Metropolitan Vulnerability and Strategic Roles for Periurban Agricultural Territories in the Context of Climate Change and Variability

Vulnerabilidad metropolitana y roles estratégicos de los territorios agrícolas periurbanos en el contexto del cambio y la variabilidad climáticos

Vulnerabilidade metropolitana e funções estratégicas dos territórios agrícolas periféricos no contexto da mudança e a variabilidade climática

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Abstract

Metropolitan regions are vulnerable to climate change from several perspectives. Their rural territories support many strategic roles essential for the quality of life in these regions, including their contribution to food security. The survival of metropolitan agriculture requires not only protecting agricultural resources. It also requires that the value of the multi-functionality of these agricultural territories be truly appreciated for its contribution to the quality of life in these regions. Finally, farmers also need to further develop their adaptive capacity to different stressors, including climate change and variability, in order to survive and prosper, so that they can continue to play and support these strategic roles in metropolitan regions.

Keywords: climate change and variability, adaptive capacity, multi-functionality of agricultural territories, urban and metropolitan regions, strategic roles of rural and periurban areas in metropolitan regions, food security.

Resumen

Las regiones metropolitanas son vulnerables al cambio climático desde distintas perspectivas. Los territorios rurales apoyan muchas funciones estratégicas esenciales para la calidad de vida de estas regiones, incluida su contribución a la seguridad alimentaria. La supervivencia de la agricultura metropolitana requiere no solo la protección de los recursos agrícolas, sino también que el valor de la funcionalidad de varios de estos territorios agrícolas sea apreciado por su contribución a la calidad de vida en estas regiones. Por último, los agricultores también deben desarrollar aún más su capacidad de adaptación a diferentes factores estresantes, tales como el cambio climático y la variabilidad, con el fin de sobrevivir, prosperar y seguir apoyando estas funciones estratégicas en la región metropolitana.

Palabras clave: cambio climático y variabilidad, capacidad de adaptación, multifuncionalidad de los territorios agrícolas, regiones urbanas y metropolitanas, roles estratégicos de las zonas rurales y periurbanas de las regiones metropolitanas, seguridad alimentaria.

Resumo

As regiões metropolitanas são vulneráveis às mudanças climáticas a partir de distintas perspectivas. Os territórios rurais apoiam muitas funções estratégicas essenciais para a qualidade de vida destas regiões, incluindo sua contribuição à segurança alimentar. A sobrevivência da agricultura metropolitana requer não apenas a proteção dos recursos agrícolas, mas também que o valor da funcionalidade de vários destes territórios agrícolas seja apreciado por sua contribuição à qualidade de vida nestas regiões. Por último, os agricultores também devem desenvolver ainda mais sua capacidade de adaptação a diferentes fatores estressantes, tais como a mudança climática e a variabilidade, com o objetivo de sobreviver, prosperar e continuar apoiando estas funções estratégicas na região metropolitana.

Palavras-chave: mudança climática e variabilidade, capacidade de adaptação multifuncionalidade dos territórios agrícolas, regiões urbanas e metropolitanas, funções estratégicas das zonas rurais e periféricas das regiões metropolitanas, segurança alimentar.

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Metropolitan regions are vulnerable in the face of climate change and their rural territories support a significant set of strategic roles that are essential for the quality of life in these regions. The challenges include food safety and the survival of metropolitan agriculture, the focus of this article of reflection.

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Introduction[1]

Sustainable development is a set of processes by which various actors (governments, Non- Governmental Organizations - NGOs, other collective actors both formal and informal, as well as citizens in general) search for and construct a convergence between integrity and environmental values, and the needs and values of society and the economy. The goal of sustainable development is to ensure that the ability of future generations to fulfill their needs is not compromised by the actions of present generations (World Commission on Environment and Development 1987). One of the greatest challenges to face sustainable development in the last quarter century has been the consequences of climate change and variability (Brklacich and Bohle 2006; Bryant et al. 2000). Even though awareness of the importance of climate change has emerged slowly since the beginning of the 1990s, it has nonetheless become increasingly the centre of political and public debates over the last 5 years or so, while at the same time as the consequences of climate change have been widely presented in the media. Among the challenges faced by society the amount of media coverage received by the phenomenon of climate change, at least in part a consequence of human actions, is unprecedented. This is undoubtedly related to the wide range of consequences linked to this phenomenon of climate change, e.g. the consequences for agricultural production and thus food safety, human health, sea level rise, biodiversity, economic activities and their production processes, and many others. Large cities and metropolitan centers in several parts of the world are particularly vulnerable in relation to many of the consequences of climate change and variability (see below).

For many observers, including the scientific community, climate change and variability has become accepted as realities linked to the current activities and those of the relatively recent past generations of human society. Observations or comments acknowledging the causal relationship between human activities and climate change have been made by many citizens of many developed countries, as by several governments of both developed and developing countries since the beginning of the 21st century, who have adopted a discourse that converges with these [...] even if concrete actions to mitigate the impact of human activities are still quite rare.

Even if it becomes possible to reduce greenhouse gas emissions, climate change will not cease from one day to the next [...], which means that human society must continue to find and construct strategies and the means to be able to adapt to the phenomenon in an attempt to reduce its worst effects. For many observers and members of the scientific community the adaptation and adaptive capacity of governments, organizations (NGOs), communities, families, individuals and businesses is now the major challenge.

The need for appropriate public and collective intervention (collective implying the different actions of NGOs, including professional and community organizations) is now generally accepted. Of central interest to us in this article are the actions that seek to improve the adaptive capacities of the actors. An interesting observation is that in several countries the scientific community has become mobilized in terms of research, the results are being increasingly disseminated, and debates among researchers, including those in the social sciences, are public and ongoing through various forms of media! All of this has thus led to awareness-building in both the population at large and an increasing number of decision-makers in the public and private sectors.

It is against this backdrop that we deal with the challenges faced by large urban areas and metropolitan centers in both developed and developing countries, particularly in relation to the direct and indirect consequences of climate change on the agricultural production of these regions[2] (Dolan et al. 2001), which

1 This article builds upon research undertaken in several domains that have been pursued in the Laboratory (co-director C. R. Bryant) of Sustainable Development and Territorial Dynamics at the Université de Montréal: 1) periurban agriculture in several jurisdictions (e.g. France and other European countries; Canada: Ontario, Quebec; Colombia [...]) as well as more recently, urban agriculture; 2) local and community development; and 3) the adaptation of human activities to climate change and variability.

