale agriculture is that it can support a much higher biodiversity than the industrial agricultural model.

"5 companies control 90% of the global grain market" (Ladner, 2)

The current system breeds fewer suppliers and crop species creating greater risk in the event of any kind of breakdown in the system, whether environmental, social or political. (This trend is discussed in more detail in section 7, BioElimination, see page 77) Decentralizing the food system is part of the urban agriculture business model encouraging diversity and providing economic and ecological resilience.

> "Of the 270,000 plants known to science only around 120 are cultivated today and just nine of them provide 80% of our food"
> (Harrison, 58)

Local agri-food systems will "ensure that towns and cities will grow to be resilient in the event that socio-economic or environmental conditions disrupt the globalized food markets." (De la Salle et al, 40) For this to occur food system planning needs to be integrated into city planning that includes the coordination of all municipal departments and stakeholders.

> Local approaches to increasing urban agriculture include:
> - Creating economic development strategies focused on agriculture and food
> - Scaling up local infrastructure, including value-added processing and distribution centers
> - Supporting initiatives focused on increasing market access for local food, such as chef-to-farm networking or local food procurement policies
> - Increasing access to farmland for new farmers
>
> (De la Salle, 41)

Urban and rooftop agriculture offers potential increased resilience in the food supply system while providing economic and environmental benefits including employment opportunities, a reduction of the heat island effect and energy reductions associated with the need for Air Conditioning (AC) to cool buildings in the heat of summer. Rooftop plants create shade reducing the solar heat gain of a building while providing additional cooling through evapotranspiration. Furthermore, local production requires shorter delivery distances reducing energy intensive shipping (including heating and cooling) reducing the overall GHG produced in the system by creating a less carbon-intensive alternative.

A resilient approach to water use is one that manages the water resource by diversifying the system and the crop to maximize the efficiency of any water used. Diversifying a crop enables different crops to use water at different soil depths maximizing efficiency by reducing competition. Diversified crops also enable a producer to absorb the loss of one crop due to lack of water while maintaining another that requires less water. These principles along with storm water management and reclamation should be integrated into urban agriculture initiatives including rooftop farming.

Figure 6: The needs of a resilient local food system

4.0 Why Rooftop Urban Agriculture & Water Management Matters Understanding the Big Picture:

The rational for rooftop agriculture and the benefits of a resilient local food system are investigated in this section of the paper.

4.1 Why Rooftop Agriculture?

> "Rooftop agriculture is powerful in its ability to enhance the diversity and resilience of the greater urban food system" (Mandel, 3)

Food access is a social justice issue and rooftop agriculture bridges a number of socio-economic gaps creating equitable access to fresh, nutritious, local food by increasing access to growing space when no land is available. This is especially beneficial in food deserts or for economically disadvantaged individuals. In recent years many public health organizations identified food security as a major contributor to poor health and the cost of health care. The lack of access to healthy nutritious, affordable food greatly contributes to many health issues including obesity, diabetes and cardiovascular heat disease. (De la Salle et al, 22 and Roukhkian, 21)

The local food movement is spreading quickly and as local, fair-trade and organic become more popular, (Elton, 2015) the potential for rooftop and urban agriculture to increase its market share is inevitable. Growing high value crops or producing value added products from local produce in certified commercial community kitchens would enable rooftop growers in small operations to compete in the global food marketplace by providing niche products.

A robust urban agriculture system that includes rooftop farming not only offers a method to add resilience to the local food system by enabling it to deal with the challenges of disruptions and uncertainty in the global food chain but it also offers a number of social, economic and environmental benefits to the city of Toronto.

Social Benefits

- Rooftop farming improves food security by providing access to space for local food production and enhanced food security when growing space is unavailable at grade taking full advantage of underutilized space within the city.
- Has the potential to ease poverty increasing access to healthy food for the poor.

- Strengthens the local food system by reconnecting people with fresh, healthy, nutritious food creating personal interaction and community through farmers markets, community gardening, CSA's, pick your own enterprises and conversation with the person who grows your food.
- Improves social justice and access to food while building community and providing space for social programing and educational opportunities to experience food production first hand. Food in the school programs provide students with a sense of social responsibility by often growing food for non profit social enterprises like the food bank. (http://www.foodshare.net/student-nutrition)
- Provides improved aesthetics in the public realm while increasing the city's green space, improving mental health. The WHO recommends a minimum of $9m^2$ of green space per person for the classification of a healthy city (optimal amounts would be between 10 and $15m^{2)}$. (Vazquez)
- Increases employment opportunities.
- Has the potential to address ethnic food needs and build community

Health Related Benefits

- Access to fresh food encourages a healthy diet; to me nothing tastes as good as a fresh picked tomato.
- Improves nutritional health by fostering faster farm to table times, important for optimizing the nutritional value of many crops. Many fruits and vegetables begin to degrade as soon as they are harvested. Most fruits and vegetables sold in Canadian supermarkets today have significantly less nutritional value compared to fifty years ago, losing as much as 100 percent of the vitamin A and 50 percent of the vitamin C, iron and riboflavin. (Ladner, 98) Rooftop agriculture allows these products to be grown close to home, minimizing travel time from harvest to plate and maximizing nutritional value.
- Rooftop agriculture in Toronto could be organic and use chemical-free growing practices providing a healthier alternative to chemically laden industrial products.
- Growing your own food encourages you to get outside, providing an opportunity for exercise and fresh air while promoting a healthy lifestyle.
- Studies have concluded that living in proximity to green space may lower anxiety and depression, improving overall health. Aesthetic improvements and the psychological benefits to human health through access to green space are

increasingly documented through quantitative research dealing with pain medication and lengths of hospital stays. (Cooper, Marcus and Barnes, 1999)

- Rooftop gardens improve the air quality in the city making it more liveable by trapping airborne particles and absorbing gaseous pollutants during photosynthesis. According to a 2008 study, An Examination of Pollution and Poverty in the Great Lakes Basin, by PollutionWatch, "approximately 1,700 premature deaths and 6,000 hospitalizations per year in Toronto can be attributed to poor air quality (Toronto Public Health 2004)" (PollutionWatch Fact Sheet, 3) The report is in response to the high burdens experienced in the last decade affecting the environment and health of people living in the Basin area.

Economic Benefits

- A healthy rooftop farming industry in Toronto could improve the local economy by providing jobs in installation, production, processing and distribution. Many jobs would require minimal skill although hydroponics offers additional employment for highly trained technicians. According to Agri Food Canada, food production is Canada's largest employment sector.
- Rooftop production could reduce the need for importing produce. In 2008 over 70% of the agri-food imports into Canada fell into the consumer-oriented category and 60% of it came for the US. (Walton, 112) "An estimated 80% of organic produce sold in Ontario is imported, most of it trucked in from California." (Seccombe, 19) Less than 1% of Ontario's agriculture acreage is devoted to organic production making it a prime candidate for a targeted import replacement strategy.
- According to Agriculture and Agri-Food Canada, "The agriculture and agri-food industry contributes $100 billion annually to Canada's gross domestic product (GDP). Robust rooftop agriculture has the potential to increase organic production reducing importation and increasing potential exports. (www.aagr.gc.ca)
- Buying direct from farmers enables them to make a liveable wage.
- Buying locally produced produce keeps money in the community, strengthening the economy by increasing the speed at which money circulates within the community. Local investment benefits more people by creating jobs in the community through multiplier effects.

- Personal production saves money on food cost. We are seeing this strategy used by restaurants, schools and community centers across the city.
- Restaurants are embracing the “Farm to Fork” philosophy, promoting local, sustainably sourced products on menus all over town expanding a niche market into the mainstream making Toronto a “Foodie” tourist destination. (Based on taste, environmental impacts, marketing and CSR.)
- Rooftop agriculture provides building owners the opportunity to increase revenues for previously un-rentable or underutilized space that may provide tax incentives or subsidies in the future.
- Building owners reap the benefits of reductions in energy expense based on the insulating qualities of the garden and reduced heating and AC costs. According to the US Department of Energy, ”air conditioning accounts for almost one-sixth of the energy generated per year” representing a cost of approximately $40 billion to fight heat gain in buildings in the US alone. (Federal Technology Alert https://www1.eere.energy.gov/femp/pdfs/fta_green_roofs.pdf) Green roofs also extend the lifespan of a building waterproof membrane by at least double, reducing the lifecycle cost of the building’s infrastructure and upkeep by eliminating direct UV radiation on the waterproof membrane.
- Green roofs reduce energy consumption. Production practices placed directly on the rooftop insulate the building below keeping it cooler in summer and warmer in winter. Cooling costs in the summer can be reduced by as much as 90%. (David Suzuki) These added insulation benefits are greatest on one or two story buildings and lose effectiveness the higher you go.
- Vegetative green roofs retain water thereby reducing strain on the city’s storm-water and wastewater management systems minimizing the cost of expanding infrastructure to keep pace with city growth.
- Improved nutritional health has the capacity to reduce stress and financial strain on the health care system.

Environmental Benefits

- Rooftop farming reduces the need to expand farmland in surrounding areas or degrade watersheds with chemically laden runoff creating a reduction of environmental impact from food production. According to Mandel, rooftop

agriculture supports the idea of building up rather than out for densely populated cities.

- Rooftop gardens reduce the “heat island effect” improving the quality of life in the city. Cities reach higher temperatures than the surrounding landscape due to the solar energy absorbed by buildings and impervious surfaces. (See fig 7)

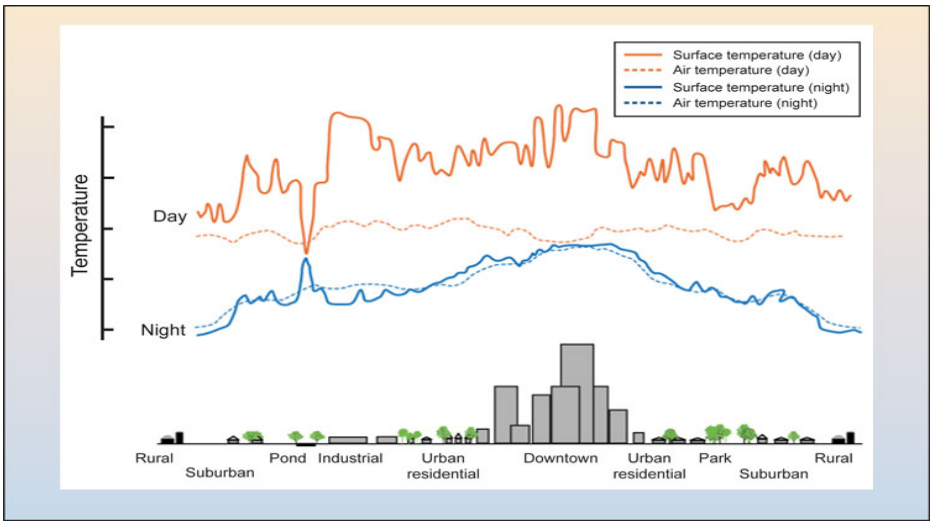


Figure 7: The Urban Heat Island Effect. Source: the Environmental Protection Agency http://www.southwestclimatechange.org/impacts/people/urban-heat-island

> “A bird’s eye view of Toronto shows a landscape dominated by hard, impervious surfaces – roads, parking lots and rooftops. These hardened surfaces alter the hydrologic cycle, meaning rainfall has to be collected, transported and treated as storm water rather than filter naturally into the ground. These hardened surfaces also increase reflection of the sun’s heat, creating what is known as a “heat island”. Replacing conventional flat roofs with green roofs can significantly reduce these problems. Green (or Living) Roofs are designed to allow groundcovers and gardens to be grown on them. Green Roofs improve air quality, reduce storm water runoff, conserve energy in buildings, reduce carbon dioxide levels, improve microclimate, increase access to green space and can support local food production (see recommendation 39). The City should take a leadership role in promoting the use of Green Roofs on its own buildings and in new developments.”
>
> (Toronto’s Environmental Plan 2000, 37)

Rooftop gardens can reduce summer ambient air temperature by as much as 8 degrees Fahrenheit compared to nearby tar roofs. This results in a reduction of fossil fuel and energy consumption with respect to the cost of air conditioning for the building below. (Frazer) Plants absorb solar energy and provide shade and

additional cooling through evapotranspiration reducing building heat gain by as much as 90%. According to the Federal Technology Alert, a conventional flat roof in the US can reach a maximum temperature of 80 degrees Celsius whereas a green roof typically reaches a maximum of 25 degrees.

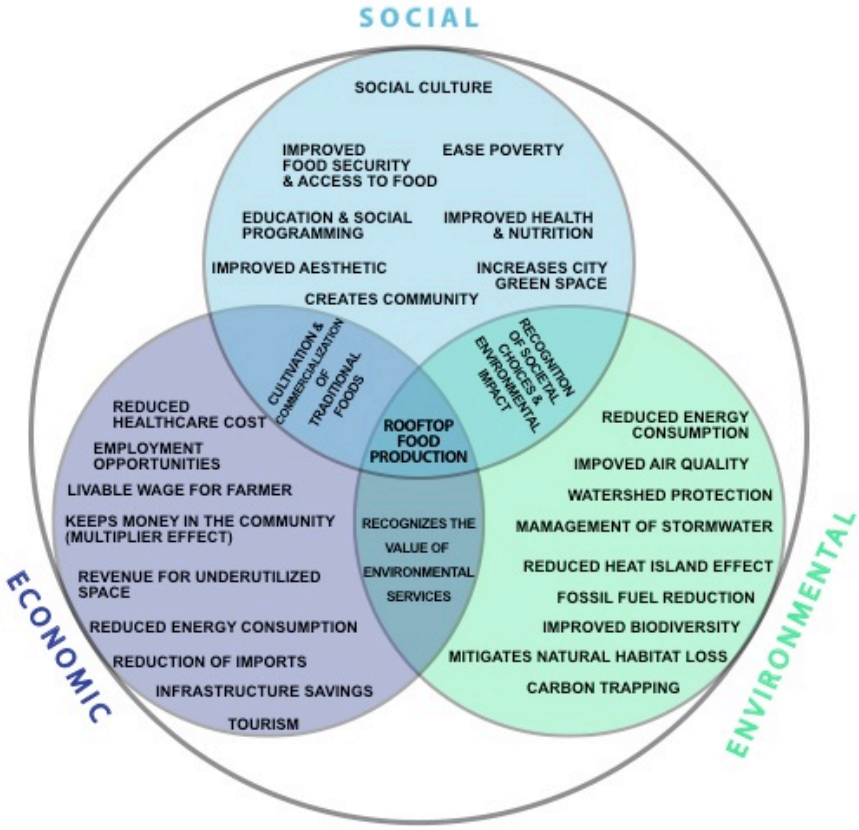
- Rooftop gardens act as a carbon sink increasing the city's ability to trap atmospheric carbon by increasing the area of soil available for carbon sequestration. According to the David Suzuki Foundation, the burning of fossil fuels has released carbon into the atmosphere that would otherwise be trapped underground releasing 8.5 million tones of carbon in 2007 alone. (David Suzuki, Forests & Sinks http://ww.davidsuzuki.org/issues/climate-change/science/climate-change-basics/forests-and-sinks) Soil naturally contains about 75% of the carbon found on land however modern practices disrupt the carbon cycle releasing the carbon into the air by reducing the amount of organic matter in the soil. Extensive gardens are more effective at carbon capture however the addition of compost in intensive practices as well as the plant material itself also offers significant benefits.
- Green roofs and rooftop agriculture effectively manage storm water runoff especially in soil-intensive strategies by absorbing, retaining, filtering and holding water, allowing it to be used by plants. This filters contaminants and reduces "Peak Flow" into the city's wastewater management system reducing stress on the city's infrastructure. According to the non-profit, Earth Pledge Foundation, a green roof can absorb as much as 75% of all rainfall. The more organic material in the soil the more water it can retain reducing the need for excessive watering. As a result compost is highly desirable in rooftop practices.
- Composting itself removes massive amounts of food waste from the city's waste stream every year turning it into a nutritious resource for the garden while reducing methane from decomposing food waste in landfills, and saving the city money for waste removal and disposal.
- Reduction in food miles, and close proximity to market reduces travel distances decreasing fossil fuel use, air pollution, packaging and food waste, which can potentially result in huge environmental savings. Food miles alone make up about 11% of a products carbon footprint. (David Suzuki)
- Organic production methods lower fossil fuel consumption by removing chemical fertilizers and pesticides, reducing fossil fuel consumption and GHG emissions.

- Green roofs minimize the negative impacts of runoff on the watershed by eliminating nutrient rich runoff from entering the watershed reducing water pollution. Pesticide use for lawns and gardens was banned in Toronto in April 2009. Gardens also reduce the temperature of water runoff that could negatively impact aquatic ecosystems, contributing to algae bloom and hypoxic zones.
- Rooftop agriculture decentralizes the food system promoting genetic diversity and resilience in Toronto's food chain.
- Increased green space allows for increased biodiversity and habitat for wildlife and insects.

Toronto recognizes the public benefits of green roofs and instituted the Green Roof Policy to encourage their widespread installation, however the bylaw does not stipulate the type of roof installed. According to the 2012 annual green roof industry survey by Green Roofs for Healthy Cities the North American industry grew by 24% in 2012 compared to figures for 2011; the number of extensive roofs however far outweigh those for intensive production by a rate of approximately sixteen to one. (Erlichman and Peck) A provision for additional support for productive spaces would go a long way to increase the installation of intensive farming or garden space rather than extensive or ornamental amenity space.

Toronto's Green roof bylaw could be the mechanism to expand urban rooftop farming increasing the amount of food grown in the city without interfering or encroaching on existing green spaces or clearing natural habitat to accommodate future increases in food production.

Benefits of Rooftop Agriculture



Adapted from IAASTD (2008)

Source: Assuring Food Security in Developing Countries under the Challenge of Climate Change
Key Trade and Development Issues of a Fundamental Transformation of Agriculture
Ulrick Hoffmann (2011) United Nations Conference in Trade Development (ONCTAD) No. 201 February 2011

Figure 8: Benefits of Rooftop Agriculture

4.2 Water and Food Security

Nothing can survive without water. The average person in the West consumes 3,496 liters of virtual water daily in food consumption alone, along with 137 liters of domestic water and 167 liters of virtual water consumed in industrial products. (Morelli) "Water and Food Security" was the focus of the 2012 Water Week in Stockholm, where more than 2,000 Politicians, CEO's, scientists and leaders from over 100 Nations were in attendance. One of the main focuses of the conference was to develop strategies to increase investment, both public and private, "to reduce losses of food in the supply chain, enhance water efficiency in agriculture and curb waste" (Crabtree, 2012). Jose'

Graziano da Silva, director–general of the UN Food and Agriculture Organization (FAO) believes “that agriculture holds the key to sustainable water use.” “Throughout the world 2.6 billion small-scale producers till the land, raise animals and fish. They are the main producers of food in the developing world” (Crabtree, 2012) As we experience more and more disruptions in the global food distribution chain we will be forced to decentralize the system and rely more on small-scale local urban producers to fill in the gaps.

Rooftop farming in Toronto has the potential to reduce the importation of virtual water from around the world by reducing our reliance on imported food products ensuring that developing countries in water stressed areas have the ability to produce enough food for local populations. Rooftop methods have the potential to produce enormous amounts of food using less water than conventional practices.

> “The 28-year-old International Water Management Institute has been the driving force promoting policies and techniques to help farmers to produce “More crop per drop,” and implement solutions that enable agriculture to cultivate enough food to feed the planet’s growing population with limited water resources.”
> (Crabtree, 2012)

As the world population increases there will be a greater demand for domestic production to feed a nation; therefore we will likely see a reduction in exported food products in the future.

Around the world aquifers and watersheds are being depleted and polluted by agricultural practices far faster than nature can replenish or purify them. This is having a catastrophically negative effect on populations around the world. According to the World Resource Institute 36 countries face extreme levels of water stress in 2015 with the western United States experiencing its worst drought in 1,200 years. (See fig. 9) According to the United Nations Environment Program (UNEP), by 2025 the number of nations facing fresh water stress or scarcity will reach 48. (Vital Water Graphics)

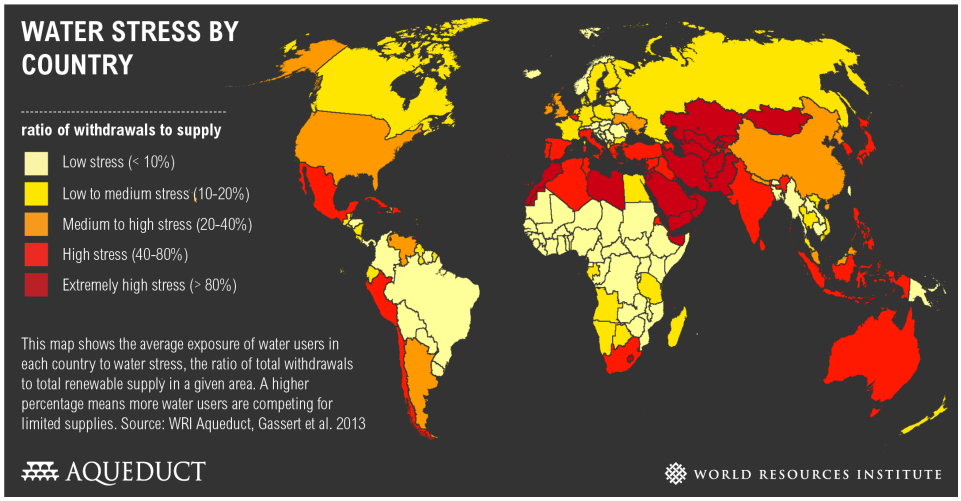


Figure 9: Water Stress by Country. Source http://www.wri.org

5.0 The Drivers of Change: Influential Forces

Drivers are the often unseen, underlying influential forces behind a trend. The following lists a number of drivers identified during the research for this paper that affect the trends in urban rooftop agriculture.

Population Growth

As the world population increases to 9 billion, more people will be living in urban centers. Between 1986 and 2006 the population of Toronto increased by 49%. “Under the provincial growth plan initiative “Places to Grow”, the population is expected to continue to increase from 5,555,912 in 2006 to 7,960,000 in 2031.” (Walton, 66)

The global population reached 7 billion on October 31, 2011 and had already risen to 7,288,991,000 by January 18, 2015. To put it in perspective our population is currently increasing by 200,000 people a day, almost 80 million a year. (Shariatmadari) It is expected to reach 8 billion by 2025 and 9.3 billion by 2050 and is not expected to stabilize until 2200 where it will reach just above 10 billion. (Source: UN http://worldometer.info)

According to UN researchers headed by Dr Ron Wimberley, by 2050 over 6 billion people representing two-thirds of the global population will be living in urban centers. (Hanlon / United Nations 2007 world Urbanization Project: the 2007 revision)

According to the World Resource Institute, 900 million people around the world today are undernourished, and 1.4 billion are overweight. This is due to the uneven distribution and waste of food, add economic instability to the issue and you get populations that have access to food but can't afford it. (Foley, 2011) Several studies indicate that by 2050 food production will need to double to meet the demand of the increased population.

Population growth is only one factor; increased standards of living will also impact the global need for more food as diets change to include more meat. Some estimates state that by 2050 agricultural production for food and fibre will need to increase by 70% to feed the population. (Crabtree, 2012)

Our growing population is the biggest threat to the planet today, due to our overconsumption of natural resources. The big question is how are we going to feed our expanding population without destroying the environment and the ecosystem services it provides?

> "Human population density is a factor in every environmental problem we've encountered from urban sprawl to urban overcrowding, disappearing tropical forests to ugly sinks of plastic waste and now the relentless increase of atmospheric pollution."
>
> David Attenbourough
> (Source: How Many People can Live on Planet Earth, Shariatmadari)

The documentary, "How Many People Can Live on Planet Earth", written and directed by Helen Shariatmadari looks at our most basic needs, water, food and energy and how they impact the number of people the planet can support.

Our increasing population is resulting in the expansion of our cities into the fertile land around them, reducing farmland and clearing natural habitats for urban development. This has a negative impact on the ecosystem services provided by these places and increases the distance our food travels from farm to table. Urban rooftop farming has the capacity to increase local food supplies to mitigate the effect of population increases in the city.

Globalization

A term emerging in the 1980's globalization resulted in a global market dominated by multinational companies and a global economy driven by improved communication. The term is derived from globalize "referring to the emergence of an international network of social and economic systems." (http://en.wikipedia.org/wiki/Globalization) In essence globalization has resulted in worldwide social relationships culminating in a global consciousness.

According to the International Monetary Fund (IMF) there are four basic aspects of globalization: "trade and transactions, capital and investment movements, migration and movement of people and the dissemination of knowledge".
(http://en.wikipedia.org/wiki/Globalization)
Major factors of globalization have included the movement of people and commodities around the world as well as the exploitation of cheaper foreign labor.

> "The impact of globalization on the shape and dynamics of cities is profound. This impact can be felt in urban centers and agricultural peripheries alike."
>
> (Terreform One: Biological Urbanism, 3. www.terreform.org, http://archinode.com/terreform-brochure.pdf)

Urbanization & Migration

Urbanization is the physical manifestation of economic, social and environmental forces that result in the migration of people into cities in search of a better quality of life and more opportunity for everything from jobs, education, healthcare, housing, entertainment and market competition. (McCammon et al.) In many cases urbanization and Rural Flight are a direct result of a changing agricultural landscape that is no longer focused on domestic consumption. Governmental support for industrial agriculture and cash crops for export has displaced many rural smallholder farmers and tenants who no longer have the means to support themselves forcing them into the city in search of employment. This has exacerbated urbanization resulting in the expansion of cities into agricultural areas through urban sprawl, forcing farms farther from the urban core.

Financial pressures are forcing the next generation of farmers off the land and into cities resulting in "Rural Flight". Farm income has steadily decreased in Canada since the

1950's, dropping from $121,170 in 2007 to $104,790 in 2011 alone. (Statistics Canada, 2014) combined with soaring debt, growing operational costs and the isolation of rural life many young people are reluctant to take up farming. (Walker) The dissolution of domestic agricultural production will become an issue if we encounter disruptions in the availability of food from the global food system, this will be discussed further in Agricultural Urbanism on page 104.

There was unprecedented urbanization during the twentieth century associated with industrialization and a shift from an agro based economy to mass industry, technology and services. One of the defining characteristics of the Industrial Age, urbanization has resulted in an explosion of "Mega Cities" across the globe. It took centuries for cities to reach populations of one million yet by 1950 there were 83 cities around the globe that exceeded that and by 2010 that number had risen to 441 and of those, 21 surpassed 10 million reaching "Mega City" status. (Tokyo is the largest with a population of 36.6 million.) Due to urbanization many of these cities tripled their population in fifty years. (United Nations http//www.un.org/esa/population/un.pop.htm) By 2025 the UN projects that there will be 29 Global Mega Cities 9 of which will have populations exceeding 20 million. (UN, World Urbanization Prospects: the 2009 revision)

The current Mega City model is unsustainable, surpassing by far the natural carrying capacity of the environment around them. Cities themselves tend to be built on the most fertile land available on the planet. As cities grow larger they exert more pressure on the rural areas around them by encroaching on farmland and consuming resources pushing agricultural production farther and farther from the city core, often compromising natural ecosystems and the services they provide. Urban agriculture is a way to mitigate or rectify this uneven distribution of pressure.

> "In Canada in the last 40 years more than 5,000 square miles of fertile soil have been lost to urban development." (Ladner, 25)

In 1900 only 13 percent of the global population was living in urban centers; according to the United Nations, on May 23, 2007 we reached a major demographic milestone referred to as the "Urban Millennium", the date the global urban population met that of the rural population. Today the number is estimated to be over 51 percent. (Hanlon) The UN estimates that it will reach 60 percent by 2030 representing about 5 billion people. (WHO

Urban Pop Growth, & Mega Cities of the Future, Forbes.com, 2007, 06, 11) Over 2 million of them will be living in the slums of Megacities. (State of the World Population 2007, UNFPA.org) According to UN researchers headed by Dr Ron Wimberley, it is estimated that by 2050 over 6 billion people, representing two thirds of humanity will live in urban centers. (Hanlon), (UN 2007, World Urbanization Prospects: the 2007 revision. UN) Today, over 81 percent of the Canadian population lives in urban centers and Toronto, Canada's largest city and the fourth largest city in North America is home to over 5.5 million. (Moloney)

> "So far, cities are getting whatever resource needs that can be had from rural area, but given global rural impoverishment, the rural-urban question for the future is not just what rural people and places can do for the world's new urban majority. Rather, what can the urban majority do for the poor rural people and the resources upon which cities depend for existence? The sustainable future of the new urban world may well depend on the answer."
>
> Dr. Ron Wimberley
> (Hanlon)

According to Statistics Canada, in 1931, 37% of Canadians lived on farms; today that number has been reduced to a meagre 2%. (Seccombe, 8) The number of Canadian farms went from 728,623 to 229,373 yet agricultural acreage increased by 3.9 million acres. (Statistics Canada, 2006 Census: Canada's Farm Population)

There have been dramatic losses of smallholder farms all over the world including Ontario. Based on data from the 2006 Farmland Preservation Research Project, in the last half of the 20th Century Ontario lost 49 percent of its farmland to the expansion of the GTA. (Seccombe, 7 source sited: Caldwell, Wayne; Hilts, Stew, and Wilton, Bronwynne. (2007) Farmland preservation: land for future generations, eds. University of Guelph, 284) Between 1996 and 2006 alone, Ontario lost 15 percent of its farms and losses for the current decade are projected to be even worse with conservative estimates hovering around 20 percent. Estimates are based on the 1996-2001 and the 2001-2006 farm censuses reports. (Seccombe, 6) As farmers leave the land they head into the city adding to its population through rural urban migration.

Sustainable urban development requires that the size be limited to the renewable carrying capacity of the resources available as well as the conservation and recycling of finite natural resources.

Immigration

> "Canada has one of the highest immigration rates in the world, over 250,000 people immigrate to Canada every year resulting in major urban growth particularly in large cities like Toronto." (McCammon 2011)

According to Statistics Canada, 60% of Canadians are first generation immigrants and 44% of recent immigrants settle in the GTA. As a result Ontario imports more food per capita than any other province due to its ethnic diversity and the unavailability of culturally appropriate food. (Seccombe, 10) Food from the homeland is a prominent driver for the importation of foreign goods. Many of these products could be grown right here in Toronto.

Global Hunger: Food Insecurity & The Need For More Food

Food security as a policy concept first appeared in the mid 1970's at the first World Food Conference in 1974. (Lay of the Land, 17)

> By 1996, the Food and Agriculture Organization of the UN (FAO) defined food security as a state which "exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life."
>
> (Trade reforms and food security: conceptualizing the linkages. Rome; Food and Agriculture Organization, 2003. 29)
> ftp://ftp.fao.org/docrep/fao/005/y4671e/y4671e00.pdf

"According to FAO (2009), despite increased world food production in the past few decades the global effort to meet the Millennium Goal of reducing hunger by half by 2015 now appears beyond reach." (Hoffmann, 1) Today the number of people globally suffering from chronic hunger is over 1 billion, or one in every seven, (Foley / Hoffman) a substantial increase from the 800 million in 1996. (Hoffman, 191)

Food security is inextricably linked to the issues associated with population growth. The fact that the global population is expected to reach 9 billion by 2050 poses a question of uncertainty around food security and how we are going to feed the world. It is estimated that food production will need to increase by 70%. (Crabtree & De la Salle et al) How and where will this increase occur? These are questions that impact global food security.

“According to the latest Canadian Community Health Survey, 11% of households with children in Canada are food insecure, meaning that they don’t have adequate supply of good food” and “50% of Canada’s lowest income group is food insecure.” (Ladner, 199) In 2008 community food programs in Toronto served almost 20,000 meals a day and over 7 million meals for the year according to The State of Toronto’s Food. In 2012 there were over 1 million visits to the Daily Bread Food Bank in the GTA alone, up 18% from 2008. This figure does not include meal programs not affiliated with the Daily Bread Food Bank. (Toward a Healthy Food System)

Food shortages are commonplace in many parts of the world and in 2008 riots broke out around the world to protest annual price increases of up to 130% for wheat, 87% for soy, 74% for rice and 31% for corn. “Globally, an estimated 963 million people or about 15% of the world’s population were undernourished in 2008” (Ladner, 5) The 2008 food crisis was the result of a complex combinations of factors including drought induced crop loses in major producing countries, dwindling reserves (54 days worth globally in 2008), increased meat consumption and the diversion of cereals for biofuel. “Biofuel may be responsible for some 30-75 million additional people being driven to hunger.” (Shah) (Although an important factor in global hunger the diversion of crops for biofuel is outside the scope of this paper.) Speculation in commodity futures also played a significant role as investors looked for security of investment in agriculture effecting price. (http://www.un.org/esa/socdev/rwss/docs/2011/chapter4.pdf) Almost 50% of the global population in 2012 was at risk of significant food related health issues with more than 2 billion people globally facing serious health risks from undernourishment while at the same time 1.5 billion suffered from obesity. (Crabtree, 2012)

Access to food is only part of the equation, the kind and quality of food is also important. It is the difference between cheap calories vs nutrition. Starvation is the effect of no food and obesity is often the result of low-income individuals in western society who can only afford cheap heavily processed high sugar and fat content foods due to their economic situation. Rooftop agriculture would increase access to nutritiously high value crops like greens and vegetables.

In the global context of the food chain, how food secure can you be when the majority of your daily consumption is imported? The big question is what would happen if the distribution chain were disrupted? Climate change brings uncertain weather patterns that

have resulted in catastrophic weather in terms of global food production and distribution. Drought in 2012 resulted in 40% of Ontario farmers loosing over 50% of their crops and in 2013 we are seeing major flooding in many parts of Canada including Ontario. In 2010 Russia banned the exportation of wheat in favour of feeding its own people due to decreased yields as a result of drought. This affected its export partners reliant on Russian wheat.

The growing cost of fossil fuel and concerns about environmental impact also have the potential to disrupt the global food system sending prices soaring creating food insecurity as a result of economics.

Urban rooftop agriculture has the potential to mitigate food insecurity and provide major contributions to a nation's food supply as seen in examples from around the world. (Ladner)

> "Urban farmers supply food to about 12% of the worlds population" and the following statistics are a few examples of their contributions in percentage of supply to specific cities.
> 45% of all vegetables consumed in Hong Kong
> 80% of all poultry in Singapore
> 60% of all vegetables, 100% of milk, 50% of pork and poultry in Shanghai
> 80% of the vegetables in Hanoi
> 100% of all fruit and vegetables consumed in Rodas Cuba (pop 33,600) in 2000
> (Ladner, 21)

By the end of the 20th Century the Urban Agriculture Network in Washington DC estimated that the number of people globally reliant on urban agriculture for income was approximately 300 million. (Graeme Smith, 5) This number will inevitably rise in the 21st Century.

- **Barriers to Food Security in the city**

Barriers to food security include

- Poverty
- A lack of conveniently located quality food stores and farmers markets
- The lack of access to transportation to and from markets
- A lack of access to affordable nutritious food
- A lack of education

Food deserts are often found in low-density neighbourhoods with poor public transportation. According to the Martin Prosperity Institute at the University of Toronto's Rotman School of Management, in 2010, 49% of the population of Toronto lived in a food desert defined by a lack of access to a major grocery store within 1 km. (Food Deserts and priority Neighbourhoods in Toronto, June 15, 2010 http://martinprosperity.org/2010/06/15/food-deserts-and-priority-neighbourhoods-in-toronto) Farmers markets and urban rooftop farming are good ways to introduce community based fresh produce into food deserts.

In recent years, public health organizations identified food security as a contributor to the cost of health care. The lack of healthy food means poor nutrition, which greatly contributes to many health issues including obesity, diabetes and cardiovascular heart disease. (Roukhklian, 21)

Public Health Concerns

> "We have a health system that doesn't care about food and a food system that doesn't care about health"
>
> (Cultivating Food Connections, 11)

"In Canada we import food from 190 countries" however, " 98% of the imported food eaten in Canada isn't inspected." (Ladner, 236) This becomes an issue when food related illnesses or epidemics are concerned, given the fact that there is often little information known about the growing and harvesting practices of imported foods making it more difficult to track down the origins of a pathogen. The United States, Center for Disease Control (CDC) estimates that there are over 76 million food borne illnesses a year causing 325,000 hospitalization and 5,000 deaths in the US alone. (Couric)

Food contamination in local products is considered low risk and can generally be easily and quickly traced back to the source, driving the public perception of local food as being safe.

According to an Ipsos Reid poll conducted for Postmedia News in July 2010,

- "77% of Canadians said they were either "very" or "somewhat concerned about the safety of the food they eat, up from 66% in 2007"
- "87% trust food that comes from Canada more than food that comes from abroad."

- 70% are willing to pay more for Canadian vs. imported food
- 85% stated that they made an effort to buy locally grown and produced food

Over the past fifty years there has been a quantifiable decline in the nutritional content of our food including both proteins and produce. (De la Salle et al, 21) According to Ladner over the past fifty years fruits and vegetable sold in Canadian supermarkets have lost as much as 100% of the vitamin A, and 50% of the vitamin C, iron and riboflavin. (98)

Diet related obesity and diabetes are epidemic in North America. Food related health issues associated with diabetes alone could cost Canadians $17 billion by 2020 according to the Canadian Diabetic Association. This is an increase of over $10 billion since 2000. “Statistics Canada found that 26% of children aged 6-11 are overweight or obese; 28% for Canadian teenagers and 61% for Canadian adults.” (Ladner, 9) In the past 30 years obesity in North America has more than doubled due largely to changes in diet and a more sedentary lifestyle. Health organizations in the US estimate that as many as 75% of the deaths in the United States can be linked to diet and other behavioural habits. (Ladner)

70% of Torontonians consume less than 50% of the daily-required fruit and vegetables recommended by Canada’s food guide (State of Toronto’s Food) and according to calculations by Toronto Public Health using Canadian Community Health Survey 3.1, in 2005, 7% of Torontonians over 40 had heart disease and 6.6% had diabetes. Health issues related to food conservatively cost the Canadian healthcare system two billion dollars a year. (De la Salle et al, 22)

According to the Conference Board of Canada, between 1961 and 2012 the life expectancy for the average Canadian increased from 71 to 80 years, however according to the data the last 10 % of their life will be spent in poor health adding to the financial strain on the healthcare system. (http://www.conferenceboard.ca)

Increased disclosure and access to product information through blogs, social media and personal devices are improving awareness of food related illness and the impact of poor dietary habits. Concerns over increased use of antibiotics in livestock as well as the use of chemicals and pesticides in food production have raised concerns by the public

regarding the need to know what they are consuming. This has been exacerbated by the plethora of recalls in recent years for contaminated food, resulting in a shift in consumer behaviour away from processed food to more natural food choices, including simple easily understood ingredients.

All of these factors have led to a loss of trust in the current food system to provide fresh, healthy, nutritious food to all people at all times. According to the World Health Organization (WHO) " Access to good, affordable food makes more difference to what people eat than health education." (The Growing Season, 22)

Increased Global Wealth

Increased global wealth and the standard of living especially in Brazil, Russia, India and China, collectively referred to as the BRIC countries, is having a major impact on the food system resulting in a shift away from grain based diets toward the consumption of more animal products and meat. Increases in meat consumption require additional land for the grazing of livestock as well as agricultural land for feed and includes an enormous increase in water consumption per calorie of food produced. This has been a major driver in agricultural land expansion with livestock already consuming 70% of all agricultural land use worldwide. (Suzuki)

Increased wealth is also a major driver for dietary changes in other parts of the world where people can afford to circumvent seasonality by importing products from around the world at a cost. This results in additions to the waste stream due to losses in long distance shipping and packaging. People also refuse to buy produce with minor imperfections that are often relegated to the rubbish heap due to cosmetics even before harvesting. The wealthy buy more than they need and discard almost half after the point of purchase unlike the poor who can't afford waste.

