Agric Res (June 2016) 5(2):162–173
DOI 10.1007/s40003-016-0208-8

FULL-LENGTH RESEARCH ARTICLE

The Co-construction Approach as Approach to Developing Adaptation Strategies in the Face of Climate Change and Variability: A Conceptual Framework

Cherine Akkari[1] · **Christopher Robin Bryant**[2]

Received: 25 June 2015 / Accepted: 21 January 2016 / Published online: 11 March 2016

Abstract The aim of this article is to introduce the co-construction process as a productive approach to developing agricultural adaptation strategies to cope with climate change and variability in Québec, Canada. The methodology is based on a critical synthesis of existing literature both of peer-reviewed articles and the grey literature that contain analyses on agriculture, climate change and adaptation. Our focus is on the approach which was used in a research project in Québec dealing with agricultural adaptation and which was the result of almost 20 years of research by the co-author of this article into agricultural adaptation to climate change and variability in several regions in Québec. Based on our research teams' experiences, the co-construction approach can lead to a planned adaptation by farmers and as well by government agencies involved in supporting farmers' adaptation to climate change and variability. While co-construction processes started as a top-down approach in Europe, it is increasingly initiated as a bottom-up approach. We introduce the origin of the adaptation concept and then differentiate between adaptation responses of biological systems and human systems. Co-construction overlaps to a certain extent with collaborative research, but co-construction does not need to incorporate researchers. Co-construction can also be part of a research action process, but once more, formal researchers need not be involved and the research action leadership can be undertaken by actors other than researchers. Adaptation has many characteristics and different types including several forms of adaptation that involve both private agents such as farmers and government agencies as well as non-governmental organizations. We also point out the similarities between the bottom-up perspective of current co-construction and the grounded theory approach in terms of methodology (i.e. data collection and analysis). Finally, we discuss the implementation of the co-construction approach in the context of agricultural adaptation to climate change and variability. Continued involvement with farmers has helped them appropriate the reality of climate change and variability which constitutes the first prerequisite in order to develop adaptation strategies.

Keywords Climate change · Action research · Collaborative research · Climate change and variability in Québec · Agricultural adaptation to climate change

Introduction

Climatic as well as non-climatic factors should be taken into consideration in the process of agricultural adaptation to climate change and variability. Agricultural adaptation places the human agent at the centre of the adaptation process, which can certainly lead to maladaptation depending upon the motivations and objectives of the different actors involved.

To deal with climate change and variability, it is not only mitigation that is important but also adaptation.

✉ Cherine Akkari
cherine.akkari@hotmail.com

Christopher Robin Bryant
christopher.robin.bryant@gmail.com

[1] Department of Geography and Environmental Management, University of Waterloo, EV1-107, Ontario N2L 3G1, Canada

[2] School of Environmental Design and Rural Planning, Landscape Architecture Bldg., University of Guelph, Ontario N1G 2W1, Canada

Understanding the importance of climate variability and extremes is the cornerstone in the analysis of adaptation especially for agriculture, which usually adapts well to average or normal climatic conditions, but on the other hand is very susceptible to irregular conditions or extremes [44, 45 in 52, 54]. After all, adaptation is about reducing the uncertainties so one needs to ask what is the range of impacts that can be expected? What exposures and disruptions might we expect? And perhaps most importantly, what does adaptation mean under rising global temperature scenarios? Also, adaptation can be oriented to benefit from opportunities associated with climate change (at least in some regions) [13, 41, 54, 58, 62, 67, 72, 73]. Increasing attention has been given to the prospects of farm-level adaptation to changed—and annually variable—climatic conditions, instead of focusing on plant growth and crop yields under long-term average climate scenarios [13, 19, 46, 56], particularly when studies have begun to focus on the role of human agency [4, 8, 16, 53, 55, 57]. The farm is the point at which ecological, economic and human factors intersect, and where performance is first assessed and decisions about intervention and resource allocation are made. Farm decision-making is an ongoing process, whereby producers are continually making short-term and long-term decisions to manage risks coming from a variety of climatic and non-climatic sources [26]. Even though recent research has focused on farmers as decision makers at the farm scale [7, 8, 27, 34], there has been little empirical analysis of farm-level decision-making with respect to climate [53, 55, 57] and hence little consideration of the role of human agency. Some exceptions can be noted however specifically in Québec, as identified in references [10, 17, 39].