2 It has been common to distinguish between 'urban' and 'periurban' agriculture, with 'urban' agriculture referring to agricultural production within the limits of an urban area (agglomeration or city limits) and 'periurban' agriculture related to agricultural production at the edges of urban areas (see Bryant, Russwurm and McLellan 1982; Bryant and Johnston 1992; Gaudreaut 2011). However, the two categories have become increasingly merged and in effect overlap; furthermore, there is no consensus on what the outer limits of the periurban area are or how to define them. Indeed, it has frequently been used as identical to the urban field of influence! Finally, this urban field of influence or urban region is not a specific statistical unit nor an administrative unit, which makes it very difficult to produce statistical data

has also to be appreciated in the context of the many other stresses that this agricultural production has to contend with.

We first present an overview of the research undertaken in the Laboratory of Sustainable Development and Territorial Dynamics over the last 20 years (and as well by the principal researcher over the last 45 years on periurban agriculture). We then deal successively with the notion of the vulnerability of urban and metropolitan regions particularly in relation to food safety, the vulnerability of agriculture in these regions, and the multi-functionality of agricultural territories in these regions and how these territories contribute to the quality of life of people in these regions and their resilience, focusing on open space and food safety functions (Bryant 2007). Food safety has already been a preoccupation at the world scale for some time (FAO 2008; 2009), but it has become even more of a preoccupation in the contemporary context of climate change and variability. Furthermore, the many other functions supported by periurban territories make important contributions to large urban and metropolitan regions generally so that anything that undermines metropolitan agriculture also undermines many of these other functions.

Research and Reflection Pursued at the University of Montreal in the Laboratory of Sustainable Development and Territorial Dynamics on the Issue of Agricultural Adaptation to Climate Change and Variability since the Beginning of the 1990s

Our research in this domain since the early 1990s has been characterized progressively by:

1. Interdisciplinary research (including the geography of territorial development and the adaptation of human activities to multiple stressors, climatology, rural economy, agronomy and environmental studies);
2. A combination of qualitative analysis (based upon interviews, focus groups, documentary analysis [...]), quantitative analysis (analysis of data dealing with compensation paid out to farmers under crop-insurance programs, climate scenario modeling, modeling of crop and vegetation growth under different climate scenarios), and action research.

The research on adaptation of human activities to climate change and variability has focused mostly on agriculture in Quebec, but it has also encompassed research on agricultural adaptation in Vermont and Eastern Ontario and the adaptation of the alpine ski and golf activities in Quebec to climate change and variability (Bryant et al. 1997; 2004; Bryant, Singh and André 2007; Bryant et al. 2007). Furthermore, for the last 10 years the research has also targeted the co-construction of public policy and collective intervention aimed at increasing the adaptive capacity of all the actors involved in the process of adaptation, including that of government and professionals associated with agriculture (Bryant, Singh and Thomassin 2008).

In our research, we have drawn on research in other domains to produce a more holistic perspective of the vulnerability of agriculture in major urban and metropolitan regions. We have therefore become concerned with both the vulnerability of major urban and metropolitan regions related to the vulnerability of agriculture both in these regions and more generally. The other domains that we have incorporated into our thinking include: 1) research on periurban agriculture in Canada and in France for some 45 years; and 2) local and community development and the analysis of actors and their dynamic.

Thus, this article is informed by the results of several research programs; however, what is most important is our attempt to try to situate this research in the context of climate change and variability which will in all likelihood modify the comparative advantage of agriculture in many major urban and metropolitan regions around the world. With the continuation of climate change and variability several large urban and metropolitan regions will certainly have to cope with changes in their comparative advantages in food production. Certain regions will undoubtedly experience an improvement in their comparative advantages (compared to other regions, not necessarily in terms of absolute increases in crop yields but especially in comparative or relative terms). Examples of the first type

specifically on these areas; to make matters even more difficult, these urban and metropolitan regions vary from country to country because the form of land use patterns in different countries and cultures varies substantially in terms of transportation technology (e.g. public transportation versus the private automobile), the temporal development of cities in relation to different transportation technologies and the levels of socio-economic development, among other factors.

will likely include regions such as Montreal, Toronto, and other more northern regions particularly where their agricultural resource base is currently very good; the second type of situation includes regions in several developing countries particularly those commonly referred to as the 'South'. In both cases, we argue that it is becoming more and more urgent to find ways of better conserving good farmland resources.

The Vulnerability of Major Urban and Metropolitan Regions Faced with Multiple Sources of Stress

There are mounting concerns about the vulnerability of metropolitan regions faced with multiple sources of stress.

Vulnerability can be analyzed from the perspective of 3 fundamental components:

a. Exposure to the source of stress. For a major urban or metropolitan region this is linked to: i) the increasing concentration of population and economic activities in a limited number of such regions; and ii) the location of such regions with respect to these stressors;
b. The potential losses, a function of the concentration of activities, the resilience of whatever aspect of society we are investigating (e.g. agriculture), the ability to ensure adequate food supplies [...]; and
c. The adaptive capacity of the human actors and of society in general, a function of our cultural values and our institutions.

For all 3 components, social construction is a major process (by citizens, collective actors including government, community organizations, NGOs [...]) even when the source of the stress is principally 'natural'. Components (b) and (c) have been directly constructed by society and its actors, including our governments. This emphasizes that an important part of vulnerability is in effect a social construction (Delusca 2010). Any concentration of human population and investments represents a potential concentration of vulnerability when there is the possibility of being confronted by a source of stress with serious negative consequences for the population and their activities. However, these potentially negative consequences can be attenuated by the cumulative and adaptive decisions of society (including all of its actors), e.g. in terms of the construction of more resistant infrastructure, proactive adaptation and more diversified activities (e.g. in terms of agricultural products since different agricultural products do not necessarily react in the same way to a given source and magnitude of stress). In the environmental domain, we simply need to reflect on the earthquake in Haiti at Port-au-Prince in January, 2010, to understand the results of the disastrous combination of a high concentration of human population and activities both of which were poorly prepared for such a phenomenon, including their lack of proactive decision-making capacity in the past. We suggest that similar situations can be encountered in relation to extreme climate events (e.g. extreme drought conditions, extreme excess of precipitation, [...]) or following a cumulative process leading to significant climate change which in turn leads to extreme environmental changes, e.g. rising sea levels.