Socio Economic Development

Providing more of our food from local sources just makes economic sense. The more robust our urban agriculture economy, the more jobs we create for local people and the less dependant on imported products we are. This in turn keeps more money circulating within our community through other businesses, creating multiplier effects estimated to be worth up to 4 times that of money spent outside. (Ladner)

The City of Toronto Economic Development Department states that one in eight jobs in the city are directly connected to food with Toronto's residents and government spending $7 billion a year on food. (The State of Toronto's Food 2008) This estimate is based on spending by Torontonians extrapolated from Statistics Canada (2003) Food Expenditures in Canada (2001) and Government spending estimates from the Food and Hunger Action Committee (2001). (The Growing Season, Phase 2 Report)

Ontario has more than half of Canada's most productive class 1 agricultural land, yet we import more food than we export resulting in a food deficit of $4.8 billion. (Ministry of Agriculture, Food and Rural Affairs (2007) Ontario Agri-food Trade by Commodity Group, January through December 2006) A study in Seattle estimated that if 20% of the food dollars spent came from local sources it would inject $1 billion into the region's economy annually. (Ladner, 103) This illustrates the potential to significantly improve the food security and economic health of a community.

> "At least 60% of the fresh produce consumed in Toronto is imported from the United States, and a third of this arrives during Ontario's own growing season, competing with local producers. This amounts to $172 million spent annually in Greater Toronto to import fresh vegetables, many of which can be grown locally"
> (Ladner, 104)

Put in the local context based on US food purchases alone Toronto could invest $17.2 million dollars into the local economy by increasing its local food production by a mere 10%. This figure is based solely on US imports and does not include imports from other nations.

Rooftop agriculture provides local jobs and nutritious healthy food to local populations improving their overall health while providing economic and environmental benefits by reducing strain on the healthcare system.

> "Green economic development will have many benefits for the city of Toronto. Health costs will be reduced as preventable diseases caused by pollution are addressed proactively. Infrastructure costs for roads, sewers, filtration plants and the like will be reduced as less demand is placed on them."
> (Toronto's Environmental Plan, 64)

The environmental benefits of storm water management, reduction of the heat island effect, reduction of energy costs for heating and cooling and the sequestering of CO2 all

have huge financial implications for the city and the stress on its infrastructure and provide environmental benefits that improve the quality of life in the city.

If designed, installed and properly maintained a green roof can extend the lifespan of a building's waterproof membrane by at least double reducing the cost of repair or replacement providing a significant benefit for building owners or taxpayers. (May 2011 Interview with Steve Peck, for Green Infrastructure Digest http://hpigreen.com/2011/05/20/interview-with-green-roof-for-healthy-cities-founder-steven-peck)

Most crops grown for export have little to do with the local community or economy and more to do with profit and bottom-line economics. The current system relies on subsidies, import quotas and tariffs driven by politics often forcing local farmers to compete with cheaper foreign products resulting from their own subsidies and cheaper labour costs. The production of meat, dairy and grain account for 80% of all federal subsidies while fruits and vegetables receive less than 1%. (Dave)

The strong Canadian dollar in comparison to the US makes it hard for Canadian farmers to compete in US markets where agricultural workers are paid on average 25% less than their Canadian counterparts. As we import 60% of our produce from the US focusing on import replacement only makes good business sense especially considering Ontario's $4.8 billion food deficit in 2006. Gaining even a small market share represents a significant amount of capital.

Environmental Concerns (Impacts of the Food System)
Our current fossil fuel dependant food system is destroying the ecology of our planet. It is responsible for the pollution of water, soil and air and is a major contributor of GHG resulting in global climate change. Environmental threats include pollution, declining global soil fertility, a loss of natural habitat and major losses in global biodiversity.

> "By clearing tropical forests, farming marginal lands and intensifying industrial farming in sensitive landscapes and water-sheds, humankind has made agriculture the planet's dominant environmental threat."
> (Foley, 62)

Many of the environmental issues surrounding agriculture are intertwined with economic, social and political forces external to agriculture itself. (Gold, 1999)

The current industrial agriculture model is epitomized by widespread monoculture farming, causing the reduction of genetic diversity and resilience found in nature due to the reliance on a few high-yielding crop varieties to create global standardization. This results in organisms that are more susceptible to disease and less capable of dealing with environmental stress due to resource competition. As a result, sustaining monoculture practices requires significantly more energy inputs than traditional farming practices. The practices of polyculture farming and crop rotation use resources like water and nutrients more efficiently by reducing resource competition and increasing biodiversity making farms more resilient by mimicking natural ecological systems. (Hoffmann) The current model includes the extensive use of poisonous chemical pesticides as a control mechanism to minimize insect damage and enormous amounts of chemical fertilizers both of which have a negative impact on the environment.

“The pesticide industry grew out of the war machine when weapons researchers were redirected to agriculture and DDT, invented for war in the early 1940’s, needed a civilian use.” (Elton, 10) Between 1961 and 1999 the use of nitrogenous and phosphate fertilizers increased by 638% and 203% (International Fertilizer Association Statistics, www.fertilizer.org/homepage/statistics) According to the UNEP the production of pesticides increased by 854% for the same time period. (UNEP Geo-3 Data Set www.unep.org/geo/geo3.asp) According to a 2013 study by the University of Maryland and the US Department of Agriculture published in the journal PLOS ONE, the pervasive use of chemical pesticides and fungicides are responsible for the decline in the global bee population as a result of Colony Collapse Disorder (CCD). (Woody) Between 2007 and 2013 CCD wiped out an estimated 10 million beehives, worth over $2 billion. Bee populations are so low in the US that it takes 60% of the country’s colonies to pollinate California’s almond crop. Bees pollinate $30 billion in crops a year in the US alone. (Woody)

Increasing local production and distribution and reducing waste in all aspects of the system could have a significant impact on global health, both for humanity and the planet itself. I believe that a robust urban agricultural practice including rooftop gardens has the capacity to make a difference.

- **Water Depletion and Contamination**

  "The world's water supply will become one of the most critical future food security issues – particularly as climate change alters the hydrological regimes around the world" (De la Salle et al, 94)

According to the 2006, Human Development Report by the United Nations Development Program (UNDP), "Over the last century our population has quadrupled but our water use has grown by a factor of seven" (137) The current agricultural mismanagement of water required for irrigation has had a profound effect on the ecological systems of the world including: declines in soil productivity caused by the erosion of exposed topsoil; the salinization of soil caused by excessive irrigation; as well as the mass pollution of the world's watersheds due to agricultural runoff.

- **Irrigation**

The negative impacts of unsustainable water withdrawals includes diminished flows of many large rivers, and the depletion of aquifers on a global scale, as well as contaminated water in nearly every ecosystem on the planet. To meet our future food requirements agriculture needs to become much more efficient at producing more food per unit of water, fertilizer and energy. Vast area of desertification around the world are being created by the over-harvesting of groundwater and the depletion of natural aquifers as a result of over-grazing livestock coupled with global climate change.

"It takes about one litre of irrigated water to grow one calorie of food." (Foley, 64) This can be significantly reduced through efficient drip irrigation systems, and other water saving strategies including mulching crops and the use of mechanisms to reduce evaporation from canals and reservoirs. According to Sandra Postel, irrigation accounts for up to 90% of all water withdrawals, including approximately 20% that is returned to the watershed heavily degraded. (Foley) In 2002, 250 million hectares of agricultural land was irrigated worldwide, almost five times more than at the start of the 20th Century. (World Water & Food to 2025) This unsustainable withdrawal of water is depleting water sources around the world. "Half of the world's people live in countries where water tables in aquifers are falling because of over pumping." (Ladner, 4) The Ogallala Aquifer is the source of water for irrigation for 20% of the farmland in the United States; it is currently being overdrawn beyond the rate of natural recharge by 3.1 trillion gallons a year. Its depletion will have devastating affects on the ability to grow food in the mid western United States. (See

appendix D: For more information on The Effects of Irrigation on the Ogallala Aquifer and the Aral Sea)

> "The inability of the industrial system to adjust gracefully to the shock of drought is just one of the many indicators that it is at the tipping point."
>
> John Gerber

> "If a farmer in an arid developing country improves water efficiency on an average of 1%, he or she will gain around 200,000 liters of fresh water per hectare per year. This amount of water would be sufficient to provide drinking water for more than 150 people."
>
> Kenji Yoshinaga
> Director of the FAO
> Land & Water Development Division
> (Croplife, 11)

- **Pollution**

  "The flows of nitrogen and phosphorus through the environment have more than doubled since 1960, causing widespread water pollution and enormous hypoxic "dead zones" at the mouths of the world's major rivers." (Foley, 63)

Agricultural practices of unsustainable irrigation and the relentless use of chemical fertilizers, pesticides and fungicide that end up in our waterways through runoff are destroying the natural environment and the ecosystem services they provide. Farmland runoff contains nearly 50% of the fertilizer applied to crops compromising coastal fishing grounds and contributing greatly to the depletion of fish stocks around the world. (Starr) As nitrogen rich runoff enters our waterways, it results in eutrophication and the development of algae blooms that consume nutrients. Once the nutrients are consumed the algae dies causing hypoxia as they decompose. Hypoxic dead zones are appearing at the mouths or rivers around the world having devastating affects on aquatic ecosystems. According to a study published in Science in 2008, there were over 400 hypoxic zones in the world affecting a total area of more than 245,000 square kilometres representing a key stressor on marine ecosystems. (Diaz and Rosenburg) In 2013 the "dead zone" in the Gulf of Mexico was 15,120 square kilometres, about double the size it was in 2012 when drought conditions reduced the flow of runoff from the Mississippi River Basin into the Gulf. (Mississippi River Gulf of Mexico Watershed Nutrient Task Force, http://water.epa.gov/type/watersheds/named/msbasin/zone.cfm)

> In 2004 the UN Environment Program published the Global Environment Outlook Yearbook (GEO yearbook, 2003) and reported 146 dead zones worldwide with the largest zone covering 70,000 square kilometres, by 2008 the number of zones increased to 405.
>
> (David Perlman)

Many parts of the world use far more fertilizer than required; reductions would likely have little or no negative affect on yields, yet would have a profound impact on the amount of chemical runoff polluting our water system. Changing to organic compost would mitigate chemical loading of runoff slowing down the release of nutrients into the soil while increasing water storage capacity. “Amazingly only 10% of the world’s cropland generates 30-40% of agriculture’s fertilizer pollution” (Foley, 65)

Rooftop agriculture could reduce the amount of agricultural pollution by minimizing chemical use and managing runoff through municipal infrastructure while improving urban air quality.

- **Soil Fertility Depletion**

> “Land degradation including soil erosion, salination, and desertification has undermined agricultural productivity worldwide.” (De la Salle et al, 22)
>
> “The current production system is one based on high inputs of synthetic fertilizers, herbicides, fungicides, and pesticides. All of theses are detrimental to our soil resource and all life that relies on that resource.” (Brown)

Agricultural practices in North America lose 18 times more top soil than the current system replaces and in many cases we are exhausting soil fertility by as much as 50%, perpetuating our dependence on fossil fuels to stay productive. (Elton)

> “The unsustainable use of water is a major issue; over eighteen percent of the formerly productive land in China is now desert resulting from the unsustainable over use of water in that country. “The Chinese Research Department for Industry, Transportation and Trade estimates that desertification directly causes $7.89 billion in losses each year due to health, economic and environmental effects of sandstorms and water shortages” (Patel, 47) The World Bank estimates that the cost could be as high as $31 billion.”
>
> (Mitchell, 13)

Climate Change

Climate change will have a profound effect on agriculture in the 21st Century and will likely lead to increased global food insecurity, famine and migration from affected areas. Increased weather volatility and changes in weather patterns around the globe will be responsible for increased agricultural losses under the current system. Agriculture is collectively the largest single source of GHG emissions "accounting for approximately 35% of the carbon dioxide, methane and nitrous oxide we release." (Foley, 63) This is more than all transportation worldwide and a major contributor to global warming which is already impacting global weather patterns and affecting our ability to grow food using conventional practices. Methane is 28 times more harmful than CO2 (http://beyondfactoryfarming.org/files/climate%20change2.pdf) and "Synthetic nitrogen fertilizers in soils produce nitrous oxide, a greenhouse gas that is approximately 300 times more powerful than carbon dioxide at trapping heat in the atmosphere." (David Suzuki)

Greenhouse Gas Emissions are higher now than at any point in history. As a result the past decade has been the warmest on record, with 2014 being the hottest year in recorded history. (Zabarenko) (See fig 10)

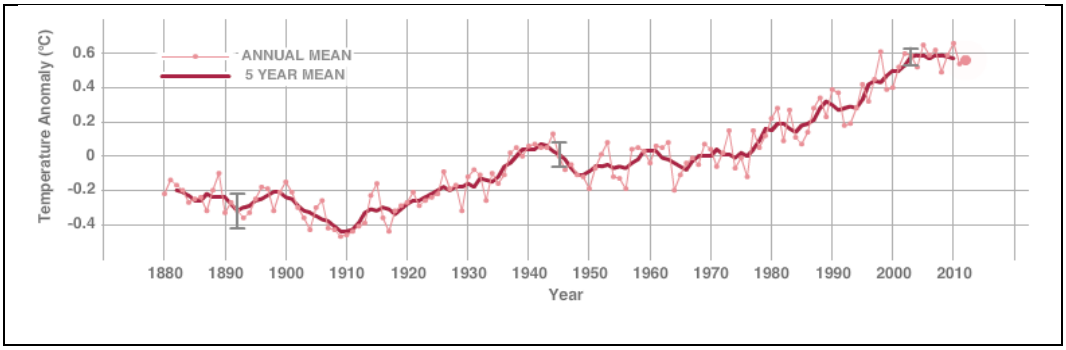


Figure 10: Global Land-Ocean Temperature Index

Data Source: NASA's Goddard Institute for Space Studies (GISS). This trend agrees with other global temperature records provided by the U. S. National Climate Data Center, the Japanese Meteorological Agency and the Met Office Hadley Centre/Climate Research Unit in the U. K. Credit: NASA/GISS.

It is estimated that for every degree of temperature increase the global grain yield will decrease by 10%, greatly affecting the sustainability of our food system and our ability to feed our increasing population. (Ladner, 7) According to the NASA Earth Observatory, in

the past it has taken the planet 5,000 years to warm 5 degrees. Today many predict that in the next century it will warm as much as 6 degrees, a rate of twenty times faster than the historic average putting us in a temperature range not seen in about 50 million years (before Homo Sapiens existed). (See fig. 11)

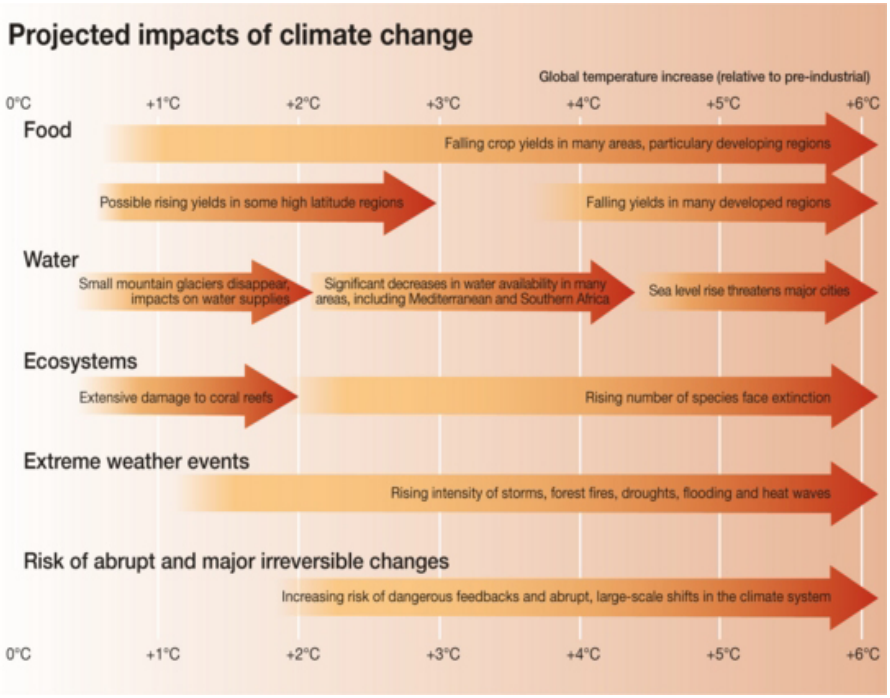


Figure 11: Projected impact of Climate Change (Hugo Ahlenius, UNEP/GRID-Arendal) http://www.grida.no/graphicslib/detail/projected-impacts-of-climate-change_154e

Twenty five percent of all global Green House Gas (GHG) emissions are a by-product of the current energy intensive food system that are released into the atmosphere; it is estimated that 17% comes from the off-gassing of manure alone. (Ladner, 7) Food waste decomposing in landfills also produces a significant quantity of methane not included in this total. Transportation and storage are also contributing sources. According to a study tracking food miles traveled for fifty imported foods traveling to Ontario, the average distance traveled was 5,000 kilometres creating 52,000 tones of GHG a year. If purchased locally the GHG emissions would be reduced by 49,000 tones, the equivalent of removing 17,000 cars from the road. (Ladner, 7) Approximately 25% of all trips in the city are associated with the procurement of food purchasing or consumption.

According to Diane Bronson, Executive Director of Food Secure Canada, “Roughly half of the GHG emissions in Canada involve some aspect of our food system.” (Walker) Toronto’s largest impacts are from food choices and transportation dominated by the industrialized global distribution of the current food system.

Strategies to mitigate GHG include:

- Allocating land for agricultural use within or close to the city minimizing travel distances
- Encouraging medium and small-scale food outlets accessible to pedestrians and transit to make purchasing smaller quantities more convenient
- Increase market access and awareness for local food
- Transform the agricultural system to cleaner energy sources than fossil fuels
- Create efficient composting systems to reduce the amount of food waste in landfills

(Modified from De la Salle et al, 40)

The high dependence on fossil fuels of the current agricultural system exacerbates climate change. This leads to further environmental destruction such as the diminution of air, water and soil health, resulting in the diversion of public funds to correct the problem. “According to the Institute for Science in Society, existing organic agriculture and localized food systems mitigate 30% of the world’s greenhouse gas emissions and save one-sixth of energy consumption” (Ladner, 109)

“Cities consume between 60-80% of the world wide energy production and account for roughly equivalent shares of Global CO2 emissions” (http://www.oceed.org) Rooftop farming and green roofs have the capacity to help balance the scale of emissions by reducing the city’s CO2 contribution. According to Environment Canada, carbon emissions in Canada’s agriculture sector increased by 19% between 1990 and 2006. Local food production is identified as a key factor in Toronto’s climate change mitigation strategy. Scientists predict that on our current path we have 20 years to reduce our carbon footprint before we reach the point of no return. (Smith)

Climate change is expected to significantly affect water flows in Canada as early as 2050, with declines of up to 71% in provinces like Alberta. (McIntyre) According to Environment Canada 2008, the Great Lakes are expected to drop by up to a meter. “A rise in temperature of 2-4 degrees could lower discharge for Lake Ontario by up to 24% negatively impacting agriculture.” (McIntyre)

> "Clean air and water, shelter, safe ambient temperatures, and nutritious food are examples of what are known as "determinants of Health," and they are all threatened by climate change."
>
> Isobel Braithwaite and Erica Parker
> Global Climate and Health Alliance

Expensive Oil

> "From the petroleum needed to produce nitrogen fertilizers and packaging for food, to the gas in the car for going to the grocery store, the main ingredient in dinner is oil" (De la Salle et al, 25)

Cheap oil of the 20th Century is largely responsible for the rise of industrial agriculture and multinational agribusiness, where all aspects of the food system are heavily dependent on fossil fuel. The low cost was a major factor in the reliance on fossil fuels for fertilizers, pesticides and packaging and contributed greatly to the globalization of food due to the inexpensive cost of long distance transportation.

There has been an upward trend in the cost of oil based on the fact that most of the cheap oil has already been extracted and we are now reliant on sources that are more expensive to get at or refine. In the past decade there has been a five-fold increase in the price of crude oil, negatively impacting the cost of both agricultural inputs and long distance exports. (Seccombe) Oil prices will undoubtedly continue to rise with expectation for demand increasing by as much as 40% over the next few decades. The inevitability of peak oil will undoubtedly send prices skyrocketing and force the issue of local, sustainable food production to the forefront of food security. I believe that the recent drops in oil prices are temporary and that it is naive to think that technological solutions will fix the problem especially when calculating oil's negative environmental impacts on climate change.

Peak Everything

- **Peak Oil**

Peak oil is a theory based on the statistical analysis work of M. King Hubbert, and is the point at which we will reach maximum global extraction followed by terminal decline. Some believe that this is exaggerated and that oil produced from hydraulic fracturing will fill the void. Hydraulic fracturing is highly controversial with proponents championing its economic benefits and opponents arguing the negative environmental impacts including the contamination and depletion of water, degrading air quality, surface pollution and the

potential hazards the public and environmental health. (http://en.wikipedia.org/wiki/Hydraulic_fracturing) Many experts optimistically estimate that peak oil will occur after 2020 and that alternative energy sources will be implemented before a crisis. Others believe that we have already reached peak oil and that demand will continue to exceed supply resulting in disruptions.

Today as we move into the 21 Century, peak oil is resulting in increased prices causing considerable vulnerability and uncertainty in our food system's security. Oil is an integral part of the current food system; the big question is how do we produce enough food to feed the population of the world without it? De la Salle asks, "what happens to our food supply when oil is gone (or when food becomes really expensive)?" (De la Salle et al, 25) The current agricultural system is experiencing a decline in Energy Return on Investment (EROI) requiring more inputs (most in the form of fossil fuel) to stay productive which in turn is negatively affecting the price and the ecological environment. "World quantity-demand is projected to increase 21% over 2007 levels by 2030" rising to 104 million barrels a day. (http://en.wikipedia.org/wiki/Peak_oil)

> "We tend to think of the looming energy crisis in terms of cars, factories, heating, and air conditioning, but the first thing to keep in mind is that fossil fuels are feeding us… how many are aware that we have literally been eating oil and gas for more than a hundred years."
>
> Ronald Wright
>
> (Forward in Homer-Dixon, T. (2009). Carbon shift: how peak oil and the climate crisis will change Canada (and our lives) Random house Canada. ISBN -13: 978-0307357199

Rooftop agriculture has the potential to produce food with less fossil fuel inputs by reducing or eliminating the use of chemical fertilizers in favor of organic compost, by insulating the building underneath reducing the need for heat in winter or AC in summer and by providing access to food without the need to travel long distances reducing energy for procurement.

- **Peak Water**

Peak water is a growing issue as we deplete aquifers and degrade the water quality in watersheds around the world. We already appropriate more than 70 % of all the available fresh water for the purpose of growing food to feed the world's current population. (FAO,

Coping With Scarcity) “Few resources have a more critical bearing on human security than water.” (Human Development Report, 133)

> “Our population in 2025 is estimated to be over 8 billion and the UN estimates that forty-eight nations will face freshwater “stress” or “scarcity”. (Water.org) Two thirds of the world’s population will be living under conditions of water stress and 1.8 billion will be living in areas of absolute scarcity. (National Geographic, Water.org) The higher the population grows in any region the more it affects the rate per capita of availability of potable water.” (Mitchell, 11)

Water shortages affect the ability of people to grow food to sustain themselves and shortages in the future will inevitably hit agriculture hard. “As our population increases so does the need for water for the domestic, agricultural and industrial sectors intensifying the pressure on water resources and the environment leading to tensions and conflicts among users.” (Mitchell, 11) “In the past decade thirty-three nations have already engaged in conflicts over reductions in water flow, pollution and silt build up in aquifers, rivers and lakes.” (Starr, 513) Fresh water is a finite resource and will remain virtually unchanged regardless of demand “even when considering interventions such as desalinization [that] currently provides about one half of one percent of the global water demand; any gains made will be absorbed by the population increase.” (Mitchell, 11: source: National Geographic Freshwater Initiative) Even in a country like Canada with a seemingly abundant water supply we are seeing evidence of peak water. “Since 2002 Toronto Water has issued annual rate increases of approximately 9%.” (Garrison, 11)

> “In a world where 2-5 million people already die every year from a lack of potable water, the demand for fresh water will exceed supply by over 60 percent within a generation.” (Ladner, 4)

- **Peak Land**

Peak land is becoming a reality in the 21st Century. According to a report released at the World Economic Conference in Davos, Switzerland in January 2014, “Assessing Global Land Use: Balancing Consumption with Sustainable Supply” by the International Resource Panel of the UN Environmental Program (UNEP), based on current practices in order to feed our growing population by 2050 we will require additional agricultural land the size of Brazil, that is over 8.5 million square kilometres. According to the UNEP Executive Director, Achim Steiner, the report identifies an “unprecedented decline in terrestrial ecosystem services and functions during the past decade. Forests and wetlands have been converted to agricultural land to feed growing populations but at a

cost that is not sustainable." (Crabtree, 2014) Factors influencing the expanding need for more land include a shift to protein-rich diets in developing countries and the need for grazing land as well as land for bio-fuels and biomaterials. 78% of the land currently under production is used for livestock and is the driving force behind cropland expansion. (IMECHE Report on Food Waste) The report recognizes that land is a finite resource identifying a need for more efficient ways to produce land-based products predicting that if we continue on our current path, by 2050 we will overshoot the environmentally sustainable land demand for food production.

> "Agriculture has already cleared or radically transformed 70% of the world's prehistoric grasslands, 50% of the savannahs, 45% of the temperate deciduous forests and 25% of the tropical forests." (Foley, 63)

According to the FAO between 1992 and 2002 global farmland expanded by 5 million hectares a year. "Between 1961 and 2007, cropland expanded by 11%, a trend that continues to grow." (Crops Eating into World's Natural Land Base, Environmental news Agency Jan 24,2014) Scientists from the University of Wisconsin-Madison estimate that we already occupy 40% of the Earth's land for agriculture, most of what remains is either unusable for agriculture or tropical forest and savannah. (Owen) Dr. Molly Brown from the NASA Goddard Space Flight Center believes global agriculture is hitting its natural limit and we will need to increase productivity rather than increase acreage.

> "Land suitable for cultivation is becoming a scarce commodity"
> Oliver de Schutter, UN Special Reporter
> (Shariatmadari)

Currently, to maintain food supplies some of the richest countries are acquiring large tracks of land from some of the poorest in order to achieve food security for their populations often at the expense of the poorer nations with regard to depletion of environmental services and national access to food. Countries like China, the European Union and the United States are acquiring large tracks of land in Africa through governmental or private sector foreign investment. By 2009 five countries in Africa including, Ethiopia, Ghana, Madagascar, Mali, and Sudan had a combined allocation of foreign investment for land of 2,493,684 ha. (Cotula et al) In these "land grabs" there is very little transparency regarding local benefits provided by the international agricultural corporations that are taking over the land.

In North America soil is eroding at an alarming rate, “the vast prairies, the famed North American breadbasket have lost half their original topsoil, and erosion from agriculture continues to sweep away soil thirty times faster than new soil is being produced.” (Ladner, 4) “Two million acres of cropland go out of production every year because of erosion, soil depletion or water logging. Another million acres a year are lost to development.” (Ladner, 4) According to new research released by the UN Desertification Convention (UNCCD), severe land degradation and drought is now affecting 168 countries worldwide at an estimated cost of US $490 billion a year. “Sustainable land management should be one of the Sustainable Development Goals set to be announced in 2015.” (King) Simply expanding cropland has huge environmental costs including diminished ecological services, which are already significant. Producing more food within the city could minimize the need to expand cropland.

Education

Community programs and non-profit organizations like FoodShare and the Stop Community Food Center, along with school grow programs in Toronto are engaging the community to provide education on food. From an urban food context, these organizations are reintroducing food production into the urban core and educating communities on the importance and impact of a healthy diet by providing training and growing space within the community. Educational awareness is building respect for both farmers and the environment.

Changing Government Policy (e.g., City CO2 reductions)

Government policies and changes to zoning laws that allow for farming and food production within the city are major drivers affecting the expansion of urban agriculture. Driven by the need to reduce the city’s environmental footprint many municipalities are beginning to see the benefits of local food production in terms of food security and sustainability.

Toronto’s Green Roof Bylaw (http://www.toronto.ca/legdocs/municode/1184_492.pdf) is an example where the city has introduced policy to mitigate storm water runoff as a management tool to help deal with inadequate infrastructure as well as other environmental issues that plague the city. Although not specifically stated in the bylaw, it opens the door to convert rooftops into productive garden spaces for the commercial production of food.

Other policies such as the Local Food Procurement Policy also support urban agriculture; how much more local can you get than the rooftop over your head?

According to Steve Peck from Green Roofs for Healthy Cities, policy tools used in the US to encourage the expansion and installation of green roofs include tax incentives, an increase in floor area beyond code for new buildings, and grants averaging $5 per square foot for installation. (May 2011 Interview with Steve Peck, for Green Infrastructure Digest http://hpigreen.com/2011/05/20/interview-with-green-roof-for-healthy-cities-founder-steven-peck)

Over the past decade Toronto has introduced a number of policies in support of the urban food movement in an attempt to produce a robust urban agriculture network in the city, however uptake has been slow.

21St Century Agro Technology

Technological advances play a major role in agriculture today, this includes engineered seed, advances in irrigation techniques and growing methods to extend growing seasons, and the use of computerized systems to monitor moisture and fertilizer needs in the field. Satellite imaging is also being incorporated into farming by organizations like NASA to develop programs such as “Precision Farming”, with a goal to increase farm productivity around the world. (Owen)

Loss of Trust in The System

The uncertainty of the reliability of the global food system in the future is driving the need to be self sufficient with regard to food production. The possibility of disruptions in the system along with numerous cases of food contamination has resulted in the loss of trust in the system opening the door for a number of certification programs and metrics designed to make consumers feel safer. The organic food movement of the 1970’s was a response to the health and environmental issues created by chemical pesticides and fertilizers and initiated the modern local food movement with formal production guidelines established in the US in the 1990’s. The movement continues to grow and independent certification programs have been developed as a result.

Taste

Taste is one of the big drivers behind the DIY, local and organic gardening movements. Nothing tastes as good as a fresh tomato straight out of the garden.

5.1 Enablers

Changing Policies

Changes to municipal zoning laws and policies that support green incentives including urban agriculture, green roof production and local markets have the ability to act as enablers or blockers for the expansion of rooftop food production in the city of Toronto.

Two examples of changing policies that support rooftop gardens are:

- Toronto's Green Roof By-law, established in 2009. This policy supports rooftop gardens due to their ability to absorb and retain water reducing the flow of runoff into the municipal water system.
- The Wet Weather Flow Master Plan of 2003. "The 5mm retention standard put forth by the Wet Weather Flow Master Plan has acted as a driver for rainwater harvesting particularly in the densely packed urban center." (Garrison, 110) This represents the minimum amount of storm water that must be retained on-site to achieve the same level of annual volume of overland runoff pre-development as a way of reaching Water Balance Targets for the Toronto's storm water management. (Wet Weather Flow Management Guidelines)

Policies that support rooftop agriculture will be discussed in section 8 of the paper.

Advances in Greenhouse Technology

Rooftop agricultural production in the city of Toronto can be extended beyond the summer months by embracing greenhouse technologies. Lufa Farms in Montreal is a perfect case study producing continuous cropping throughout the year through the use of a rooftop greenhouse. A robust rooftop farm system incorporating greenhouses in Toronto has the capacity to provide local produce year round and more opportunities will exist as inexpensive technology becomes available. Extending the season makes the investment much more appealing to both farmers and investors by increasing the annual production and the Return On Investment (ROI).

The development of affordable reliable green energy also makes greenhouses more accessible. This included solar and wind energy and the development of low energy LED lighting to reduce cost.

5.2 Blockers

Cost

High Initial investment in terms of both time and money prior to the return makes it hard to establish a commercial garden without some form of backing. The cost of retrofitting existing buildings can also be considered a blocker or barrier to the uptake of rooftop agriculture.

Agri-business Lobbyists

The “bigger is better” philosophy of agribusiness makes it hard for small-scale producers to enter the market due to the economy of scale and political pressure.

Limited Outdoor Growing Season

Without the use of season extending technologies like greenhouses the growing season in Toronto is limited to six months of the year. To eat locally it requires a shift in behavior to include seasonal eating and the preservation of fruits and vegetables during peak season for consumption during off-season.

Trade Rules (World Trade Organization (WTO) and the North American Free Trade Agreement (NAFTA)

Government policies, trade rules and subsidies affecting global trade can be blockers or enablers depending on how open they are.

Restrictive Policies

Zoning laws and policies regarding regulations and requirements for the production and sale of agricultural products within the city make it difficult for individuals to enter the marketplace.

Rooftop Access

Throughout my interviews one of the consistent barriers was independent access to rooftop spaces. In many cases it is a social issue, where building residents do not want to

share the elevator with the farmer on the roof. Without adequate access it becomes difficult to move resources and product up or down from the roof.

6.0 **Trends: Identifying Signals of Change**

Trends are the visible results of the drivers that can be quantified over a period of time and have significant impacts on the system through social, economic or political implications. Trends tend to be long lived and affect a wide range of people.

Trend: Urbanization social

Description:

Urbanization is the physical manifestation of economic, social, and environmental forces that result in the migration of people into cities. It is based on the population living in urban centers compared to the overall population of an area or region. There was unprecedented urbanization during the twentieth century associated with industrialization and a shift from an agro-based economy to mass industry, technology and services.

The industrialization of farming has had a profound effect on the viability of the 'small holder' farm, resulting in 'Rural Flight'. Rural flight is the negative consequence of industrial agriculture that affects the viability of small-scale farmers to compete with agri-

business. Rural urban migration is expected to continue into the future with 70% of the estimated 9.2 billion people on the planet in 2050 living in urban centers. As of 2011, (the most recent statistics available) the urban population of Canada reached 81%. (Statistics Canada, 2011)

Increased global populations, globalization, migration and 'rural flight' are major factors contributing to the development of urbanization into a mega trend. Through this trend more of the population is removed from first hand production or knowledge of the food system, becoming consumers at the end of the food chain rather than participants in production itself. All of these factors combined have resulted in historically unprecedented urban expansion around the globe, resulting in increasingly larger cities and the loss of cropland due to urban development. "By 2001, about half of Canada's total urbanized area was located on what was once quality agricultural land, and is now irrevocably lost." (Lister, 162)

Other factors in the migration to urban areas include the search for a better quality of life; this includes improved job opportunities, education, health care, housing, transportation and entertainment. All of which have resulted in an explosion of 'Mega Cities' across the globe as cities reach populations of ten million or more.

Urbanization and the car are two of the most dominant trends that have negatively impacted food connections, by eliminating food from the city and forcing it into the fringes. The car itself has enabled the centralization of food supplies to be relegated to large stores away from the city core.

Urban agriculture has the capacity to mitigate some of the stress on both the food system and the ecological environment as urbanization continues to gobble up surrounding farmland and natural ecosystems. As our cities grow so does our need to sustainably feed our population while protecting ecosystem services.

Signals of Change:

- The UN refers to 2008 as the "Urban Millennium or the tipping point; a milestone at which point more than 50% of the global population was living in urban centers." (http://en.wikipedia.org/wiki/urbanization)

- The number of cities with a population of one million or more rose from 83 in 1950 to over 441 in 2010 with 21 of those cities surpassed the 10 million mark reaching Mega City status. (http://www.un.org/esa/population/un.pop.htm)
- By 2025 the UN predicts that there will be 29 global mega cities, nine of which are expected to have populations exceeding 20 million. (UN. World Urbanization Prospects: the 2009 revision)
- Rural Flight - Between 1996 and 2006 Canadian farm acreage grew but the number of farms declined by more than 17% totaling a loss of 47,000 farms nationally. (McKeon)
- The Urban population of Canada has increased from 13% in 1851 to 81% in 2011. (Statistics Canada, 2011)
- According to Statistics Canada in 1961 Toronto's population was 1,824,481; by 2011, it had increased to 2,615,060. (Statistics Canada, 2011)
- Estimates put Toronto's population in 2020 at 3 million with the GTA reaching 7.5 million. (Demographics of Toronto, http://en.wikipedia.org/wiki/Demographics_of_Toronto)

Counter Trend (s): Counter-urbanism: "A demographic and social process whereby people migrate from urban to rural areas, motivated by overcrowding, housing density, high prices, pollution, crime levels and a desire for a quieter life." (McCammon, Mitchell and Veale)

Trend: Urban Sprawl social/environment

Description:

Driven by urbanization and the proliferation of the car, urban sprawl has had a significant negative effect on our food system and natural habitats as cities expand to engulf the farmland surrounding them forcing food production and farming further and further from the urban core while significantly reducing natural ecological environments and global biodiversity.

Over the past 20 years we have expanded agriculture into tropical regions at a rate of 5-10 million hectares a year negatively impacting the planet's natural carbon stores and its biodiversity. These expansions have only added 3% to the cultivated land when you

calculate cropland losses due to urban development and the expansion of cities around the world. (Foley, 62)

Every year Canada loses more of its best farmland to low-density urban sprawl.

Signals of Change:

- "Between 1982 and 1997, America converted approximately 25 million acres (39,000 square miles) of rural land, forests, rangeland, pastures, cropland and wetlands to developed land: that is, subdivisions, freeways, factories, strip malls, airports, and the like." (Camarota)
- According to Gold, thirty million acres of farmland in the U.S were absorbed by urban and suburban sprawl between 1970 and 1999. (Gold, 2007)
- Between 1966 and 1996 Ontario lost over 1.5 million hectares of agricultural land to non-agrarian uses. In the last fifty years of the 20th Century, the central Ontario region lost 49% of its farmland due to the expansion of the GTA. (Seccombe, 7)
- By 2000, the GTA's urban sprawl was expanding by roughly 5,000 hectares a year consuming the farmland surrounding it. (Smith, Graeme, 5)
- Farmland continues to decline, "between 2001 and 2006, the area of farmland in the GTA declined by 31,476 acres or 4%." (Walton, 64)
- "In the last 40 years more than 5,000 square miles of fertile soil have been lost to urban development in Canada alone." (Ladner, 25)

Counter Trend (s): Increased Urban Density and Policy Changes (Ontario safeguards top-quality farmland around the GTA, North America's fourth largest urban area through the Golden Horseshoe Green Belt Protection act of 2005)

Trend: The Globalization of Food social/political/economic

Description:

The globalization of populations around the world, cheap oil for transportation and a desire to circumvent seasonality have been driving factors in the globalization of food. Toronto is one of the most multicultural cities in the world with over 50% of our population coming from outside of Canada. (http://www.Toronto.ca/Toronto_facts/diversity.htm) According to Statistics Canada 60% of all Canadians are immigrants resulting in a greater demand for ethnically diverse foods than ever seen in history. This has been a major

factor in creating a truly global food system. As a result Canada imports food from 190 countries. (Ladner)

Food companies became global in the 1990's, "farmers and processors [became] suppliers to the global food chain rather than local communities". (McKeown, 12) The globalization of the food system has resulted in the off-loading of food production to the country of origin rather than the country of consumption making imported food the norm for many countries around the world, particularly in the west where most consumers are unaware of the origin of their purchases. Ontario has an $8.4 Billion food deficit importing more food in 2012 than it exported. (Liedtke) Toronto alone had a $4 Million dollar food deficit in 2012 importing much of its food from the US and Mexico, taking advantage of cheaper labor and lower environmental regulations in place due to the 1994 North American Free Trade Act. The global market combined with subsidies and trade agreements have allowed international agri-business to move production to developing countries; this strategy allows them to capitalize on cheap labour, resources and often lower environmental standards, while keeping costs and prices low. As a result North Americans spend less on food than any other county in the world.

> "Today we are using more kilocalories to grow and move food than there are calories in the food itself" at a rate of about 10-1. (Elton, 13)

Consumer behavior and increased global wealth have influenced the globalization of food production and distribution with consumers demanding fresh produce 365 days a year, weather or not it is in season as long as it is not cost prohibitive.

Signals of Change:

- The World Trade Organization (WTO) was established in 1996 with more than 130 members creating unprecedented trade in the 21st Century (Harrison)
- The exportation of food as a commodity has drastically increased over the past few decades. As a result of the globalization of food China grows more than 50% of the fruit and vegetables on the planet due to a rapidly expanding export industry. (Elton)
- In a 2005 study by FoodShare, the average distance traveled in a sample basket of groceries in Toronto is over 5,000 km.