Moreover, given the importance of weather as a fundamental resource component in the context of agricultural production, on the one hand there is a significant interest in studying the implications of likely changes in climate on agriculture—global and/or local, and on the other hand, there is naturally a strong interest in identifying the best adaptation options [43, 70, 71, 76]. More recently, adaptation measures are increasing and becoming more integrated within broader policy making [28], but scientists and government officials are questioning the way the Intergovernmental Panel on Climate Change handles its major reports. The suggestion is that more frequent and more focused reports, such as studies focused on specific regions or phenomena, would be more useful to policymakers [24], not to mention farmers and their associations. In addition, although it is recognized that modern agriculture, at least the main type pursued in industrialized countries, has reduced its dependence on natural factors thanks to technology, the fact remains that amplification of climatic upheavals will, in the future, affect agricultural production even in these countries, a phenomenon that is already occurring. In terms of soil erosion and water pollution (both of which are negative externalities associated with modern agricultural technology), modern agriculture has contributed to several environmental concerns which make any analysis of the impacts of climate change and variability much more complex. The objective of this article is to introduce and shed light on the co-construction approach as way to develop appropriate adaptation strategies and to improve our understanding of the processes of adaptation and the adaptive capacity of farmers and the farming community.

The Study Area

The surface area of Québec accounts for 1,667,441 km^2 of Canada's total surface area. Between the latitudes of 45° and 62° North, Québec extends nearly 2000 km from north to south, and almost 1500 km from east to west. This vast expanse of territory already suggests that Québec contains several diverse climatic zones and ecosystems [18].

Three vegetation zones—the northern temperate zone, dominated by hardwood and mixed stands; the boreal zone, characterized by softwood stands; and the Arctic zone, where the vegetation is mostly made of shrubs and herbaceous plants—reflect Québec's major climatological divisions, harbour their own distinct plant communities and correspond to world biome categories [48]. For example, mixed forests—a combination of deciduous and coniferous trees, and a home to an even larger diversity of plant and animal species—cover the St. Lawrence Lowlands [18].

Québec has 3 % of the planet's renewable water resources due to its large river system and its numerous lakes and rivers. A third of Québec's territory lies within the watershed of the St. Lawrence, in which 80 % of its population lives [36]. This is also where the most fertile land is concentrated.

The region in which the field research was carried out is centred on the Regional Municipal County (RCM) of Haut-Richelieu, Québec, a region characterized by a relatively modern farm structure either of a productivist nature as well as more traditional family farm systems. Farming in the RCM of Haut-Richelieu is fairly diversified—with 50 % in crop production and 50 % in animal production. Cereal and oilseed production is the main agricultural activity in the RCM of Haut-Richelieu, representing 39 % of all the agricultural activities in the RCM in relation to the value of production. Also cattle farming occupies a prominent place in the RCM of Haut-Richelieu in relation to the value of production, representing 20 % of all the agricultural activities in the RCM (Fig. 1). In Sect. 2.1, we refer to the geographic variations in climate conditions and potential changes which have significantly different