The concentration of population and activities in our major urban and metropolitan regions is the result of our decisions at the individual and family level, of businesses and [...] of governments. We need only to think of Canada and the geographic distribution of the efforts of our governments (federal and provincial) to pull the economy out of the economic recession over the last 4 years to see how many of these efforts have been concentrated in the larger urban and metropolitan regions (renewal of road infrastructure, other infrastructure projects, aid to businesses [...]). At the same time many territories that have suffered more seriously the effects of the recession have received far less attention and resources. The emphasis on spending in the larger urban and metropolitan regions simply reinforces their potential for further concentration of population and economic activities, with the potential to further undermine development in more peripheral regions.

Cities, of course, represent an important share of Gross Domestic Product (GDP) and thus account for a large, often dominant, and increasing share of job creation at the national scale (Sulaiman 2010). Bogotá, for example, accounts for over 50% of the GPD in certain sectors. The manufacturing sector represents 40% of national production (in terms of GDP) and the service sector 43% (UNDP 2008). However, despite the advantages of large cities and metropolitan centers in terms of income and living conditions, such centers also account for an important share of the poorest and most vulnerable segments of the population, simply reflecting the large concentration of population and economic activity generally. As well, land use development

processes and patterns contribute significantly to the resulting environmental impacts.

It is important to recognize that the vulnerability of large urban and metropolitan regions is itself very variable. Not only are there important differences between large cities and metropolitan centers and their regions in terms of exposure to different sources of stress related to climate change and variability: there are also important differences in terms of their capacity to deal with these negative impacts and even, depending on the circumstances, how to benefit from them! This is the case of agriculture in several metropolitan regions in developed countries such as Canada where the negative consequences of climate change and variability in some regions are attenuated by the relatively high quality of their agricultural resources (e.g. their soils, climate conditions even subsequent to climate change, and water resources), in contrast with several developing countries such as those in West Africa. Furthermore, the different agricultural systems of these regions in countries such as Canada already have a relatively high level of decision-making capacity, a relatively solid financial footing, and extensive experience over the course of the 20th century with having to adjust and adapt to many different types of changes in their decision-making environment.

In Colombia, especially in Bogotá, different governmental organizations are developing an integrated pilot plan to deal with climate change, as part of the worldwide initiative of the UNDP known as Strategies for the Development of Low Levels of Carbon Adapted to Climate. This plan is based on support provided to regional governments to incorporate climate change and variability into regional development and planning. The plan (2011-2013) incorporates the following strategic components: an analysis and projections of the inter-annual climate variability in relation to the climate phenomena of El Niño and La Niña, an inventory of greenhouse gas emissions, the design and application of a methodology for the analysis of territorial vulnerability, the design and dissemination of public education and awareness materials about climate change and variability, and the broad methodological approach needed to incorporate the management of risk associated with climate change and variability into territorial planning and development (IDEAM 2011). In the research community, land use planners have also begun to explore how land use planning and management can be adapted to the realities of climate change and variability (Richardson and Otero 2012). Given the heterogeneity of metropolitan regions confronted with climate change and variability, it is clear that there are 'winners' and 'losers'.

This heterogeneity, which is linked to differences in their exposure to stresses, to potential losses but also and especially to differences in the adaptive capacity of their actors (governmental and non government actors, and citizens generally), has some very important implications for the elaboration and the application of collective interventions. This suggests that it is essential to take into account the territorial specificities of each urban and metropolitan region and that the policies of Central States (in Canada, this includes the federal government as well as its different provinces) need to support the adaptive actions of other actors instead of imposing a standardized or 'cookie cutter' approach.

Furthermore, it is important to acknowledge the fact that the adaptive capacity and vulnerability of communities and different segments of the population dependent on a given activity (e.g. agriculture) can also vary within a given metropolitan region. Their adaptive capacity and vulnerability can also vary according to the functions or groupings of activities present (e.g. the different sub-sectors of agricultural production, leisure functions supported by agricultural areas [...]), in other words, the multi-functionality of agricultural territories and activities in metropolitan regions.

The Case of Periurban Agriculture

Periurban[3] agricultural territories support several strategic roles and functions that contribute to the quality of life and the general functioning of large urban and metropolitan regions. The roles and functions have become better understood since the 1980s (Fleury 2005). We suggest that several of these functions can help conserve periurban agricultural territories in these regions (Bryant 2011; Bryant and Granjon 2007) when they are appropriated by non-agricultural actors and citizens as being valuable to the quality of life in large urban and metropolitan regions. The roles supported by farmland provide many functions for metropolitan society in addition to food and food security (Bryant 2007). These roles are found in both developed and developing countries, though the relative importance

3 The same argument can be made for urban agriculture which is also multi-functional in most cases (e.g. St-Amour 2010).

associated with the different functions varies depending upon geographic and cultural circumstances.

Our understanding of periurban agriculture in metropolitan regions has evolved considerably during the last half of the 20th century and the beginning of the 21st century. Starting off with a space valued more for its role in urban development - as 'land reserves' to accommodate urban development (!), over the last 30 years or so, other functions of these territories have become more and more appreciated, especially in Western Europe but also in North America. In addition to food production, these other functions include the conservation of heritage landscapes, the conservation of water resources and farmland resources, and providing for both leisure and tourism activities. Anything that renders periurban agriculture difficult may also undermine the ability of agricultural land to support these other functions.

Thus, climate change and variability are likely to alter the capacity of these periurban agricultural territories to continue supporting these various functions, but this again is likely to vary considerably depending upon how the agricultural resources are impacted by climate change and variability in different major urban and metropolitan regions. The question of the food safety of large urban centers and metropolis (e.g. Montreal, Toronto, Dakar, Bogotá, [...]) is, of course, of particular concern. This partly overlaps with the increased importance attached to 'local' food production by different segments of the urban consumer food market. These concerns underscore the necessity of finding ways of conserving these farmlands (which certainly in many developed countries have better agricultural resources[4] on average than more remote agricultural regions, i.e. in the most generous definition of 'periurban', remote peripheral regions would refer to regions beyond the fields of influence of major urban and metropolitan regions (Bryant 1976)). The measures of conservation include: 1) legislative programs to protect farmland from urban development such as in British Columbia (1973) and Quebec (1978) (for Canada generally, see Caldwell, Hilts and Wilton 2007) and in several American states; and 2) local development processes aimed at encouraging agricultural development adapted to climate change and variability and the urban market place, and the use of the multi-functionality tools to garner support for the conservation of farmland resources (Bryant 2011).