- More than 2.2 million kg of fruit and vegetables from around the world pass through the Ontario Food Terminal every day facilitating the long distance trade in food. (Elton)
- The Vineland Institute collaborates with local growers and rooftop gardeners around the GTA on research projects with the intention of growing ethnic food not native to Ontario. (Mrosovsky)
- "In 1960 most of Toronto's food came from within 350 kilometers of the city, or almost entirely from within its foodshed. Today, at least 60 percent of the fresh produce consumed in Toronto is imported from the United States, a third of this arrives during Ontario's own growing season." (Lister)

Counter Trend (s): Local Food Movements / Seasonal diets

Trend: Tragedy of the Commons 2.0 environmental

Description:

As we head into the 21st Century and our population expands even farther beyond the natural carrying capacity of our world we are confronted by the theory of Peak Everything. In the drive to feed our ever-expanding population we have abandoned the need to balance our environmental demands with the natural replenishment of the planets natural resources and the ecosystem services they provide neglecting sustainability and the needs of future generations. This has resulted in the alarming depletion of natural resources. Today there is evidence of significant decline in the global quality of everything from the air we breath to the water we drink, the soil we stand on and the food we eat. According to the WHO "outdoor urban air pollution is responsible for 1.3 million deaths annually." (www.who.int/hia/green_economy/indicators_cities.pdf)

At the start of the 20th Century we thought that the natural environment could sustain us indefinitely and handle whatever we could throw at it. By the end of the century the environmental damage to the planet instigated by mankind was undeniable.

"Agriculture already consumes a large percentage of the earth's land surface and is destroying habitat, using up fresh water, polluting rivers and oceans, and emitting greenhouse gases more extensively than any other human activity." (Foley, 62)

“Fresh water withdrawals have tripled over the last 50 years, demand for fresh water is increasing by 64 billion cubic meters a year (1 cubic meter = 1,000 liters.)” (http://www.worldometers.info/water)

Signals of Change:

- The depletion of fresh water resources from rivers and aquifers around the world including the depletion of the Aral Sea (Erkin) and the Ogallala Aquifer (Pore).
- Biodiversity depletion is the result of a concentration on agricultural standardization in the last century focused on high yield varieties at the expense of genetic biodiversity as well as the depletion of natural habitat for agricultural purposes. Today nine crops provide seventy-five percent of our food. (Harrison, and Pearce)
- Peak Water
    - Peter Gleick and Meena Palaniappan define peak water in terms of renewable, non-renewable and ecological water in the Proceedings of the National Academy of Sciences. (Gleick, and Palaniappan)
    - Lester R Brown in his July 09, 2013 article for the Earth Policy Institute writes, “Peak oil has generated headlines in recent years, but the real threat to our future is peak water. There are substitutes for oil, but not for water.” (Brown)
    - The New York Times declares “Peak Water” as one of the words of the year for 2010. (Sifton, and Barrett)
- Peak Oil is a theory by American geophysicist M. King Hubbert, based on mapping the peak production and consumption of oil using a bell curve. Pre-peak production and discovery is seen in a rising curve until the peak, which is then followed by a decline. Today many believe we have or will soon reach Peak Oil. Hubbert’s peak theory has been applied to a wide number of resources from used in the agriculture from oil and water to phosphorus. (http://en.wikipedia.org/wiki/Hubbert_peak_theory)
- Pollution causes massive Hypoxic zones at the mouth of many of the world’s rivers referred to as Dead Zones. According scientists like Robert J Diaz, a biological oceanographer at the Virginia Institute of Marine Science, runoff of chemicals and fertilizers from agriculture are largely to blame. As of 2008 there were over 400 dead zones around the world up from 49 in the 1960’s. The size of

the dead zone in the Gulf of Mexico at the mouth of the Mississippi River covered an area of over 8,500 square miles in 2008. (Perlman)

Counter Trend (s): Return of Heirloom Varieties
Social Consciousness (evidenced by CSR and LEED)

Trend: BioElimination/Eradication environmental

Description:

At the start of the 20th Century we thought that the natural environment could absorb the damage created by the industrial agricultural system, but it has grown beyond what the biosphere can handle. The environmental cost of the current global agricultural system has had huge negative ecological impacts reducing biodiversity around the world through crop species elimination, expansion into and elimination of natural habitats, and through the destruction and pollution of natural ecosystems.

The move to an industrial model of agriculture in the last century has resulted in a major loss in the biodiversity in the global food system. “Of the 270,000 plant species known to science only around 120 are cultivated today and just nine of them provide 80 percent of our food.” (Harrison, 58) Biodiversity has been lost in the farm system in an attempt to standardize production through the use of a few high-yielding crop varieties farmed on large monoculture farms designed for consistency and efficiency. Monoculture cropping as well as genetic manipulation and selective breeding has had a negative impact on biodiversity. According to the Food and Agriculture Organization of the UN (FAO) 75% of the global crop diversity was eliminated during the 20th Century. (Lister, 165)

In an attempt to control the natural environment and eliminate pests and resource competition the use of chemical pesticides, herbicides and fertilizers have also negatively impacted biodiversity.

“Agricultural expansion has also reduced the diversity of natural habitats, including tropical forests, grasslands, and wetland areas.” (The Environmental Benefits of Well-Managed Farmland, 75) Over the past 20 years agriculture has expanded into tropical regions at a rate of 5-10 million hectares a year, negatively impacting the planet’s natural carbon stores and its biodiversity, while only expanding cropland by 3% after factoring in losses due to urban expansion. (Foley, 62) Many of the conventional forms of agricultural

expansion cause the erosion of the biodiversity of both the flora and fauna of a natural ecosystem.

The current system is based on eliminating variety and centralizing production putting food security at risk by reducing the resilience of the system. In the natural ecosystem variety reduces resource competition and if one species falters, another replaces it in the system, eliminating the risk of stress or collapse of the greater system. As we eradicate biodiversity we eliminate the ability for one species to replace another without a significant disruption to the system. Any breakdown or failure in the system has immediate and potentially devastating consequences especially in the case of a major food staple with minimal alternatives. The loss of genetic diversity is a huge concern for global food security and the resilience of the food system as a whole.

This trend is changing with education and an informed public pushing for environmental protection.

Signals of Change:

- According to the World Resource Institute (WRI) between 1903 and 1983 the varieties of thirteen common vegetables held at the US National Seed Storage Laboratory at Colorado State University declined by between 82.7 percent and 97.8 percent. (Harrison, 58) Many of the varieties listed by the USDA in 1903 are now extinct. (Harrison and Pearce) (See fig12)

Table 3. Reduction of Diversity in Fruits and Vegetables, 1903 to 1983 Vegetable	Taxonomic Name	Number in 1903	Number in 1983	Loss (Percent)
Asparagus	*Asparagus officinalis*	46	1	97.8
Bean	*Phaseolus vulgaris*	578	32	94.5
Beet	*Beta vulgaris*	288	17	94.1
Carrot	*Daucus carota*	287	21	92.7
Leek	*Allium ampeloprasum*	39	5	87.2
Lettuce	*Lactuca sativa*	487	36	92.8
Onion	*Allium cepa*	357	21	94.1
Parsnip	*Pastinaca sativa*	75	5	93.3
Pea	*Pisum sativum*	408	25	93.9
Radish	*Raphanus sativus*	463	27	94.2
Spinach	*Spinacia oleracea*	109	7	93.6
Squash	*Cucurbita spp.*	341	40	88.3
Turnip	*Brassica rapa*	237	24	89.9
Source: Carry Flower, and Pat Mooney. 1990. *The Threatened Gene -- Food, Politics, and the Loss of Genetic Diversity.*Cambridge: The Luthworth Press; World Resources Institute (1997).				

Figure 12: Reduction of Diversity in Fruits and Vegetables, 1903 to 1983

- Of the 7,000 varieties of apples grown in the US between 1804 and 1904 only fourteen percent are still under cultivation and of the 2,683 pear varieties only 12 percent are available today. (The Environmental Benefits of Well-Managed Farmland, Center for Agriculture in the Environment, American Farmland Trust, DeKalb, Illinois. Center for Agriculture in the Environment Working Paper: Number 2005-01. March 2005.)
- "Between 1982 and 1997 America converted approximately 25 million acres (39,000 square miles) of rural land, forests, rangeland, pastures, cropland and wet land (to create) subdivisions, freeways, factories, strip malls, airports and the like" (Camarota, Beck, and Kolankiewicz)
- In a study published in the journal PLOS ONE, scientists at the University of Maryland link pesticides and fungicides to Colony Collapse Disorder (CCD) that has decimated the global bee population wiping out an estimated 10 million bee hives in the US alone over the past six years. (Woody)
- Hypoxic Dead Zones around the world have increased from 49 in the 1960's to over 400 today, eliminating aquatic life in their wake. (Perlman)

- According to an FAO report 75% of the world's agricultural biodiversity was lost in the 20th Century due to the shift to industrial agribusiness. (De la Salle and Holland)

Counter Trend (s): Return to the Past and the restoration of Heirloom varieties

Trend: The Rising True Cost of Food social/economic/environmental

Description:

The pricing and global distribution of food is no longer based solely on supply and demand: governments, global corporations, lobbyists, politics and environmental impacts all play a part.

There are a number of aspects that are inextricably tied to the cost of food; first is the social cost of healthcare associated with the lack of access to healthy, nutritious affordable food; the second is the financial cost of food itself the third is the environmental cost of production, distribution and waste management.

In recent years many public health organizations identified food security as a major contributor to poor health and the cost of healthcare. The lack of healthy food means poor nutrition a major contributing factor to many health issues including obesity, diabetes, hypertension and cardiovascular heart disease. (Heart and Stroke Foundation of Canada) Medical research has demonstrated that the connections between food and health have become undeniable proving that we need to reduce the reliance on an industrial food system that has made non-nutritious food the cheapest and most easily available. (Leeder) This is due in part to massive government subsidies that promote the unsustainable farming of crops and livestock that would otherwise not be viable such as corn and beef. According to Wayne Roberts, a Toronto food policy writer, in 2008 there were no programs to support small-scale organic farming of fruit and vegetable and government trade policies undermined their uptake by importing cheap foreign products. (Walker) This hasn't changed much over the years.

The higher cost of fossil fuel and its pervasive use in agriculture is resulting in increasing costs for food production and constant price increases at the market in order to maintain profit margins. Canadian food costs rose 13.8% between 1997 and 2003. (Seccombe) Improved supply chain efficiencies have helped to mitigate price increases in the past,

but where do we go from here? As the cost of pumping water, applying fertilizer and transporting production go up so does the cost of food, often making healthy food unattainable by the poor.

The awareness of the environmental cost of the current agricultural system became more apparent at the end of the 20th Century when environmental problems became global in scale and could no longer be ignored. However, food in Canada remains relatively inexpensive because we don't pay the true cost of production at the point of purchase. External costs associated with production (including environmental and health related costs) are rarely calculated into the purchase price, which also dose not include the cost of government subsidies. This is changing due in part to the development of metrics like Mathis Wackernagel's "Ecological Footprint" an ecological resource accounting tool.

The trend of the increasing cost of food is going to continue and we will need a robust, resilient local food system if we are to mitigate the effect of global food shortages and fluctuations in the future.

Signals of Change:

- In 2008, riots broke out around the world protesting annual price increases of up to 130% for wheat, 87% for soy, 74% for rice and 31% for corn. (Ladner)
- In 2009, food was the third largest household expense in Canada after shelter and transportation. (Roukhkian)
- According to the Canadian Diabetic Association, food related issues associated with diabetes alone could cost Canadians $17 billion by 2020. (Ladner)
- The Toronto Food Policy Council was established in 1991 as a subcommittee of the Toronto Board of Health because access to healthier food can reduce health costs borne by the city. It has been instrumental in major policy changes including Toronto's Food Strategy, Environmental Plan and Food Charter to name a few. (The Toronto Food Policy Council website)
- The true cost of food is clearly articulated to the public through the publication of books like Raj Patel's The Value of Nothing (Patel)
- The development of quantitative metrics like the Ecological Footprint developed by William Rees and Mathis Wackernagel, provide an accounting tool to

determine the environmental impact and cost of our activities on the natural environment and the services they provide.

Counter Trend (s): Cheap Food (High calorie, highly processed foods)
People with low-incomes or on assistance are forced to live off high fat, sugar and sodium laden processed food because it's what they can afford. These high calorie convenience foods began to fill supermarket shelves in the 1990's as food production became more global. (McKeown) This shift in diet has a profoundly negative effect on public health, causing widespread obesity and is linked to diabetes, cardiovascular disease and certain types of cancer.

Trend: The Rise of Food Insecurity & The Non-profit social/economic/political
Description:
As Toronto increases in size, the number of low-income residences also increases, and as a result, the number of assistance programs has also increased to help minimize the number of marginalized individuals without access to fresh, healthy, culturally appropriate food.

Non-profits such as the Stop Community Food Center and FoodShare provide assistance and education on food nutrition through community garden programs, community kitchens and food box programs that help people understand how to grow and prepare healthy food, all while providing a sense of community and belonging.

As the population rises and density in the city increases, the number of people requiring assistance in accessing food is expected to multiply.

Food Banks
"Food banks didn't exist in Canada until 1981; they were introduced as a short-term solution to a hunger emergency" however by 2010, 80,000 Canadians a month used a food bank for the first time. (Ladner, 199) In 2012 there were 1,123,500 visits to Daily Food Banks in the GTA alone, up 18% from 2008. (2012 Profile of Hunger in the GTA: Who's hungry faces of hunger) This number only refers to visits to the Daily Bread Food Bank member agencies and does not include meal programs or non-Daily Bread affiliated organizations. Other charitable food programs serve an estimated 128,000 meals/snacks a week in Toronto. (Toward a healthy food system, 9)

A 2012 study supported by the Canadian Institute of Health Research, "Household Food Insecurity in Canada" estimated that four million people in Canada experience some level of food insecurity. (Walker) According to the 2012 Daily Bread Food Bank report, the Profile of Hunger in The GTA "for every one person who comes to a food bank there is at least one other person who cannot afford food and is struggling with hunger that does not come." (2012 Profile of Hunger in the GTA: Who's hungry faces of hunger, 10) The report lists stigma and pride as primary barriers to food bank use and a lack of income as the main driver.

Signals of Change:

- According to the latest Canadian Community Health Survey, 11% of Canadian households with children and 50% of the lowest income group are food insecure (Ladner, 99)
- The Stop Community Food Center was established in 1982, and is one of the country's oldest food banks; it changed its name to the Stop Community Food Center in 2001.
- Established in 1985, FoodShare, based in Toronto, is Canada's largest food security organization.
- Food Forward is a registered non-profit formed in 2010 focusing on promoting local food and food jobs in the city of Toronto. The organization provides a list of certified commercial kitchens that can be rented by small producers to create value added products without the expense of owning equipment or permanent space. (http://pushforward.com)
- Sustain Ontario was launched in 2009, a project of Tides Canada Initiatives (TCI) led by the Metcalf Foundation, working to transform Ontario's food system through education, advocacy and policy development. "Sustain Ontario takes a collaborative approach to research, policy development, and action by addressing the intersecting issues related to healthy food and local sustainable agriculture." (http://www.sustainontario.com)
- Food bank use in Toronto has increased more than 79% since 1995, in 2009 alone following the economic market crash in 2008, food bank use in Ontario increased by 19%. (Ladner, 199)
- According to Raj Patel, 1 in 6 people in the United States, 50 million citizens are food insecure. (Patel, 2013)

Counter Trend (s): Cheap Processed Food

Trend: Declining Nutritional Health social/economic

Description:

The current food system is predicated on the mass production of cheap calories, breeding the nutrition out of food in favor of features driven by cosmetics or ability to travel long distances well. As discussed earlier in the paper today many of our foods have less nutritional value (see Public Health Concerns page 50) than in the past and more chemicals, hormones and preservatives in an attempt to produce food that has a longer shelf life.

If installed on the large-scale, rooftop agriculture has the capability to improve a community's health by providing access to healthy fresh nutritious food while providing a number of environmental and economic benefits. Better access to healthy food improves overall health, potentially reducing strain on the health care system.

Signals of Change:

- The United States introduction of the Healthy, Hunger Free Kids Act in 2010, "aimed to improve school meals, supporting farmers through Farm to School Programs, address skyrocketing obesity rates, and feed more hungry children." (Ladner, 242)
- Food related health issues associated with diabetes alone could cost Canadians $17 billion by 2020 according to the Canadian Diabetes Association (Ladner)
- 70% of Torontonians consume less than 50% of the daily fruit and vegetables recommended by Canada's food guide. (The State of Toronto's Food)
- Statistics Canada found that 26% of children aged 6-11, 28% of teenagers and 61% of adults are overweight or obese. (Ladner)
- In 2012 more than 2 billion people globally face health risks from undernourishment while 1.5 billion suffer from obesity. Both groups face serous health risks. (Quarter of the world food)
- The report, '$11 Trillion Reward: how simple dietary changes can save money and lives, and how we get there', produced by the Union of Concerned Scientists (UCS) in August 2013, discusses the virtues of a healthier diet that includes more

fruits and vegetables. The report states that cardiovascular disease is responsible for 750,000 deaths in the US annually at a medical cost of approximately $11 trillion dollars; increasing fruits and vegetables by one portion a day would save more than $2.7 trillion. (O'Hara) Report -.

- In 2013 the Center for Disease Control (CDC) in the United States estimated that there were over 76 million cases of food bourn illness a year causing 325,00 hospitalizations and 5,000 deaths in the US alone (Couric)

Counter Trend (s): Increased use of Supplements and a Return to Organics

Trend: Nature Goes from Niche to Mainstream value

Description:

This trend is based on the environmental movement and the social understanding of the value of ecosystems as providers of valuable services. There is a societal shift toward environmental consciousness in the West, valuing natural and financial capital equally. The ever-growing understanding that ecological debts must be paid through the restoration of ecosystems is brought to light through better understanding of environmental impact and humanity's contributions to them. This shift is evidenced by a number of metrics and certification programs representing a shift in value.

Signals of Change:

- Lobbying to reduce packaging
- Adoption of government policies around environmental protection such as the Toronto Green Roof Bylaw in 2010
- Through the expansion of Corporate Social Responsibility programs (CSR) projects are increasingly designed to serve multiple needs and deliver more holistic value from an economic, social and ecological perspective.
- The adoption of building codes that address environmental concerns such as LEED Certification
- The success of Certification programs for example:
    - Local (LFP)
    - Certified Organic
    - Fair Trade

    - The Marine Stewardship Council certification program for sustainable seafood choices
- War on Garbage, the introduction of waste and organic recycling through programs such as Toronto's Green Bin Recycling program
- The awareness of environmental footprints and metrics as a result of the development of Apps for smart devices to inform the public
- Access to information on labels including "grown close to home" "organic" and "Ontario Grown"

Counter Trend (s): Suburbanization and Overconsumption

Trend: Tracking Climate Change Volatility environmental/value

Description:

Metrics indicate that agriculture is collectively the largest single source of GHG emissions, accounting for about 35% of the carbon dioxide, methane, and nitrous gas we release into the atmosphere. (Foley) Gas passed by farm animals along with the methane created from decaying food in landfills is a major contributor to GHG. A study by a UK agency calculated that if the country's edible food waste were eliminated from the waste stream the CO2 impact would be the equivalent of removing 25% of the cars from the road. (Ladner) According to the Organization for Economic Co-operation and Development (OECD) cities consume up to 80% of the world's energy production and account for roughly equivalent shares of global CO2 emissions. (www.oecd.org)

Signals of Change:

- Al Gore increased public awareness of global warming with the release of An Inconvenient Truth in 2006, directed by Davis Guggenheim.
- In the summer of 2012 more than 60% of the USA is affected by the worst drought in 50 years, by mid August 221,000 square miles experience exceptional drought conditions, a land mass the size of the state of California. (Archbald)
- Global Toronto reports massive flooding south of Barrie, wiping out farms in Bradford Ontario estimating the damage to farmers at over a million dollars. (The Morning Show, June 18, 2013)
- According to Shane Smith, of Vice, "The past decade was the hottest in recorded history" resulting in rising sea levels and changes to precipitation patterns.

- Carbon emissions in Canada's agriculture sector have increased by 21% between 1990 and 2006.
- According to Chris Scoll, Chief Meteorologist reporting for the Weather Network on August 4, 2013, Goderich Ontario on Lake Huron had a daytime high temperature of 18.5 degrees C while Kuglulktuk Nunavut on the Arctic Ocean reached a record breaking high of 29.8 degrees C. (The Weather Network, August 4, 2013)
- As mentioned earlier in the paper 'food miles' are the source of a large number of studies trying to track global GHG emissions.
- The National Resources Defense Council tracks the GHG emissions, pollution, air quality and health impacts of the six top imported products into California based on the number of miles traveled and concludes that the imports caused 45 times more pollution than local or regional transportation. (National Resource Defense Council. (Nov. 2007)

Counter Trend (s): Climate Change Denial

Trend: The industrialization and Chemicalization of Food technology

Description:

During the last century, agriculture has been characterized by enhanced productivity through the use of synthetic fertilizers and pesticides, selective breeding, genetic manipulation, increased pollution, and the substitution of labour for mechanization. Since the industrial revolution and in particular since WW II, farms have gone from small-scale family operations to large industrial agri-business operations. Based on the efficiency of the industrial model, major actors in the food production arena become national or multi-national conglomerates. Monoculture farming, the use of chemicals and the standardization of production are the outcome of the shift toward the efficiency of the industrial model. The use of artificial chemicals has dramatically increased production but at a major cost to the environment.

Signals of Change:

- The Green Revolution, between 1961 and 1998 the caloric intake in the developing world increase by 38% due to advances in technology and the use of synthetic fertilizers and pesticides. (Harrison)

- Between 1961 and 1998 the use of nitrogenous and phosphate fertilizers increase by 638% and 203%. (International Fertilizer Association Statistics, www.fertilizer.org/homepage/STATISTICS)
- Production of pesticides increases by 854% (UNEP GEO-3 Data Set. www.unep.org/geo/geo3.asp)
- Between 1960 and 2000 production of rice, maize and wheat grew between 66-88% in Asian and Latin America due to new high yield varieties, chemical fertilizers and advances in crop management techniques. (Sanchez)
- The use of DDT (a chemical developed during the war as a major component in Agent Orange and banned in the US in 1972 due to toxicity) was introduced to farming in1939, marking the beginning of agricultures heavy use of chemicals and pesticides. (Xtimeline)
- Monsanto, a multinational agriculture biotechnology corporation becomes the world's leading producer of genetically engineered seed and chemical herbicides. (http://en.wikipedia.org/wiki/Monsanto)
- The use of hormones and antibiotics in our food system enable the economic production of livestock on the large scale. (EatRight Ontario)
- Based on dates from the U.S. department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA), between 2001 and 2010 herbicide use in the US alone increased by 26%, or a staggering 37 million kilograms bringing the total herbicide use in the US to 142.3 million kilograms a year. (Glasser)
- The Food & Water Watch report: Superweeds: How Biotech Crops Bolster the Pesticide Industry, reveals increases in herbicide and pesticide use following the adoption of GE crops demonstrating an interdependence between biotechnology and their use. (Glasser)

Counter Trend (s): The organic and local food movements

Trend: Bigger is Better: If You Want It We Have It economic

Description:

The philosophy of 'bigger is better' or "supersize" as a trend is applicable to both the farm production and retail aspect of the current food system. In both cases fewer people are in control of larger portions of the market share in essence eliminating competition and resilience from the system.

From the farm perspective, industrial agriculture has resulted in a decline in the family farm in favor of large-scale agri-business focused on monoculture farming, standardization and efficiency. Between 1996 and 2006 farm acreage in Canada increases but the number of farms declines by more than 17% totaling a loss of 47,000 farms nationally. (McKeown)

The grocery store is the primary gateway and the norm for most Canadians to access food. As a result of the rise of the suburb and the proliferation of the car, today's grocery stores are larger than ever. Driven by the convenience of one stop shopping and a desire to command a larger market share, grocery stores are expanding their offerings to include whatever you need whenever you need it. The demand for food access and the growing food market has attracted new entrants and encouraged non-traditional food retailers to enter the market with hybrid stores. Groceries are now available anywhere from department stores to gas stations.

In both cases, producers and retailers are leveraging their corporate size to provide more offerings or obtain better pricing through the scale of economy. This results in pressure on smaller operations to compete, and when they can't it often results in their elimination from the market and a decrease is diversity.

This trend is slowly changing as an increased number of niche or specialty markets begin to appear in the marketplace.

Signals of Change:

- The development of large transnational agri-business
- The five top food retailers in Canada (Loblaws, Sobeys, Metro, Walmart and Costco) account for approximately 80% of all food sales in Canada. (Roukhkian)
- The average Canadian grocery store carries 30-40 thousand products (Elton)
- The average American grocery store carries as many as 50 thousand products (Ladner)
- Loblaws unveils $12.4 Billion dollar deal to buy Shoppers Drug Mart merging Canada's largest grocery and pharmacy chains in a response to increased competition from US chains like Target, Walmart and Costco that already sell a broad range of products. (CTV News.ca, July 15, 2013)

- In June 2013, Sobeys acquires Safeway's Canadian assets including 199 pharmacies. (CTV News.ca, July 15, 2013)
- Large chains like Walmart are entering the grocery sector and taking market share resulting in traditional grocers branching out to include household goods to compete.
- The number of big box stores proliferates in the urban landscape.
- "Multinational agriculture corporations currently control over 40 percent of the world's food trade." (Kwong, 28)

Counter Trend (s): The proliferation of small niche market shops including bakeries, organic butchers etc.

Trend: Convenience is King: the fast food invasion social/economic

Description:

Convenience is King signals the proliferation of fast food establishments and packaged prepared foods in grocery stores. Between working long hours and the commute to and from work, people are looking for convenient, fast alternatives to cooking in order to spend more time doing other things.

In western society, provisioning of food has been downloaded from the family to the grocery store or super market resulting in a disconnection between the grower and producer of food and the consumer. Grocery stores are the main gateway to food for most westerners. In Canada 77% of all food expenditures are purchased directly from retail stores. (Roukhkian)

As of the 1990's "convenience foods" have filled supermarket shelves and the supermarkets themselves have continued to expand to provide one stop shopping where patrons get everything they need under one roof. This convenience influences consumer choice because it is viewed as fast, easy and efficient. The introduction of ready made fresh or frozen prepared meals available at grocery stores as well as the proliferation of fast food and restaurant delivery are evidence of this trend compounded by the decline of the family meal in favor of grabbing something on the go. Consumers are looking for easy-to-prepare options, and producers are looking to extend shelf life and eliminate waste in the processing stream. Consumers in general trust in the system to provide

healthy nutritious products based on appropriate standards however this is not always the case; often nutritional value is compromised at the expense of convenience.

Signals of Change:

- Loblaws unveils $12.4 billion deal to buy Shoppers Drug Mart. The deal merges Canada's largest grocery and pharmacy chains. (http://www.ctvnews.ca/business/loblaw-unveils-12-4b-deal-to-buy-shoppers-drug-mart-1.1367346)
- In June 2013, Sobeys acquired Safeway's Canadian assets including 199 Pharmacies. (http://www.ctvnews.ca/business/loblaw-unveils-12-4b-deal-to-buy-shoppers-drug-mart-1.1367346)
- McDonalds first Canadian restaurant opened in 1967 and by 2007 it had expanded to 1,400 stores. (http://en.wikipedia.org/wiki/McDonald's_Canada)
- Tim Horton's surpasses McDonalds as the largest fast food chain in Canada in 2005. (http://en.wikipedia.org/wiki/McDonald's_Canada)
- SupperWorks, "The best place to prepare delicious home cooking without the planning, shopping, slicing or clean up," started in Seattle Washington in 2002 and expanded to over 1,400 stores in the United States and Canada by 2007. Providing a convenient way to provide healthier choices than fast food including delivery. (http://supperworks.com)
- According to Mark McEwan of McEwan's Market in Toronto prepared foods at his grocery store are the biggest selling items compared to uncooked ingredients. (Kwong)
- The average American dines out five times a week. (Couric)

Counter Trend (s): The Slow Food Movement

Trend: Circumventing Seasonality: I Want it and I Want it Now social/economic/value
Description:
Grocery stores circumvent seasonality, providing anything you want when you want it offering a season-less selection of produce from around the globe.

Canada imports food from 190 countries to ensure year round availability of the products we desire. (Ladner) Large food retailers leverage their corporate size to obtain better

pricing from suppliers, resulting in pressure on smaller operations to compete often resulting in their closure. Offering out of season-imported products and providing consistent availability are strategies used by retailers to gain a larger share of the market and garner customer loyalty. “Food once considered luxuries or specialty items are now staples branded by every supermarket chain, while imported delicacies fill entire grocery aisles.” (Lister, 150)

Sixty percent of all produce consumed in Toronto is imported from the United States at an annual cost of $172 million. Much of this could be grown locally and the cost does not include imports from other countries.

Another aspect of this trend is that grocery stores move to 24-hour access allowing patrons to shop day or night.

Signals of Change:

- The Ontario Food Terminal opens in 1954 facilitating the long-distance trade in food. Over 2.2 million kilograms of global produce pass through the terminal every day. (Elton)
- BlogTO provides a list of Toronto’s 24-hour grocery stores. (Ohi)
- “Consumers in North America are generally complacent to the idea that they can have what they want, when they want it so long as the economic factors limited to business transactions are balanced.” (Tilley, Mitchell, Kwong and Norman)
- In 1960 almost all of Toronto’s food came from within its own foodshed, today we import more than 60% from the United States alone, with two thirds of it arriving when our season is over. (Lister)

Counter Trend (s): A Return to The Past, Local Seasonal Diets, Slow Food

Trend: Waste Not Want Not social/environmental/value

Description:

Food waste represents an unnecessary burden on vulnerable natural resources such as water, energy and land while adding to environmental degradation and pollution without providing any benefit and it occurs in all aspects of food production. It is estimated that 25% of the world’s fresh water is used to grow wasted food adding pressure on one of the

world's most vulnerable natural resources. (Crabtree) In the United States alone, food waste represents the loss of 40 trillion litres of water a year, and it is estimated that over 30% of the fruits and vegetables in North America are discarded before harvesting based on cosmetics alone. (Suzuki)

> "Today we produce about four billion metric tones of food per annum. Yet due to poor practices in harvesting, storage and transportation, as well as market and consumer wastage, it is estimated that 30-50% (or 1.2-2 billion tones) of all food produced never reaches a human stomach. Furthermore, this figure does not reflect the fact that large amounts of land, energy, fertilizer and water have also been lost in the production of foodstuff which simply end up as waste."
>
> (Global Food; Waste Not Want Not (IMECHE), 2)

> "A [survey] in India showed that at least 40% of all fruit and vegetables are lost between grower and consumer due to a lack of refrigerated transport, poor roads, inclement weather and corruption." (Plumer)

Inefficient and out-dated storage and processing facilities around the world are responsible for losses in many cases. Grain losses for example can range from .75% in countries like Australia to 16% in Pakistan. Losses in Pakistan alone represent 3.2 million tones annually. (Plumer)

In many less developed nations in the hotter regions of the world, post-harvest losses of fruit and vegetables can be as high as 50% and if you have been to a grocery store lately you will see that much of the imports still come from these countries, often leaving their own populations exposed to hunger. (Plumer)

"A Canadian study in 2007 estimated that 38% of food available for retail sale was wasted." (Ladner, 134)

Consumer behaviour adds to waste with approximately 30% of all unprepared food purchases in the US going to waste before every reaching the plate at a cost of about $48 billion dollars. (Suzuki, What you can do) This is often avoidable and is the result of excessive purchasing. According to Ladner, if as little as 5% of the edible food was recovered it could feed 4 million Americans for a day. (Ladner, 134)

> "In Toronto, single family households discard about 275 kilograms of food waste each year (although [the] city's expanding composting program captures about

> 75% of that). That means one in four food purchases still end up in the garbage. (Toronto taxpayers spend nearly $10 million a year getting rid of food waste that's not composted)." (Suzuki http://www.davidsuzuki.org/what-you-can-do/food-and-our-planet/help-end-food-waste)

According to Environment Canada, food decomposing in landfills contributes 20% of Canada's methane, a major contributor to GHG emissions and global warming. There are some that argue that methane from decomposing food can be used to generate biogas, but this discussion is outside the scope of this paper.

> "One UK agency calculated that if we all stopped wasting food that could be eaten, the CO2 impact would be the equivalent of taking 1 out of every 4 cars off the road." (Ladner, 134)

Composting reduces the waste that ends up in landfills by creating a closed loop system in the garden reclaiming production waste as a garden resource, contributing to soil fertility and the reduction of chemical fertilizers. Composting of imported food doesn't allow for the nutrients to go back into the soil that produced it. Adding organic material to the soil increases soil water retention, minimizing excess use of water resources while also minimizing runoff that would otherwise be added to the city's wastewater management infrastructure ultimately reducing costs to the city.

One third to half of all household waste could be composted back into nutrient rich soil. Milwaukee's Growing Power composts more than 180,000 pounds of waste a week at its 2.5 acre urban farm creating nutritious garden compost to increase soil fertility and removing 10 million pounds of food waste from landfills annually. (Grow TO, 17) With a population of 596,000 Milwaukee is approximately 4.7 times smaller than Toronto therefore Toronto could potentially remove up to 47 million pounds of food waste from landfills by improving its composting system.

With a large number of composters on the market the key is finding the appropriate size and method for your space. Composters are divided into two primary groups: layering systems, or vermiculture systems that incorporate the use of worms to accelerate the decomposition of organic waste.

In order to mitigate hunger in poor or marginalized communities' local food banks and soup kitchens utilize food that would otherwise be added to the waste stream. The impact on the greater system however is minimal.

Possible solutions include investing in improved storage facilities and better harvesting technologies as well as societal and political changes designed to cut down on global waste. Changing social behaviour around food choices could have huge impacts regarding food rejected for cosmetic reasons alone. Efficiencies in these areas could be the means to feed more people without the need to increase production while reducing environmental costs.

Local rooftop production has the capacity to address a number of these issues through organic growing practices, shorter delivery and travel times, and the recycling of waste on site.

Signals of Change:

- CropMobster, (Supporting Local Producers, Preventing Food Waste & Feeding People) is an online web-based organization connecting farmers, non-profits and consumers, while promoting the 'visibility" of agriculture and minimizing food waste at the production level. They connect farmers with other stakeholders and find buyers and new markets for products that would otherwise go to waste. (Jykka)
- The 2013, Report on Food Waste by The Institute of Mechanical Engineers, estimated that we waste up to 50% of all global food production (Report on Food Waste. (January 2013))
- Entire crops or portions of crops are rejected prior to harvest based on physical appearance alone, resulting in up to 30% of the United Kingdom's vegetable crop never being harvested. (Plumer)
- Poor storage and shipping of perishable products can result in post harvest losses of up to 50%. (Plumer)

Counter Trend (s): Composting and Second Harvest programs

Trend: Shifting Consumer Behavior social/value

Description:

Consumption habits are based on social constructions and value judgements that may or may not be based on an adequate understanding of the true nature of food's nutritional, environmental or social implications. Large-scale agribusiness and food lobbyists greatly influence consumption habits through marketing and product placement. Price plays a pivotal role in purchasing and the perception of good value. In terms of price, the economy of scale is a huge factor, allowing large corporations to control the price in the market often allowing them to sell for less because of volume discounts.

According to a 2010 report on the Canadian Food Retail Market by the Swiss Business Hub Canada, the food retail sector in Canada is worth an estimated $84 billion and is expected to grow by 1.4% reaching $100 Billion by the end of 2014. (Roukhkian, 5) With 62% of the country's population, Ontario and Quebec represent more than 50% of all food retail sales and operate 60% of the nation's stores. (Roukhkian, 5) The report identifies the chain store as the purchase point for 70% of the market share for all food sales in Ontario. (Roukhkian, 14)

In Canada, "in 2009, food was the third largest household expenditure after shelter and transportation" (Roukhkian, 11) More than 73% of Canadians shop at least once a week and "Statistics Canada reports that food purchases directly from retail stores comprise 77% of all food expenditures in Canada" (Roukhkian, 12)

Grocery stores circumvent seasonality providing anything you want, when you want it providing a season-less selection of produce. To be more sustainable we need to change our purchasing habits to include more sustainably grown local, seasonal products. "Local food has replaced organic food as the fasted growing sector of the retail food market" (Ladner, 22)

Marketing encourages overconsumption and labeling in most cases does not provide enough information for consumers to make informed choices when it comes to the "true cost" of goods including all external environmental and social debits incurred in the growth, production and distribution of a product. The consumer is "implicitly forced to believe the price incorporates a fair reflection of the costs" (Tilley, Mitchell, Kwong and

Norman, 6) Processed foods are comprised of global components from around the world making it difficult to track sources.

Today the most influential drivers of nutritious food choices based on percentages provided by a 2008 survey are as follows:

- Low trans fat content (80%)
- Made with whole grain (78%)
- Low sugar content (72%)
- Low salt or sodium (71%)
- Country of origin (50%)

Tracking Nutrition Trends Survey 2008: Source CCFN 2008

In terms of behaviour, a study on grocery store visiting patterns by Environics World of Shopper identified that 25% of trips to the grocery store are general stocking up trips while 56% are quick trips, 11% are emergency trips and 7% are for personal care. (Roukhkian, 12)

Overconsumption (in the west) is one of the biggest concerns of consumer behaviour today and a major contributor to declining health as well as the health of the planet with regard to the amount of waste generated. The impact of waste was discussed in the earlier trend, Waste Not Want Not.

Trends in consumer behaviour in the retail food industry include:

- Aging population - “Spend disproportionately more on premium and gourmet products and demand healthier food choices” (Garen, 21)
- Consumer behaviour is driven in part by smaller household size. According to the Canadian Census one-two member households increased from 57% in 2001 to 62% in 2009 resulting in a move to smaller retail portions for food and increased packaging. (Roukhkian, 21)

Signals of Change:

- I believe that a loss of trust in the food system has resulted in a number of certification programs including Organic, Fair Trade, and Local Food Plus certification
- The Local Food Plus certification and brand making it easier for consumers to identify local and ecologically sustainable products. Through education and

awareness LFP found that between 2007 and 2008 customers interested in buying sustainable local food rose 92% (Elton, 148)

- In 2008 Loblaw introduced, “grown close to home” due primarily to pressure from consumers and produce sales increase by 12% (Ladner, 23)
- In 2009, ten Ontario Grocers abandon their Sobeys affiliation in order to meet their customers’ demands for local meat. (Elton, 148)
- 79% of the Torontonians surveyed in a telephone survey agreed with the statement, “I prefer to buy locally grown fruits, vegetables and meats” and “almost everyone -97% - agree that supermarkets should create dedicated and visible sections to make it more convenient to buy locally grown food.” (Ladner, 23)
- “Local food has replaced organic food as the fastest growing sector of the retail food market” (Ladner, 22)
- Growing consumer demand for fresh, local, organic foods indicates a shift in consumer behavior.

Counter Trend (s):

Trend: The Local Food Revolution social/value

Description:

“Within the city, new forms and spaces of food production and distribution test just how local food can get: from rooftop gardens and backyard chicken coops to urban farmer’s markets in the condo parking lot.” (McCammon, Mitchell, and Veale)

The local food movement is largely a reaction against the industrialization and chemicalization of the food we eat. As more consumers are demanding local products education and demand are changing the system, and mainstream grocery stores are beginning to brand local food separately.

Local Food Plus, a Toronto based organization established in 2005, found that between 2007 and 2008 customers interested in buying local sustainable food rose 92% resulting in large chains changing their purchasing habits based on consumer demand. Local Food Plus is trying to create supply chains to link local farmers with the people of Toronto creating a local food system by linking farmers with institutions that buy local food. In

Toronto they work closely with the Local Food Procurement Policy. Through a number of metrics and guidelines the organization has created a certification brand for local and sustainable food (LFP) that define local as products that have been produced, processed, and distributed within the province in which they are consumed. (http://www.localfoodplus.ca) Products can be purchased in Toronto with the LFP Logo on the label; the logo helps inform purchasers making it easy to identify products. The criteria for the label are based on local production using ecologically sustainable methods of production as standards. To date over 200 local farmers and processors partnered with almost half as many "retailers, restaurants, caterers, distributors, and institutions" have been certified by LFP. (http://www.localfoodplus.ca) In 2009 LFP received funding from World Wildlife Fund (WWF) to test the program in other provinces. It is important to state that all local food is equal, Ontario's winter greenhouse trend may be local but has a huge GHG footprint. According to De la Salle, statistics show that the energy required to heat a greenhouse in Canada to grow tomatoes in winter produces more GHG than importing field tomatoes from Mexico including all aspects of production including transportation.