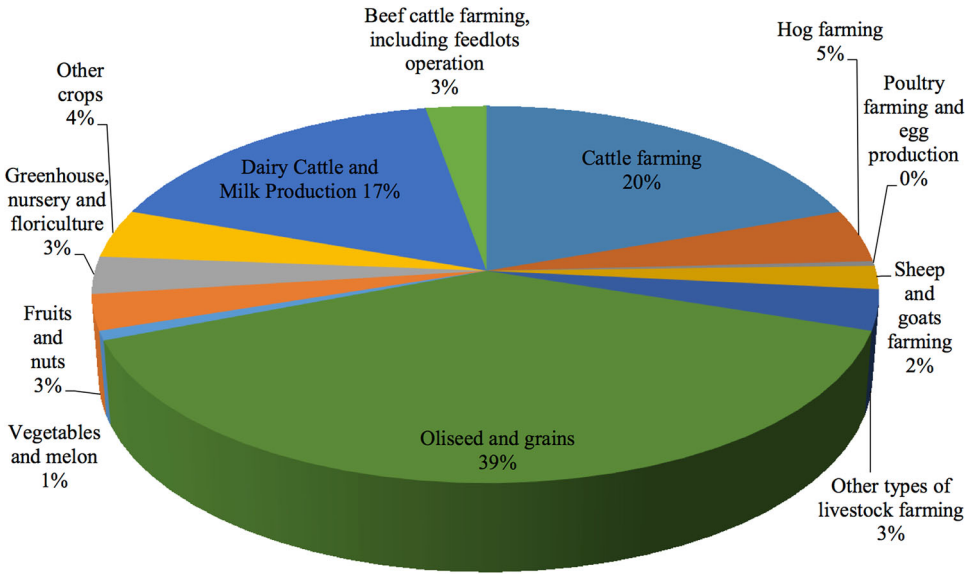

Fig. 1 Percentage distribution of different components of Agriculture by Sector of Production in the RCM of Haut-Richelieu, 2011. Statistics Canada, 2013 Agricultural Census

impacts on agricultural yields depending upon the specific region under study.

Climate Variables and Agriculture in Québec

Climate, with or without climate change and along with soil type and quality, is a major determining factor for agricultural activities such as crop farming and livestock farming (in terms of feed production). According to a model of regional agricultural adjustment to climatic variability, there are four agro-climatic conditions that are generally held to be of importance for agriculture: (1) growing season length (measured as the frost-free period or growing season start and end); (2) temperature or growing degree days (often expressed in corn heat units); (3) precipitation (drought, excess precipitation); and (4) sudden storms and shocks (i.e. wind, hail, early frost) [61]. In Québec, the length of the crop growing season and the accumulation of heat during this season are the two agro-climatic factors that govern crop selection and yield [18].

Agriculture is inherently sensitive to climate. Relatively cool and humid climate conditions in Quebec's agricultural areas are favourable to forage crops and cereals such as wheat, barley, oats and rye, which explains to a certain extent the importance of dairy production. Land dedicated to crops that are more reliant on heat, such as corn and soybeans, tends to be concentrated in the southern parts of Québec. It is noteworthy that the productivity of crops that require more heat is usually greater than for crops that are better adapted to cool climates. Integrating crop models with general circulation model (GCM) output for a $2 \times CO_2$ climate scenario for the period 2040–2069 [50] suggested that corn and sorghum yields in Québec could increase by 20 %, whereas wheat and soybean yields could decline by 20–30 %. As for canola, sunflowers, potatoes, tobacco and sugar beets, yields are expected to increase (unspecified quantitatively however), while a decrease in yields, also unspecified quantitatively, was anticipated for green peas, onions, tomatoes and cabbage.

Given the fact that climate conditions are especially experienced by farmers during the growing season; the conditions of the growing season (i.e. length of the growing season and other climate variables) vary from one year to another and inter-annual climate variability is an important indicator of the agricultural sector's sensitivity to climate conditions. An example of this is the greatest drop in grain corn production in the period from 1987 to 2001 that occurred in 2000. This particular year was highlighted by excessive moisture and insufficient sunlight to promote growth [21]. As an outcome of this problem, crop insurance compensations for corn production increased tremendously, reaching a record level of $97 million in 2000, compared to $191,000 in 1999 [33]. At the same time, the sub-regions showed different responses to the impacts of climate variability due to their different biophysical environments: soil type, topography and temperature [9]. This example of crop insurance compensations shows that there is an interest from governments in policy consideration of agricultural adaptation to current climatic variation and uncertainty, apart from the issue of long-term climate change. However, such institutional mechanisms can also lead to maladaptation. In fact, adaptation to climate is a complex process that occurs as a result of the influence of climatic (or environmental) forces as well as other external forces such as the actions of government, and economic, socio-cultural and technological factors.

Both sets of factors define the context of human–environment interaction at the same time. In human systems, non-environmental forces outweigh—either impeding or mediating—environmental factors; hence, the notion of maladaptation to climate [60]. The earliest recognition of maladaptation is included in Smit [11, 49, 52] and has recently been defined in the IPCC fifth assessment report [23, p. 857, Chapter 14] as "actions (i.e. inadvertent badly planned adaptation actions or deliberate decisions where wider considerations place greater emphasis on short-term outcomes ahead of longer-term threats, or that discount, or fail to consider, the full range of interactions arising from the planned actions), or inaction that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future."