Multi–Functionality of Periurban Agricultural Territories: Concepts and Examples

As argued earlier in this article, from the perspective of the contribution of urban and metropolitan regions and their periurban territories to the production of food and to agricultural production in general, agricultural spaces often support other strategic roles and functions that can enhance the quality of life of the residents of these regions. This is partly because of the multiple functions supported by agricultural spaces, both commercial functions (e.g. agricultural production for the urban food market, agrotourism [...]) and non-commercial functions (e.g. the conservation of natural, historic and cultural heritage embedded in agricultural landscapes, conservation of water resources [...]) (Bryant 2009). The multi-functionality of open spaces, including agricultural spaces, in metropolitan regions can thus support some very important functions and roles.

Faced with the negative consequences for the capacity of agricultural production in many developing countries (and also in several developed countries in regions with geographic vulnerabilities to climate change, such as the Montpellier region in the south of France), we argue that the conservation of the best agricultural land resources in these regions has become even more significant. In several countries, such as Canada, many of the large urban and metropolitan regions include some of the best agricultural land resources; in addition, these same regions are often amongst the most efficient agricultural regions, which places them in an enviable position to contribute significantly not only to the food security of their own regions but also to food safety on a planetary basis (UNDP 1996). In the context of a developing country such as Columbia, it is also interesting to note that the metropolitan region of Bogotá and the departments of Boyacá, Meta and Tolima contributed 33% of the national total of food products (by weight) (Secretaría de Desarrollo Económico de

4 For instance, the Montérégie region just to the south of the Montréal agglomeration, is the region which contributes the most (29% in 2007) to the GDP generated by agriculture in the province (Eco Ressources Consultants 2009), and which is very much related to the excellent soil resources and climate conditions currently in this region.

Bogotá 2010)[5] in 2010. This therefore provides an additional and important motivation for maintaining farmland protection programs wherever they have been put in place (such as in Quebec and British Columbia (Bryant and Granjon 2007; Caldwell, Hilts and Wilton 2007) and in several American states (Bryant and Russwurm 1979) or of putting in place such programs where they do not currently exist.

Furthermore, we argue that because many agricultural territories in periurban zones as well as *within* many agglomerations (e.g. the 'urban' agriculture in the agglomerations of Montreal and Laval in Quebec) support both commercial and non-commercial functions, these other functions provide an important tool to 'sell' the conservation of farmland. Indeed, this multi-functionality can be appropriated by non-agricultural actors and citizens, thus contributing to the conservation of these agricultural territories in the long term. An example of this is found in the Municipality of Senneville in the Montreal Agglomeration, where a project —initiated by 3 farmers— that was aimed at conserving the farmland they used and their own agricultural activity over the long term ended up being used to mobilize a significant number of non-agricultural actors including several major land owners. This project then became the centre of a much larger project with functions for the conservation of natural, historic and cultural heritage landscapes (Bryant et al. 2009; Bryant 2011; Bryant and Chahine 2010). The original farmland used by the small core of farmers is still being farmed and the farm produce mostly sold in suburban markets as well as being sold directly from farm to the consumer through 'food baskets'. Furthermore, this initially small project has given momentum to other agricultural production projects both in the municipality and beyond.

There has also been an increasingly important preoccupation with the distances that foodstuffs have to be transported, especially internationally in order to reach the major metropolitan markets. This has given rise to the local food systems movement (LSM), often known as the '100 mile food radius' movement (Smith and MacKinnon 2007) or the 'locavores', involving particular segments of the urban and metropolitan food market. This movement's concern to reduce the assumed negative environmental effects of long distance transportation of food produce, together with an even broader preoccupation for food security for the poorer segments of urban and metropolitan society, also accounts for the increased interest in 'urban' agriculture[6] in many metropolitan centers, such as Toronto, Montreal, New York, [...], with projects such as 'community gardens', 'roof top' gardens and so forth (Délavar Esfahani 2007; St-Amour 2010; Ville de Montréal 2005). The Botanical Garden of Bogotá has also worked in the context of urban agriculture for several years. The approach used involves learning through practice by means of demonstration garden and orchard projects or collective orchards. The aim of this program is to try to eliminate poverty and exclusion, which affect an important proportion of Bogotá's population (Jardín Botánico de Bogotá 2007).

There are opposing perspectives which argue against focusing so much on local agricultural production for local markets (e.g. Desrochers and Shimizu 2012) because of the need to take account of the total costs of production and the quality of the produce. This underscores the point made earlier that in many major urban and metropolitan regions, the existing agriculture has an important role to play in both serving the local and regional markets and contributing to food production on a planetary basis because of the frequently very good agricultural resources in such regions. This point

5 This does not mean of course that the urban region is a major contributor to the food supplies required by the city or metropolis. Thus, Alfonso Bohórquez (2009) used a series of calculations to estimate that the periurban and rural agricultural areas in the Bogotá region only accounted for a maximum of 1% of the food demand of the city of Bogotá. Even though the Ministry of Agriculture (Agronet 2012) provides information on the total supplies of farm production arriving in Bogotá in 2011, it is not possible to identify the proportion of this food supply that is derived from the Bogotá region. A similar situation is found in other major urban or metropolitan regions. Thus, for the province of Quebec, data are available on the value of agricultural production and the associated GDP for each major administrative region (Eco Ressources Consultants 2009; Portal Québec 2012), but not on the value of products or their amounts shipped for consumption to the nearby major urban or metropolitan region.

6 Much of the production of 'urban' agriculture is in effect directly aimed at the urban market or is for self-consumption and this is also true for some areas in periurban territories. For instance, in the Bogotá region, Mosquera Domínguez (2009) argues that agricultural production in El Rincón and Tibabuyes, in the locality of Suba, is mostly for self-consumption. And in the Montreal agglomeration, community gardens and collective gardens are very much oriented to self-consumption (St-Amour 2010) while some of the large scale urban agriculture projects (e.g. the roof-top Ferme Lufa) directly provide food to the nearby urban population.

simply strengthens the argument for conserving agricultural land resources near major urban and metropolitan centers.

Conclusions

Many major urban and metropolitan regions are characterized by vulnerability in the face of climate change and variability, which may, depending on the circumstances, compound other stresses faced by these regions, and their regional agriculture in particular. This vulnerability is closely related to the concentration of population and economic activities in these regions. The agriculture in these regions faced with climate change and variability can contribute to urban and metropolitan vulnerability. But, at the same time, this agriculture plays a significant strategic role from several points of view. Food security at the world scale and particularly in relation to the poorer segments of society in these large urban and metropolitan regions poses some important challenges for the conservation of the farmland resources of these regions; often their farmland resources are amongst the best in their respective countries and their agriculture has a relatively high capacity of adaptation, having had to adapt to multiple pressures over a relatively long period of time.