There are a large number of factors driving the local food revolution. More and more people want to know where their food comes from and how it is grown, resulting in the high demand for community gardens and the conversion of front and back yards into productive garden spaces and edible landscapes.

Drivers include:

- Health concerns over chemical use and the increasing number of food contamination cases in the news such as ecoli, listeria and salmonella in everything from spinach and meat products to strawberries.
- Concerns over environmental impacts and sustainability as a result of a changing social culture that understands the concept of natural capital and the ecosystem as a provider of valuable services.
- The public understanding of the challenges and uncertainty faced by local farmers.
- Celebrity chefs are promoting local food on menus and TV programs across the country expounding on the virtues of local, organic products and the flavor and added nutrition they provide often providing recipes on line to promote local food and their "Farm to Fork" point of view.

Signals of Change:

- Toronto.com highlights 26 of the best farmers markets in Toronto in 2013. (Penny)
- There are 84 farmers markets and food festivals listed on the city of Toronto website for the summer of 2013, under the Toronto festivals and events calendar. (City of Toronto Website http://wx.toronto.ca/festevents.nsf/farmers+markets?openform)
- The number of farmers markets in the United States rose from 340 in 1970 to 7,864 in 2012. (O'Hara)
- Farmers markets are the number two-grocery source for 62% of Canadians. (Ladner)
- "Local food has replaced organic food as the fastest growing sector of the retail market." (Ladner, 22)
- There is a plethora of popular books on the subject including:
    - Peter Ladner's book The Urban Food Revolution, Changing the Way we Feed Cities (Ladner)
    - Sarah Elton's national bestseller, Locavore - the term Locavore was first coined in San Francisco in 2005 and was based on the realization of the true cost food. (Elton)
- In 2008 Loblaws introduces "grown close to home" and produce sales increased 12%. (Elton)
- "In July 2009, ten Ontario Grocers abandoned their Sobeys affiliation so they could meet their customer demand for local meats. Sobeys company policy, which stated that all meat sold in their stores be processed at a federally (vs provincially) inspected processor, had prevented the grocers from buying meat from nearby farms." (Elton, 148)
- The introduction of the Local Food Plus (LFP) certification programs in 2005 for locally and sustainably grown products. (Local Food Plus website, http://www.localfoodplus.ca)
- The popularity of the 100 Mile Diet and The Slow food Movement are evidence of the local food revolution.
- A number of celebrity chefs are shifting restaurant menus to focus on local, organic, free range, sustainable products following "farm to table', "snout to tail" or head to hoof" philosophies. Toronto's Lynn Crawford from Ruby Watchco

(D'Agostino and Edwards) and Carl Heinrich (http://www.torontolife.com/daily-dish/new-reviews/2012/11/15/review-richmond-station/) are prime local examples of this phenomenon.

- There are a large number of small local specialty shops popping up in Toronto promoting local, sustainable niche market products.
- The unprecedented growth of CSA programs in Toronto in the past ten years support the local food movement. A list of CSA's in and around Toronto is available from the Ontario CSA Directory. (The Ontario Community Supported Agriculture Directory, http://csafarms.ca)
- The popularity of YIMBY programs like the Neighborhood Farm established in 2012. (Hirsch)
- Toronto adopts the Local Food Procurement Policy in October 2008. (Toronto Local Food Procurement Policy and Implementation Plan)

Counter Trend (s): The Globalization of Food and Transnational Agribusiness

Trend: 21st -Century Policy and Planning: Promoting Urban Agriculture

social/political/value

Description:

In the past few decades' cities have begun to readdress policy and planning that includes food production in the city embracing urban agricultural practices including edible landscapes, community gardens and rooftop gardens after ignoring agricultural production in the city for over half a century.

Urban planners need to take their lead from LEED. Planners need to adapt to the current changes and challenges of the expanding global population and dwindling resources by going beyond sustainability to push for regenerative practices in city planning such as local food production and alternative water management practices. Rooftop agriculture has the capacity to address a number of these issues:

- Minimizing the heat island effect
- Storm water management
- Prevention of ecosystem encroachment
- Providing additional carbon sequestration
- Improving air quality in cities

- Improving access to food

Signals of Change:

- Toronto's Green Roof Policy implemented in December, 2009 (http://www.toronto.ca/legdocs/municode/1184_492.pdf)
- Toronto Food Policy Council (http://tfpc.to)
- Toronto's Local Food Procurement policy (http://www.toronto.ca/legdocs/mmis/2009/gm/bgrd/backgroundfile-24259.pdf)

Counter Trend (s):

Trend: New Business Models for 21st Century Food Production

economic/environmental

Description:

As uncertainty builds regarding food security and the reliability of the global food chain more cities are looking to provide more of their food from local sources. This is the driving force behind a number of new business models promoting local versus global food procurement, including the use of rooftop spaces for farming.

Hydroponic rooftop productions like that at Lufa Farms in Montreal is gaining traction as a way of producing substantial amounts of food within the city itself. According to Aalia Adam, a reporter for Global News, Lufa Farms is the world's first commercial rooftop greenhouse and is planning major expansions in the next few years. As more evidence-based data comes becomes available proving its production capacity it is sure to inspire rooftop expansion. Lufa Farms is already offering turnkey solutions to individuals or organizations looking to enter the urban agriculture market leveraging their expertise and success in the rooftop-farming arena.

In 2013, Chicago's the Plant used a Kickstarter campaign to raise $65,230 to fund a living foyer for their building's lobby raising more than they needed for the project. The Plant is a closed loop sustainable food production center supporting small net-zero craft food businesses and uses social media to keep the community involved. (http://www.plantchicago.com)

Other Models include:

- YIMBY programs
- Community Kitchen Programs (Providing access to certified kitchens for small scale producers to produce value added products without the expense of their own facilities)
- Community and senior centers providing growing space for stakeholders to participate in their own food security
- School Grow programs are providing food and social responsibility education to youth.
- Community Supported Agriculture (CSA) is engaging the community to share the risks faced by farmers
- Social media are being used more and more as a tool to link producers and consumers
- Farmers, processers, distributers and retailers are collaborating to create regional food value chains based on market demands (This is a relatively new concept to Canada and is still in development)

Signals of Change:

- Toronto introduces the "Farm Fresh Locator", an online interactive web-based map of Toronto's food shed (http://ontariofarmfresh.com/locator)
- Community Supported Agriculture (CSA) is on the rise and growing in popularity in North America. The first CSA's in North America began in 1986, and by 2012, that number surpassed 13,000. (http://en.wikipedia.org/wiki/Community-supported_agriculture)
- "Food Box" programs containing locally grown produce are on the rise. FoodShare's, Field to Table Good Food Box program delivers approximately 4,000 boxes of locally grown produce a month including produce from FoodShare's rooftop garden. (FoodShare.com)
- Local food procurement policies are being introduced in cities across the country
- Co-operative equipment sharing programs are increasing to help reduce the cost of farm operations by as much as 30% compared to ownership models (de la Salle)

- Urban Farming 2.0. The Internet has had a huge influence by increasing access to information, networking, and bringing buyers and sellers together more efficiently than ever before. (Ladner)
    - It has also helped perpetuate the YIMBY movement by connecting people with backyards with people looking for space
    - City Farmer, launched in 1994 provided online education on urban agriculture
    - Greenbeltfresh.ca connects producers with consumers and commercial buyers in Southern Ontario's Golden Horseshoe
    - Foodhub.org from Portland Oregon is like a Craig's list for regional food
    - Social media is also being used by groups like Crop Mobster to gather groups of individuals at designated locations to plant gardens (Ladner)
- The use of KickStarter to engage the public and raise funds for green initiatives like Chicago's the Plant is becoming commonplace. (http://www.plantchicago.com)

Counter Trend (s): A return to the Past

Trend: Agricultural Urbanism social/environment/value

Description:

Agricultural Urbanism is a term used by Janine de la Salle and Mark Holland in their book by the same name. In an attempt to reconnect people to food, agricultural urbanism converts under-utilized city spaces including rooftops into areas for food production in an attempt to address environmental, economic, educational and health related issues regarding access to food. This trend is in its infancy and is primarily focused on planning, policy and the development of a sustainable food system within the urban environment.

"Agricultural Urbanism is about providing opportunities to:

- Grow food
- Experience food
- Support local processing and distribution systems for food
- Plan in a wide array of wholesale, retail, and restaurant or food service opportunities and experiences
- Embed a rich tapestry of formal and informal learning opportunities around food
- Create a culture of celebrating food and those who make it
- Ensure that everyone in the community is fed

- Reduce food and agricultural waste"

Janine de la Salle & Mark Holland (32)

(See appendix E for an annotated list of The Ten Principles of Agricultural Urbanism)

Urban agricultural activities in Toronto are quite robust however most of what is currently happening is based on self-provisioning or the promotion of food security and health through community programming and non-profit organizations. As the commercial success of urban agriculture and its economic development potential become more public things are beginning to change yet commercial rooftop production currently remains untapped.

Signals of Change:

- The increased number of Torontonians actively participating in Community Gardens in the city
- The plethora of organizations in Toronto like FoodShare, The Stop Community Food Center and Evergreen Brickworks devoted to urban growing and education
- Toronto has made a number of policy changes recently to include urban agriculture driven by the Toronto Food Policy Council.
- Increased government, public and private support of urban agriculture projects in Toronto including the Toronto & Region Conservation Authority (TRCA) and organization like the Metcalf Foundation.

Counter Trend (s): Importation of Cheap Foreign Processed Food

Trend: Rooftop Food Production social/environmental/economic

Description:

At the end of the 20th Century rooftops are viewed as underutilized space and major contributors to negative environmental impacts affecting the health of cities. Barren rooftops contribute to the heat island effect, resulting in poor air quality and often have no means to control storm water run off, resulting in stress on city infrastructure and poor water quality in local watersheds.

As our cities grow larger and larger engulfing surrounding farmland people in urban centers are beginning to envision a new way to access food grown within the city itself.

Due to population density and the shade caused by buildings, access to land suitable for agriculture in the city has traditionally been a barrier to urban production.

According to Brown and Carter, agricultural green roofs are designed for four main purposes:

- Food Production
- Active Recreation
- Waste Reclamation (Compost and Storm-water)
- Education

(Hui, 2)

In a time of increasing pressure and uncertainty of the long term access to global markets rooftop agriculture has the potential to create a sustainable, resilient food system for the city of Toronto while addressing the environmental impacts of the city's expansion.

Signals of Change:

- Fairmont Royal York Hotel installed a 4,000 square foot rooftop garden in 1998 for use in its restaurants to promote local produce and provide its kitchens with the freshest ingredients including hard to find produce like Wasabi Arugula or Alpine strawberries. Restaurants all over the city and the country are embracing rooftop gardens. (Court)
- AccessPoint Alliance, part of Access Alliance – Multicultural Health and Community Services was the first Community Health Center in Ontario to install an intensive Green roof back in 2011. Covering an area of 6,500 square feet the garden is used as a launching pad for activities that bring together community development, environmental education and social health, engaging residents in environmental stewardship relevant to urban settings while promoting environmental education that makes the links with food security and social issues. The rooftop also houses a solar hot water collector, rain barrels and compost bins. (Personal Interview with Lara Mrosovsky, Health Promoter, Access Alliance Multicultural Health and Community Services)
- Non-Profits such as FoodShare use urban community and rooftop gardens to address issues regarding food security, environmental stewardship and education offering dozens of community programs. "By growing our own food we can reduce our ecological footprint and ensure that what we eat has the best

possible flavor and highest nutritional value." (http://www.foodshare.net/urban-agriculture)

- The University of Toronto's Sky Garden on the roof of the Galbraith Building is a student run initiative of the Urban Agriculture Society started in 2009. A project of the Food and Water Institute, it was expanded in 2010 through funding from a Live Green Toronto Grant and incorporates traditional and semi-hydroponic containers. All produce is donated with 90% going to the student union food bank and 10% to the volunteers. (Suzin and Liu and the Sky Garden website, http://www.foodandwaterinstitute.org/skygarden.html)
- Rooftop farms like Lufa Farms in Montreal, and Gotham Greens and Brooklyn Grange in New York are establishing themselves as success stories and going from niche to mainstream.
- Live Green Toronto and Ontario's Trillium Foundation promote rooftop food production through funding
- Use of rooftop farms in non-profit community centers, The Stop Community Food Center, FoodShare, AccessPoint Alliance –Multi Cultural Health and Community Services all use rooftop gardens as an education tool to engage stakeholders and promote community.
- Introduction of rooftop gardens for Food in the School Programs across the GTA. (Brown, Louise)

Counter Trend (s): Rooftop Competition

Trend: Rooftop Competition social/economic/technology

Description:

As we move into the 21 Century, urbanization is expected to increase, creating larger, denser cities resulting in a need to find alternative space for many human activities, including agricultural production, recreation and energy production. The rooftop will be increasingly seen as valuable space for everything from amenity space in luxury condos, to rooftop agriculture for commercial, educational, recreational and therapeutic purposes, to spaces to house green technology such as solar or wind farms for the production of alternative energy.

City policies like Toronto's Green Roof policy looks at the rooftop as a means to address environmental issues including the reduction of the city's heat island effect, and controlling wastewater management as the city expands beyond its current infrastructure capacity. The green roof has the potential to reduce stress on the energy grid during the hot months by cooling buildings during the heat of summer and insulating them during the winter. This is good for the city's bottom line. Green roofs themselves are not necessarily productive spaces. If converted to agricultural space they can provide a number of socio-economic values to the city as well as the environmental benefits. Rooftop agriculture itself is heavily tied to both architecture and urban ecology. LEED certification is directly linked to the environmental impacts of the built environment as a rating system for the design, construction, operation, and maintenance of green buildings. (http://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design)

As cities continue to expand the rooftop will be seen as the last frontier of untapped space within the city. Competition for this space comes in the form of alternative uses with the potential to increase revenues for both building owners (in the form of increased rental space) and the city (in the form of tax revenues).

Signals of Change:

- Leadership in Energy and Environmental Design (LEED) certification, established in 1998 by the U.S. Green Building Council (USGBC) to promote environmental responsibility and resource efficiency. (http://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design)
- Many buildings in Toronto like 401 Richmond, The Carrot Common and The Toronto YMCA to name a few have intensive rooftop gardens for use as amenity space for tenants. Upscale buildings like Toronto's Tiff building include rooftop terrace space for tenants as well.
- Rooftop amenity space on a number of buildings is being turned into profitable rooftop patio space. The Toronto Star lists the city's best rooftop patio pubs. (Korducki)
- Rooftops are also being used for research. AccessPoint Alliance is collaborating with the Vineland Research Institute researching the viability of growing non-native crops in demand in Ontario. (Mrosovsky)

- The Green Roof Innovation Testing Laboratory (Gritlab) is performing research on the roof of the John H Daniels Faculty of Architecture, Landscape and Design building. The goal is to investigate the environmental performance associated with “green & clean” technologies such as green roofs, green walls and photovoltaic arrays. (Gritlab website. http://grit.daniels.utoronto.ca)
- Toronto adopts its Environmental Plan in 2000 that includes green roofs as a strategy to address environmental issues affecting the city’s infrastructure and provide a cleaner, greener, healthier and more sustainable future for Toronto. (http://www.toronto.ca/council/environtf_clean_green.htm)
- Rooftop gardens like Lufa Farms in Montreal, and Gotham Greens and Brooklyn Grange in New York establish themselves as success stories and go from niche to mainstream through the publication of books like Eat Up by Lauren Mandel.
- In 2013 The Toronto District School Board (TDSB) in partnership with solar energy firm Potentia Solar Inc. began a three-year project to install solar panels on the roof of 311 schools in Toronto. This is the largest project of its kind in Canada. “Once installed, the panels will generate enough energy to power 4,500 homes each year.” (CBC News September 19, 2013 http://www.cbc.ca/news/canada/toronto/repairs-begin-on-32-schools-in-tdsb-solar-rooftop-plan-1.1861324)

Counter Trend (s): Rooftop Food Production

Trend: DIY Food Security social/economic

Description:

Driven by a decline in trust in the industrial food system and the corporate machines behind them, many people are looking to local or personal food production as a way of controlling what they eat.

In recent years the number of outbreaks of food borne illness such as ecoli, listeria or salmonella in the news have caused consumers concerns over food safety, where their food comes from, and how it is handled. 98% of the food imported into Canada is never inspected and food related illnesses result in a loss of consumer confidence when products can’t easily be tracked. (Ladner) The general public perception is that local food is safer. Growing your own food allows you to control the chemicals, hormones and

preservatives in your diet while producing products that may not always be readily available.

Economics as well as a change in the social consciousness around the environmental impacts of the global food system are also strong drivers in the DIY food movement. Personal canning as a way of preserving and processing perishable goods is on the rise and indicates a lack of trust in the current system and a desire to control what's in our food including sugar, sodium and preservatives. It also allows us to enjoy summer crops in the winter without the need for long distance imports.

One of the strongest drivers in the DIY food movement is taste. There is nothing like the taste of a fresh tomato or beans right out of the garden. Other drivers include the soaring price of food and the desire to control what we eat.

Signals of Change:

- "With the renewed popularity of seasonal, local eating, and the desire to be more environmentally sustainable many people are looking to home canning to preserve food for later use." (Health Canada http://www.hc-sc.gc.ca/fn-an/security/kitchen-cuisine/food-canning-conserve-aliment-eng.php)
- A study tracking food miles for 50 imported foods travelling into Ontario concluded the average distance was 5,000 kilometers creating 52,000 tones of GHG a year. If purchased locally the GHG emissions would be reduced by 49,000 tones, the equivalent of removing 17,000 cars from the road in the same time period. (http://batemanfood2.wordpress.com/canning)
- Increasing demand for community garden space. According to Lara Mrosovsky a Health Promoter from AccessPoint on Danforth, part of Access Alliance Multicultural Health and Community Services, community garden space was a priority for stakeholders involved in the consultation around the development of the hub and its programs. They are also involved in a more traditional ground level community garden with 24 plots and a 75-person waiting list with no advertising. This is the same situation for many other community gardens and is a testament to public demand. (Personal Interview)
- A number of health and community agencies are including vegetable gardening in their programming because of the numerous benefits to health.

- Popularity of YIMBY (Yes in my back yard) programs in Toronto.
- "Kickstarter provides crowd sourced co-financing for innovative ventures and products, like window farms and vertical gardens (http://www.kickstarter.com)
- Landshare.net, sharing of garden space, started in the UK. Now spread globally (http://www.landshare.net)
- The CDC estimates that there are over 76 million food born illnesses a year causing 325,000 hospitalizations and 5,000 deaths annually in the United States alone. (Couric)

Counter Trend (s): Convenience is King

Trend: Chef as Celebrity social

Description:

The introduction of the Television Food Network in 1993 was the catalyst for launching chefs into the mainstream world of celebrity. As of August 2013, just less 100 million households in the US alone receive the Food Network exposing millions of people to ingredients, recipes and the passion for good food. Since the mid 1990's chef personalities such as Emeril Lagasse, Mario Batali, and Bobby Flay have used the network to influence and educate the public on what to eat and how to cook it by sharing their point of view on food on national TV. Today chefs have reached stardom by making food accessible. (http://en.wikipedia.org/wiki/Food_Network) In 2005 the Food Network entered the reality TV scene broadening its already sizable audience and solidifying the chef as celebrity.

Today many chefs are celebrated for their talents and embrace the "Farm to Fork" philosophy that promotes local, organic, seasonal products for their freshness, flavor and nutritional value. This is a common ethos in the minds of many of Toronto's top chefs making it a slow food tourist destination.

Signals of Change:

- Popularity of the Food Network and other food related TV programming to meet public demand.
- Increased number of restaurants and chefs promote local, organic products and "farm to table' or "snout to tail" philosophies at many restaurants in Toronto.

- The number of chefs in mainstream culture promoting food and other products for example Giada De Laurentis promoting hair care products. (http://www.ispot.tv/ad/7tPH/clairol-natural-instincts-hot-coco-featuring-giada-de-laurentiis)
- Increasing demand for ready made and gourmet meals. In 2008 the Barilla Group along with De Laurentis launch their first celebrity product line. (http://www.italian-food-lovers.com/2008/07/giada-de-laurentiis-selected-by-academia-barilla)
- Loblaws launches its Black Label gourmet products in 2011. The *Toronto Star* reports that the Black Label products will be supported by displays that tell how they were sourced, from whom, and how they might be used to transform an ordinary meal. (Rosolen)
- 2011, chef Mark McEwan is Head judge for Top Chef Canada. (Russell) Toronto Life covers Top Chef Canada with a weekly recap of each episode. (http://www.torontolife.com/tag/loblaws/page/3/)
- Royal York Executive Sous Chef, Andrew Court, promotes Farm to Fork philosophy and encourages rooftop gardening; every plate served in the dinning room contains one or two items from their own rooftop garden. (Personal interview)
- Promotion of Toronto's best Farm to Table Restaurants promotes tourism (Faba)
- At Bouley Botanical, chef David Bouley uses his windows to create controlled environments for urban farm production for his restaurant engaging patrons as a destination eatery in downtown TriBeCa. (Gordinier)

Counter Trend (s): Convenience is King

Trend: Food as Science technology

Description:

Throughout the 20th Century science and technology were used around the world to engineer the increased production of crops and the crops themselves. As we move into the 21st Century our understanding in these areas has become increasingly more sophisticated and many are looking to the science of food to help increase productivity as it did during the Green Revolution.

Multinational companies like Monsanto and Dupont developed genetically engineered seeds designed to improve yields while making them dependent on pesticides and herbicides like “Round Up”. Genetic engineering in recent decades has gone on to produce seeds with “terminator technology” designed to produce sterile seeds to prevent self-harvesting creating a culture of economic dependence based on improving the companies’ economic bottom line. (Lister, 167)

In 1996, the scientific community created the first cloned mammal from adult cells; “Dolly” was considered to be one of the most significant scientific breakthroughs of our time and sparking controversy over the ethical and moral implications of cloning. Dolly died February 4, 2003. (Vos)

There have been a number of improvements based on science and technology including the development of hydroponics, aquaponics, and sub-irrigation based on computerized programs and sensors that read everything from moisture content to chemical inputs. The development of scientific theories such as vertical farms is also coming out of this understanding of food through the lens of science and technology.

Signals of Change:

- The age of genetic engineering in agriculture begins in the 1970’s. Monsanto scientists create the first genetically modified plants in 1982. (http://en.wikipedia.org/wiki/Monsanto)
- The United States government approves genetically engineered crop cultivation in the 1990’s launching biotechnology into the mainstream consciousness and expanding it into a $14.8 billion (US) industry. (Glasser)
- In 2007, scientists from the Universities of Applied Science (UAS) developed the first drought tolerant rice. (Gandhi)
- In 2013, Franken-burger, the world’s first lab grown hamburger is developed and eaten. (Hines)

Counter Trend (s): the Organic movement

Trend: Techno Food Farming technology

Description:

Throughout our history man has used technological innovations and solutions to increase crop yield in order to meet the demands of an increasing population. The blending of science, technology and engineering have changed the way we grow, distribute and transport food.

The global food system has been dramatically altered in the last century through bioengineering, chemical developments, advances in mechanization and the use of computer aided systems, and the development of hydroponics and aquiculture.

As agricultural production embraces modern technology the perception of farming and food production is changing. According to Christopher Mims, technological advances in 3-D printing will enable food to be printed, building food based on organic molecules and proteins from currently underutilized sources like insects. It may not be what we think of as food today but it may be a way of preserving excess for times of scarcity. The synthetic meals are made from powders, oils and water with a thirty-year shelf life. Anjan Contractor from the Systems & Material Research Corporation envisions a day when the world's population will feed themselves using 3-D printers and food cartridges purchased from any corner store. As the population continues to rise so does the cost of food. "I think, and many economists think that the current food system can't supply 12 billion people sufficiently," says Contractor, "so we eventually have to change our perception of what we see as food." (Mims) The printers will include open source software for recipe sharing as well as software to provide personalized nutrition. Contractor believes that the printers have the capacity to minimize waste from the food stream and is currently working on developing the prototype with funding from NASA.

> "Twentieth century food systems have largely stripped the meaning of food from our lives, reducing food to a collection of molecules and severed the psychological and functional connections to the rural hinterland where most of our food originates." (De la Salle et al, 21)

Signals of Change:

- NASA funds research for 3-D printed food. (Mims)
- MELiSSA, (Micro-Ecological Life Support System Alternative) is a closed loop regenerative life support system planned for long-term space missions. It is a

collaborative project including over thirty organizations from Europe and Canada that is managed by the European Space Agency (ESA) (The MELiSSA Home Page) “The driving elements of MELiSSA are the production of food, water and oxygen from organic wastes of the mission.” (http://en.wikipedia.org/wiki/MELiSSA) Waste products and air pollution are processed through the natural process of plants providing food and contributing to water and air purification. Many solutions developed by the program have direct impacts as solutions to current environmental issues on earth including optimizing water treatment systems and controlled crop growth. (http://en.wikipedia.org/wiki/MELiSSA)

- Vertical Farming Theory, using green tech to grow enough food to feed an estimated 50,000 people annually in a single vertical farm. (Chamberlain)
- Computer Assisted farming, controlling everything from temperature to the administration of irrigation and fertilizer.
- NASA geoscientists are currently developing an agricultural system incorporating satellite data to pinpoint resource requirements for different areas of a field. Referred to as “precision farming”, the system “uses technology to improve productivity while reducing the use of water and the application of fertilizer and other potentially harmful chemicals” (Owen)

Counter Trend (s): The Organic Food Movement, Back to Basics Philosophy

Trend: The Aging Rural Farmer social

Description:

The average farmer in Canada is 60 years old and the children of farmers in rural areas don’t want to take over the family farm. (Walker) This will result in a serious decline in the number of people farming rural areas within the next 15 years if unaddressed. Based on 2006 figures, one third of all Canadian farmers will retire by 2021, and three quarters of them have no succession plan for the future of the farm. (Seccombe)

Signals of Change:

- Young people are leaving the farm to pursue a better life and opportunity in the city, resulting in a decline in farm population and an aging farmer demographic.

- Statistics Canada confirms the number of rural farmers is decreasing while the average age is climbing.

Counter Trend (s): Young Urban Farmers and Urbanites moving to farms using new funding models like CSA's

7.0 Why Rooftop Agriculture in Toronto?

> "Toronto has long been known as a North American leader in the global movement for sustainable food."
>
> Lauren Baker
> Coordinator of the Toronto Food Policy Council and a member of Toronto Public Health's Food Strategy Team

The high cost of living in Toronto, especially housing and the cost of fresh healthy food choices create a barrier for many Torontonians when it comes to putting nutritious food on the table.

As Canada's largest city and the 4th largest city in North America, Toronto is one of the fastest growing cities in North America covering an area of 641square kilometres (158,395 acres). (http://www.toronto.ca/toronto_facts/geography.htm) According to a 2005 research study by Ryerson University, Toronto had 5,000 hectares of available roof space suitable for green roof installations that would have significant environmental and economic benefits for the city, including reducing the Heat Island by as much as 2 degrees Celsius, reducing the city's CO2 levels and energy consumption for cooling buildings as well as managing storm-water. According to the study Toronto would save over $37 million a year in environmental and infrastructure savings alone, (Banting et al.) making it the perfect location to implement sustainable urban agriculture. The availability of rooftop space in the report is based on flat roofs within the city with more than 350 square meters of roof area and assumes that at least 75% of the area would be greened.

According to the Toronto Food Policy Council, in 2007 the city of Toronto consumed an estimated 167,000 tones of vegetables and the council believed that it was possible to grow 10% of the city's vegetable needs within or very close to the city. Based on quantitative information on the yield of various rooftop growing techniques gathered during case studies for this paper if this space was converted to year round rooftop hydroponic greenhouse farms like Lufa Farms, it could produce as much as 500,017 metric tones of produce or 299% of what the city consumed in 2007. According to information obtained from Brooklyn Grange, if the same rooftop space was converted to row farm under production form April to November it could produce 108,726 metric tones or 65% of the produce consumed in the same period. It is unrealistic to think that production would be all one or the other, extrapolating a 20% / 80% split between the two

methodologies the city could produce 186,984.59 metric tones of produce or 112% of our vegetable needs.

Toronto is one of the most multicultural cities in the world, with over half of the population being born outside of Canada making it a destination for imported food from around the world. (http://www.Toronto.ca/toronto_facts/diversity.htm) According to a 2010 Globe and Mail article, “100,000 immigrants arrive in Toronto every year.” (Wente) Many bring farm knowledge with them, but do not have access to land. Rooftop farming could be a solution and growing more ethnic food in the city could reduce imports allowing us to achieve a more sustainable food system. According to the 2011 census the population of the GTA was 5,583,064 with an annual growth rate of .9%. Projections for the city’s growth put the population of the GTA at over 7.5 million by 2025. As the city and population expands we are going to need more food and a resilient local system to mitigate possible disruptions in the global food chain. Future disruptions in the industrial food supply network may be caused by a number of factors including declining yields or crop losses due to severe weather events as a result of climate change or a change in global distribution habits based on a higher cost of fossil fuel and changing dietary habits.

We currently import more food than we export. According to Mark Cripps, from the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), in 2012 Ontario had an $8.4 billion dollar food deficit spending more on imported food than we do on locally grown sources. (Liedtke) “If Ontario’s farm production was increased just enough to replace its top 10 fruit and vegetable imports, it would boost the provinces’ economy by adding nearly $250 million to its gross domestic product creating 3,400 full-time jobs.” (Miner) Less than 1% of Ontario agricultural acreage is organic production, making it a prime candidate for targeted import replacement strategies. “An estimated 80% of organic produce sold in Ontario is imported, most of it trucked in from California.” (Seccombe, 19) Seccombe suggests that people would pay a premium for locally produced goods if they new more of their spending was going to the farmer or staying in the community. “The rationale behind the price premium on Fair Trade products” could be applied locally. (Seccombe, 17) Torontonians spend over $8 billion a year on food. (McKeown, 9) The more food we can grow within the city itself the less reliant we will be on imports. We will need to live within our ecological means without relying so heavily on imports from other countries due to the future uncertainty of the availability of exports that may be required to feed the population of origin. The 2010 Russian ban on the exportation of wheat is a good example of the volatility of export dependence. (Kramer) Protectionist attitudes

around the exportation and importation of food will increase as the global population increases and crop yields decrease as a result of global warming. Politics may also play a role in the global distribution of food evidenced by Russia's ban on imported agricultural products from a number of countries including Canada in 2014 in retaliation for economic sanctions after the Kremlin destabilized Ukraine. (MacFarquhar)

The environmental impact of importing food for the largest city in Canada or any city for that matter it is huge. The carbon footprint from transportation alone is massive, not to mention the environmental impacts of exported embedded water and resources from around the world. As fuel costs soar, the sustainability of the global food system becomes even more uncertain.

Located in a plant hardiness zone of 6, Toronto's climate is ideal for agriculture with the last frost date in the spring in mid May and the first of the fall in mid October. Toronto receives an average of 2,066 sunshine hours annually with daylight hours reaching a low of 28% in December and reaching a high of 60% in July. The average summer daytime temperatures range from 23 -31 degrees Celsius and occasionally surpass 35 degrees with fairly even precipitation averaging approximately 32.7 inches annually. Drought conditionals are rare, but do occur occasionally. According to the Ontario Ministry of Agriculture & Food, "Annual precipitation is considered to be non-limiting for the whole province while heat energy and growing season length become generally more limiting with latitude" with no climactic limitations in Southern Ontario. (http://www.omafra.gove.on.ca/english/landuse/classify.html#climate) The city's microclimates offer the opportunity to diversify niche crops grown with in the city while using the city's heat gain to extended the growing season.

Toronto is full of eco-conscious people looking for healthy local food and a robust rooftop farming system would put it on their doorstep or at least their roof making it more accessible to the broader population. The Municipal Government, local institutions, community organizations and the greater community at large have enthusiastically supported local food growing efforts.

Toronto has the second largest food distribution hub in North America and 12.5% of Torontonian jobs are directly related to food, not including jobs created by the multiplier

effects. Increasing local food production, packaging and distribution could have a huge impact on job creation and the local economy. (The State of Toronto's Food, 7)

In the future every city will be looking for ways to produce more food close to home, urban grown produce will become the defacto standard and the new norm for accessing fresh fruits and vegetables, and Toronto has the potential to lead the way. Toronto's Green Roof Bylaw is the perfect gateway to robust rooftop agriculture in the city.

7.1 Toronto Policy Affecting Urban Agriculture and Green Roofs

Policies have the power to act as barriers or enablers; this section of the paper discusses some of the more relevant policies in regard to creating a robust rooftop agriculture sector in Toronto.

"The city of Toronto is a Global leader in municipal food policy development. Across North America municipalities look to the city of Toronto and in particular Toronto Public Health and the Toronto Food Policy Council for leadership, guidance and advice." (Lauren Baker, Toronto's Food Strategy Unveiled, February 16, 2010)

Although Toronto is a leader until recently food policy was fragmented consisting of disparate pieces of regulation, policy and programing with no overarching connection at the local, provincial or national level.

(See Appendix F for a detailed timeline of the History of Toronto Policies Affecting Urban Agriculture and Green Roofs from 1991-2014)

7.2 Building Codes and Rooftop Agriculture

Regulated under provincial building codes, building permits are required from the municipality in order to install a green roof. According to the city of Toronto, green roof building permits must comply with the Green Roof Construction Standard, Ontario Building Code (OBC), Local Zoning Bylaws and other applicable laws.

Rooftop gardens are not specifically mentioned in the OBC. Access and safety are the two most important concerns in local building codes. As building codes vary from city to city, I am focusing here on those of Toronto.

As safety is a major concern, building codes often dictate that protective infrastructure in the form of railings must be applied to the roof perimeter to enable regular legal access. In Toronto The Green Roof Construction Standard dictates that a guard or secure railing of no less than 42 inches (1070 mm) is required around any roof to which access is provided for anything more than maintenance, especially those used to produce and harvest vegetables. For non-accessible green roofs with no guard railings, a 2-meter vegetation free zone is required. According to the OBC, rooftop structural loading and moisture protection must also be considered when planning a rooftop garden.

"If the green roof is accessible for more than routine maintenance – in other words, if tenants or the public use the roof as an accessible outdoor space – then the design must also comply with requirements for occupancy, exiting, lighting, guardrails and barrier free access."

Steve Peck
(Design Guidelines for Green Roofs, 11)

Building codes often specify a "setback, or specific no-build zone, from the street-side edge of the roof" that preserves and promotes a certain exterior aesthetic based on what is visible from the street (Mandel, 94) This can quickly reduce the garden space on any roof.

Zoning

Value added agricultural production industries are considered "manufacturing" and according to many zoning codes, can only be performed in areas of the city zoned for industrial or commercial use. (Ladner, 123) The Canadian Food Inspection Agency (CFIA) is the governing body responsible for enforcing food laws in Canada and all food sold in Canada must comply with the Food & Drug Act which sets health and safety requirements.

Revising Zoning that recognizes community gardens and urban farms is critical to the success of urban agriculture. North American communities like Milwaukee, Baltimore, Cleveland, Montreal, Vancouver and Toronto have already added new zoning codes to allow for urban farming. In 2012, Toronto's Planning and Growth Management Committee proposed and endorsed a new Residential Apartment-Commercial Zone (referred to as the RAC zone) "to encourage retail and service uses that fulfill the needs

of residents and allow for small-scale enterprise." (Scaling up Urban Agriculture In Toronto http://tfpc.to/news/scaling-up-urban-agriculture-in-toronto) Market gardens and eating establishments are specifically mentioned under the new zoning category. This is recognized as an important new zoning designation allowing space in the city to be used for urban agriculture. Farmers investing in growing spaces are looking for some assurance that they will have access for a long enough period to gain a return on their investment of time and soil building, bringing the question of tenure to the forefront of the access to space question. The new zoning laws provide a sense of protection and security and are key to urban agriculture's expansion.

> "Cities are now recognizing that securing tenure for urban farms is the way to opening the gates on urban agriculture" (Ladner, 46)

Declining cities have an easier time finding available land, but in a city like Toronto where we are continuing to prosper and grow space is hard to come by. That's why rooftop agriculture is so important, as it allows access to space that is underutilized or virtually neglected without encroaching on the cities limited existing green space.

7.3 Toronto's Green Roof by-law No. 583-2009

The main focus of the bylaw is to address environmental issues affecting the quality of life in the city. " In 2000, Toronto's City Council adopted an environmental plan that recommended the city develop a strategy to encourage green roofs and rooftop gardens. In 2002, an official plan was approved that promoted green building designs and construction practices, such as green roofs and green spaces." (Garrison, 110)

> "Green storm water management requires lower initial and life-cycle costs while improving water quality, and reducing the need for storm water systems to expand as quickly to accommodate growth and development." (Garrison, 110)

> "A 2008 study on the Toronto Green Development Standard estimated that, at a cost of $36 million over 10 years, borne largely by private building owners and developers, 6% of Toronto's roofs can become green roofs, resulting in an annual saving of $100 million in storm water costs and $40 million in Combined Sewer Overflow (CSO) capital costs." (Garrison, 111)

The Toronto Green Roof Bylaw became an applicable law under the Ontario Building Code through an amendment in late 2009. According to the bylaw a green roof is defined as "an extension of an above Grade roof, built on top of a human-made

structure, that allows vegetation to grow in a growing medium and which is designed, constructed and maintained in accordance with the Toronto Green Roof Construction Standard." (Green Roof Bylaw) All buildings or building additions built after January 30, 2010, with a gross area of 2,000 square meters or more are required to install a green roof. Coverage ranges from 20-60 per cent based on the gross floor area of the building. Existing buildings were also encouraged to install green roofs through the Eco-Roof Incentive Program. (See fig. 13) Permits are required under Toronto Municipal Code Chapter 492 from The Chief Building Official at City Hall to install a green roof whether or not it is required under the bylaw. According to section 492-5-B of the Toronto Municipal Code, residential buildings or residential building additions less than 20 meters or six stories tall are exempt from the green roof bylaw but may still install one. There is a mechanism within the bylaw that enables contractors to pay penalties rather than install a green roof. For background information on the development of Toronto's Green Roof Construction Standard see appendix G.

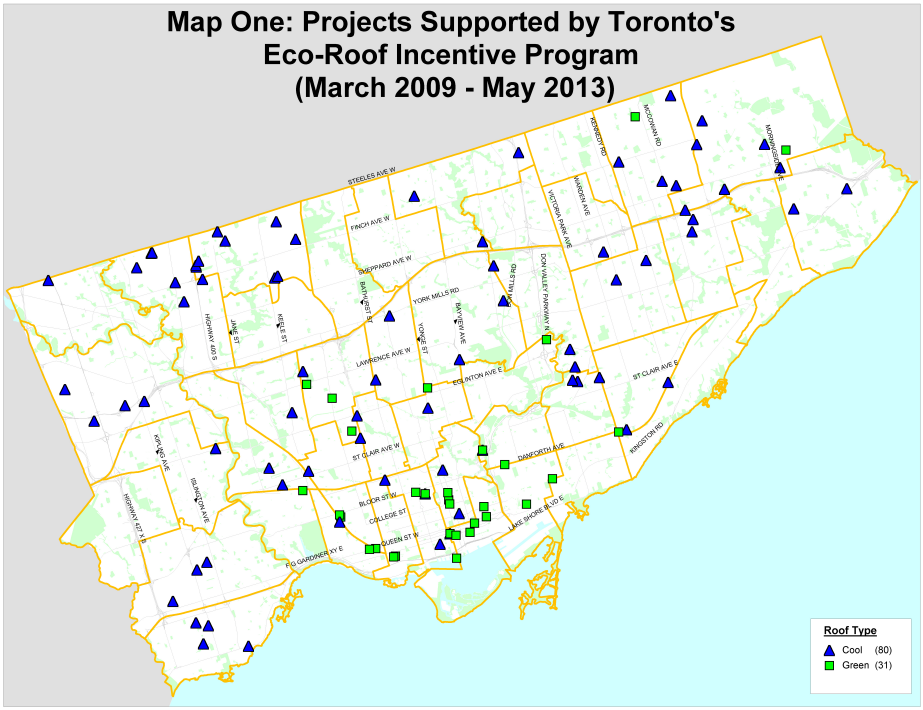


Figure 13: Map of Eco-Roof Installations, May 2009 – May 2013
Source: http://www.toronto.ca/livegreen/downloads/lge-co-roofmap.pdf

"The Toronto Green Roof Construction Standard (TGRCS) is the first municipal standard in North America to establish the minimum requirements for the design

and construction of green roofs." (Toronto Green Roof Construction Standard: supplementary Guidelines, http://www.toronto.ca/greenroofs/pdf/GreenRoof-supGuidelines.pdf)

Developed with public consultation, the standard identifies best practices and includes a number of recommendations or considerations rather than being exclusively prescriptive while identifying the OBCs that apply to green roofs. The Standard also includes OBC requirements on designing for water load accumulation from rainfall and the installation of "Scuppers" to limit the rainwater load to within the structural limits of the building below and includes storm water management systems. The standard provides detailed information on the installation and engineering requirements of the roof as well as the structural integrity of the building below. More information can be found at http://www.toronto.ca/greenroofs/pdf/GreenRoof-supGuidelines.pdf.