Furthermore, urban agriculture (Mougeot 2006), e.g. the development of community gardens in the city, has experienced a surge in interest recently to the point that it is possible to state that it is no longer considered to be a marginal activity, but has become recognized as a key component in the collective response aimed at helping underprivileged populations in many metropolis such as Montreal.

In those regions with a sound agricultural base and good farmland resources, urban and metropolitan region agriculture —both urban and periurban— is central to strategies aimed at fighting food insecurity, for both the urban and metropolitan populations, as well as for populations in other countries, many of which are even more vulnerable in relation to food production in the face of climate change and variability. However, even if this urban and metropolitan agriculture has recently experienced a substantial increase in mediatisation in several countries such as Canada, where local agricultural production for local consumption has been associated with various environmental preoccupations (e.g. the reduction in energy used for food transportation and an increasing preoccupation on the part of several segments of the metropolitan food market to consume organic produce), it is clear that the simple protection of the farmland in these regions —at least until the present time— is not adequate in itself to ensure the survival and development of this metropolitan agriculture.

As part of the efforts aimed at ensuring the survival and development of metropolitan agriculture and thereby reducing the vulnerability of the nearby urban and metropolitan populations, several pertinent points have been raised in the research programs at the University of Montreal:

1. It is essential that farmers and food producers generally are able to generate an adequate income in order to be able to maintain their own quality of life both in absolute terms and relative to that of their non-farm neighbors (which, at least for young people would reduce their exodus from farming).
2. It is important that the farmers involved particularly in periurban agriculture are able to adapt continually to the different sources of stress such as climate change and variability, competition, the evolution of national and international markets and political changes (including public policy change). While many of these farmers already possess a good adaptive capacity, they nonetheless need support in reinforcing their adaptive capacities because the changes are becoming more stressful with the addition of the consequences of climate change and variability.
3. It is also important to recognize that there are differences between regions and within regions in terms of the consequences of climate change and variability. In terms of the variability of climate conditions between and within regions, we can look at the situation in 2000 in Quebec when one of the principal farm crops of the province, grain corn, experienced significant losses because of climate conditions (figures 1 and 2). Figure 1 shows the evolution of grain corn yields for Quebec's regions for the period 1987-2001[7]. While the ups and downs of the yields follow a similar pattern in the different regions, when conditions are poor, the differences are much greater (contrast the region of Ste Hyacinthe

7 These yields are taken from the farmers who were clients in the Financière Agricole du Québec's crop-insurance program in those years.

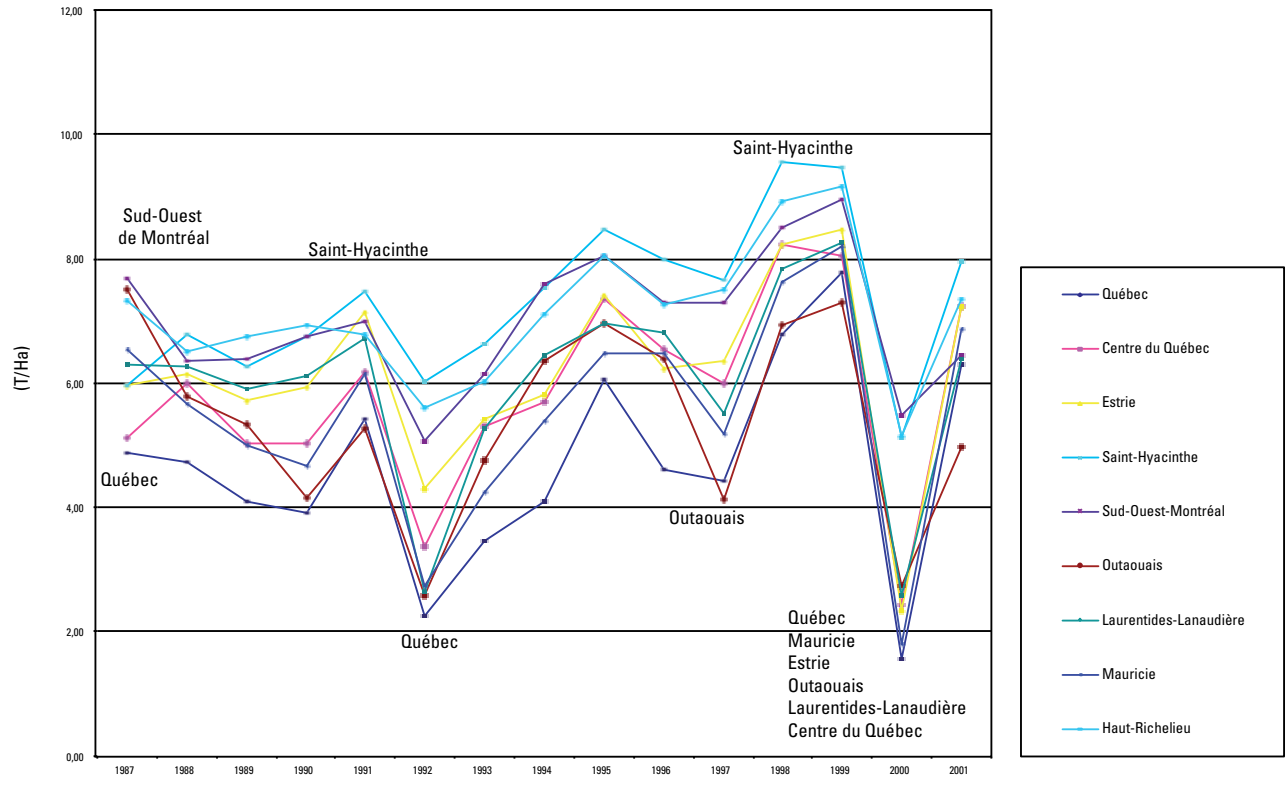

Figure 1. Evolution of Grain Corn Yield by Region, Quebec 1987-2001.
Source: La Financière Agricole du Québec (2004); figure 3 from Bryant et al. 2007.

and the South West of Québec (the *sud-ouest du Québec*) which includes the Montérégie region) with the other regions. Focusing on 2000, and based on the calculation of the Crop Loss Index for grain corn for three of Québec's agricultural regions (figure 2), it is very clear that the South West region experienced a relatively small Crop Loss Index[8] and that the variation between its sub-regions was not very large; this contrasts with the other two regions, the Centre-du-Québec (the Centre of Quebec) and the Saguenay-Lac-St-Jean region where the Crop Loss Index was large and the internal variation within each of these two regions was very large). The geographic variation indicated by this brief example is found in many, if not most, regions and has implications for the need for collective intervention and public policy to be able to respond to such differences in a constructive manner.