As of 2011 Toronto had an estimated 135 green roofs with an estimated total of 120,000 square feet. (Information complied from City of Toronto, 2011 "Green Roofs Around Toronto" www.toronto.ca/greenroofs/experience.htm) According to a May 20, 2011 interview with Green Roofs for Healthy Cities Founder Stephen Peck, since the Green Roof Bylaw passed in 2009 approximately I million additional square feet of green roof development had entered the planning phase for the city of Toronto. ("Interview with Green Roof for Healthy Cities Founder Steven Peck," Green Infrastructure Digest (May 20, 2011), accessed at www.hpigreen.com/2011/05/20/interview-with-green-roof-for-healthy-cities-founder-steven-peck) According to the Green Roofs for Healthy Cities annual green roof industry survey for 2012, Toronto experienced a 33% growth of installed green roofs in 2012, with the Toronto Metropolitan Region installing 338,310 square feet of green rooftop space, up from 227,657 in 2011. (Renew Canada the Infrastructure Magazine) According to the survey the North American Green Roof market grew 24% in 2012 based on 2011 figures. Toronto ranked fourth in North America for green roof installations in 2012 behind Washington DC, Chicago and New York. In the 2012 article, Rooftop Gardens Bring Healthy Home, Peck states that Toronto already had permits for 2 million square feet of green roof and that the potential is in the hundreds of millions. (Lepage) I feel that the city missed the mark by not including food production as part of the rubric for evaluating the value of a green roof and see it as a prime opportunity space to increase the city's food security.

To date there are over 550 Green Roof Professional (GRP) organizations in North America trained and accredited through Green Roofs for Healthy Cities to promote best

practices in green roof design, installation and maintenance. A full list of organizations can be found at www.greenroofs.org (Erlichman and Peck, 2013)

7.4 Toronto's Environmental Plan

Toronto's Environmental Plan: Clean, Green and Healthy, A Plan for an Environmentally Sustainable Toronto from 2000 is the city's first-ever Environmental Plan. The plan "calls for action that will lead the city to a sustainable future in which we consider economic, environmental and social implications together" (3) In the report the plan looks at four key areas:

- Sustainable Transportation
- Sustainable Energy
- Green Economic Development
- Education & Awareness

Rooftop urban agriculture has the potential to address all these areas of concern.

The main focus of the document is planning for the needs of future generations of Torontonians by investigating sustainable transportation, energy production and the need to protect and enhance Toronto's green infrastructure. Rooftop gardens are specifically mentioned in a number of sections of the plan;

- First on page 17 as a part of section 3, "*A Vision of a Sustainable Future*" whereby a scenario of the city set in 2025 makes reference to the city's green space being the "lungs" of the city improving air quality by increasing oxygen while filtering air pollution and improving storm water management. There is a direct reference to rooftop gardening in the scenario that states, "Increasing amounts of food are generated within the city's borders in allotments, yards and rooftop gardens." (17)

- Under the section, *Getting to Clean, Green and Healthy*, the report lists a number of strategies and recommendations to improve Land, Water and Air put forth by the Environmental Task Force. Although they are divided into sections the authors of the report note that they are in fact interconnected, and that as a part of the ecosystem in which we live the negative impacts we have on the environment create conditions that impact our health. This section of the report addresses the need for pollution prevention referring to how green spaces

"perform important ecological, social and recreational functions" and identify the need to expand these spaces as the city grows. (33)

Under this section Strategy number 8, "*Encourage Green Roofs***"**, the report **"**Recommended that the city report to council and the Sustainable Roundtable before the end of 2000 on a strategy to encourage green roofs and rooftop gardens." (37)

According to the report this strategy should:

a) Address the potential for retrofitting green roofs and rooftop gardens on City-owned buildings;
b) Address how green roofs and rooftop gardens can be implemented in new developments; and
c) Address the environmental benefits that can be derived from green roofs and rooftop gardens (e.g., CO2 reduction, storm water retention, microclimate improvements, etc.). (38)

- Under section 6.4, *Green Economic Development*, the report discusses the importance of developing "businesses and social entrepreneurship that promotes the joint goals of a healthy economy in a healthy environment," including the production of goods and services "that reduce the use and waste of natural and non-renewable resources and thereby protect the natural environment." (64) "Green economic development will help create healthy, vibrant and friendly communities that support the public good and public peace. Community gardens, for instance, provide fresh and nutritious food at a low cost, reduce the pollution and congestion from long-haul trucking of imported foods, and create oases of cooperation and eye-pleasers across the city." (64)

  The importance of growing food locally is examined in this section of the report that states, "The City should support local food production. It can do this in many ways, by expanding community gardening, by encouraging the use of rooftop gardens, and by making municipal compost available to local food projects and businesses." (69) The need to address local food production is based on the need to address the ever-increasing amount of imported food into Toronto and the negative impact of its transportation as well as the economic implications. Growing more food locally would improve sustainability while boosting the local

economy.

- In the report, Section 39 of Appendix A, Consolidated Recommendations, *Promote Local Food Production*, recommended that the city support local food production by carrying out a number of initiatives. Initiative number three under subsection c refers specifically to the development of an action plan to build rooftop gardens on City buildings. (70) (See appendix H for a complete list of initiatives recommended in section 39 of Toronto's Environmental Plan)

  Consolidated Recommendation number 8, *Encourage Green Roofs*, referrers specifically to green roofs and rooftop gardens recommending that the City report to Council and the Sustainability Roundtable before the end of 2000 on a strategy to encourage green roofs and rooftop gardens stating that the strategy should address the following:

  a) The potential for retrofitting green roofs and rooftop gardens on City-owned buildings;
  b) How green roofs and rooftop gardens can be implemented in new developments; and
  c) The environmental benefits that can be derived from green roofs and rooftop gardens (e.g., CO2 reduction, storm water retention, microclimate improvements, etc.)

Section 44 of the Plan is devoted to education and awareness, encouraging the city to become a leader by supporting the outreach work of others. Rooftop gardens have the potential to play an important role in both education and environmental stewardship through outreach initiatives in partnership with city and community stakeholders. (113)

Section 45, *Help Integrate the Environment and Sustainability into the Formal Education System*, encouraging the Toronto School Board as well as local Universities and Colleges and the Ontario Ministries of Education and Training to include environmental and sustainability education in their curriculum.

Under Appendix B the report identified a number of "Quick Start" Action Plans developed by the Environmental Task Force and published as Status Report No. 6 – February 21,

2000. Recommendations in the report under Food and Agriculture Quick Starts that have a barring on the green roof movement are as follows:

"1a. That as a Green Procurement Policy for the City of Toronto is developed, a system be implemented to gradually increase the purchase of Canadian organic food over the term of food service contracts between the Corporation and food service providers." This was led by the Food Policy Council.

"1b. That a report be prepared, perhaps by the Board of Directors of the Toronto Housing Company, on opportunities to establish rooftop gardens on residential buildings owned by the city of Toronto Housing Company, with estimates of costs and possible sources of funding."

"1c. That an action plan to increase the area of the City devoted to community gardens and the number of participants in community gardens be developed."

These policies and initiatives illustrate the political will of Torontonians and the desire to create a more resilient livable city and the value of the rooftop garden to meet that goal.

8.0 Imagining Diverse Futures: Developing Scenarios

Four scenarios were developed based on the impact of drivers and trends of urban agriculture and food security identified during the research for this paper. These provocative stories follow the "what if" philosophy to its conclusion in order to create plausible narratives to describe divergent possible futures of Toronto's food system. Will Toronto become a self sufficient, resilient city growing its own food or will it be dependent on the global food system?

Movement in the urban agriculture sector has been slow over the last decade and a half however momentum is picking up due to public pressure, education and a renewed sense of political will. "Basic beliefs and values that people develop in communities are slow to change." (Van Der Heijden, 101) therefore I am looking to 2035 as the horizon for my scenarios.

To generate enough variety the scenarios were developed using Van der Heijden's 2 x 2 Matrix method and the polarity of two key uncertainties within the trends or drivers identified earlier. The challenge was to identify not only highly uncertain aspects but also characteristics that would have a high impact on the outcome. This means that ultimately they could go either way having serious negative or positive consequences for a stable resilient food system in Toronto. The goal was to create two independent axes that created the framework for the creation of the most plausible yet diverse future worlds.

After a number of iterations, the following critical uncertainties were selected for this purpose:

1. Will Toronto's food supply be local or global in the future?
2. Will the future of food be large-scale industrial or small-scale organic?

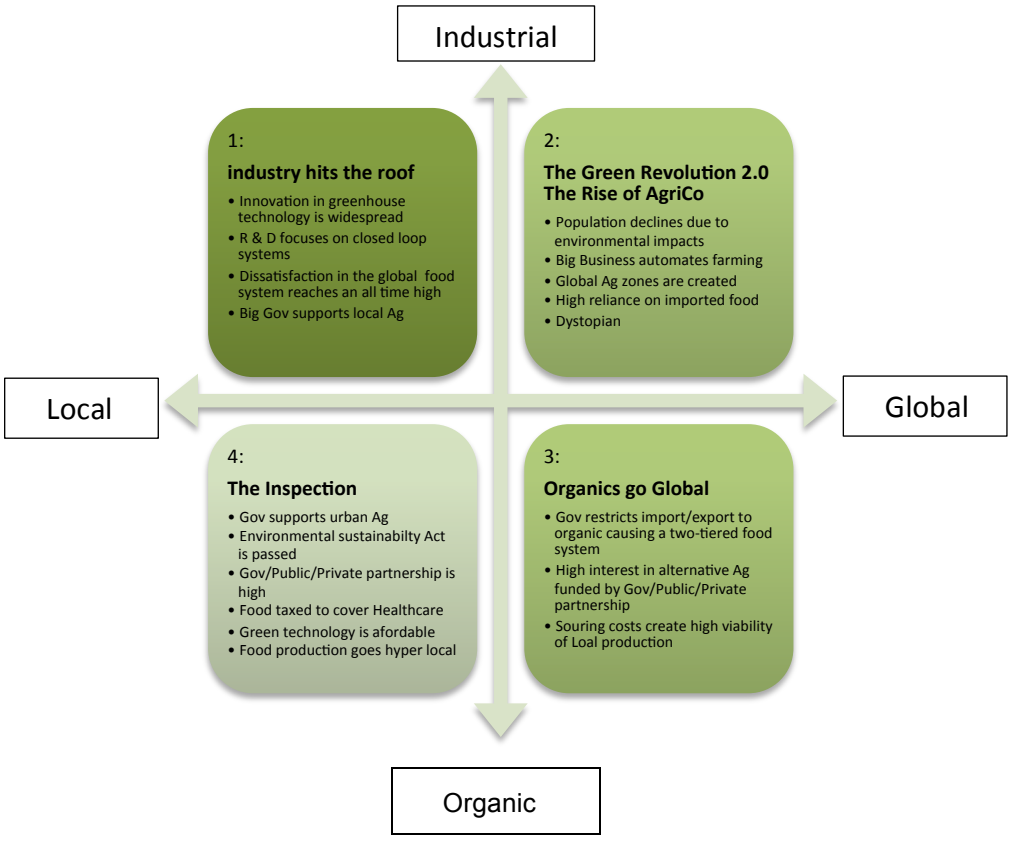
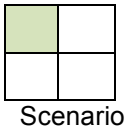


Figure 14: The 2 x 2 Matrix



Scenario 1: **Industry Hits the Roof**

As Toronto's population continues to climb and the city expands further into rural spaces the need for more local food becomes even more urgent. With more trade barriers being imposed every day Toronto needs to supply a greater share of the food required to feed its burgeoning population from within the city.

In an attempt to reduce Ontario's food deficit all three levels of government support incentives for agricultural import replacement crops resulting in the industrialization of farming in the city. In 2025 the Canadian Government passed legislation to protect the agricultural sector reducing import quotas for anything that can be sustainably grown in Canada. Bans on chemical use in the city have been lifted for agricultural production thanks to innovations in closed loop filtration systems and political pressure to compete

with global markets. Changes to zoning and regulatory bylaws allow agricultural production anywhere in the city including rooftops.

At today's board meeting Carlos, armed with an impressive presentation of graphs and charts will announce the expansion of the down**TO**wn Farm to include two rooftops adjacent to the current operation. The expansion is the result of successful grant applications incentivizing increased city production from both the Municipal and Provincial Government. The success of the farm's current location and the introduction of the new chemical filtration system will enable them to expand production while filtering and eliminating the negative impacts from traditional agricultural chemical use. According to Carlos, they can increase production by almost 20 percent while eliminating negative impacts using the new greenhouse system. The expansion will allow the farm to produce enough to meet the demands of their local clients year round while keeping costs down though the economy of scale and increased efficiency. There is also potential to sell or trade excess harvest to neighboring communities or to export partners like the United States who continues to suffer due to the relentless drought in California.

Carlos is excited about the expansion not only because of the farm's success but because it will have a huge impact on the local community providing social, and economic benefits. The expansion will provide an additional 60 jobs on the farm alone not including the construction or jobs created by the multiplier effect.

In his presentation, Carlos clearly demonstrates the need to expand industrial agriculture in the city as a way of producing the fruits and vegetables that are no longer being grown in Ontario.

The success of the rooftop gardens of the early 2020's to capture a greater percent of the local fruit and vegetable market have caught the attention of industry and catapulted rooftop farming from niche to mainstream resulting in the industrialization of the rooftop farm.

Scenario Context

Global political tensions and trade sanctions have steadily increased since 2014 resulting in limited access to certain imported agricultural products causing countries to rely more on home grown produce, dairy and meat. Driven by global trade barriers and the need for

more food supply and demand has caused food prices to skyrocket forcing Toronto to grow what it can where it can. Ontario attempts to reduce the food deficit demanding more produce from close to home offering incentives for import replacement crops. The cost of what is imported is far beyond what the average Torontonian can afford driving the municipal and provincial government to find alternatives to feed the city's burgeoning population. Innovation and investment in green energy and technology is high and rooftop agriculture expands to meet supply and demand for fresh produce as city density continues to increase.

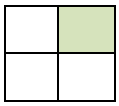
By 2030 affordable advances in green house technology allows for the development of closed loop rooftop systems that eliminate the negative impacts of chemical use allowing Toronto to create almost any environment year round, increasing the variety of non-traditional crops locally grown to satisfying the demand of a growingly diverse demographic. Sophisticated filter systems recycle water and air purifying discharge to prevent environmental damage and public health risks at the source. Greenhouse advances include modular, scalable panels, improved solar and water collection, improvements in engineered growing media, computer aided monitoring systems as well as the integration of advanced green energy use. Every rooftop in Toronto is allocated for food production.

Industrial farming in the city takes over multiple buildings to attain the economy of scale in a more humanistic approach to farming than rural industrial farms. The city expands further into rural spaces as chemical use in traditional land based industrial agriculture is banned due to degraded ecosystems forcing farmers off the land.

Scenario Backcast

Time	Event
2015	• Innovation and development in Green Technologies are private/public sector including Lufa Farms, the Federation of Canadian Municipalities (FCM), Metcalf Foundation, and the Vineland Institute.
2020	• Interest in rebuilding the local food system is high based on shared value and cooperation between all stakeholders. • Research and development is focused on innovation in closed loop systems to allow for increased chemical use in contained environments

	to reduce environmental impacts, filtering air, water and solar radiation reminiscent of the dreams of Buckminster Fuller. Supported by NASA.
2025	• Canadian Government passes legislation to protect the agricultural sector reducing import quotas for anything that can be sustainably grown in Canada through trade barriers. • Public dissatisfaction in the global food system reaches an all-time high due to relentless disruptions resulting in high public/private and government investment in advancements in growing technologies.
2030	• Affordable advances in green house technology are commonplace and widespread. • Provincial and Federal Government bans chemical use in traditional agriculture to protected environmental interests.
2035	• Industrial rooftop farming attains the economy of scale as Toronto population continues to rise reaching over 9 million by 2035. • City food production is controlled and regulated by the Toronto Board of Health, Agriculture and Agri-Food Canada (AAFC) and the EPA.



Scenario 2: **The Green Revolution 2.0: the rise of AgriCo**

In an attempt to recapture the Green Revolution of the mid 20th Century regional garden states are created in chemical zones around the world dedicated to increasing food production for the global market as GMO's fail to meet demand. This shift is driven by the profit margins of multinational corporations like AgriCo, the exportation of resources and the removal of global trade barriers. These large-scale operations rely heavily on petrochemicals, automation and precision farming perfected by NASA in the early 2020's.

Oil production reached its peak in 2024 resulting in high investment in renewable energy, yet over the last 20 years oil consumption for agricultural production has risen by more than 20 percent making Agri-chemicals one the highest commodities on the market as global powers leverage them to increase control over the world market. Food costs continued to rise as Global Warming reduced harvests around the world resulting in the increased use of chemicals that only exacerbated the problem while degrading the environment even further. This in turn decimates the remaining bee population and by

2025 migrant workers are exploited to hand pollinate the world's remaining food crops. Many in western society continue to turn a blind eye offloading the cost of agriculture to the country of origin, not accepting their role as contributors until it is too late.

Political unrest and rioting over farmer exploitation, global food inflation and the exportation of resources through food caused big business and government to partner to protect global agricultural interests. In many cases the indigenous populations in these countries of origin were unable to afford the food they were growing creating a two-tiered global system. Baring the brunt of the environmental impact of high chemical agriculture while reaping minimal benefit, the countries of origin began to fight back. As a result the military was enlisted to protect global operations under direct supervision of the UN.

Severe weather events and declining harvests resulted in declining populations due to water and food shortages, malnutrition, and disease. Pollution is so high that all water is filtered and the death rate caused by water and food borne pathogens, and poor air quality surpasses even the most pessimistic predictions of the World Health Organization (WHO). As the global population declined, immigration and migration caused Toronto's population to explode beyond all expectations. By 2030 Toronto had expanded into farmland and ecologically protected rural spaces around the city through political loopholes and back room deals, limiting how much could be conventionally grown locally. Virtually all food beyond self-provisioning and assistance provided by non-profits like the Toronto Food Bank was imported from the global system making Toronto a terrorist target for food sovereignty activists around the world. In 2032 the Toronto Food Terminal was bombed in retaliation for Canada's import behavior resulting in a renewed interest in a local food system.

Scenario Context

The global population falls short of the early 21st Century projections due to negative environmental impacts caused by intensified chemical agriculture and climate change, ultimately resulting in the apocalyptic collapse of the global food system. The excessive use of chemicals causes global warming to accelerate, increasing temperatures by 4 degrees between 2000 and 2035 cause a 20% reduction in global food harvests and increased volatile weather resulting in additional losses. Canada's main agricultural supplier, the United States is hit hard by climate change. Florida is no longer productive agriculturally, with almost half of its land under water due to rising sea levels. Continued

drought in California reduces crop success. The 2014 drought caused a 20% cost increase for Canadians who at the time imported 80% of their organic produce from California. Since then costs have tripled and the volume has been reduced to less than 12%. America's Bread Basket, the Mid West has all but dried up after depleting the Ogallala below recharge levels in the first quarter of the 21st century. By 2035 we will already see evidence of the mega drought predicted by scientist to hit the Southwest and Central Plains region of the US by mid century.

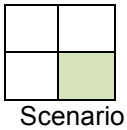
In response to reduced harvests, agri-chemical use increases fueling climate change and decimating the remaining bee population, forcing food costs to rise even higher as farmers resort to migrant labour to hand pollinate crops. Global leaders take charge with the UN and the FOA creating regional agricultural zones based on NASA data and analytics for optimizing large-scale global agricultural output.

By 2035 the trend of mega slums in cities around the world continues including Toronto due primarily to rural flight, migration, immigration, the overwhelming cost of food and reduced local employment. The number of Torontonians reliant on food aid skyrockets as the middle class virtually disappears and the popular majority is relegated to lower class status reliant on cheap overly processed food, self-provisioning and the non-profit sector. The global industrialization of the food chain and additional processing and packaging results in mass commodity stockpiling in attempts to minimize the impact of disruptions in the system. By this time, the supply and demand model of agricultural consumption being fed by the global market is in serious question. A robust rooftop agriculture sector is embraced to fill the gap of shortfalls and disruptions in the global supply chain increasing local supply for local demand. This follows a similar path to the Cuban food crisis and the collapse of the Soviet Bloc in 1989. As its major trade partner Cuba lost 80% of its foreign trade including fossil fuel and fertilizer along with its ability to import food due to economic decline. As a result, Cuba rapidly shifted to local/urban small-scale organic farming to fill the gap and recovered within a decade. (Burley)

Scenario Backcast

Time	Event
2015	• Ontario's/Toronto's technology and finance based economy makes it the financial hub for many multinational companies (including AgriCo a shell corporation of Monsanto) contributing to a dwindling agricultural sector.
2020	• NASA perfects Precision Farming. • Peak Oil hits in the early 2020's and high investment into renewable energy diverts oil to agriculture. • Farm automation is widely embraced.
2025	• Global harvests decline due to environmental impacts. • Bee population is decimated by 2028 resulting in migrant workers hand pollinating all major crops. • Food production goes ultra global controlled by big business and big government (A few multinational corporations control all food production on the planet with AgriCo, a shell company of Monsanto leading the pack.) • The UN and the FAO establish global agricultural chemical zones for the mass production of food for global consumption. • Political unrest causes mass riots over food exportation and inflation causing big business and government to partner to protect agricultural interests.
2030	• Toronto relies on imported food for virtually all of its provisioning, fresh produce is only affordable by the wealthy. (Most of the land in and around the GTA has eliminated fresh produce production in favor of high-end niche products like wine.) • Global population is decimated by increased food contamination, pandemics and starvation while the population of Toronto continues to grow with a diverse demographic due to immigration and migration (the number of Torontonians born outside of Canada surpasses 60%.) • Research and development is focused on innovation in closed loop systems to allow for increased chemical use in contained environments to reduce environmental impacts, filtering air, water and solar radiation reminiscent of the dreams of Buckminster Fuller. Supported by NASA.

	• Food sovereignty activists bomb Toronto Food Terminal.
2035	• Toronto expands in density and scale surpassing 10 million. • Food cost continues to rise due to the high cost of oil and external inputs. • Toronto embraces rooftop agriculture to feed its expanding population.



Scenario 3: **Global Organic**

The global population continues to rise, due in part to a better standard of living in Brazil, Russia, India and China, often referred to as the BRIC countries. This is the result of the shift to organic farm production through global cooperation precipitated by an attempt by big government to curb the environmental damage caused by the industrial food system. In the wake of devastating environmental impacts, the UN, FAO and the Global EPA, endorse global food production while regulating chemical use setting limited use guidelines for the exportation of agricultural products in an attempt to minimize the effects of chemical pesticides, fertilizers and fungicides. Climate change is a major catalyst creating a sense of urgency with regard to global food production and its sustainability. The UN announced the new restrictions in 2025, with the expectation of being phased in over the next decade. At the time of its publication there was a lot of speculation and trepidation regarding its success however there were already a number of early adopters.

The early move to global organic production was driven by a number of additional factors. Even prior to the UN announcement large scale multi-national agri-corps were switching to organic production due in part to pressure from local governments to increased local benefits, including higher rates of employment, better wages and access to better quality food for local populations. This was a reaction against the large automated, monoculture farms of industrial farming, and was partially driven by a better understanding of the exportation of virtual resources and the global acceptance of food access as a basic human right. The two tiered system of access to food was being challenged by governments around the world however it was not until the 2025 announcement that global unity around the issue took hold.

Other influential factors contributing to the early move to organic were, demand in the west as a result of increased social responsibility and a desire for higher profit margins due to demand. Social concerns over the environmental impact and healthcare concerns over chemical consumption and unregulated growing practices also played a role as the public viewed organic as safe. As a result of these concerns there was an increased level of product certification, public awareness and transparency.

By 2035 Increased wealth and population in countries of origin reducing export quantities causing political stain between export partners and a need to grow more at home. Rooftop farming is widely embraced to fill the gap and make the city more self sufficient and resilient.

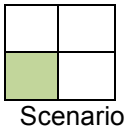
Scenario Context

In this scenario increased agricultural inputs result in decreasing returns on investment as the quality of food-sheds around the world are undermined by the heavy use of chemicals, pesticides and fertilizers. The negative environmental impacts of the current food system are globally recognized. As a result by 2025 all food imports and exports are strictly regulated through international government policy requiring all imports to be grown sustainably including organic practices and the ethical and equitable treatment for farms. Education and awareness and consumer behavior are important factors in this scenario.

Scenario Backcast

Time	Event
2015	• The UN Sustainable Development Goals replace the Millennium Development Goals in 2015; a number of the goals specifically address the need for sustainable agriculture and water management • Global competition continues to undermine local employment in the agricultural sector due to cheap imports of foreign products • The Organization for Economic Co-operation and Development (OECD) works with OECD members to create trade agreements and promote policies that improve the economic and social well being of people around the world focusing on environmentally friendly green growth and organic farming practices.
2020	• UN and FAO ban exporting highly chemicalized food resulting in a two-tiered system – low chemical use for export and high chemical use for

	local production in an attempt to meet local demand in less space. • Canada strictly enforces importation guidelines set forth by the OECD and the Global EPA to monitor environmental impacts of imported produce • Government, public and private sector Increase funding for alternative agriculture due to shortfalls and delays in global distribution
2025	• Global organic cost increase due to labour and transportation causing more people in Toronto to rely on self-provisioning and Food Banks • Long supply chains result in more disruptions as less is grown locally • The UN, FAO and the Global EPA join forces to create a unified global agriculture policy • The Global Food Council make use of Precision Farming and satellite technology to approve crop locations based on climate and environmental factors creating a global network of organic farms for global consumption
2030	• Local production becomes more viable as the cost of imported organic goods continues to rise due to cost the increasing cost of labour and transportation • Resource scarcity including water causes global tension • Government subsidizes local organic production as a means to reduce health care cost
2035	• Rooftop organic farming in Toronto is wide spread, embraced as an alternative to the high cost of imported produce and the need for more food to feed the city



Scenario 4: **The Inspection**

Charlie woke up early in anticipation of the day. Today the inspectors were coming (to inspect the farm). The Merlin was up for neighborhood producer of the year and agents from the Toronto Food Procurement Agency (TFPA), the Canadian Food Inspection Agency (CFIA) and Agriculture and Agri Food Canada (AAFC) were coming to assess the efficiency and productivity of the Merlin operation. They will be paying close attention to the environmental impact of the facility as well as the quality of the production.

The inspectors will start on the 20th floor terrace garden taking air, soil and water samples as they go, then head to the 36th floor to check out the rooftop hybrid plot and the solar greenhouse before inspecting the processing and packaging facility on 35 to ensure that everything is prepared and packaged according to code. Marianne, the Merlin's public heath inspector has been busy over the last few days making sure that the community kitchen will pass the inspection with flying colours. The team will finish off in the hubs retail space and send a report of their findings sometime in the next few days. The tenants are all really excited, they came so close to being awarded a city contract last year that they can taste it. They hope that the upgrades to the grey-water filtration system and the new high tech sensors for the greenhouse that are allowing Charlie to grow lemons are enough to push them ahead of the Haven over on Lakeshore. They have been rivals ever since the city started awarding Local Food Procurement contracts to neighborhood food hubs back in 2025. Since its organic certification the Merlin has done well but it has yet to win a city contract.

The contracts were a smart strategy on the part of the city to provide incentives for communities to get involved in food production, increasing the quantity and quality of affordable food in the city as an extension of the green roof bylaw back in 2018. Due to the increased population density and the expansion of the GTA, many in the city would go hungry without the rooftop farms including people living in the Merlin. Mary from next door is particularly fond of the Hub's online crowdsourcing capability, it allows her to make a little extra money selling her heirloom tomatoes when she has a bumper crop like this year. She hates it when they go to waste and the Hub makes it easy to find someone to purchase or trade with depending on her needs.

The cost of imported products has reached an all time high and only the wealthy can afford fresh produce forcing people like Charlie, an educated middle class 30 something to rely on local goods. We all know how expensive our grocery bills are especially now that the environmental impact tax and the social health tax have been included at the point of sale to augment the crippling cost of healthcare.

The issues of constant disruptions in the supply chain and food safety or contamination were key factors in the city's decision to actively promote agricultural production. Today almost every roof in the city is devoted to food production, making local food more

accessible and affordable. And many tenants rely on the local hub's food box program for their everyday needs.

Scenario Context

The population of Toronto continues to diversify and climb reaching over 9 million by 2035. Toronto's human centric approach to growth makes it one of the top livable cities in the world. As the city density increases and the population builds, low-rises are replaced and new buildings are required to have productive green roofs to contribute to the city's food supply and reduce strain on infrastructure and healthcare.

Municipal officials from Agriculture, Environmental Services and Healthcare are united politically integrating stakeholders for optimal benefit. Committees work together on policies related to public health in the aftermath of numerous epidemics of mass food contamination, culminating in the pandemic that swept the city in 2023 killing 12% of the urban population. Losing trust in the global system, Torontonians look to certification programs to reinitiate trust between producers and consumers on a local level.

The environmental and economic cost of importing food is beyond what many in Toronto can afford due to a lack of supply and increased global dependence and diminishing availability of oil. The unreliability of globally imports reaches an all-time high as global warming continues to reduce crop harvests around the world (reducing harvests by 20% between 2010 and 2035). The escalating global population and increased standard of living in the BRIC countries results in the need for once exported food to be consumed in the country of origin, leaving Torontonians to fend for themselves. The cost of fossil fuel makes importing organic food more costly, allowing local producers to increase market share reducing the price gap between imports and local production. Provisioning is driven by citizen engagement and a return to social value and urban citizenship, as a result of bottom up innovation and government policy support, resulting in an abundance of fresh produce grown in the city. Local food is supported through incubator programs, grants and city contracts, encouraging the introduction of culturally diverse crops to meet the needs of Toronto's population. By 2035 Neighborhood Food Hubs become a hybrid of non-profit and commercial venture, combining self-provisioning with commercialization often relying on small diverse operations in the neighborhood to fill consumer demand, decentralizing the system while increasing the city's biodiversity. The Hubs become the number one source of food in the city as traditional grocery stores dwindle in size.

Research and development into agricultural innovation (green tech) is high driven by collaborations between government, non-profits and the private sector. Affordable technological advances include:

- State of the art lightweight green houses with automated feedback.
- Improvements in green energy production including solar and wind.
- Improved water collection, filtration and irrigation techniques.
- Improved engineered soil, soilless growing media and hydroponics.
- Improvements to self-reliant, resilient closed loop farm management systems.
- The development of adaptive, hybrid, scalable growing systems.

As a result Toronto can grow almost anything at reduced ecological and economic cost and most buildings in the city have a productive green roof providing either food or energy to the citizens making Toronto one of the most resilient, livable cities in the world.

Scenario Backcast

Time	Event
2015	• The success of the Waterfront Toronto Project in early 2012 is the catalyst for further integrated live work communities throughout the GTA. • Agriculture and Agri-Food Canada (AAFG) work with Ontario universities to create bio-pesticides delivered in greenhouses by bumblebees. • Meat, dairy and grain subsidies = 80% of all government subsidies while fruit and vegetables receive less than 1%. • Less than 1% of Ontario agriculture is organic. (80% of all organic produce sold in Ontario is imported from the US with most coming from California.) • Changes in government policy support local producers. o Ontario passed Bill 36, the Ontario Local Food Act, in 2013 to foster a resilient local food system focusing on increased awareness, food diversity and market development. The first of its kind in Canada.
2020	• The Greater Toronto Clean Air Council (GTA-CAC) continues to work on behalf of all three levels of government but has more power in terms of regulating air quality and GHG emissions for Toronto.

	• The Environmental Sustainability Act (ESA) is passed. • Public private partnerships lead the way to multi-stakeholder innovation. • The interest in rebuilding the local food system is high, driven by political will, corporate social responsibility (CSR), public opinion, and social networking. • Government bans imports during peak season and imposes political sanctions and higher tariffs on imports that can be grown in ON. • Government taxes grocery stores based on quality of food they provide to balance the healthcare cost of poor diets. • Affordable innovations in high efficiency green house technologies resulting in high uptake of rooftop farming. • High reliance on integrated pest management systems (IPMS) eliminate the use of pesticides in an attempt to increase the apiary population in Toronto.
2025	• City of Toronto awards Local Food Provisioning contracts to Certified Neighborhood Food Hubs and extends it to include public spaces like shopping mall cafeterias and residential buildings over a certain size. • Environmental Impact and Social Health taxes are passed on to consumers at point of sale for food. • Research and development into agricultural innovation is high, supported by collaboration between government, non-profits and public/private partnership. • Affordable innovation in green technology including high efficiency green house develop resulting in high uptake of rooftop farming. • City of Toronto offers tax incentives for urban rooftop farming. • Government subsidies for fruit and vegetables increase substantially from 2015. • Ontario increases organic production to replace losses from California due to extended drought.
2030	• Food provisioning goes hyper local. Local becomes the defacto standard. o Reducing supply chain distances and interruptions.

	○ Rooftop and vertical farm production are commonplace. ○ Community kitchens and food sharing become the norm as more people live busier lives either alone or in communal living spaces. ○ Increases local employment, architectural labour and design, farm workers, processors, distribution, inspectors etc. • All three levels of government and the public/private sector provide collaborative support for infrastructure for green roofs. • Toronto grocery stores source more food locally and reduce in size as neighborhood hubs and farmers markets take a greater share of the market
2035	• Rooftop Farming is commonplace with Toronto providing most of its produce needs from within the city. • Healthcare costs decline as a result of healthier diets.

8.1 Scenario Analysis

Based on the scenarios rooftop agriculture is ultimately engaged in all four scenarios. The best outcome for rooftop agriculture and its optimal development is in Scenario 4: The Inspection. This is the most utopian and optimistic of the scenarios with widespread grassroots engagement from a broad spectrum of stakeholders. (See fig 15)

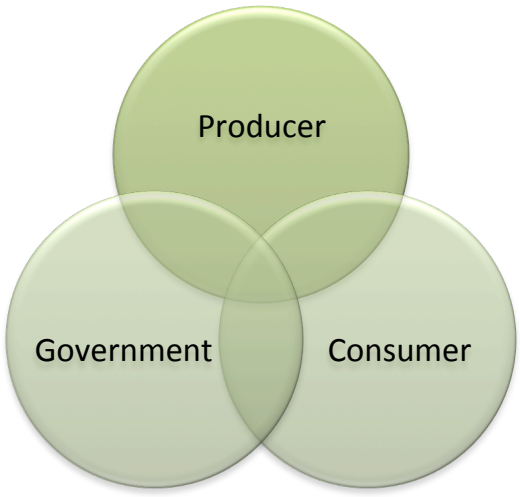


Figure 15: Stakeholder Engagement from Scenario 4: The Inspection

Scenario 1: Industry Hits the Roof, comes in at close second with both of them relying heavily of supportive changes to policy and high stakeholder uptake.

Scenario 3: Global Organic is also very successful however it is driven by global politics and increased social responsibility taking longer to take hold than Scenario 1 and 4.

Scenario 4: The Green Revolution 2.0: The Rise of AgriCo, is the most dystopian of all the scenarios. Local rooftop agriculture is a last resort as food sovereignty and security around the world becomes uncertain and political unrest reaches an all-time high.

The scenarios illustrate that the success of rooftop Agriculture is Toronto is highly connected to collaboration and support from a number of stakeholders including, innovators, producers, consumers and government.

9.0 Existing Strategies: How Torontonians Access Food

The supermarket is the main gateway for Torontonians to access food however they are not accessible for a large percentage of the population. Food deserts or financial difficulties force people to access food elsewhere. People in Toronto access food in the following ways:

- Supermarket or Major Chain
- Farmers Markets
- Community Supported Agriculture Programs (CSA) Food Box Delivery
- Community Gardens / Backyard Gardens
- Convenience Stores
- Drug Stores (Expanding into the food Market)
- Gas Stations
- Restaurants / Fast Food Establishments
- Non-profit Organizations, Community Centers and Food Banks

9.1 Current Agricultural Trends in Toronto

- **Farmers Markets**

Today's farmers' markets are an evolution of the markets that have been selling produce direct to consumers for centuries, and are the most visible means of presenting local food to the public. Consumers feel good about buying local. Studies in London found markets to be major economic drivers attracting business for local retailers while acting as the "social glue" holding communities together. (Ladner 168)

"A 2005 study in Ontario revealed that out of 3,066 market shoppers, 92% were satisfied with the quality of products and 95% stated "buying products produced in your community, " was very important." (Lay of the Land, 12 – statistics from http://farmersmarketsontario.com/Documents/ShoppersProfile2006.pdf)
The estimated value of direct sales from farmers' markets in Canada in 2008, including local and imported goods was $1.08 billion and according to the National Farmers' Market Impact 2009 Report by Farmers' Market Canada (FMC) Canadian farmers' markets had an overall economic impact of $3.09 billion. (Lay of The Land, 12) Farmers traditionally get about 18 cents on the dollar from the grocery store but as much as 90 cents at the market enabling smallholder farmers to make a living wage.

Farmers' markets are a trend that is growing fast and in Canada there is often a waiting list of up to three years for a booth. In 2009 the population of the GTA was 5.5 million and the city had 24 public farmers' markets many of them on temporary sites. (Lay of the Land, 12) People that shop at the market feel safer about their purchases, believing their products to be fresher, healthier and safer from contaminants. According to Ladner, farmers' markets are the number-two grocery source for 62% of Canadians after big box stores. (Ladner, 169) Market participants employ 1-5 people, creating $2 million in economic spin-off in Canada alone. There were 84 Farmers' Markets and festivals listed on the City of Toronto Website for the summer of 2013. http://wx.toronto.ca/festevents.nsf/farmers+markets?openform As of 2014 Toronto had 7 farmers markets that were open year round.

> Farmers' markets "strike the same cord that lights up everything to with local food: support for small farms and local economy, fresh food, unique local flavour, neighbourhood festivals, better health, and the opportunity to make a personal link with the farmers who grow the food you put in your body." (Ladner, 169)

Farmers markets tend to deal in organic products and are often cheaper than other sources of organic products however for individuals that do not usually buy organic there is a perception of higher price associated with the market. Value should not be based on price alone; nutritional value, freshness, safety and location of production need to be a part of the equation. In the US, the Supplemental Nutrition Assistance Program (SNAP) or the Special Supplemental Nutritional Program for Women, Infants, and Children (WIC) allow for the use of food stamps by low-income people at farmers markets to help improve access to healthy nutritious food.

Between 2002 and 2007 direct sales of agricultural products in the US jumped 55%. As of mid 2010 there were 6,132 farmers markets in the US representing a 16% increase from 2009 and more than 100% in the past decade. (Ladner, 169)

- **Community Supported Agriculture (CSA)**

Flourishing in areas of high population density, CSA's represent one of a number of new business models in support of urban agriculture and is suited to urban and near urban markets.

The way community supported agriculture works is that customers prepay for a weekly food box of fresh local produce to be delivered to the home or a pick up depot during the harvest months; boxes are usually filled with whatever is in season and picked that week. There is usually some variety and a member may get some choice as to what is in the box; different sized boxes are often available as well. Members must be committed enough to share in the farmer's risk, financially investing a lump sum at the beginning of the season and deal with the uncertainty of the crop together as well as make other trips to the store for staples not available from the farmer.

Community Supported Agriculture (CSA) was developed in Austria in the 1920's by Rudolf Steiner but did not take hold in the United States until 1986. (Ladner, 176) "Between 1990 and 2006 the number of CSA's in the US increased from 50-2,200" (Lay of The Land, 14 – original statistic from, Local Harvest, Community Supported Agriculture, 2008, http://www.localharvest.org/csa/ (3 February 2009) According to localharvest.org, the most comprehensive list of CSA's in the US, by February 2014 the number listed on their database exceeded 4,000.

The first CSA program in Canada was in Goderich Ontario in 1998, and a study in 2009 by the Canadian CO-OP Association indicated that there were 298 CSA's in Canada with 104 in Ontario alone. According to Local Food Plus, CSA and food box programs represent about 4% of the Canadian market share for grocery dollars. Toronto alone has 12 programs delivering to 4,000 food boxes a month. (Lay of the Land, 16)

(For a list of CAS's with delivery to Toronto see http://csafarms.ca.)

- **Community Gardens**

  "Community gardens are places where people come together to grow fruits, vegetables, herbs, flowers, families, and friendships.

  Community gardens are run by communities for communities, and can be organized in any way that the community decides.

  The eligible community gardens must involve 3 or more households and cannot be in residential backyards."

  The Toronto Community Garden Network

Community gardens are a global phenomenon and have been around since the

beginning of civilization, and continue to emerge whenever a community is threatened with food insecurity. The formal community garden has been around since the 1800's but was virtually forgotten by city planners during the post war boom. It wasn't until the later part of the 20th Century that the community garden movement was reignited and in 1978 the American Community Garden Association was established, including members from across North America including Canada. The first community garden in Toronto was established in 1973 in High Park and today there are more than 100 across the city, including over 3,000 individual plots "on a range of properties including city parks, rooftops, senior citizens' residences, school properties, churches, community & health centers, and many more places." (Toronto Community Garden Network http://www.tcgn.ca/wiki/wiki.php) In a 2010 National Post article by Lia Grainger, Susan Berman, coordinator of the Perth Dupont Community Garden stated that in 2010 there were over 200 community gardens with multiple plots in Toronto. (Grainger)

Community gardens provide social services improving the physical and mental health of a community. Supported by public health authorities, community gardens also have an economic impact by promoting exercise and healthy eating habits; they are viewed as a way to help mitigate the soaring cost of obesity and diabetes within a community. When a derelict space is converted into a productive community garden it has the potential to impact the economic value of a neighborhood by raising its property values and in turn tax revenue for the city. These effects are amplified in disadvantaged areas and can result in a reduction in maintenance costs for the city when the gardens are in a publicly funded park. "Gardens deliver their biggest added value when they're sited in places that are not already green and protected – places like parking lots and abandoned industrial sites" (Ladner, 190) Finding space is a challenge especially due to a lack of land tenure considering the investment of time and energy to amend soil and develop a garden can take years.

AccessPoint Alliance on the Danforth installed a rooftop community garden in 2010 in response to community engagement in a high-density area of the city were residents could not access space at grade. The demand for space is high, resulting in a wait list for a private community garden plot run by AccessPoint in a nearby neighborhood.

"From 2006-2011, The Toronto Community Food Animators, a partnership between FoodShare, Afi-Can FoodBasket, and the Stop Community Food Center, encouraged and

advocated on behalf of gardeners throughout Toronto and started over 15 community gardens" (http://ww.foodshare.net/community-gardens)

- **Community Kitchens**

  What is a community kitchen?

  "A community kitchen is a public space where people get together and cook on a regular basis. Community kitchens offer the opportunity to share skills, socialize and reduce costs by purchasing collectively. Kitchens are as diverse in their purpose and organization as the people who participate in them – some groups only prepare enough food to sit down and eat one meal together, while others prepare several meals in large portions to take home to their families"

  Food Share
  http://www.foodshare.net/community-kitchens

The community kitchen movement started in Peru in the 1960's and 70's as a result of necessity in large squatter settlements; by 2003 there were approximately 10,000 in Peru alone. "In Canada, Montreal's Diane Norman is credited as the founder of the formal community kitchen movement", opening the first kitchen in Canada in 1986. (Ladner, 204) Today there are more than 1,400 in Quebec alone and thousands more across North America. My mother started a community kitchen in her church in Sault Ste. Marie in 1995 to help people on social assistance eat healthier, save money and have a sense of community.

Food Forward is a registered non-profit formed in 2010 to promote food and food jobs in the city of Toronto with a strong focus on advancing food policy change at City Hall. On their website, Food Forward provides a Commercial Kitchen Directory of commercially-certified kitchens in the city that can be rented by the hour, the day or longer for the preparation and processing of food. http://pushfoodforward.com/kitchens This is a great opportunity for small-scale urban producers to create value added products through processing their harvest in a commercial space without the expense of ownership making small food enterprises in Toronto viable. The site also provides a links to many community kitchens in Toronto certified by Toronto Public Health for non-commercial purposes.

> ***"Food Forward** is where Torontonians meet to create a better City through food. We act together to educate and advocate effectively for healthy food and communities that are inclusive, diverse, ethical, local, and resilient."*
>
> Food Forward http://pushfoodforward.com/about

There are community kitchens in churches and community centers all over the city of Toronto, including FoodShare Toronto and The Stop Community Food Centre to name just a few. FoodShare is Canada's largest food security organization and in Toronto alone it supports more than 50 community kitchens. (Yaworski) Community kitchens provide a number of socioeconomic benefits breaking down social isolation especially for seniors or new immigrants, providing economic benefits while promoting healthy affordable food habits for individuals on fixed or low income.

10.0 Approaches to Rooftop Agriculture (Farming)

> "From human and social health benefits to environmental improvements, economic advantages to enhanced food access, rooftop agriculture enables and empowers people to make their communities healthier, more enjoyable places to live."
>
> (Mandel, 14)

Rooftop agriculture is exactly what it sounds like; it is the cultivation of agricultural products on rooftops and one part of the greater urban food system. It is relatively new to North America and has been under constant development over the past decade or so. Mandel's book, Eat Up from 2013 provides the tools and understanding to turn rooftops into space to feed people, offering valuable information gleaned from interviews with leading rooftop agriculturists.

The main inputs in all forms of rooftop agriculture are water, nutrients, solar energy and the physical labour of the gardener. Most rooftop practices include the use of engineered growing mediums rather than soil to maximize moisture-holding capacity while minimizing weight.

There are differences in the rooftop community. First you have the green roof, which is broken down into two categories, extensive and intensive. According to Green Roofs for Healthy Cities an extensive green roof is defined by 6 inches or less of growing medium and are essentially self sufficient requiring minimum care whereas intensive roofs are 6 inches of growing medium or deeper and plants or vegetation require maintenance and care. Second, are rooftop gardens that often include amenity space and are based on production for self-consumption or ornamentation. The third is rooftop farming which is based on production for profit or commercial enterprise on the medium to large scale. Rooftop farming can be further broken down by farming method, the most common include: container gardens, raised bed production, row farming, greenhouse production and semi-hydroponic or hydroponics. The final category is industrial rooftop agriculture for large-scale commercial operations.

10.1 Rooftop Practices and Methodology

Regardless of the method practiced there are a number of considerations to be thinking about beyond the logistics of zoning and legal issues including: weight, substructure drainage, and wind (shear and uplift). Solar orientation is critical, unimpeded southern

exposures are ideal “with effectiveness decreasing as a building angle shifts away from an east-west orientation” (Mandel, 53) When choosing a location make sure that there are no buildings or vacant lots to the south that could result in shading the garden as solar radiation is a key ingredient for success.

10.2 Container Gardens

Containers are the most basic form of rooftop agriculture; they can be easily reconfigured or moved and are appropriate when your roof cannot support a lot of weight or when flexible amenity space is a desired part of the garden. Containers are more vulnerable to temperature fluctuations than any other rooftop method practiced, the smaller the container the more pronounced the effect. Larger containers hold more water adding to the weight but also hold water longer resulting in less water loss and less labour for watering in general. The size of the container also dictates what you can grow due to the fact that different plants require specific soil depths or space for root development. (For more information see Ohio State University’s fact Sheet on Horticulture and Crop Science at http://ohio.osu.edu/hyg-fact/1000/164.html)

Wind is the biggest issue desiccating soil in containers quickly depending on their composition resulting in potential erosion and more frequent watering. Wind can also cause plants to topple over resulting in damage or loss. Using existing structures on the roof as windbreaks can mitigate some of these effects. Self-watering or semi-hydroponic containers are often used to minimize surface evaporation by wind allowing plants to absorb water from the bottom rather than the surface. (See fig 16)

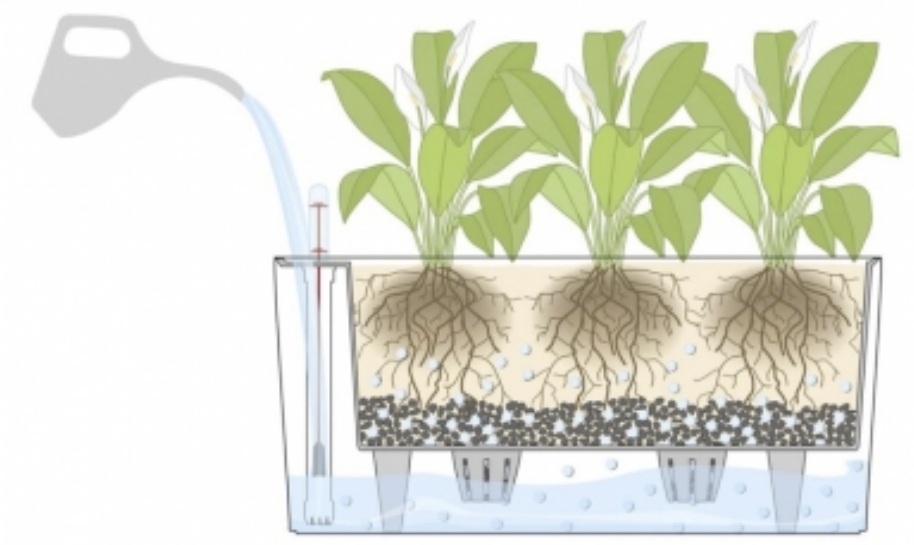


Figure 16: Sub-irrigated or semi-hydroponic container:
The Delta 20 All-Inclusive Windowsill Planter by Lechuza. www.lechuza.ca
Image Source: http://www.betterlivingthroughdesign.com/wp-content/themes/bltd/lib/timthumb.php?src=http://www.betterlivingthroughdesign.com/images/delta-planter.jpg&h=&w=513&zc=1

The type and composition of the container is also important to consider. Plastic as opposed to ceramic also requires less water as water is evaporated through the clay by the wind. Color also plays a role, darker colors absorb radiation from the sun and heat up causing water to evaporate while light colors absorb less heat and therefore require less water. Pleated pots are also self-shading; creating a microclimate with a cooling effect that may be beneficial in hotter climates.

When thinking about weight distribution standardized containers provide predictable loads making it easier to determine weight distribution once you know how much weight a roof can support.

Containers can be used virtually anywhere with no added infrastructure and at a minimal cost easily allowing a family to grow its herb or salad green needs. Roofs in Ontario are designed to withstand snow load in winter and can therefore accommodate the weight of most containers in summer as long as they are removed for winter. If you are unsure of your roof capacity consult a structural engineer for clarification.

Case Study: University of Toronto Sky Garden (Toronto)

(Interview with Alexander Suzin –manager and project coordinator and Weijie Liu – a volunteer as well as http://www.foodandwaterinstitute.org/skygarden.html)

Image 4: The Sky Garden: Onsite Images by Robert Mitchell

The Sky Garden is a volunteer-run 810 square foot organic rooftop vegetable garden maintained and coordinated by students through the University of Toronto's Urban Agriculture Society. Located on the roof of U of T's four story Galbraith Building at 35 St George Street the garden is a project of The Food And Water Institute (FWI), a Canadian registered charity and the first Canadian campus rooftop garden. 90% of the garden production goes to the University of Toronto Food Bank providing access to healthy nutritious food to students that may not otherwise have access; the remaining 10% goes to the volunteers. All produce from the garden is identified with a sticker promoting the Sky Garden.

> "Run by volunteers with the aim of increasing local, organic food availability for the student community, the Sky Garden uses a network of lightweight, semi-hydroponic containers and a drip irrigation system to grow around 500Lbs of vegetables each season." Http://www.foodandwaterinstitute.org/skygarden.html

Established in 2009 by three students as a pilot container garden using standard nursery garden pots and hand watering the garden was expanded in 2010 with a seed grant from Live Green Toronto allowing the purchase of approximately 100 specialized semi-hydroponic containers from BioTop in Montreal. According to a January 12, 2012 article by the Ontario Healthy Communities Coalition "The project currently has a multitude of sponsors including The Food and Water Institute, biotope, Live green Toronto, Urban Harvest Garden Alternatives, U of T Environmental Resource Network, The Home Depot,

MBNA, and TD Manulife Financial." (http://www.ohcc-ccso.ca/en/the-sky-garden-rooftop-gardening-at-the-university-of-toronto)

The goal of the Sky Garden has been to perfect the green roof as a "farm on a rooftop" rather than create a traditional patio green roof. The lightweight, semi-hydroponic system is a model that will work on virtually any existing roof, without the need for extensive structural changes resulting in a scalable food-production model that can be installed on almost any roof. The garden uses a number of water saving strategies even though they are connected to the municipal water system.

> "[The garden uses], sub irrigated containers, semi-hydroponic containers, drip irrigation as well as some hand watering." "The water is on an automatic timer for about five minutes every six hours, sometimes we have to adjust it based on the weather, at the same time we also fertilize through the water system using organic liquid fertilizer."
>
> (Alexander Suzin)

The Sky Garden is an education space for community engagement and hands on learning offering regular workshops on urban agriculture practices. The only access to the garden is via a staircase and when I asked if it was a problem the response I got from Weijie was that it was part of the healthy lifestyle promoted by the garden.
(See appendix I: Case Studies for more information)

10.3 Raised Bed Production

Raised beds are more permanent than containers but are lighter than row farming and must be designed with the building roof bearing load in mind. Size restrictions may be required and they may need to be placed farther apart or strategically placed over support columns to distribute their weight. A structural engineer must be consulted to evaluate the rooftop load before construction begins. Certified Green Roof installers often have structural engineers on staff and can help with these specifications as well as the installation of commercial green roof materials.

The beds themselves must be made of lightweight materials usually wood with a metal frame for structure. It is important to use non-pressure treated wood to avoid chemical contamination from treated wood leaching into the growing medium or the water causing accidental contamination. Cedar is the best wood and will last longer than most other woods extending the life of the beds however even they will need to be replaced approximately every four years. The beds are usually a maximum of 4 feet wide when

accessed from both sides or 3 feet wide when accessed by only one with a length that is determined by the space or the gardeners design. As little as two feet of space is needed between beds for access but can be significantly more depending on the access needs of the gardens (for example gardens that require wheel chair access would need wider aisles between beds). Raised beds make gardening easier for the elderly or people with physical challenges by raising the garden. The bottoms of the beds are usually a commercially available permeable product that allows for water storage and drainage and protected from damage by what is referred to as the “shovel guard” by the green roof industry.

The growing medium in raised beds is often an engineered mix of medias including soil, peat, vermiculite, perlite, coconut core and compost blended to the specifications of the farmer. The more compost or organic material in the mix the more water it will retain and the heavier the beds will be. This can be beneficial in terms of minimizing water use but detrimental if weight is an issue. Beds are often watered by hand or drip irrigation in larger situations and incorporate mulch to reduce the rate of desiccation minimizing water losses and maximizing water use efficiency.

Soil depth is often less than 12 inches depending on the crop grown, salad greens or herbs for example do well in depths of as little as 4 inches. These beds tend to be lighter and are susceptible to “wind uplift” and are therefore often secured to the decking of the roof. Bed depths of 6 inches are appropriate for most Brassicas such as broccoli, cauliflower or kale and 12 inch depths or more are required for tomatoes or eggplants. Depths of 18 inches are commonly used for tomatoes, beets or carrots. (See fig 17) During the growing season regular applications of organic fertilizer and compost are used to restore nutrients to the soil and improve water retention.

4-6”	6-8”	8-10”	10-12”	12-14”	14-
Herbs	Lettuces	Beans	Onions	Beets	Tomatoes
Leafy Greens	Beans	Chard	Tomatoes	Broccoli	Eggplant
Radishes	Herbs	Kale	Turnips	Carrots	Peas
Spinach				Cabbage	Peppers
				Cauliflower	Cucumbers
				Peas	
				Tomatoes	

Figure 17: Crops and Soil Depth

Raised beds can easily be installed on any flat roof however they should be installed on decking over the existing roof to prevent damage to the waterproofing barrier. Lighter beds should also be physically attached to the decking or anchored to prevent wind uplift.

Case Study: The Fairmont Royal York Rooftop Garden (Toronto)

(Interview with Executive Sous Chef, Andrew Court)

Image 5: The Fairmont Royal York Rooftop Garden: Onsite Images by Robert Mitchell

The 4,000 square foot intensive rooftop garden on the 18th floor of Toronto's Fairmont Royal York was initially installed in 1998 in response to the hotel's environmental impact. Believing that the hotel is part of the community, the rooftop garden was a way to address the hotel's carbon footprint illustrating the green culture of the company. The Fairmont grows more than 50 herbs and spices along with a large variety of vegetables, fruit and edible flowers for use in the hotel's kitchens, often growing things they can't easily get from suppliers such as wasabi arugula or alpine strawberries.

> "We produce enough of most things that we grow that we don't need to purchase them for 4 months." (Andrew Court)

> "It's about community and partnership. We need to live here and we do live here so we need to keep thinking about sustainability. It's not just about the food it's about being mindful of what you're doing." (Andrew Court)

The garden consists of sixteen large raised 12-inch deep beds and various containers with a growing medium of engineered soil and compost. According to Andrew the wooden

raised beds last about 10-12 years before the bottoms fall out and they need to be replaced. The raised beds allow for easy access and distribute weight across the roof. The Fairmont is also conducting research in collaboration with the Vineland Research and Innovation Center, experimenting to expand the diversity of Ontario crops by growing possible import replacement crops such as South Asian vegetables, okra, round eggplant, and hot peppers.

There is no official gardener, Andrew Court, executive Sous Chef oversees the garden and can maintain it along with his other duties, any larger and it would be too hard. (See appendix I: Case Studies for more information)

10.4 Rooftop Row Farming

> "Solar orientation, wind screening, water access, degree of mechanization and desired crops are essential to consider when designing a rooftop row farm."
>
> (Mandel, 44)

Row farming is practiced primarily in North America and is ideal for large-scale moderate to high yield production, and offers high storm water management and flexible layouts. It is appropriate for most crops, however low yield crops like corn and wheat or crops requiring large area like squash or pumpkin are not recommended. This method of farming is the closest to ground production and usually focuses on organic poly-culture practices that rely heavily on compost to renew soil fertility. With soil depths often ranging from 4- 18 inches buildings must have the capacity to support extreme loads. The high level of organic material in the soil increases water retention and weight. "A 12 inch deep area, for example, will weigh 84 pounds per square foot at the very least." (Mandel, 42) Success and yield increase with additional depth in growing media. (See fig.10 for crop recommendations based on medium depth.)

Growing systems are always built over a building's waterproof membrane and include a root barrier of some kind, usually polyethylene, followed by a drainage sheet and a filter fabric between the drainage and soil level to prevent soil infiltration into the drainage system. (See fig. 18) These systems should be installed by a certified Green Roof Installer and have the potential to increase the lifespan of the waterproof barrier by at least double due to the lack of exposure to the sun.

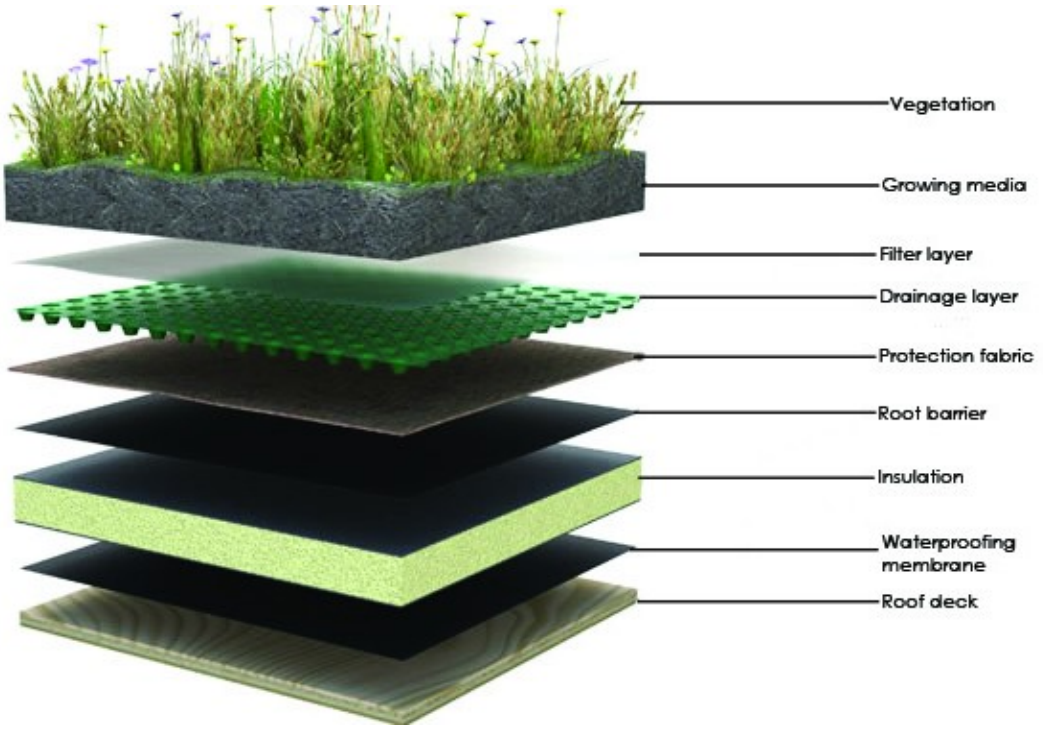


Figure 18: Typical Components of a Green Roof: Source http://dcgreenworks.org/programs/rainwater-conservation-and-reuse/green-roofs-2-0/ (For more information on various components see Appendix J)

Spacing requirements and soil depths in row farming are similar to raised beds with rows 4 feet wide however, paths between can be as little as 1-2 feet separated from the bed by some form of edging. It is necessary in row farming to have room on the roof for garden essentials such as composters, tool sheds and if you are lucky and have the space a beehive or two. It is also beneficial to have education or entertainment space within the garden to encourage community involvement as well as spaces close to the proximity of the garden but not necessarily on the roof for washing, processing and marketing your product.

The farming practice itself is similar to poly-culture farming on the ground including crop rotation, succession planting and relay planting. Most rooftop row farmers focus on a narrow highly profitable crop selection or specific ingredients for value added products.

Irrigation is a must for row farming with most crops requiring one inch of water a week on average. Today drip irrigation systems are inexpensive and conserve significant amounts of water, “burying the drip lines two inches below the surface of the media conserves even more water and encourages deeper root growth.” (Mandel, 44) The use of mulch reduces water loss by minimizing soil moisture evaporation reducing strain on the water system even further. Rain barrels can also be used to supplement water needs without drawing from the municipal water system and the water retention capacity of the growing medium contributes to the city’s storm water management.

As always, to protect the local water shed from any contaminated runoff that makes its way into the system, organic fertilizers, pesticides and herbicides are recommended if they are used at all.

Case Study: AccessPoint on the Danforth part of Access Alliance Multicultural Health and Community Services (Toronto)

(Interview with Lara Mrosovsky and http://accessalliance.ca/accesspoint)

Image 6: The Rooftop Garden at AccessPoint Alliance: Onsite Images by Robert Mitchell

AccessPoint on the Danforth is a multiservice Hub housing four social service agencies and the first Community Health Center in Ontario to have an intensive Green Roof. The 6,500 square foot organic community garden is located on the roof of the two-story building and utilizes container and conventional row farming practices with an engineered soil depth of 8 inches. The garden was established in 2011 with funding from a Live Green Toronto Grant, United Way Toronto, and the Ontario Trillium Foundation. AccessPoint is currently conducting research for the Vineland Research and Innovation

Center on the introduction of culturally appropriate crops not traditionally grown in Ontario.

The local community was heavily involved in the formation of the garden through stakeholder engagement and community consultation. The multicultural garden grows a large number of herbs and vegetables and the harvest is shared among a large number of stakeholders that share the garden. The garden produces an annual yield of over 350 kg of fresh produce a year.

> "Allowing access to fresh food helps address the issues within food security; this provides an equal opportunity for all people to have access to healthy nutritious food- especially those (in the community) who live in poverty or have a low income." "The produce is shared by the community garden volunteers and programming through the community kitchen."
>
> Lara Mrosovsky

The garden incorporates a number of water saving strategies including rainwater capture, sub-surface drip irrigation, semi-hydroponic containers, organic compost, mulch and drought tolerant plant selection.

Through the Green Access Program the community center sets the context for the garden and programming that incorporates the garden and amenity space as a pathway for community engagement and development.

The main focus of the garden is education.

> "Access Alliance has used the Green Roof for community engagement and to encourage learning on environmental issues and healthy eating. Programs and events are tailored to meet the needs and interests of participants and participating organizations or groups. These include garden drop-in, public events, educational workshops about organic food and the environment and hands-on learning." (Lara Mrosovsky)

Lara Mrosovsky is a Health Promoter and the full time garden coordinator.
(See appendix I: Case Studies for more information)

Case Study: Brooklyn Grange (NYC) (http://brooklyngrangefarm.com)


Image 7: Brooklyn Grange Farm. Photo: Anastasia Cole Plakias. Source: http://brooklyngrangefarm.com. Photo Gonzlaught, Source: Flickr https://farm9.staticflickr.com/8431/7797107938_20be5a3a73_o.jpg

Brooklyn Grange Farm operates two rooftop farms, one in Long Island City, Queens and the other at the Brooklyn Navy Yard. Established in 2010 and 2012 the farm was started with a grant from the New York Department of Environmental Protection as a part of NYC's Green Infrastructure Stormwater Initiative, part of Mayor Michael Bloomberg's goal to reduce city carbon emissions by 30% by 2030. (Goldman) Today, "the farm is financed through a combination of private equity, loans, grassroots fundraising events and crowd-funding platforms like Kickstarter.com and ioby.com." (http://brooklyngrangefarm.com/about/)

Brooklyn Grange is the world's largest industrial rooftop row farm, utilizing conventional organic farming methods and is a leader in the intensive green roof industry in the United States, providing consultation and installation services to clients worldwide. With an engineered soil depth of up to 12 inches the combined size of the garden is 108,000 square feet or 2.5 acres. The garden produces over 22 metric tones of organic vegetables, salad greens, heirloom tomatoes and herbs annually between April and November. Produce is sold to local markets, restaurants and residents through CSA programs.

Brooklyn Grange's mission is "to create a fiscally sustainable model for urban agriculture and to produce healthy, delicious vegetables for our local community while doing the ecosystem a few favors as well." (http://brooklyngrangefarm.com/about/)

The farm employs the use of the a green roof installation that includes conservation technologies, including a drainage layer comprised of a water retention surface that holds back water for consumption during dry periods distributed by Conservation Technologies.

> "[The] garden manages over a million gallons of storm-water each year easing the burden on the overtaxed Red Hook Wastewater Pollution Control Plant, which services 32,000 acres of Northwest Brooklyn, and ultimately reduces the amount of waste water that flows into [the] city's open waterways."
> (http://brooklyngrangefarm.com/navy-yard-farm/)

Brooklyn Grange is also involved in community engagement through education programs, non-profit partnerships, training programs and public and private tours. They believe that rooftop gardens have the capacity to make the city more sustainable reducing the heat island effect and filtering water for cleaner local waterways while producing fresher, tastier, more nutritious food than that shipped over long distances and time. The ecological impact of the food system on New York City is important to Brooklyn Grange.

78% of New York's urban surface is impervious including rooftops, sidewalks, streets and open spaces; according to the Department of Environmental Protection, rooftops alone make up 28% of the cities impervious space. (Goldman)

> "Roof farms have the potential to improve urban quality of life, create jobs, increase access to healthy fresh foods, and provide environmental and agricultural education to those of us who live in and love the city."
> (http://brooklyngrangefarm.com/about/)

Ben Flanner is the head farmer and president of Brooklyn Grange.
(See appendix J: Case Studies for more information)

10.5 Greenhouse

There are several styles of greenhouse on the market however rooftop greenhouses are highly engineered to withstand extreme winds and snow loads. To avoid wind uplift they are sealed and bolted to the deck of the roof. New technological advances have developed more energy efficient greenhouses with a lower initial investment and reduced weight ideal for rooftop applications.

The reliance on traditional field agriculture is becoming increasingly vulnerable to negative impacts due to the uncertainty and volatility of weather conditions as result of global warming and climate change. Greenhouses offer some protection reducing crop

losses due to weather related events and pest management issues minimizing disruptions in the supply chain.

According to a 2010 study, the Greater Toronto Area Profile of Agricultural Attributes in the GTA, greenhouse production became the leading agricultural sector in the GTA in 2006 based on Gross Farm Receipts (GFR's). (Walton)

10.6 Hydroponic Greenhouse

Hydroponics is a method of growing plants in a nutrient rich solution, without soil, examples include coconut coir, mineral wool, perlite or expanded clay. They are often housed in high tech green houses in cooler climates allowing yearlong production. According to Gotham Greens cofounder and CEO, Viraj Ruri, hydroponics as a growing method is well suited to urban areas because of its higher yield capacity than other agricultural methods as well as its efficiency in terms of space and water use. (Mandel, 161) "The re-circulating irrigation system at Gotham Green, in fact, uses 20 times less water than conventional agriculture, according to the company's website." (Mandel, 50) Gotham Greens production is more than 20-30 times higher per acre than a typical ground level row farm. (Manel, 48)

Another hydroponic success story is Lufa Farms, a commercial rooftop farm in Montréal producing 10-15 times the produce it could on the same land using soil based production methods. The green house allows for the potential for yearlong production even in Montreal and their proximity to the local market reduces energy consumption by minimizing transportation and packaging costs. Rooftop hydroponic greenhouses generally use less energy than their grade level counterparts by taking advantage of more sun exposure and the heat escaping from the buildings below. Many also use photovoltaic technologies allowing them to create their own solar energy.

Semi-hydroponic methods of food production are also practiced; the UofT Sky garden and AccessPoint on the Danforth are two examples in Toronto. Water use is minimized through integrated approaches including rainwater harvesting and the use of mulch. In many cases the surface of the growing media is covered with black plastic in which holes are cut for the plants, this prevents evaporation while acting as a weed suppressant. Watering is performed through an intake pipe that goes to the bottom of the container where it fills a reservoir used to water the plants from below again reducing surface

evaporation. The reservoir is protected from “soil” infiltration by a plastic grid covered with landscape fabric.

Pest control and pollination often incorporates Integrated Pest Management systems (IPM) that include natural predators to control insects allowing for chemical free production. Bees are often included as pollinators.

Case Study: Lufa Farms (Montreal) (http://lufa.com/en/)

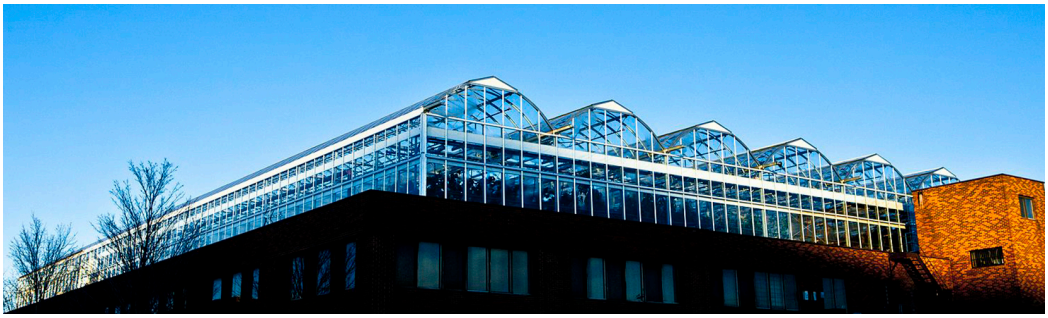


Image 8: Lufa Farms. Photo: Benoit Rochon Source: Wikimedia https://commons.wikimedia.org/wiki/File:Lufa_Farms_Montreal_rooftop_greenhouse_in_Sunlight.jpg

Lufa Farms is the world’s first privately held commercial-scale greenhouse perched on a two story rooftop pioneering innovations in all aspects of the project from logistics, changes in zoning and building codes to legal and taxation issues. The first green house was installed in Montreal in 2011 with a second following in Laval in 2013. Combined the farm covers 74,000 square feet or 1.7 acres and is operational year round.

Westbrook Greenhouse Systems from Beamsville, Ontario, architects GKC of Montreal and FDA Construction of Montreal (the general contractor) were all instrumental in designing and engineering the greenhouse to Lufa Farms specifications maintaining the structural integrity of the building below while dealing with issues of snow loading and water drainage. (http://www.marketwired.com/printer_frendly?id=1345427)

> “Lufa’s high-density farming will allow production of fresher and tastier vegetables. Moreover, our crop will be pesticide and herbicide free, will be harvested and distributed to consumers the same day – and use energy sources in symbiosis with urban buildings to the benefit of both.” Mohamed Hage – Founder and CEO. (Lufa Farms: world’s first commercial-scale production greenhouse-on-a-roof rises in. Montreal, Quebec. – Marketwire – November 2, 2010. Montreal (http://www.marketwired.com/printer_frendly?id=1345427)

Lufa Farms uses a closed loop hydroponic system for both nutrient and water delivery using harvested rainwater and re-circulated water to reduce municipal water demand losing only the water consumed by the plants. To maximize water use efficiency, compost is used for biomass and water holding capacity for seedling propagation. The entire system is highly computerized including irrigation, temperature control, and fertilization schedules.

Lufa Farms produced over 70 metric tons of produce in 2012 growing a wide variety of vegetables, salad green and herbs. The farms products are marketed through a CSA program with weekly deliveries to approximately 150-drop points serving 3,000 subscribers in Montreal as well as to restaurants and individual consumers within a 15-mile radius.

The future goal for the company is to build an expanding network of urban rooftop gardens and they are currently working on a proprietary turnkey green roof system for the marketplace. According to founder Mohamed Hage if Lufa Farms expanded to cover 19 Montreal shopping center roofs the city would be self-sufficient.

Mohamed Hage is the founder and CEO of Lufa Farms.
(See appendix I: Case Studies for more information)

Case Study: Gotham Greens (NYC) (http://gothamgreens.com/)

Image 9: Gotham Greens. Photos by Reana. Source Flickr
https://www.flickr.com/photos/reana/13544188343
https://www.flickr.com/photos/reana/13544051093
https://www.flickr.com/photos/reana/13544122273

In 2010 Gotham Greens built the first commercial scale rooftop greenhouse in the United States, Greenpoint, Brooklyn and has expanded to include two other locations, Gowanus,

Brooklyn @ Whole Foods Market in 2013 and Jamaica, Queens in 2014. These expansions were funded through private investment and supported by profits. As of 2014 Gotham Greens covered a total rooftop area of over 95,000 square feet or just under 2.2 acres producing over 200 tonnes of produce annually. Gotham Greens is the top rooftop yield producer in New York City "[producing] 20-30 times the yield of typical ground level field production while using 20 times less water." (Mandel, 158)

The main crops for Gotham Greens are leafy greens and tomatoes, sold to local retailers, restaurants and institutional customers along with local residents through farmers markets.

> "Our proximity to our customers ensures that the extended shelf life is passed onto the customer and not the food delivery chain."
>
> (http://gothamgreens.com/our-farm/)

All three locations are designed, built, owned and operated by Gotham Greens with a focus and commitment to promote local, healthy and sustainably produced food with dependable year round yields. The farms incorporate advanced horticultural and energy techniques to optimize production, quality and efficiency through complete environmental control. "Fully enclosed, sterile greenhouses minimize pest and disease risk" (http://gothamgreens.com/our-farm/) while protecting against losses due to extreme weather events ensuring crop reliability. The hydroponic system not only uses less water than conventional agriculture it eliminates water pollution from runoff. The farm also offsets its electrical needs using solar PV panels, high efficiency LED lighting, advanced glazing, passive ventilation systems and thermal curtains. The insulating properties of the garden itself also reduce energy costs for the buildings below. This is a good start however unless linked to sustainable aquaculture, composting etc. hydroponic systems are still net users of energy including other inputs such as industrial hydroponic nutrients or organic mixes from other ecosystems.

11.0 The Future of Rooftop Urban Agriculture in Toronto

The following is a list identifying issues that require further investigation and resolution if we are to create a more resilient, sustainable, food secure Toronto in the future.

- How do we grow more food for the city within the city?
- How do we increase access to rooftops for food production, in terms of both space and physical access?
- How do we store and process rooftop goods?
- How do we market and distribute rooftop produce?
- How do we garner buy-in from stakeholders and change consumer behavior in favor of local urban production?
- Where does the urban farm workforce come from?
- How do we leverage legislation and zoning restrictions to increase urban agriculture?
- How do we access water needs for rooftop production?

11.1 Identifying barriers and opportunities

Barriers

The research for this paper uncovered three main barriers to robust urban rooftop agriculture in Toronto; the lack of space, land tenure and rooftop access; social behavior, both purchasing and the acceptance of agriculture as an urban activity; and legislative barriers such as zoning regulations. Other barriers include the following:

- Lack of education or understanding
- The lack of access to funding and large start up costs
- Seasonal limits (in cases where no green house is used)
- Restrictive regulations and policies regarding food sales
- Lack of political will – seen as a low priority for many planners and politicians (most of the policies in Toronto are driven by the financial cost of infrastructure or environmental concerns regarding storm water management, energy costs for heating and cooling or waste disposal.)

Opportunities

As we move into the 21st Century and consumer awareness and the need for more local food increases there are numerous opportunities for the expansion of rooftop agriculture and the creation of a sustainable local food system that benefits all Torontonians. Opportunities can be used to leverage the following:

- Changing consumer behaviour to embrace local production
- The creation of additional jobs in Toronto through government and private sector opportunities for R&D funding for entrepreneurial innovation in green technology focused on agriculture
- Diversifying distribution channels including small scale and major actors In the food system (from the neighbourhood corner store to the mega super store selling produce from the neighbourhood)
- Identify possible alternative distribution channels
- Increase the biodiversity in the city
- Reduce the environmental impact and cost of infrastructure of the city
- Opportunity to broaden the waste recovery of the green bin program through increased quality of compost

11.2 Future Innovations

Research clearly identifies the need to increase food production if we are to sustain the expanding population of the world. If we are to survive, the challenges will be to negotiate the opportunities and barriers and protect the ecosystem services provided by the natural world while balancing the need for increased food production.

Rooftop gardens offer a number of opportunities to expand the capacity of growing food locally improving the socio economic and environmental health of the city while creating a more resilient food shed for its inhabitants. Opportunities for strategic innovation fall into three broad categories: hard solutions, soft solutions and organizational innovations. While the number of opportunities is optimistic they come with their share of challenges. By embracing multiple stakeholders and considering stewardship and engagement as a strategy to mitigate future disruptions we can create the conditions for a resilient food system for the city of Toronto. Solutions that incorporate a number of the STEEPV categories will have a better chance for success. The following is a list of possible

solutions and implementation strategies that identify key areas of leverage to increase rooftop agriculture in Toronto.