8 The Crop Loss Index is the amounts in $ paid out to farmers who filed claims under the crop-insurance program divided by the total value of crops insured when the farmers joined the program in each year.

Collective intervention, including that of involving governments, can play an important role in building greater levels of adaptive capacity. This support is not necessarily financial in nature, but rather being able to assume (or getting other actors to assume) the roles of counseling and assisting farmers, in providing strategic information (on markets, on the potential consequences of climate change and variability [...]) and in facilitating the development of local agricultural development initiatives. In many cases, the appropriate actors to assume these roles are collective actors at the local and regional levels. Examples from our research in Quebec include Rural Development Officers who work for Local Development Centers (*Centres Locaux de Développement (CLD*) that are part of the Regional Municipal Counties (*Municipalités Régionales de Comté - MRC*) in Quebec, the Agricultural Advisory Clubs (*Clubs Conseils en Agriculture*) with their specialists including agronomists, the Quebec Farmers Union (*Union de Producteurs Agricoles - UPA du Québec*) and their local branches, and the Committees for Integrated Watershed Management. The latter could assume a more and

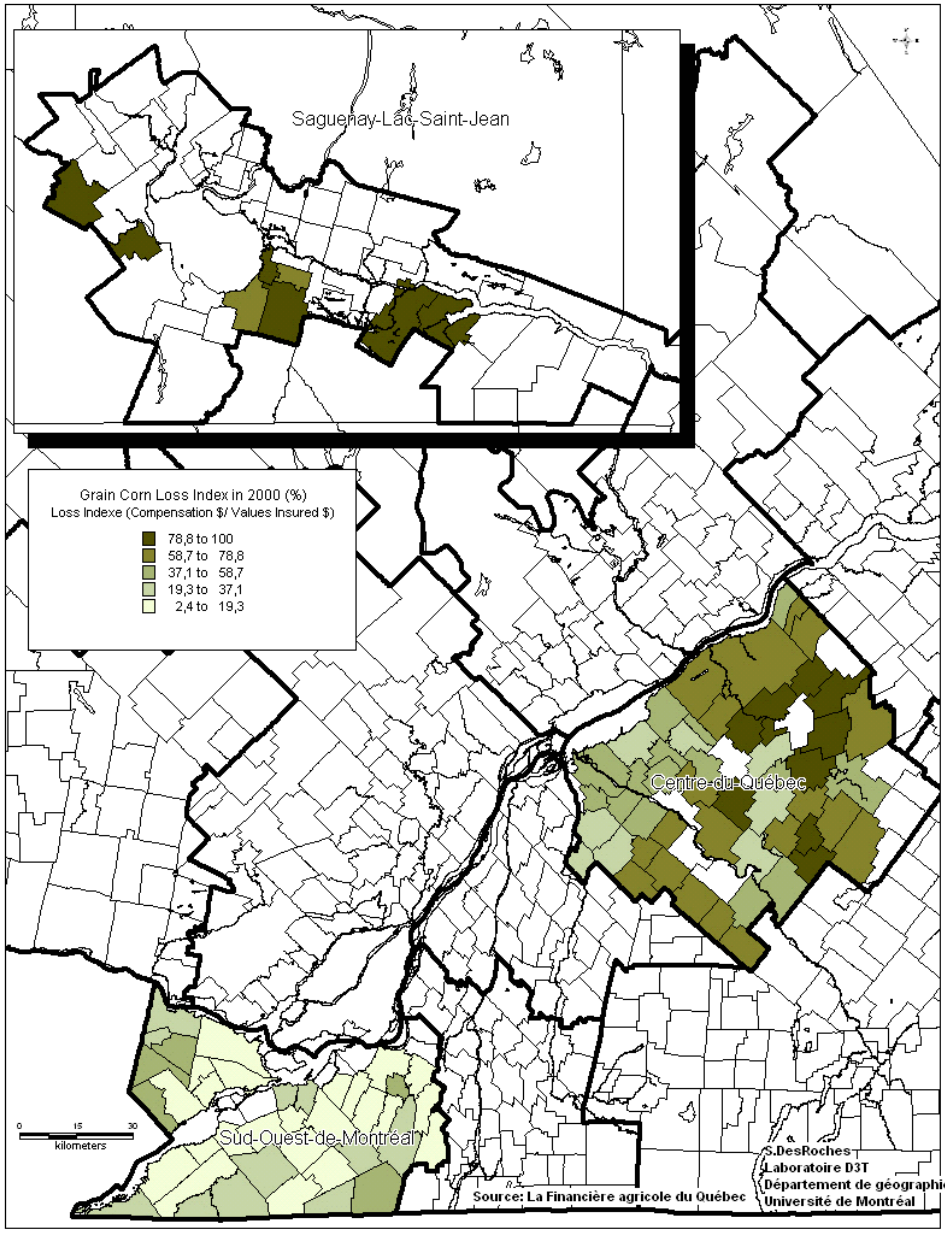

Figure 2. Grain Corn Loss Index (Compensation in $/Values insured) for Three Regions in Quebec, 2000: Intra-Regional Analysis. Source: La Financière Agricole du Québec (2004); figure 4 from Bryant et al. 2007.

more important role in relation to urban and metropolitan agriculture because of the central importance of the water resource that was regularly stressed by farmers in our research as a central component of adaptation strategies for agriculture faced with climate change and variability (Bryant, Bhawan and Thomassin 2008).

4. Finally, ensuring the survival and development of this urban and metropolitan agriculture demands that the importance of this agriculture and its territories are appropriated by non-farm actors, including non-farm citizens. We have argued that this is possible by calling upon the multiple functions supported by this agriculture and food production in general. Several non-commercial functions of urban and metropolitan agriculture are at the heart of open space and greenbelts. In the metropolitan region of Montreal, several ca-

ses have emerged over the last two decades where the survival and development of agriculture in the areas have depended upon the appropriation of these multiple functions by a surprisingly large number of non-farm actors, e.g. Senneville in the West Island of the Island of Montreal (Bryant et al. 2009; Bryant and Chahine 2010; Bryant 2011) and in the City of Longueil on the South Shore of the Metropolitan Community of Montreal with its project 'City-Countryside' (*Ville-Campagne*) (Charbonneau 2010; Planchenault 2008).

The reduction of the vulnerability of metropolitan regions in relation to food insecurity risks being accentuated in many regions by the consequences of climate change and variability. Being able to combat this requires situating urban and metropolitan agriculture in a more global and holistic context. Legislation to protect farmland resources against urban sprawl can be very important in this (e.g. the Quebec legislation of 1978 which aimed to protect the farmland resource against urban sprawl and as well to conserve the capacity of Quebec agriculture to respond to the food needs of Quebec's population); but this protection is not in itself adequate to ensure the survival and development of urban and metropolitan agriculture over the long term. What is needed above all is the development of a viable foodland production system supported by the various farm and non-farm actors at the local and regional levels to ensure this agriculture continues to build its capacity to adapt to changing circumstances, including climate change and variability.

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References

Agronet. 2012. *Sistema de Estadísticas Agropecuarias - SEA*. Bogotá: Ministerio de Agricultura y Desarrollo Rural. http://www.agronet.gov.co/agronetweb1/Estad%c3%adsticas.aspx (accessed in february 2013).

Bohórquez Alfonso, Ivonne Alexandra. 2009. La Frontera Rural de Bogotá: Un debate sobre sostenibilidad ambiental y crecimiento urbano. *VIII Seminario de Investigación Urbano-Regional ACIUR*. Mesa de Trabajo: Medio Ambiente y Desarrollo Urbano-Regional. Bogotá.

Brklacich, Michael and Hans George Bohle. 2006. Assessing Human Vulnerability to Climatic Change. In *Earth System Science in the Anthropocene: Emerging Issues and Problems,* eds. Thomas Kraft and Eckhart Ehliers, 51-61. Amsterdam: Springer Verlag.

Bryant, Christopher. 1976. *Farm-Generated Determinants of Land Use Change in the Rural-Urban Fringe in Canada 1961-75*. Ottawa: Lands Directorate, Environment Canada.

Bryant, Christopher. 2007. La place des espaces ruraux périurbains et de l'environnement dans le développement régional. In *Territoires et enjeux du développement régional*, coords. Amédée Mollard, Emmanuelle Sauboua and Maud Hirzak, 159-171. Versailles: Quæ.

Bryant, Christopher. 2009. Multifonctionalité et le développement des territoires ruraux: conceptualisation, mise en oeuvre et défis. *Working Group on the multi-functionality of rural territories, Solidarité Rurale du Québec, Nicolet, Solidarité Rurale du Québec*. Montreal: Laboratoire de développementde durable et dynamique territoriale-Université de Montréal.

Bryant, Christopher. 2011. Les dynamiques des agricultures périurbaines autour de Montréal: défis et opportunités au service de la société métropolitaine. In *Panorama des Régions du Québec, Édition 2011*, coords. Pierre Cambon and Stéphane Ladouceur, Chapter 1:13-28. Québec: Institut de la Statistique du Québec. http://www.stat.gouv.qc.ca/publications/regions/panorama.htm (accessed in january 2013).

Bryant, Christopher and Denis Granjon. 2007. Agricultural Land Protection in Quebec: From Provincial Framework to Local Initiatives. In *Farmland Preservation: Land for Future Generations,* eds. Wayne Caldwell, Stew Hilts and Bronwynne Wilton, 61-86. Guelph: Centre for Land and Water Stewardship-University of Guelph.

Bryant, Christopher and Ghalia Chahine. 2010, Pour un rapprochement entre urbanité et agriculture, ou la protection de l'agriculture par le développement local et la multifonctionnalité. *Développement social: Villes et campagnes, une complicité à cultiver* 11 (2): 36-37. www.revueds.ca/sommaire-volume-11-no-2.aspx (accessed in january 2013).

Bryant, Christopher and Lorne. H. Russwurm. 1979. The impact of nonagricultural development on agriculture: A synthesis. *Plan Canada* 19 (2): 122-139.

Bryant, Christopher and Thomas R. Johnston. 1992. *Agriculture in the City's Countryside*. London: University of Toronto Press.

Bryant, Christopher, Barry Smit, Michael Brklacich, Thomas R. Johnston, John Smitherd, Quentin Chiotti and Singh Brawan. 2000. Adaptation in Canadian Agriculture to Climatic Variability and Change. *Climatic Change* 45 (1): 181-201.

Bryant, Christopher, Singh Bhawan and Pierre André. 2007. The Perception of Risk to Agriculture and Climatic Variability in Quebec: Implications for Farmer Adaptation to Climatic Variability and Change. In *Farming in a Changing Climate*, eds. Ellen Wall, Barry Smit and Johana Wandel, 157-170. Vancouver: University of British Columbia Press.

Bryant, Christopher, Singh Bhawan, Paul Thomassin and Laurie Baker. 2007. *Farm-level Vulnerabilities and Adaptations to Climate Change in Quebec: Lessons from Farmer Risk Management and Adaptations to Climatic Variability*. Research Report submitted to Natural Resources Canada. Ottawa: CCIAP.

Bryant, Christopher, Singh Bhawan and Paul Thomassin. 2008. *Evaluation of Agricultural Adaptation Processes and Adaptive Capacity to Climate Change and Variability: The Co-construction of New (Climate Change) Adaptation Planning Tools with Stakeholders and Farming Communities in the Saguenay-Lac-Saint-Jean and Montérégie Regions of Québec*. Research Report submitted to Natural Resources Canada. Ottawa: CCIAP.

Bryant, Christopher, Ghalia Chahine, Éve Saymard, Monique Poulot, Jena Paul Charvet, André Fleury, Roland Vidal and Salma Loudiyi. 2009. The Direct Contribution of Research to Modifying Spatial Patterns of Local Development: Action Research to Reduce Vulnerabilities and Re-Build Agricultural Activity in Urban and Periurban Areas of Montreal and Paris. In *Conference Proceedings, Mid-Continent Regional Science Association 40th Annual Conference-Canadian Regional Science Association 31st Annual Conference*, 67-78. May 28-30 of 2009 Wisconsin. www.oznet.ksu.edu/mcrsa/pdf_files/2009_conference_proceedings.pdf (accessed in december 2012).

Bryant, Christopher, Lorne H. Russwurm and A. G. McLellan. 1982. *The City's Countryside: Land and its Management in the Rural-Urban Fringe*. London: Longman.

Bryant, Christopher, Pierre André, D. Provençal, Bhawan Singh, J. P. Thouez and M. El Mayaar. 1997. L'adaptation agricole aux changements climatiques: le cas du Québec. *Le Climat: Les défis des changements environnementaux à l'échelle planétaire* 14 (2): 81-97.