Hard Solutions

- New innovation in greenhouse technology following in the footsteps of companies like Lufa Farms who currently offers a turnkey solution to the rooftop hydroponic greenhouse including all aspects of the project including all hard technology and growing cycle data. Brooklyn Grange offers a similar turnkey solution for a rooftop row farm. I believe there is room in this arena for alternatives including collaborative hybrid solutions that incorporate different farming techniques with advances in solar, wind and water filtration on the same roof.
- There is opportunity for the development of smarter greenhouse technologies including improved solar efficiency and lightweight construction specific to rooftop applications. Ian Clarke from OCAD University is currently pursuing such an opportunity through a grant from the Metcalf Foundation. (http://research.ocadu.ca/sbl/home)
- Water management systems including efficient irrigation design, evaporative prevention, water capture and storage and hydroponics are areas for innovative investigation.
- Planting systems including modular installation and water preserving planters are recent additions to the urban farm market and ripe for further innovation.
- The development and management of facilities for Value Added production and processing such as expanding the certification and installation of community kitchens.
- Throughout my research one of the biggest challenges was the lack of access to rooftop spaces. The development of external lift mechanisms for moving people and products to and from the roof without interfering with daily operations of a building would be very advantageous. These types of systems already exist in the construction trade and could be adapted for rooftop farms.

Recommendations For Moving Forward

- Municipal and Provincial Government along with Public/Private Partnerships should work together to invest in research and development focused on methods of urban food production that go beyond sustainability, working toward practices with

regenerative ecological impact. This could include improvements to green energy use, water filtration and irrigation and growing medium technologies. Net 'O' greenhouse development is a step in this direction.

- Rooftop greenhouse initiatives should be actively supported by government, public and private funding to expedite the research and development of affordable, scalable rooftop models in an attempt to increase uptake extending the cities growing season and the viability of local year round production. (Mechanisms for rooftop access including external lifts etc. could be developed under this initiative.)

Soft Solutions

- Educational programing on the importance of local healthy nutritious food.
    - Knowledge is the driving force behind change, understanding the implications and issues faced by the global food system regarding food security and the environmental impacts of the current food system enables individuals to make better choices. In her 2011 article, "Teaching People to Cook Outside the Box", Jessica Leeder stresses the high social value of education and teaching kids how to cook real food emphasizing the "need to reduce the reliance on an industrial food system that has made non-nutritious food the cheapest and most easily available." The article focused on the Stop Community Food Center and the reinvented Toronto Food Bank and the need to ensure that everyone has access to the best and healthiest food out there.

      Today the Toronto District School Board (TDSB) and schools across the GTA have embraced rooftop gardens as an educational tool through eco-school programs supported by non-profit community groups like FoodShare and funding organizations such as Live Green Toronto, Ontario's Trillium Foundation, the Counselling Foundation and Slow Food Toronto. In 2013, Eastdale Collegiate installed 450 garden beds on its 16,000-squre foot asphalt roof in partnership with FoodShare making it the largest food-producing roof in Toronto. (Brown, Louise) University programs like Ryerson University's certificate program in food security. (http://www.ryerson.ca/foodsecurity/certificate/) All recognize the

importance of local food and nutrition education and its power to make socio-economic and environmental change by instilling students with a sense of value and stewardship.

The development of educational material and programming needs to be continued and made available to all schools in an accessible way. Education could also be extended to consumers at the point of purchase.

- Computer programing for everything from planting cycles to marketing including water and pest management cycles, to temperature controls and ventilation based on automated technologies.
- Apps can be used as a tool to manage spaces or identify the availability from a supplier or source, as well as identify the nutritional value or pesticide contamination of a product based on probes or algorithms. Apps can let you know when a product is ripe and ready for harvest and where you can get it similar to the "Car to Go" app, which allows you to input the product you are looking for and search in real time for available locations. (https://www.car2go.com/en/austin/car2go-apps/)
- YOMR (Yes on My Roof) program similar to the YIMBY, yes in my back yard online connection connecting people that want space to farm with building owners who would like a rooftop garden but don't have the skill, time or desire to maintain it themselves.

Leveraging soft solutions and knowledge could lead to the development of branding promoting rooftop urban agriculture such as "roofTOp grown" or the "downTOwn farm" making products easily identifiable in the marketplace. Apps could be included to facilitate the delivery of information at point of sale including environmental impact, nutritional value, growing methods and farmer information. As well as statistical information on community, environmental and economic benefits such as local employment benefits etc. This is an opportunity to illustrate how knowledge and purchasing power benefits your community and addresses a number of the SEEPV classifications.

Recommendations For Moving Forward

- Local labeling of certified products could be used as an educational strategy to better inform the consumer of the benefits of buying city grown fruits and vegetables. This would encourage environmental stewardship, import replacement, improved nutrition health and entrepreneurship.

- Educational rooftop gardens should be expanded to include every school in the Toronto District School Board over the next 10 years.

- The city needs to establish an online resource of apps for urban agriculture including Yes On My Roof (YOMR) programs that connect farmers that need space with building owners who have appropriate rooftops and would like a garden but don't have the skill, time or desire to maintain it themselves. Apps could also be used to buy and sell products at their peak reducing spoilage and increasing access, or provide additional information to consumers.

Organizational Innovations

- Including changes to policy in all aspects of government from municipal, provincial and federal to enable and encourage the growing of food in the city. Changes to zoning and regulations that support urban farmers and enable the production, processing and selling of their produce is crucial for a robust, sustainable food system.
    - Political incentives. Tax breaks could be established for building owners and/or renters that participate in green roof productive gardens based on environmental service metrics and production based subsidies similar to the current practice of farm subsidies.
    - Changing policies to include subsidies for locally grown fruit and vegetables to replace imports for local consumption rather than subsidizing exported crops only.
    - The provision of government funding in the form of grants or reimbursements for the installation of productive roof top farms. This could be similar to funding programs like that for solar energy at all three levels of government.

- Social Return on Investment (SROI) is a major concern for lending institutions. These institutions need to embrace SROI as a criterion for loans based on urban agriculture and its benefits to society to encourage the uptake of farming projects by offering incentives such as lower initial interest rates to offset start up costs.
- Toronto's Local Food Procurement Policy could be expanded to include all food retailers. The new policy would require local food retailers to increase their offerings of locally sourced produce especially during peek seasons when availability is high and ideally throughout the entire year. There are some that argue that the importation of foreign produce is what keeps prices low and affordable to the city's poor. I believe that supply and demand plays a big role in this issue, as crop yields decrease the cost of foreign imports will rise minimizing the price gap between foreign and local produce. By reaching critical mass for urban agriculture we may be able to keep prices reasonable due to volume and through government-imposed restrictions on imports or subsidies for urban practices. Through these initiatives we can make local food affordable to all Torontonians.

  The need to increase the purchase of local produce would mean more local farms and the creation of additional jobs reinforcing investment in the community while increasing the social return on investment (SROI). The increase in cost would be partially offset by the increase in jobs with a prioritized focus on employing the urban poor or marginalized individuals. The surplus from these farms would be a valuable resource of fresh produce for community organizations, shelters and food banks across the GTA.
- The institution of neighborhood or community food hubs. These could be locations for individual backyard farmers, community gardeners and rooftop farmers to collect, process and distribute local food similar to the co-op model of the past or the CSA's of today. Hubs could include growing and storage space along with certified community kitchens to enable the processing of value added products and would operate as a collective enabling someone to sell two baskets of tomatoes or process and distribute a value added product line on a larger scale. This idea expands the community kitchen and organizations like The Stop or Food Share to commercial scale.

Recommendations for Moving Forward

- The Green Roof Bylaw needs to be amended to promote productive spaces that incentivize the installation of intensive garden spaces for fruits and vegetables rather than extensive or ornamental amenity space. This could be similar to the Solar Incentive Program offering rebates for the installation of commercial rooftop gardens. Rebates could be based on metrics that include environmental, social and economic benefits for the city and its inhabitants as well as the percentage of productive rooftop space cultivated.

- Toronto should amend zoning bylaws to allow agricultural on all appropriate rooftops in the city removing policy barriers that impede agriculture in the city such as zoning restrictions and policies around selling local produce. This would require the development of clear guidelines and supportive regulations and may require studies to investigate the implications of such changes.

- Toronto needs to establish well-defined policies to support the growing and marketing of urban agriculture and import replacement crops. This must including supportive strategies around funding, space procurement, and the development of agricultural entrepreneurial programs for educating urban commercial growers on how to grow non-traditional crops. The government should subsidize these programs in an attempt to reduce the provinces' food deficit. This could be an opportunity to expand local employment through training and certification programs as well as increasing the number of inspection agents to ensure safe practices and community health are upheld. Jobs would be created in training and certification, production, distribution, inspection and marketing. (The institution of an environmental tax paid at the time of purchase for imported products could minimize the price gap and balance the scale making locally grown produce more appealing.)

- "As part of its overall greening strategy, the City should develop an incentive program for food production on rooftops. Special funding should be made available to building owners willing to retrofit their rooftops for commercial scale food production." (Feeding the city from the back 40: a commercial food production plan for the city of Toronto, 3) A legislative mechanism should be included to encourage the long-term lease of public building rooftops for small-scale commercial production.

- Local food procurement policies should be expanded to include all public spaces and amended to include a greater percentage from the city itself guaranteeing markets for government funded rooftop producers. To minimize negative impacts on the city's infrastructure producers should be required to follow organic practices in keeping with Toronto's chemical use restrictions while employing bio intensive pest management practices, onsite composting and water saving strategies. (A study must be developed for Toronto's Green Bin Program to be revised, eliminating bio waste or other materials not suitable of high quality organic compost.)

- Following the work of GRIT Lab, the city should create a metric for measuring the financial benefit for the environmental, social and economic value provided by productive green roofs. This would require an environmental cost – benefit analysis (ECBA) to develop some form of quantifiable metric for the various different rooftop methodologies. This metric could be used as an incentive for tax breaks, or some form of benefit for building owners based on the amount of rooftop space designated for food production.

- The city should devise a funding program for the development of innovation focusing on the expansion of urban agriculture. Areas of innovation could be around access, technology, organization or education with a focus on multi stakeholder collaborative hybrid solutions. (Mechanisms for accessing rooftops without interfering with the day-to-day operations of a building would fall into this category.)

- The city should expand certified food hubs into every neighborhood in the city.

- The Toronto Food Strategy team and the Toronto Food Policy Council needs to establish a committee devoted specifically to the development of urban rooftop agriculture. This committee must be comprised of a wide range of stakeholders and tasked with the job of increasing the number of commercial rooftop farms in the city. This committee would be responsible for developing policy, identify appropriate buildings and vetting potential producers.

12.0 Conclusion

Viewed through a Toronto centric lens this paper investigates food security through rooftop agriculture and sustainable water management by asking the question,

How might the evolution of urban agriculture advance sustainable agriculture in the future?

To better understand the problem this paper looks at the history of agriculture and the current food system as a basis for understanding its future and investigates the need and condition to create a resilient local food system while providing social, economic and environmental benefits for all Torontonian's.

Research for this paper was conducted through an extensive literature review, expert interviews, horizon scans and case studies with the data being primarily organized into historical background, to set the stage; benefits; drivers; trends; scenarios and future innovations. Collected data was analyzed using the STEEPV methodology for classification and the scenarios illustrate the potential value of rooftop gardens in the future. The paper also examines existing strategies of how Torontonians access food as well as urban approaches to agricultural practices already being utilized to identifying barriers and opportunities for future innovations in the rooftop sector.

Focused on a return to the local foodshed and the diversity that comes with a decentralized system of small-scale producers leveraging the niche microclimates provided within the urban context of the city's rooftops; case studies illustrate the success of rooftop farming and the value of a robust urban agricultural system to provide a sustainable, resilient food supply as well as managing urban storm water. The research indicates that the development of import replacement crops has the potential to increase food production in the city without affecting local farmers. This will reduce the provinces food deficit and mitigate disruptions in the global system as the availability of imported food becomes uncertain making the city's food system more resilient. Rooftop agriculture may never feed all of Toronto's needs but it offers a number of optimistic benefits while providing additional food security in a time of political and environmental uncertainty with regard to food access.

The research for this paper uncovered a three major factors limiting rooftop agriculture; the lack of physical access to space and space itself, the need to change consumer behavior and need to eliminate political barriers. The paper offers multi-level, actionable solutions for future innovations to support a more resilient local food system through a number of recommendations.

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Appendix A: Glossary of Terms

Agri-business: a term first coined in the 1950's to describe the shift to large scale corporate farming based on the industrial model producing national and international conglomerates concentrating ownership based on the economy of scale.

Agrology: The science to agriculture.

Algae Bloom: A rapid increase or accumulation of algae, a large group of simple non flowering plants including many single celled forms.

Aquaponics: A closed system containing plants and aquatic animals that share a symbiotic relationship providing food and cleaning functions.

BRIC Countries: An Acronym that refers to the countries of Brazil, Russia, India and China deemed to be at the point of newly advanced economic development poised for a shift in global economic power.

Community Supported Agriculture (CSA): "Community supported agriculture is an arrangement whereby local households invest in a season share of a farmer's harvest, thus sharing the risks and rewards of the season with those who grow the food." (Seccombe, 19)

Conventional Agriculture: "refers to a method of farming in which the use of GMO's, chemical pesticides/herbicides and chemical fertilizers is allowed." also known as industrial agriculture. (http://www.appropedia.org/Conventional_farming)

Dead Zone: Dead zones are hypoxic areas in oceans and lakes where the oxygen concentration is so low that nothing can live, often the result of excessive nutrient pollution from human activity. (National Oceanic and Atmospheric Administration, NOAA)

Desertification: the process by which fertile land becomes desert, typically as a result of drought, deforestation, excessive agricultural irrigation or climate change.

Ecogastronomy: A term connected to the "Slow Food" movement, a philosophy recognizing strong ties between food and the environment.
Ecological Footprint: A metric system developed by William Rees and Mathis Wackernagel based on quantitative data to provide an accounting tool to determine our impact on the natural environment and the ecosystem services they provide. "The Ecological Footprint of any defined population (from a single individual, household, city, region or nation) is the area of biologically productive land and water area occupied exclusively to produce the resources and assimilate the waste generated by that population, using the prevailing technology." (Lawrence J. Onisto, Eric Krause and Mathis Wachernagel, 1998, 8)

Ecosystem Services: are the direct and indirect contributions of ecosystems to human wellbeing supporting directly or indirectly our survival and quality of life. Categorized in four areas, provisioning, regulating, supporting and cultural. (The Economics of Ecosystems and Biodiversity (TEEB)

Engineered Growing Medium: a lightweight growing media often devoid of soil due its weight and tendency to pack down. Growing media's are specifically designed for rooftop gardens and include a number of criteria including weight, grain size, density, water absorbing capacity, ph, lime & salt content and nutrient content.

Evapotranspiration: the process by which water is transferred from land to the atmosphere by evaporation from the soil and other surfaces and by the transpiration from plants

Farm to Fork: A philosophy that promotes local, organic, seasonal products for their freshness, flavor, nutritional value and environmental impact.

Food flow analysis: A study that documents the movement of food through the food system, including the production, transportation, distribution and retailing stages. (Toronto Environmental Plan Pg. 133)

Food Miles: Food miles represent the distance food is transported from the time of its harvest and production until it reaches the consumers table. In some cases Waste disposal may also be included.

Food Shed: the geographic region that produces the food for a particular population. (Wikipedia)

Food System: "The term "food system" is commonly defined as the complex set of activities and relationships related to every aspect of the food cycle, including production, processing, distribution, marketing, retail, preparation, consumption and disposal." (Cultivating Food Connections, 5)

Globalization: the process of international integration arising from the interchange of worldviews, products, ideas and other aspects of culture. (Wikipedia) Globalization also includes the dispersion of populations around the world through immigration.

Green economic development: The development of "green industries", industries that promote a healthy environment along with a vital economy. Also, the development of economic activities that use systems of production, consumption, distribution and waste management that have a benign or beneficial impact on the environment. (Toronto Environmental Plan, 133

Green Power: Energy that is generated from renewable sources such as water, solar and wind. (Toronto Environmental Plan, 133)

Green Roof: An extension of an above grade roof, built on top of a human-made structure, that allows vegetation to grow in a growing medium and which is designed, constructed and maintained in accordance with the Toronto Green Roof Construction Standard. (Toronto Municipal Code Chapter 492, Green Roofs)

Green Roof: Extensive: A green roof with six inches or less of growing medium where the vegetation is essentially self-sufficient requiring a minimum of care. The amount of care is the defining characteristic.

Green Roof: Intensive: A green roof with six inched or more of growing medium with vegetation that requires maintenance, care or harvesting.

Green Water: rainwater water stored in the soil as soil moisture

Grey water: Any water that has been used in the home, except water from toilets. Dish, shower, sink and laundry water comprise 50-80% of residential wastewater. This may be reused for other purposes, especially landscape irrigation. (Toronto Environmental Plan, 134)

Heat Island Effect: "defined as the rise in temperature of any man-made area, resulting in a well-defined, distinct "warm island" among the "cool sea" represented by the lower temperature of the area's nearby natural landscape." (http://www.urbanheatislands.com)

Hydrology: The study of the earth's water, especially its movement and distribution in relation to the world's landmasses.

Hydroponics: The cultivation of plants in a nutrient solution rather than soil.

Hypermarket: A combined supermarket and discount store greater than 200,000 square feet. (Source Canadian Grocer)

Hypoxic Zone: Dead zones are hypoxic areas in oceans and lakes where the oxygen concentration is so low that nothing can live, often the result of excessive nutrient pollution from human activity. (National Oceanic and Atmospheric Administration, NOAA)

Insect Frass: is the excrement of herbivore insects (http://www.onfrass.com/faq.html)

Integrated pest management (**IPM**): An ecosystem-based strategy that focuses on long-term prevention of **pests** or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. (www.**ipm**.ucdavis.edu/GENERAL/**ipm**definition.html)

Land Grab: a term used to describe the large-scale acquisition of fertile land often in developing countries though purchase or lease by public or private entities

Mega City: Cities surpassing a population of 10 million.

Monoculture: The practice of producing or growing one single crop over a wide area.

Mycrorrhizae: a fungus that grows in association with the roots of a plant in a symbiotic or mildly pathogenic relationship. The fungus assists in the absorption of minerals and water from the soil and defends the roots from other fungi and nematodes, while the plant provides carbohydrates to the fungus.
(http://dictionary.reference.com/browse/mycorrhiza)

Mycorrhizal Inoculum: a microbial soil inoculant used as in agriculture to amend soil to promote plant health.

Parapet: A protective wall or railing. According to The Green Roof Construction Standard the parapet height above the growing medium on a rooftop for a building height of 46 meters or less is 15 cm; for building over 46 meters the height required height is 75 cm.

Peak Flow: the point of highest flow

Peak Theory: the point at which we reach maximum global extraction followed by terminal decline, a theory based on the statistical analysis of M King Hubbert.

Pedestrian Shed: The way pedestrians move through an area that is centered on common destinations and applied to structured communities. There are three types:

- Standard Pedestrian Shed – the distance of the average 5-minute walk
- Long Pedestrian Shed – about 10-minute average walk, often used to propose transit stops as a destination
- Linear Pedestrian Shed – approximately half a kilometer walk along a mixed use corridor such as a main street.

Permaculture: An agricultural approach that mimics patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for the provision of local needs.

Precision Agriculture: One of the key agricultural breakthroughs of the first decade of the 21 Century developed by NASA. Precision agriculture "involves the integration of satellite observations, on-the-ground instruments, and sophisticated farm machinery to apply the appropriate amount of seed, water, fertilizer, and so on… so that maximum efficiency in food production is realized." (Hiemstra)

Roof: The overhead structural component of a building or a part of a building supported by walls or columns and which functions primarily to shelter the interior of the building from the effects of weather and the infiltration of water. (Toronto Municipal Code Chapter 492, Green Roofs)

Rural Flight: As farmers abandon the farm they head into the city in favour of a better life and more opportunity adding to urban populations through rural urban migration.

Scuppers: An opening allowing for drainage in the parapet of a building.

Set Back: The vegetation free zone on the perimeter of a buildings roof. According to the Green Roof Construction Standard; building height equal to or less than 46 meters = .5 meter set back; building height over 46 meters = .9 meters set back.
Slow Food: An international movement promoted as an alternative to fast food, focused on the preservation of traditional and regional cuisine based on sustainable food and the promotion of local products.

Solar Energy: Energy from the sun that is converted to produce electrical or thermal energy. (Toronto Municipal Code Chapter 492, Green Roofs)

Solar Reflectance Index: With reference to an Industrial Building or building addition, is a measurement of a roof's ability to reject solar heat, where a reference black roof (solar reflectance 0.05, thermal emittance 0.90) is 0 and a reference white roof (solar reflectance 0.80, thermal emittance 0.90) is 100. [Added 2011-12-01 by By-law No. 1381-2011] (Toronto Municipal Code Chapter 492, Green Roofs)

SPIN Farming: A growing system for small plot intensive farming to increase yields on sub acre farms.

Supermarket: A large full line grocery store with annual sales over $2 million. (Source Canadian Grocer)

Sustainable development: A term popularized by the World Commission on Environment and Development in1987. The commission's report, "Our Common Future," defines sustainable development as "economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Toronto's Environmental Plan pg 49) Today the concept has been integrated into economic, social and environmental policy planning to encourage long-term decision-making on the local, national and global scale. Sustainability considers economic, environmental and societal implications together in holistic approaches rather than as disparate issues that exist in a vacuum.

Sustainable Agriculture: A term that refers to methods and practices of farming using principles of ecology that meet the need of the present without compromising the ability of future generations to meet their own needs.

The Yield Gap: "the differences between observed yields and those attainable in a given region" (http://www.nature.com/nature/journal/v490/n7419/full/nature11420.html)

Toronto Green Roof Construction Standard: The minimum mandatory standards for construction of a green roof as set out in Article IV of this chapter. (Toronto Municipal Code Chapter 492, Green Roofs)

Urbanization: is the social shift from rural to urban areas

Urban Agriculture: "Urban agriculture is the practice of gardening and growing crops within a city." (The Stop Community Food Center website)

Urban Millennium: The date the global urban population met that of the rural population.

Vermiculture: A composting system that incorporates the use of worms to accelerate the decomposition of organic waste.

Vertical Farming: "is the practice of cultivating plant life within a skyscraper greenhouse or on vertically inclined surfaces. The modern idea of vertical farming uses techniques similar to glass houses, where natural sunlight can be augmented with artificial lighting." (Wikipedia)

Vegetation: Plants selected in accordance with the plant selection criteria of the Toronto Green Roof Construction Standard. (Toronto Municipal Code Chapter 492, Green Roofs)

Watershed: The drainage area, basin or catchment area for a watercourse. (Toronto Environmental Plan Pg 134)

Appendix B: Acronyms and Abbreviations

AAFC – Agriculture and Agri-Food Canada. AAFC's vision is focused on driving innovation and ingenuity to build a world leading agricultural and food economy for the benefit of all Canadians.

AC – Air Conditioning

B.E.E.S. – Beekeeping Education Enthusiast Society

BRIC – Acronym for Brazil, Russia, India and China

CAP – Clean Air Partnership

CCD – Colony Collapse Disorder

CCFN – the Canadian Council of Food and Nutrition

CDC – the United States Center for Disease Control

CO2 – Carbon Dioxide

CSA – Community Supported Agriculture

CSO – Combined Sewer Overflow

CSR – Corporate Social Responsibility

DDT – Dichlorodiphenyltrichloroethane, a man made chemical weaponized during WW II and later used as a pesticide, banned in most developing countries in the 1970's and 80's due to concerns over environmental and human health implication.

DIY – Do It Yourself

EPA - the United States Environmental Protection Agency

EROI – Energy Return on Investment

ESA – European Space Agency

FAO – The Food & Agriculture Organization of the United Nations

FMC – Farmers Market Canada

GHG – Green House Gas

GRP – Green Roof Professional

GTA – Greater Toronto Area

IMF – International Monetary Fund

IPM – Integrated Pest Management

LEED – Leadership in Energy & Environmental Design certification

LFP – Local Food Plus

MELiSSA – Micro-Ecological Life Support System Alternative

NAFTA – North American Free Trade Agreement

NASA – The National Aeronautics and Space Administration, "(NASA) is the agency of the United States government that is responsible for the nation's civilian space program and for aeronautics and aerospace research." (http://en.wikipedia.org/wiki/NASA)

OBC – Ontario Building Code

OECD - Organization for Economic Co-operation and Development

OMAFRA – Ontario Ministry of Agriculture, Food and Rural Affairs

RAC – Residential Apartment-Commercial zone

REB – Research Ethics Board

ROI – Return on Investment

SNAP –Supplemental Nutrition Assistance Program (Unites States)

SPIN - Small Plot Intensive

SPUD – Sustainable Produce Urban Delivery (a Vancouver based company that sources local food for home delivery)

STEEPV – A foresight methodology for analyzing factors effecting populations including Social, Technological, Economic, Environmental, Political and Value

TCGN – the Toronto Community Garden Network

TCI – Tides Canada Initiatives

TDSB – Toronto District School Board

TFPC – Toronto Food Policy Council

TGRCS – Toronto Green Roof Construction Standards

TRCA – Toronto Region Conservation Authority

UAS – Universities of Applied Science

UN – United Nations

UNCCD – United Nations Desertification Convention

UNCTAD – United Nations Conference on Trade and Development

UNEP – United Nations Environmental Program

UNFPA – United Nations Population Fund (Formerly the United Nations Fund for Population Activities) an international development agency tracking "population dynamics including growth rates, age structures, fertility and mortality, migration and more, influencing every aspect of human, social and economic development." (http://www.unfpa.org/pds/)

USDA – the United States Department of Agriculture

USGBC – United States Green Building Council

WHO – World Health Organization

WIC – Supplemental Nutritional Program for Women, Infants and Children (US)

WRI – World Resource Institute

WTO – World Trade Organization

WWF – World Wildlife Fund

WWFMP – Wet Weather Flow Master Plan

YIMBY – Yes in My Back Yard

Appendix C: General Principles of Sustainable Agriculture

1. A sustainable agricultural system is based on the prudent use of renewable and/or recyclable resources. *A system that depends on exhaustible (finite) resources such as fossil fuels cannot be sustained indefinitely. A sustainable system would use renewable energy sources such as biological, geothermal, hydroelectric, solar, or wind. Use of recyclable resources such as groundwater at rates greater than recharge depletes reserves and cannot be sustained.*

2. A sustainable agricultural system protects the integrity of natural systems so that natural resources are continually regenerated. *Our current thinking focuses on reducing the rate of degradation of natural and agricultural ecosystems. A system will not be sustainable as long as the goal is simply to decrease the rate of its degradation. Sustainable agricultural systems should maintain or improve groundwater and surface water quality and regenerate healthy agricultural soils.*

3. A sustainable agricultural system improves the quality of life of individuals and communities. *In order to stem the rural to urban migration, rural communities must offer people a good standard of living including diverse employment opportunities, health care, education, social services and cultural activities. Young people must be afforded opportunities to develop rural enterprises, including farming, in ways that care for the land so that it may be passed onto future generations in as good or in better condition than it was received.*

4. A sustainable agricultural system is profitable. *Transition to new ways of knowing, doing and being require incentives for all participants. Some of these incentives are necessarily economic. Systems and practices that do not include profitability as one of the prime motivators will not be voluntarily implemented.*

5. A sustainable agricultural system is guided by a land ethic that considers the long-term good of all members of the land community. *Holistic or whole-system analysis views an agro ecosystem as a dynamic community of soil, water, air and biotic species. All parts are important because they contribute to the whole. This ethic strives to protect the health of the land community, that is its capacity for self-renewal.*

John M. Gerber, 1990

Appendix D: The Effect of Irrigation on the Ogallala Aquifer and the Aral Sea

Ogallala Aquifer

Located in Nebraska, USA the Ogallala Aquifer is one of the largest sources of fresh water in the world. It is a vast underground system spanning from South Dakota to Texas touching eight states along the way and storing almost as much water as Lake Eerie and Lake Huron combined. (Pore) It underlies just over 450,000 square km of the American Mid West (Conkwright) and is a key source of water for the agricultural production of the Great Plains. The yield of wells drilled into the aquifer can produce anywhere from eight liters of water to over 4,500 liters a minute or more. (Conkwright) There are numerous metrics used to evaluate the amount of water contained in the aquifer and the amount withdrawn yet according to researchers at Michigan State University (MSU) it has been unsustainably managed and is shrinking as a result.

The economy of Nebraska relies on the aquifer for its water resources. The state is trying to conserve water by improving technologies in water application and developing new crop hybrids in an attempt to use resources more efficiently. In 2010, the National Science Foundation awarded MSU a $1.2 million dollar, four-year grant to develop a plan to better manage this important natural resource led by hydro-geologist David Hyndman. The goal is to "develop a sustainability plan based on economic, sociological and geographic issues affecting the aquifer" (Pore) According to Hyndman, "We are on an unsustainable course and must make difficult changes if we are to keep using some of the best agricultural land in the country" …"for more than 80 years, the Ogallala Aquifer has been used for irrigation, and the withdrawals far exceed it ability to replenish itself" (Pore) The outcome of the project is expected to be predictions and impact assessments for a range of potential solutions in hopes to adjust land management policies toward a goal of sustainable water use practices. Hyndman states that "Navigating a patchwork of state laws, regulations and economics means any change will require complex solutions and since scientific solutions don't live in a vacuum, our plan will also address social and economic variables". (Pore)

Aral Sea

In 1960, the Aral Sea basin was the fourth largest inland water source in the world supplying the water needs for seven current Central Asian countries; Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and the Islamic Republic

of Iran. Between 1960 and 1996 the surface area of the sea declined from 67,000 square km to 30,000 square km reducing its surface by more than fifty percent and according to the World Bank the sea level dropped by sixteen meters. By 1987, 27,000 square km of the lake bottom had become dry land; about sixty percent of the water volume had been lost. By 1987, the salt concentration had doubled. (Erkin)

Between the 1940's and the 1970's, the water from the two rivers that feed the Aral Sea, the Amu Dar'ya and Syr Dar'ya, were diverted for agriculture in order to grow cotton on the arid land of Soviet Central Asia. During that time "Ninety-four water reservoirs and 24,000 km of channels were constructed on these two rivers to support the irrigation of 7 million ha of agricultural land" (Erkin) By 1990 the sea received less than ten percent of its previous flow from the rivers that supply it. (Erkin) This resulted in the sea split in two, a larger southern Uzbek portion and a smaller northern Kazakh portion. (Evans)

Today the sea has about ten percent of the water volume it had in 1960. In less than sixty years it has gone from a vibrant source of water providing a robust economic base for fishing and agriculture to a salty puddle in the desert that is often considered to be one of the worst man-made ecological disasters in history.

Environmental and economic conditions in the region have suffered greatly due tot of the los of the Aral Sea.

Economy

As a result of the decline of water volume and quality in the Aral Sea Basin the fish stock has been reduced by more than eighty percent since the 1960's greatly impacting the economy and health of local populations. According to the World Bank, high salinity and environmental pollution have resulted in a decline of fresh water supplies and human health has suffered as a result.

The demise of the Sea is partially linked to global warming but is mainly due to mismanagement of water resources. By 1960, up to sixty cubic km of water were annually being diverted for irrigation to support the Soviet Union's desire to develop huge cotton plantations. (Mail)

“Experts including the World Back, doubt the Aral Sea will ever be restored to its original size” Many experts believe that based on the 2009 rate of decline the Aral Sea will disappear completely by 2020. (Erkin) “Other endangered sites include Central Asia’s second largest lake, Balkhash, as well as Lake Chad in Africa and Lake Qinghai, China’s largest expanse of inland water” (Evans)

Pollution

As of 2009, “200,000 tones of salt and sand are carried by wind from the Aral Sea region every day, and dumped within a 300 km radius”. (Erkin) This is resulting in declining agricultural viability due to soil salinization and the destruction of pastureland resulting in declining food security. Water in the region contains four times more salt per liter than the limit recommended by the World Health Organization (WHO). Much of the water is also contaminated with fertilizers and chemicals making it unsuitable for human consumption or agriculture. The Health consequences have been severe, “ Some 70% of the 1.1 million people living in Karakalpakstan suffer from chronic maladies, respiratory illness, typhoid fever, hepatitis, and esophageal cancer” “Tuberculosis has reached epidemic proportions, In some towns there are an estimated 400 cases out of a population of 100,000.” (Erkin)

In 2001, the World Bank initiated a rehabilitation project in partnership with Kazakhstan to rehabilitate the water levels in the northern part of the Sea, recognizing its importance of the Sea to the economic and environmental stability of the region. In the past eight years, the surface area of this portion of the Sea has increased by about a third.

In April 2010, “UN Secretary-General Ban Ki-moon urged Central Asian leaders to step up efforts to solve the problems after touring the Sea by helicopter” in a visit to a number of the countries in the former Soviet Central Asia. (Mail) In an interview he urged leaders of the countries to come together to find solutions promising UN support. Cooperation is hampered by tensions in the region driven by disagreements over who has water rites, diversions of flow and disagreements on how water should be used. These tensions are exacerbated by increased competition for water resources as a result of rising population and a continually decreasing amount of water available per capita. (Mail)

Cotton is still the main pillar of the economy in many parts of the region like Uzbekistan

Appendix E: The Ten Principles of Agricultural Urbanism

1. **Take an integrated, food and agriculture-system perspective**
   Promoting the broadest range of elements including production, processing, distribution, retailing, education, celebration, infrastructure and food security

2. **Create a rich experience of food and agriculture**
   Use a variety of strategies to make all aspects of food more visible

3. **Build the food and Agriculture economy**
   Plan for the widest range of food-system elements into every neighborhood to increase the economic activity of the food system.

4. **Increase access to food**
   Make food available to all people in all neighborhoods at all times including access to growing space, grocery of food stores, restaurants and food outlets.

5. **Educate about food**
   Plan to provide formal and informal education opportunities promoting engagement in all aspects of the food system in every neighborhood through plans, designs and community programming.

6. **Manage to support sustainable food systems**
   Through government policy, programs and institutional mandates and development plans while at the same time including food system stakeholders in the decision-making process.

7. **Provide food and habitat for other species**
   Agricultural urbanism recognizes the importance of biodiversity and the protection of habitat. A more robust urban agriculture system has the potential to increase food production while minimizing the negative effects of production increases encroaching on natural habitats.

8. **Organize for food**
   Maintain partnerships and organizations to take responsibility for managing successful urban food systems, policies, programs and physical spaces.

9. **Construct sustainable infrastructure for food and agriculture**
   Urban food systems have the potential to address reductions in infrastructure regarding energy, water, wastewater, and solid waste management.

10. **Bring food and agriculture into the full suite of climate change solutions**
    Urban agriculture has the potential to help develop a deeper understanding of the agricultural systems contributions to climate change and develop mitigating strategies.

Janine de la Salle & Mark Holland pg. 31

Appendix F: The History of Toronto Policy Effecting Urban Agriculture and Green Roofs, 1991-2014

1991 -**Toronto Food Policy Council (TFPC)** is established. Toronto's Board of Health creates one of the world's first food policy councils pioneering the field of urban food systems thinking as a subcommittee to advise the City of Toronto on food policy issues. The council is made up of 30 citizen members from Toronto's food community led by Lauren Baker. The main focus is developing municipal food related planning, policy and programming to encourage a healthy food system in Toronto. Members support numerous programs focused on "equitable access to food, nutrition, community development and environmental health, acting as professional lobbyist for the people on food and related issues". (Wikipedia http://en.wikipedia.org/wiki/Toronto_Food_Policy_Council)

Responsible to the Toronto Department of Public Health the TFPC has contributed greatly to food related strategies for Toronto through their participation in the development of numerous policies. (See appendix H for a list Toronto Food Policies involving the TFPC)

1993 -Collaborative report for the city: "Supports for Urban Food Production: Creating a Garden City"

1996 -Toronto's first rooftop farm, Annex Organics is founded

1997 -The Cities Parks, Forestry, and Recreation division creates a Community Gardens Program Coordinator Position

1999 -City Council endorses the Community Garden Action Plan with the goal of establishing a community garden in every ward of the city

- The Toronto Food and Hunger action Committee was formed in December 1999 "to study food security in Toronto and recommend ways to reduce hunger, improve the nutritional health of Torontonians, and support food-based initiatives that benefit Toronto's economy, environment and quality of life." (http://www.toronto.ca/food_hunger)

2000 -**Toronto's Environmental Plan:** Clean, Green and Healthy, A Plan for an Environmentally Sustainable Toronto is adopted by city council. The city's first-ever Environmental Plan, the plan recommends the city develop strategies to encourage green roofs and rooftop gardens.

2001-**The Toronto Food Charter**

http://www.city.toronto.on.ca/food_hunger/pdf/food_charter.pdf

> "A Food Charter is a statement of values, principles, and priorities for a just and sustainable food system that will promote health and food security for all. Developed by the public, a Food Charter represents the voices and visions of community members, resulting in a community-owned and locally focused action plan to improve food access and sustainability."
>
> Rachael Goodmurphy
> http://www.kflahealthycommunitiespartnership.com/FoodCharterBackgrounder.pdf
> (Taken from: Jacquith M. An Assessment of Canadian Food Charters: highlights and recommendations for the KFL&A Healthy Eating Working Group. KFL&A Public Health; 2011 Sept 6:6-8.)

Toronto City Council adopted the Toronto Food Charter in 2001 after working collaboratively on food security with the City of Toronto's Food and Hunger Action Committee and the Food Policy Council since 1992. The charter is Toronto's official vision for a food secure city and represents a willingness to address goals related to nutrition and an adequate supply of affordable and culturally appropriate food for all. The charter also addresses the need for urban agriculture, environmental responsibility and waste management. The implementation of the charter is still a work in progress.

> "Toronto is one of the first municipalities in North America to take a leadership role in food policy. Cities across Canada and the US have used the Toronto Food Charter as a model for developing their own."
> (The State of Toronto's Food, May 2008)

Through the charter City Council commits to support community gardening and urban agriculture in the interest of increasing food security in the city. Under the summary of the Growing Season Recommendations section 34d the report recommends the promotion of urban agriculture by "requesting that Economic

Development, Culture and Tourism identify private-sector investment opportunity in food-producing rooftop greenhouses with a case study on the financial viability of at least one prototype." (The growing Season action Plan pg 33)

- Toronto City Council adopts The Growing Season, an Action Plan for food security proposed by the Food and Hunger Action Committee.

2002 **-Toronto's Official Plan**

http://www.toronto.ca/planning/official_plan/pdf_chapter1-5/chapters1_5_dec2010.pdr

Toronto's Official Plan is approved and expresses support for community and rooftop gardens. The plan, authored by Gary Wright, Chief Planner and Executive Director of the City Planning Division, was adopted by City Council in November 2002 and was consolidated by the city in December 2010.The Plan sets out the vision for how Toronto will grow to the year 2031 and makes a number of references to the importance of rooftop gardens throughout the plan.

> "Toronto's Official Plan establishes policies for the built environment, for improvements to the city's hard surfaces (such as transit, roads, and sewers) and for the protection of the city's natural environment. All development applications are evaluated against the Official Plan and the city's zoning bylaws must reflect the intent of the plan." (Planning and the City of Toronto Pamphlet) (http://www1.toronto.ca/city_of_toronto/city_managers_office/civic_engagement/learning_materials/files/pdf/planning.pdf)

According to the Official Plan "people choose to live and businesses invest in beautiful cities and as a "City of Beauty" Toronto's future must be one that includes well maintained clean and beautiful green spaces including community and rooftop gardens." (1-4)

The plan is intended to facilitate and shape the cities growth by engaging local stakeholders including "investment in community improvements by public agencies or public/private partnerships that are needed to support city living." This includes parks and open spaces, community and rooftop gardens and community services and facilities. (2-16) Chapter three of the Plan includes requirements for all new multi-unit residential developments to include indoor and outdoor amenity space for residence and specifically mentions rooftop gardens as an appropriate option.

- The City of Toronto partners with the Toronto Region Conservation Authority (TRCA) to create the Toronto Urban Farm at Black Creek. The TRCA turned over 8 acres of land within the Parks, Forestry and Recreation Division to the City of Toronto's Community Garden Program (CGP) under a management agreement.
- "The Toronto Urban Farm Project objectives fulfill Toronto City Councils' mandate to promote urban agriculture and create local food production pilot programs." (Toronto and Region Conservation for the Living City: Toronto Urban Farm http://www.trca.on.ca/the-living-city/programs-of-the-living-city/near-urban-agriculture/toronto-urban-farm.dot)
  Source: http://www.citnews.ca/news/news_24850.aspx

2003 -The Green Roof Taskforce was formed (Garrison)

- Ryerson University initiates a certificate program in food security.