Bryant, Christopher, Pierre André, J. P. Thouez, Bhawan Singh, S. Frej, Denis Granjon, J. P. Brassard and G. Beaulac. 2004. Agricultural Adaptation to Climatic Change: The Incidental Consequences of Managing Risk. In *The Structure and Dynamics of Rural Territories: Geographical Perspectives*, 2001 and 2002 Annual Meetings, eds. Doug Ramsey and Christopher Bryant, 260-271. Brandon: University of Brandon - Rural Development Institute.

Caldwell, Wayne, Stew Hilts and Bronwynne Wilton. eds. 2007. *Farmland Preservation: Land for Future Generations*. Guelph: University of Guelph.

Charbonneau, Kaissy. 2010. Continuum ville/campagne: un projet territorial intégré. *Villes et campagnes: une complicité à cultiver* 11 (2): 24.

Délavar Esfahani, Fahimeh. 2007. *Les activités sociales et l'emplacement du jardin communautaire: le cas des jardins Angrignon et de la Savane*. Montréal: Université de Montréal.

Delusca, Kénel. 2010. *Évaluation de la vulnérabilité des fermes productrices de maïs-grain du Québec aux variabilités et changements climatiques: Les cas de Montérégie-Ouest et du Lac-St-Jean-Est*. Doctorat en géographie, Département de Géographie, Faculté des Arts et des Sciences, Université de Montréal, Montréal.

Desrochers, Pierre and Hiroco Shimizu. 2012. *The Locavore's Dilemma: In Praise of the 10,000-Mile Diet*. New York: Public Affairs.

Dolan, Holly A., Barry Smit, Mark W. Skinner, Ben Bradshaw and Christopher Bryant. 2001. *Adaptation to Climate Change in Agriculture: Evaluation of Options*. Guelp: University of Guelph.

Eco Ressources Consultants. 2009. *Retombées économiques de l'agriculture pour le Québec et ses régions*. Montréal: L'Union des Producteurs Agricoles (UPA).

Fleury, André. 2005. L'agriculture dans la planification de l'Ile-de-France: du vide urbain à la multifonctionnalité territoriale. *Les Cahiers de la multifonctionnalité, multifonctionnalité de l'agriculture périurbaine, vers une agriculture du projet urbain* 8:33-46.

Food and Agriculture Organization of the United Nations (FAO). 2008. *State of Food Insecurity in the World 2008: High Food Prices and Food Security; Threats and Opportunities*. Rome: FAO.

Food and Agriculture Organization of the United Nations (FAO). 2009. *More People than Ever are Victims of Hunger*. FAO Press release, June 19. http://www.fao.org/fileadmin/user_upload/newsroom/docs/Press%20release%20june-en.pdf (accessed in december 2012).

Gaudreault, Virginie. 2011. *Analyse de l'agriculture urbaine dans les grands centres urbains en Amérique du nord*. Masters in Environment, Centre Universitaire de Formation en Environnement, Université de Sherbrooke, Montréal, Canada.

Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM). 2011. *Memorias II Congreso Nacional del Clima 2011: La Adaptación de Colombia*. Bogotá: Ministerio de Ministerio de Ambiente, Vivienda y Desarrollo Territorial-IDEAM.

Jardín Botánico de Bogotá. 2007. *Cartillas técnicas, agricultura urbana*. Bogotá: Alcaldía Mayor de Bogotá, Secretaría de Gobierno-Jardín Botánico de Bogotá, José Celestino Mutis.

Mosquera Domínguez, Jackson Emilio. 2009. *Efectos socioeconómicos y ambientales de la agricultura urbana en las unidades de planeamiento zonal (UPZ) de Rincón y Tibabuyes de la localidad de Suba, Bogotá, D.C*. Tesis de Maestría, Facultad de Estudios Ambientales y Rurales, Universidad Javeriana, Bogotá.

Mougeot, Luc. 2006. *Cultiver de meilleures villes: Agriculture urbaine et développement durable*. Ottawa: International Development Research Centre (IRDC).

Planchenault, Mélina. 2008. Le projet pilote 'Continuum ville-campagne' de Longueuil: de la résilience territoriale à la gouvernance responsable. In *Territoires Périurbains et Gouvernance. Perspectives de Recherche*, eds. Salma Loudiyi, Christopher Bryant and Lucette Laurens, 65-74. Montréal: Laboratoire de Développement Durable et Dynamique Territoriale, Département de Géographie, Université de Montréal.

Québec, Portal Québec. 2012. *Nouvel outil d'investissement pour l'industrie de la transformation alimentaire - Création du Fonds de l'industrie bioalimentaire du Québec (FIBEC)* http://communiques.gouv.qc.ca/gouvqc/communiques/GPQF/Juillet2012/27/c3123.html (accessed in december 2012).

Richardson, Gregory and José Otero. 2012. *Land use planning tools for local adaptation to climate change*. Ottawa: Government of Canada.

Secretaría de Desarrollo Económico de Bogotá. 2010. *Plan maestro de abastecimiento de alimentos y seguridad alimentaria*

"Alimenta Bogotá". Bogotá: Alcaldia Mayor de Bogotá. http://www.minagricultura.gov.co/archivos/presentacion_plan_maestro_seguridad_alimentaria.pdf (accessed in december 2012).

Smith, Alisa and James Mackinnon. 2007. *The 100-mile Diet: A Year of Local Eating*. Toronto: Random House Canada.

St-Amour, B. 2010. *Espaces de défavorisation et accessibilité au jardin communautaire à Montréal*. Montréal: Département de Géographie, Université de Montréal.

Sulaiman, Ablajan. 2010, *Regional Economic Development, Policy and Regional Disparity in Large Territories: The Case of Canada and China*. Thesis Ph. D., Département de Géographie, Université de Montréal, Montreal.

United Nations Development Programme (UNDP). 1996. Urban Agriculture: Food, Job and Sustainable Cities. *Habitat II* vol. 1.

United Nations Development Programme (UNDP). 2008. *Bogotá una apuesta por Colombia: Informe de Desarrollo Humano*. http://www.pnud.org.co/sitio.shtml/ (accessed in january 2013).

Ville de Montréal. 2005. *Le cahier de gestion du programme des jardins communautaires*. Montréal: Services des sports, des loisirs et du développement social-Direction de la cultura, des loisirs et du développement social. Montréal: Ville de Montréal.

World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press.