2004 -Toronto hosts the American Community Garden Association annual conference

2005 -The Toronto Community Food Animators Program is established, funded through the City's Community Partnership and Investment Program

- Local Food Plus (LFP) established linking farmer with institutions that buy local food and creating a certification program and brand for local sustainable food
- Places to Grow Act – under the act he growth plan for the Greater Golden Horseshoe was prepared as a framework for implementing the Ontario Governments vision for managing growth in the region to 2031. The plan also includes the Oak Ridges Moraine and the Niagara Escarpment.

2006 -City supports The Toronto District School Board (TDSB) research on market gardens

- Toronto's Official Plan is updated but still includes support for community and rooftop gardens.
- A two-year Green Roof Incentive Pilot Program was initiated under the Toronto Water Agency the agency responsible for the cities Wet Weather Flow Master Plan. With a budget of $200,000, participants were offered $20,000 in incentive to install a green roof. (Garrison)
- Ontario's Building Code is amended to allow the use of rainwater inside a building.

- The city of Toronto adopts the Toronto Green Standard, Toronto's building certification program which becomes the basis for the adoption of the Green Roof bylaw in 2009

2007 -Toronto Community Housing publishes a Community Garden Manual

- Mama Earth Organics established as part of the Toronto Local Food Movement providing a service where local farmers are given priority and members are able to access the freshest organic items available at a fair price (http://www.mamaearth.ca/about-us)
- The State of Toronto's Food a report for the Toronto Public Heath is published

2008 -Toronto adopted the Local Food Procurement Policy in October, leveraging purchasing power in favour of home grown products

- Toronto Public Heath endorsed the State of Toronto's Food: discussion paper for a Toronto Food Strategy the basis for Toronto's Food Strategy unveiled in 2010. At the time "Toronto [was] the only municipality in North America that [had] a designated Food &Beverage Sector specialist in its Economic Development Division to support the growth of the food industry locally." (The State of Toronto's Food, pg. 4)
- City Council approves the Climate Change Action Plan making a commitment to double the existing tree canopy to mitigate environmental issues including a reduction of the heat island effect and reducing storm water runoff (Garrison pg110)
- May 2008 Carrot City Design for Urban Agriculture Initiative organized a symposium entitles "The Role of Food and Agriculture in the Design and Planning of Buildings and Cities" held at Ryerson University in Toronto. Leading to the Carrot City exhibition at the Design Exchange in the winter of 2009 followed by the launch of an informative website and the publication of a book. (More info) http://www.ryerson.ca/carrotcity/rooftops.html

2009 -The Toronto Regional Conservation Authority (TRCA) introduces a progressive Sustainable Near-Urban Agriculture Policy

- City Council adopts the report “Identifying Urban Agriculture Opportunities in the City of Toronto,” affirming its support for strategies and initiatives that expand opportunities for local food production in the city
- “On June 3,2009 the Greater Toronto Area Clean Air Council (GTA_CAC) member municipalities sign the GTA_CAC Inter-Governmental Declaration on Clean Air, committing members to take action on clean air and climate change” (Jones pg 4) Article 3.3 of the declaration calls for the development of a Local Food Solution Paper that provides guidance and lessons learned on the development and implementation of local food procurement policies.
- Sustain Ontario is launched. A project of Tides Canada Initiatives led by the Metcalf Foundation. Sustain Ontario was launched in 2009 and is a province wide alliance that promotes a food system that is healthy, ecological, equitable and financially viable. “Sustain Ontario takes a collaborative approach to research, policy development and action by addressing the intersecting issues related to healthy food and local sustainable agriculture.” (Sustain Ontario website http://sustainontario.com/about/about)

  As of November 28, 2012, Sustain Ontario had 349 members organizations province wide and 132 in Toronto alone. Members include a cross section of organizations and institutions connected to food including farmers, non-for-profits, producers, educators, health organizations, environmental agencies, social and political activists and restaurants like Allen’s, serving and promoting sustainable locally grown seasonal food to name just a few.
- Toronto’s Green Roof by-law No. 583-2009 became an applicable law under the Ontario Building Code through an amendment in late 2009 creating a gateway for rooftop agriculture in the city. The Green Roof By-law requires all new buildings or building additions built after January 30, 2010, with a gross floor area of 2,000 square meters or more to install a green roof. Coverage ranges from 20-60 per cent based on the gross floor area. Toronto is the first city in North America to instate such a bylaw.

2010 -The Toronto Food Strategy is established through Toronto Public Health, and unveiled by Sustain Ontario, the Toronto Board of Health endorses the consultation report, “Food Connections: Toward a Healthy and Sustainable Food System for

Toronto. Goals include policy and programming development to support an increase in urban agriculture activities across the city

- The Metcalf Foundation publishes the report “Scaling Up Urban Agriculture in Toronto: Building the Infrastructure.” The report outlines key opportunities and barriers to growing food in the city of Toronto.
- Cultivating Food Connections: Toward a Healthy and Sustainable Food System for Toronto. “Proposes a new vision for Toronto’s food, one that unites health and city building” created with input from numerous stakeholder groups.

2011-The city supports the GrowTO speakers Series and the report, GrowTO an Urban Agriculture Action Plan for Toronto. GrowTO was established to create an action plan for the city based on issues identified in the Metcalf Foundation report, “Scaling Up Urban Agriculture in Toronto: Building the Infrastructure” from 2010 with a goal of achieving the following:

    - Bringing stakeholders together.
    - Propose both policy and actionable solutions to increase urban agriculture in the city.
    - Highlight economic and social development opportunities for communities and neighbourhoods.
    - Focus on the potential for urban agriculture in Toronto.

The report was written in the context of propelling urban agriculture forward and making it more robust and is the result of a collaboration between a large number of stakeholders culminating in a series of recommendation that identify gaps in the current system as well as policy hurdles to be overcome.

The action plan creates a “vision of a green city full of fresh, local, healthy, nutritious, affordable, culturally diverse, and flavourful food available for all.” (Baker, Aug 2012)

- “Local Food Procurement Actions and Reports Scan” a report to the Greater Toronto Area Clean Air Council, prepared by the Clean Air Partnership

2012 -City council endorses the Greater Golden Horseshoe Action Plan, promoting the preservation of farmland in Ontario and the expansion of urban agriculture opportunities.

The Golden Horseshoe Green Belt was established in 2005 to protect 1.2 million acres of farmland in southern Ontario.

(Information based on GrowTO)

2012 -Toronto Hosts the Urban Agriculture Summit at Ryerson University, the first large conference of its kind in Canada according to the Star.com reporter Laura Kane.

- The Black Creek Community Farm, Toronto's largest urban farm was announced at the conference, 10 years after its conception.

2013 -The Urban Ecology Conference held in Toronto in May

- In 2013 the Legislative Assembly of Ontario passed Bill36, Local Food Act, 2013 as a part of its local food strategy to foster resilient local food economies and systems in Ontario while developing markets for local food.

  The first of its kind in Canada the act aims to:

  - Increase access to local food
  - Improve food literacy on local food
  - Encourage increased use of local food through consultation with organizations
  - Proclaim Local Food Week beginning the first Monday of June

  (www.omafra.gov.ca)

Appendix G: Toronto's Green Roofs and Green Standard: Background

In 2003 the Green Roof Taskforce was established to investigate and promote the benefits of green roofs. "A 2005 Ryerson University Study estimated that if a green roof were installed on every flat roof in the city, the city would save nearly $270 million in municipal capital costs and more than $30 million annually." (Garrison, 110)

By 2006 the city offered a two-year Green Roof Incentive Pilot program to investigate the benefits of different green roof technologies and planting styles. With a budget of $200,000 the program offered participants an incentive of up to $20,000 per project to install a green roof. Funding was provided through Toronto Water, the agency responsible for implementing Toronto's Wet Weather Flow Master Plan. (Garrison and Toronto Water 2007 Wet Weather Flow master Plan Implementation Report, 2006) As a result of the program 100 green roofs were built or planned in the city of Toronto in 2006. (Garrison) At the time Toronto Water was also working on a joint project with Environment Canada, the Toronto And Region Conservation Authority and Ryerson University to evaluate the performance of urban green roofs. Analyzed data collected from green roof sites in Toronto demonstrated quantitative reductions of 30% on average in peak flow and runoff volumes were reduced on average by 50%; the deeper the soil the greater the reduction. (Toronto Water (2007). Wet Weather Flow Master Plan (WWFMP) Implementation Report, 2006.) Findings from this research were used to develop the storm water management standards and guidelines and methodologies for the quantification of storm water drainage benefits from green roofs.

The City of Toronto Act was also passed in 2006 giving the city the authority to mandate green roofs on all new buildings or retrofits with more than 2,000 square meters of floor area however it wasn't until May 2009 that Toronto City Council adopted the Green Roof Construction Standard setting performance standards to promote environmentally sustainable development on two levels. The first is the mandatory compliance for all new buildings with a floor space over 2,000 square meters as of January 31, 2010. The second is a voluntary compliance for existing buildings through the Eco Incentive Program whereby the city provides refunds up to 20% of the cost.

In 2008 Toronto approved its Climate Change Action Plan committing to doubling the existing tree canopy to increase shade in an attempt to reduce the urban heat island effect and reduce storm water runoff. Toronto's Green Roof Bylaw was initiated to

promote more environmentally sustainable development as a storm water management system and a way to mitigate environmental factors like the heat Island effect while relieving pressure on the cities energy consumption by cooling buildings in summer and insolating them during the winter. Green wastewater management is an effective way to deal with the additional flows caused from the cities expansion while avoiding additional costs for water and sewage treatment by eliminating excess runoff from entering the system.

"Green Roofs deliver a number of benefits, outlined in the City's green roof strategy, "*Making Green Roofs Happen"*, including storm water management, energy efficiency, urban air quality and managing the urban heat island effect of urbanization."

Ann Borooah
Chief Building Official and Executive
Director Toronto Building

The Toronto Green Roof Construction Standard (Toronto Municipal Code Chapter 492, Green Roofs, Article IV)

- **Calculating Green Roof Space requirements on Low-Rise Commercial Buildings**
  When working out calculations any area required for renewable energy sources may be deducted or excluded from the total roof area available for the garden leaving the remainder to act as the total available space to be cultivated therefore reducing the size of the garden.

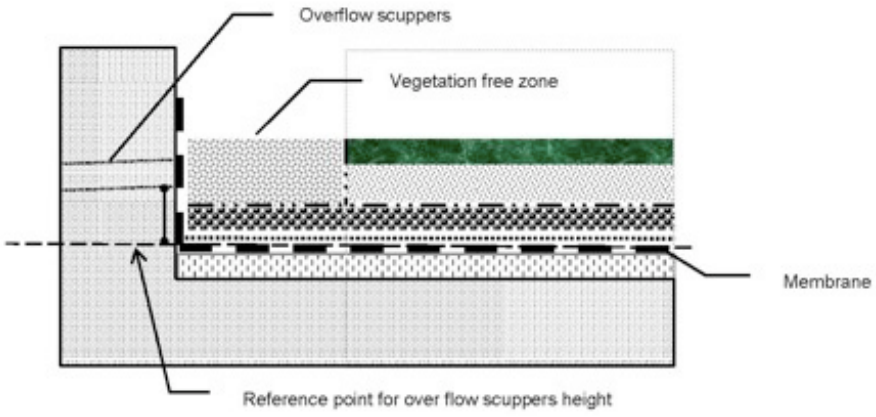
- **Calculating Green Roof Space requirements on Mid-Rise Buildings**
  When calculating green roof requirements for mid-rise buildings the total roof area includes roof areas as well as maintenance and mechanical areas but may exclude any renewable energy, private terraces o outdoor amenity space. Amenity space is restricted to a maximum of 2m squares per unit.

- **Calculating Green Roof Space requirements on High-Rise Buildings**

When calculating green roof requirements for high-rise buildings the total roof area includes roof areas of towers with a floor plate of 750 m square as well as any roof area on podium levels. This includes all maintenance and mechanical areas but may exclude any renewable energy, private terraces or outdoor amenity space. Amenity space is restricted to a maximum of 2m squares per unit.

Mandatory provisions are included in the Toronto Green Roof Construction Standard for the following areas:

- Green Roof Assembly



Source: http://www.toronto.ca/greenroofs/pdf/GreenRoof-supGuidelines.pdf

- **Gravity Loads**
  Gravity load is set by the OBC and represents the maximum load a roof can structurally handle.
- **Slope Stability**
- **Parapet Height**
  The standard recommends a minimum parapet height above the growth media and vegetation free border zones as follows:

Building Height	Parapet height (above growth media)	Vegetation free/ border zone
≤46 m	150 mm	0.5 m
>46	750 mm	≥0.9 m

- **Overflow Scupper Locations**
  Designed and installed to limit the rainwater loads to within the structural limits of the building below scuppers are installed as a backup drainage system.
- **Wind Uplift**
  The Standard addresses the risks of Wind Uplift that need to be addressed to ensure that any design resists “blow-off” by the wind, an engineer’s report is required.
- **Safety: Fire**
  Safety is also addressed and fire safety issues dictate a vegetation free zone of the height of the mature crop or a minimum of 0.5 meters around any “roof penetrations, intersecting walls, parapets, upturns or mechanical equipment clad with combustible materials” pg11.
- **Safety: Occupancy**
  A Guard or secure railing of no less than 42’’ (1070 mm) is required around any roof to which access is provided for anything other than maintenance especial those used to produce and harvest vegetables.

  For non-accessible green roofs with no guard railing a 2-meter vegetation free zone is required. The vegetation free border zone is a critical component as it quickly consumes space on the roof.
- **Waterproofing**
  Prior to installing of any green roof system an architect or engineer must perform one of a number of leakage testing protocols on the roof based on OBC requirements and provide a document identifying the success of the test to the

Chief Building Official. The waterproofing installation must also include a root barrier to prevent damage to the underlying roof from the plants themselves.

- **Drainage**
  Drainage and water retention issues are also addressed in the TGRCS along with any additional need for irrigation including its method to ensure plant survivability for the duration of the roofs lifespan. The growing media and plant selection are also covered to ensure performance and plant survival.

- Water Retention
- Vegetation Performance
- Plant Selection
- Irrigation

Maintenance Plan

A maintenance plan for the longevity of the project is required by the TGRCS and must be filed with the permit application.

The Green Roof Construction Standard provides detailed information on the installation and engineering requirements of the roof as well as the structural integrity of the building below. More information can be found at http://www.toronto.ca/greenroofs/pdf/GreenRoof-supGuidelines.pdf

- **Toronto's Eco-Roof Incentive Program**

This is a grant-based program designed to promote the use of green and cool roofs on existing commercial, industrial and institutional buildings as well as new buildings with a gross floor area under the 2,000 with performance criteria consistent with the Green Roof Bylaw.

"Adopted by City Council in 2009, the Eco-Roof Incentive Program is a key element of the City's Climate Change Action Plan, an aggressive environmental framework aimed at reducing Toronto's greenhouse gas emissions by 80 per cent by 2050." (Eco-Roof

Incentive Program http://www.toronto.ca/livegreen/greenbusiness_greenroofs_eco-roof.htm)

Appendix H: Recommended in Section 39 of Toronto's Environmental Plan:

a) Recognize the City's potential for increased urban food production in the Official Plan;
b) Implement the action plan that is being developed by Economic Development, Culture and Tourism to expand community gardening;
c) Develop an action plan to build rooftop gardens on City buildings;
d) Prepare an inventory of potential locations where greenhouse facilities could be located near potential energy co-generation projects or landfills with methane recovery;
e) Make compost from wet waste recovery readily available to urban food production projects and businesses;
f) Report on the feasibility of developing a cluster of local food industries;
g) Determine the need for "incubator" programs to support emerging local food businesses;
h) Carry out a food flow analysis for the City to determine the amount of food imported and its sources;
i) Analyze existing food procurement arrangements to identify potential products that could be produced through an urban food production system;
j) Create urban food production pilot projects; and
k) Prepare an inventory of sources of organic food in Toronto and make this information available to the public in the form of a directory.

Appendix I: Case Studies

Case Study: The University of Toronto Sky Garden (Toronto)
Location:
35 St. George Street
Toronto, ON, Canada
(U of T's Galbraith Building)

Year Established:
2009 expanded in 2010

Funding:
Began in 2009 as a pilot garden using nursery pots with internal funding from the University of Toronto civil engineering department

2010 received a seed grant from Live Green Toronto to expand to include 113 specialized semi-hydroponic containers from BioTop in Montreal (http://biotopcanada.com/?lang=en)

According to a January 12, 2012 article by the Ontario Healthy Communities Coalition "The project currently has a multitude of sponsors including The Food and Water Institute, biotope, Live green Toronto, Urban Harvest Garden Alternatives, U of T Environmental Resource Network, The Home Depot, MBNA, and TD Manulife Financial." (http://www.ohcc-ccso.ca/en/the-sky-garden-rooftop-gardening-at-the-university-of-toronto)

Building Type and Height:
4 story institutional building, part of the University of Toronto

Garden Size:
810 square feet – Approximately 0.02 acres

Type of Garden Practice:
- A lightweight semi-hydroponic container garden suitable for virtually any existing rooftop
- Sub irrigated planters
- Conventional containers
- Lightweight greenhouse to extend growing season

Growing Media:
The semi hydroponic containers use engineered soil an exclusive blend of high performance mycorrhizal inoculum from BioTop along with compost

Soil Depth:
6 – 8 Inches
Standard nursery pots are about 12 Inches

Crops:
Vegetables, heirloom tomatoes, and herbs

Annual Yield:
Approximately 350 kg (770 pounds) of organic vegetables

Season of Operation:
April – November

Water Saving Strategies:

- Sub irrigated containers (water source: rain barrel)
- Semi-hydroponic containers
- Timed drip irrigation (5 minutes every 6hrs)
- Rain barrel hand watering
- Us of straw mulch
- Use compost created on site

Water is not an issue for the garden they are tied into the municipal water main.

> "[The garden uses], sub irrigated containers, semi-hydroponic containers, drip irrigation as well as some hand watering." "The water is on an automatic timer for about five minutes every six hours, sometimes we have to adjust it based on the weather, at the same time we also fertilize through the water system using organic liquid fertilizer."
>
> (Alexander Suzin)

Consumers/Market:
90% of the garden production goes to the University of Toronto Food Bank providing access to healthy nutritious food to students that may not otherwise have access. All produce from the garden is identified with a sticker promoting the Sky Garden to ensure users know.
10% goes to the volunteers.

Bees:
Yes, the garden includes three beehives for pollination operated and maintained by the Beekeeping Education Enthusiast Society (B.E.E.S).

Tenure:
Long-term arrangement with the University

Other:

- Outreach to community through garden tours, workshops, website and social media presence
- Only use organic farming practices
- BioTop Canada
  365 rue du Sanctuaire
  Sherbrooke, Qc
  Canada, J1C 0B9
  http://biotopcanada.com/?lang=en

Case Study: The Fairmont Royal York (Toronto)
Location:
The Fairmont Royal York
100 Front Street West
Toronto, Ontario, Canada
M5J 1E3

Year Established:
1998

Building Type and Height:
Commercial Hotel with the garden on the 18th floor or the East wing
Everything for the garden is transported from the 17th floor rooftop to the 11th floor via stairs then by elevator to the kitchen on the 1st floor.

Garden Size:
4,000 square feet intensive rooftop garden

Type of Garden Practice:
- Raised bed – 16 large beds
- Container gardens
- Companion planting
- Intercropping
- Crop Rotation
- Succession planting
- Composting
- Conducting research in collaboration with the Vinland Research and Innovation Center to grow South Asian vegetables, okra, round eggplant, and hot peppers on the roof experimenting to expand the diversity of Ontario crops.
- Apiary

According to Andrew the wooden raised beds last about 10-12 years before the bottoms fall out and they need to be replaced. The raised beds allow for easy access and distribute weight across the roof.

Growing Media:
Engineered soil and compost

Soil Depth:
10-12 Inches

Crops:
- A large variety of vegetables, heirloom tomatoes, herbs, edible flowers and fruits
- Growing more than 50 herbs and spices for use in the hotel kitchens, often growing things they can't readily get from suppliers such as wasabi arugula or alpine strawberries.

"We produce enough of most things that we grow that we don't need to purchase them for 4 months." (Andrew Court)

'We mainly grow herbs, garnish or lettuce and everything is used on the premises in the kitchen. Lavender for example is used mainly in cookies or pastries and anything left over is used in house made bath salts. "(Andrew Court)

Annual Yield:
NA

Season of Operation:
Mid May – Mid October

Water Saving Strategies:
- Water is not an issue the garden has access to municipal water
- Irrigate with spray irrigation twice a day when necessary 6am and 8pm.
- Use of Mulch

Consumers/Market:
Used in the hotel kitchens, each dish in Epicure, the hotels restaurant contains on average two ingredients from the rooftop garden. Everything from the garden is processed in the hotel kitchen that is located on the 1st floor.

Bees:
Bees were introduced in June of 2008 in partnership with the Toronto Beekeeping Cooperative and FoodShare. The Fairmont Royal York was the first hotel in the world to house bees. Today they have 6 hives harvesting 800 pounds of honey in 2011. Today 22 Fairmont Hotels around the world have apiaries.

> "In a partnership with Millstreet Brewery 200 pounds of honey are used every year to produce a beer specifically for the hotel. Small jars of the hotel's honey are also provided to VIP guests and dignitaries as a marketing tool." (Andrew Court)

Other:
- The Royal York has over 1200 staff, 106 in the kitchen alone of that there are about 20 people, mainly apprentices in the kitchen that are involved in the garden.
- All garden waste is composted on the roof
- Embrace farm to fork philosophy promote local, 100 mile in their menu already
- All centerpieces come from the garden upstairs and are labeled
- 1 or 2 items on every plate served in the hotel comes from the garden
- Engage the community promoting the garden through high tea on the weekends that includes a tour of the garden.

Case Study: AccessPoint Alliance (Toronto)
Location:
3079 Danforth Avenue
Scarborough, ON, Canada

Funding:
Funded by:
A Live Green Toronto Grant
United Way Toronto

Ontario Trillium Foundation

Designed by David Fujiwara Architects

Year Established:
2011

Building Type and Height:
A two story industrial building – a purposefully renovated old tile factory

Garden Size:
6,500 square feet (0.15 acres)

Type of Garden Practice:
Conventional row farm community garden and container garden designed in collaboration with volunteers with blocks of planned activity including:

"We use a large number of methods including:

- Companion planting
- Intercropping
- Crop Rotation
- Succession Planting
- Sub irrigated Self Watering Container Gardening
- Drip Irrigation
- Hoop Houses (Wind is an issue even though they are only one floor up because on the ground the hoops can be pushed into the ground for support but not on the roof when the soil is only 7 inches deep)
- Indoor seedling Propagation

(Lara Mrosovsky)

Composting on Site using one 3-cell compost bin and two single compost bins

Growing Media:
Engineered growing media by Earth Co. Soil Mixtures, amended with compost vermin-compost, composted duck manure, kelp meal, greensand, insect frass, and microrrhizae,

Soil Depth:
7-8 Inches

Crops:
Multicultural vegetable gardens (40 + varieties)
Culinary and healing herbs (approximately 45 varieties)
Pollinator garden
Children's garden
Butterfly Garden

> "The gardens feature a collection of fruits, vegetables, herbs and flowers. The gardens have provided visitors with an opportunity to see the crops they have helped produce through tasks like watering, weeding, and harvesting. All the plants are organically grown - we don't use any synthetic fertilizers, or

insecticides, herbicides or fungicides."
(http://accessalliance.ca/services/community/green-access-program/whats-roof)

Annual Yield:
350 kg in 2012

Season of Operation:
April- November

Water Saving Strategies:

- Rainwater capture – 4 barrels totaling 1320 Liters – Specifically located based on engineers blue prints for structural support
- Mulch for water retention – Straw, landscape fabric
- Drip Irrigation
- Sub-irrigated containers
- Plant selection – native drought tolerant pollinator garden
- Soil amendment to increase organic material and water retention (Need to be carful based on water weight of the soil to much retention could be a problem)
- Also incorporates a passive solar water heater for the building

Consumers/Market:
The garden harvest is shared among a large number of stakeholders who share the garden.

> "Allowing access to fresh food helps address the issues within food security; this provides an equal opportunity for all people to have access to healthy nutritious food- especially those (in the community) who live in poverty or have a low income." "The produce is shared by the community garden volunteers and programming through the community kitchen."
>
> Lara Mrosovsky

Bees:
No

Full sun:
Yes

Tenure:
Access Alliance does not own the building however they do have a long-term arrangement with the owner.

Other:
The garden includes amenity space with a Pergola for shade, seating areas and is wheelchair accessible.

Case Study: Brooklyn Grange Farm (NYC)
Location:
Brooklyn Grange Flagship Farm
37-18 Northern Blvd
Long Island City, NY 11101

Brooklyn Grange - Navy Yard Farm
63 Flushing Ave
Building #3
Brooklyn, NY 11205

Year Established:
Brooklyn Grange Flagship Farm - 2010
Brooklyn Grange - Navy Yard Farm - 2012

Funding:
The farm was started with a $592,730 grant from the New York Department of Environmental Protection as a part of NYC's Green Infrastructure Stormwater Initiative, part of Mayor Michael Bloomberg's goal to reduce city carbon emissions by 30% by 2030. (Goldman) Until 2013 the city provided property-tax abatements of $4.50 per square foot up to $100,000 as an incentive promote green roof installations.

Today, "the farm is financed through a combination of private equity, loans, grassroots fundraising events and crowdfunding platforms like Kickstarter.com and ioby.com." (http://brooklyngrangefarm.com/about/)

Height and Type of Building:
Flagship Farm – 6-story industrial building, the Standard Moor Products building
Navy Yard Farm - 11 story industrial building, in the Brooklyn Navy Yard

Garden Size:
Flagship Farm - 43,000 square feet – 1.0 acre
Navy yard Farm - 65,000 square feet – 1.5 acre (New York City's Largest rooftop garden)

Total garden size 2.5 acres

Type of Garden Practice:
- Industrial rooftop row farm using conventional organic farming methods
- Perennial and annual crops
- Hens

Growing Media:
Engineered growing media - Rooflite AG blend with added compost sourced through Skyland a green roof media supplier in Pennsylvania.

Soil Depth:
10-12 Inches

Crops:
- A wide range of organic vegetables, salad greens, heirloom tomatoes and herbs.

Annual Yield:
Collectively the gardens produce 50,000 pounds of organic vegetables -22,680 kg (over 22 metric tons)

Season of Operation:
April - November

Water and Water Saving Strategies:
The use of the a green roof installation that includes conservation technologies including a drainage layer comprised of a water retention surface that holds back water for consumption during dry periods distributed by Conservation Technologies.

New York city receives between 43 and 50 inches of annual precipitation

> "[The] garden manages over a million gallons of storm-water each year easing the burden on the overtaxed Red Hook Wastewater Pollution Control Plant, which services 32,000 acres of Northwest Brooklyn, and ultimately reduces the amount of waste water that flows into [the] city's open waterways." (http://brooklyngrangefarm.com/navy-yard-farm/)

Consumers/Market:
Local stores, markets, restaurants and local residents and a CSA program
(Post over 20 wholesale and restaurant locations they supply on their website)

Bees:
Yes - Brooklyn Grange has a 30-hive apiary producing about 1,500 pounds of honey annually

Full Sun:
Yes

Tenure:
Long-term rental agreements, 10 years for the Flagship Farm and 20 years for the Navy Yard Farm

Other:
- Brooklyn Grange is an organic farm
- Composts organic material from a number of sources diverting it from land fill and converting it to garden nutrients
- Brooklyn Grange also uses Sub-Irrigated Planters (SIPs) in its planning for other small urban spaces like the roof of Louis Vuitton

Case Study: Lufa Farms (Montreal)
Location:
Lufa Farms flagship farm (31,000 square feet)
1400 Antonio-Barbeau Street,
Montreal, Quebec, Canada.

2nd Location
Laval (43,000 square feet)

Year Established:
2011
2013

Building Type and Height:
2 Story mixed-use commercial office building

Garden Size:
31,000 square feet – 0.7 acre
43,000 square feet – 1.0 acre

Total **1.7 acre**

Type of Garden Practice:
- Lufa uses controlled environment agriculture and hydroponic practices in a Rooftop Greenhouse
- The greenhouse allows for the development of microclimates for cool or hot climate crops as well as microclimates zones in each.

Growing Media:
NA hydroponic solution

Soil Depth:
NA

Crops:
Pesticide and herbicide free vegetables and salad greens
5 varieties of tomatoes, cucumbers, peppers, eggplants, herbs, salad greens, bok choy, kohlrabi, Swiss chard

Annual Yield:
70.5 metric tons in 2012

Season of Operation:
Year round production

Water Saving Strategies:
- Lufa Farms uses a closed loop hydroponic system for both nutrient and water delivery using harvested rainwater and re-circulated water to reduce municipal water demand. (The system only losses the water consumed by the plants)
- Use of compost for biomass and water holding capacity

Consumers/Market:
Based on a CSA program with weekly deliveries to approximately 150 drop points serving 3,000 subscribers in Montreal, restaurants and individual consumers within a 15 mile radius

Bees:
NO

Full Sun:
NA use a combination of natural and artificial light

Tenure:
Long-term lease agreement

Other:
- Green waste is composted on site

- Lufa Farms also incorporates local products to round out their CSA offerings
- Employs a team of 30 people
- The rooftop greenhouse consumes 50% less energy than if it were at grade.
- Product is harvested and delivered within 12 hours.
- Selling direct was the key issue to breaking even financially along with the efficiency of scale due to the size of the greenhouse.

Case Study: Gotham Greens (NYC)
Location:
Greenpoint, Brooklyn - 15,000 Square feet ((Flagship greenhouse) - 2010
Gowanus, Brooklyn @ Whole Foods Market - 20,000 square feet - 2013
Jamaica, Queens - 60,000 square feet - 2014

Year Established:
2010
2013

Funding:
Private investment funded and supported by profits

Building Type and Height:
Two story Industrial building, "the first commercial scale greenhouse farm integrated into a supermarket" in partnership with Whole Foods Market.

Garden Size:
Over 20,000 square feet – 0.46 acres

Type of Garden Practice:
Commercial climate controlled rooftop hydroponic greenhouse

Growing Media:
Mineral nutrient solution eliminating the need for soil

Soil Depth:
NA

Crops:
Leafy greens and tomatoes harvested to achieve optimal taste and nutrition

Annual Yield:
Over 200 tons annually

Season of Operation:
Year Round Production

Water Saving Strategies:
Hydroponics in the most water efficient form of agricultural irrigation incorporating recirculation systems that capture water for re-use, Gotham Greens system uses 20 times less water than conventional agriculture eliminating runoff a major source of global water pollution.

Consumers/Market:
Local retail, restaurants, and institutional customers
Farmers markets

> "Our proximity to our customers ensures that the extended shelf life is passed onto the customer and not the food delivery chain."
> (http://gothamgreens.com/our-farm/)

Bees:
Not at this time

Other:

- Incorporate Integrated Pest Management systems
- Offset electrical needs using solar PV panels, high efficiency LED lighting, advanced glazing, passive ventilation systems and thermal curtains. The insulating properties of the garden itself also reduces energy costs fro the building below.
- Pesticide-free production based on ecologically sustainable methods
- "Sophisticated computer control systems manage heating, cooling, irrigation and plant nutrition." (http://gothamgreens.com/our-farm/)
- No use of GMO's

Appendix J: Typical Components of a Green Roof

Vegetation refers to the choice of plant material on the roof.

Growing media usually an engineered soil designed with specific characteristics including weight, organic content, and water retention.

- Minimum depths of 4 inches are recommended and in the case of rooftop agriculture depths may need to be 12 -18 inches deep depending on the desired crop.
- If depths are less than 4 inches a report confirming the survivability of the plants chosen must be filed with the application based on the comparative survival in an un-irrigated system with growing mediums of 4 inches.

Filter fabric protects the water reservoir and drainage system from the infiltration of soil or growing media as water percolates through it especially during rainy days.

Drainage panels collect and store water for later use.

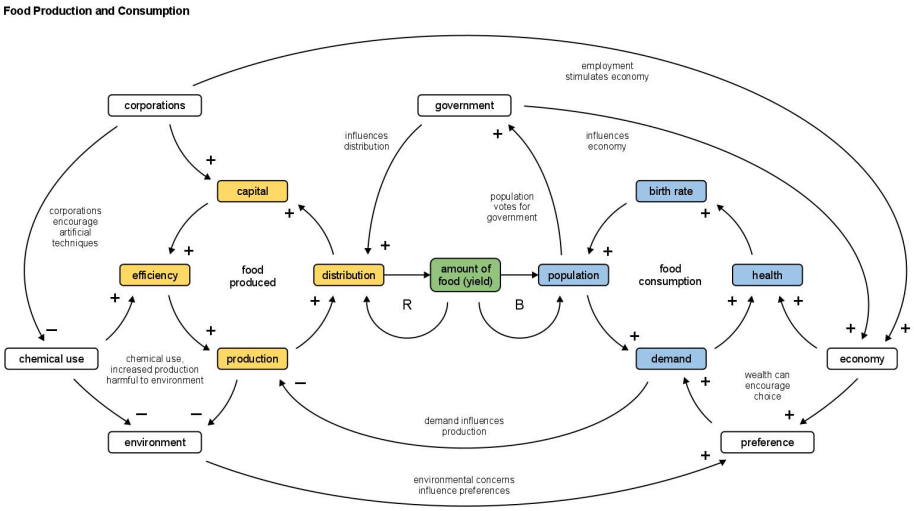
Insulation protects the waterproof membrane and keeps the growing medium protected in winter.

Membrane protection and root barriers protect the roofs waterproof membrane from damage caused from plant roots. Often made of thermoplastic sheets such as PVC, TPO or polyethylene

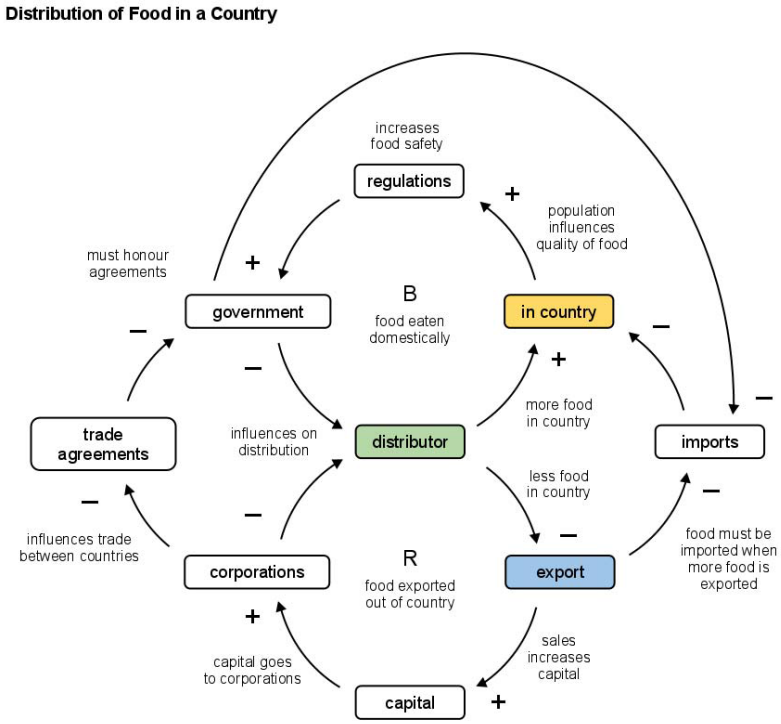
The roof membrane is the conventional roof or waterproofing membrane of the building below.

Structural Support, the Ontario Building Code in conjunction with the Green Roof Bylaw provide general requirements for the installation of Green Roofs but you will need an engineer and it is recommended to hire a certified green roof installer. Green Roofs for Healthy Cities provides list of trained and certified Green Roof Professionals on their website at www.greenroofs.org.

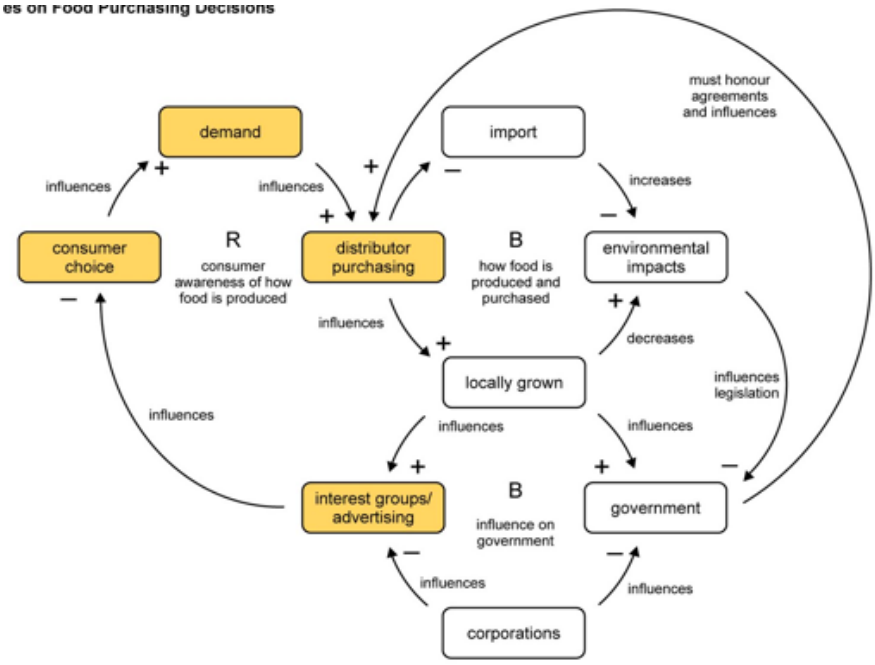
Appendix K: Agricultural Systems Maps



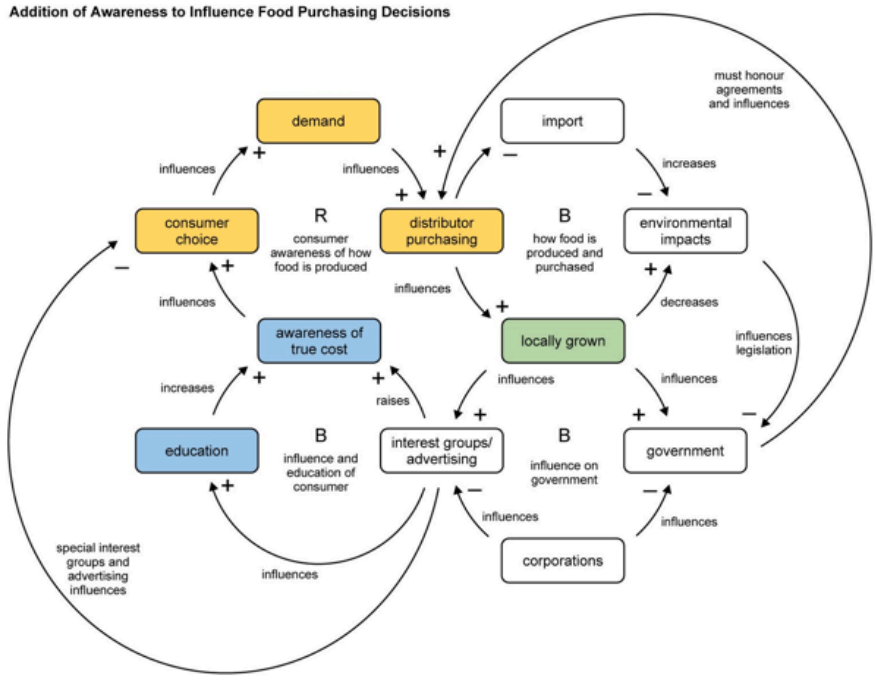
Food Production and Consumption
Source: Kwong, Mitchell, Norman, Food Secuity:Understnading systems



Agricultural Distribution
Source: Kwong, Mitchell, Norman, Food Secuity:Understnading systems



Current Food System
Source: Kwong, Mitchell, Norman, Food Secuity:Understnading systems



Future Food System
Source: Kwong, Mitchell, Norman, Food Secuity:Understnading systems