Methodology

The methodology is based on a critical synthesis of existing literature both of peer-reviewed articles and the grey literature that contain analyses on agriculture, climate change and adaptation. The key searches were either based at the global scale or more specifically research that had been published on parts of Canada, particularly in Québec. All the papers consulted were written in English or French and were obtained from Google Scholar and online university libraries. This eventually led to undertaking interviews with farmers and other actors and especially the management of focus groups involving farmers and other actors in a co-construction approach to identify key challenges of climate change and variability for agriculture in this region and then to identify what could be the most appropriate adaptation strategies for farming in the region.

Agricultural Adaptation

While recognizing that reduction of greenhouse gas emissions on a global scale and mitigation of atmospheric greenhouse gases—through strategies that capture and store them in the long term—represent potentially important conditions, it is also important to adapt to the ongoing effects of climate change as well as planning for new or increased impacts in the future. Adaptation has received increased attention from several governments and international negotiations [32, 58, 65]. Adaptation is seen as a necessary complement to mitigation measures [22, 31, 41, 59]. The trend is no longer only about how to save the planet by cutting carbon emissions; it is becoming more imperative to focus on how to save ourselves from the negative impacts of changing climatic conditions [2, 74]. Without adaptation, climate change is generally problematic for agricultural production, agricultural economies and communities, but with adaptation, vulnerability can be reduced in many contexts and there are many opportunities to make this happen [20, 22, 35, 38, 40, 47, 59, 73]. The United Nations' Framework Convention on Climate Change, to which Canada is a signatory, identifies agriculture—including food production—as an important vulnerable area [63, 64, 66]. Adaptation includes the adaptation process and the condition of being adapted [54]. It is about how to approach the linkages between natural and human systems [53, 55]. For human environments, like agriculture, adaptation can involve preparing for changing climatic conditions; hence, the dominant adaptation response is anticipatory, with the other type of response being reactive. In natural environments, plant and animal populations will also adapt, but in a reactive way, thus suffering the more negative short-term impacts of climate change. We should add that it is the responsibility of human society to ease the independent and spontaneous response of the natural environment to adapt to climate change and its variability.

As for non-climatic factors (such as political, social, cultural and economic conditions) [5 in 30, 55, 53], they may amplify or exacerbate climate risks, just as they can also reduce or neutralize them.

Results and Discussion

Here, we present concepts regarding the co-construction approach and adaptation in the context of agricultural adaptation to climate change and variability.

Co-construction of Public Policies: Definition and Origin

Public policy always involves participation by the state sphere and public authorities [65]. Because it involves only those two, public policy tends not to take into account the needs of the communities concerned which can be quite variable or heterogeneous. This is why it is referred to as the mono-construction of public policy, meaning that the authoritarian state constructs public policy on its own (or mono-constructs) [67].

When some progressive circles tried to adjust their focus so as to tighten the links between policy and the needs of the communities concerned due to the hindsight gained following the welfare state and employment crisis of the 1980s, the co-construction of public policies emerged [29, 68, 69]. As a governmental policy, the notion of co-construction was placed on the table of discussion in the first place in the European Union in 1985 by CRESAL (Centre

de Recherches et d'Études Sociologiques Appliquées de la Loire) in Saint-Étienne [14].

Some situations when co-construction has been engaged in belong to some extent to the consultation process, so it is necessary to define consultation before proceeding with the definition of co-construction. For many observers, consultation is the action to agree on a common project. It is a process of dialogue to achieve proposals, policies or projects [37]. It is noteworthy, however, that the co-construction approach goes beyond the consultation process. According to [67], the term 'co-construction' has evolved as a result of the participation of different stakeholders in the making of public policy. It can also contribute to identifying and building appropriate forms of collective intervention. Co-construction means the participation by stakeholders from civil society and understanding the market in the design of public policy [67]. The term stands upstream from the adoption of public policy. In other words, it really refers to the creation of public policy. To understand the co-construction process, we should break down the various stages involved in the genesis of public policy, which are: "identification of the main goals for attaining the general interest; choice of regulation standards to foster quality; determination of funding means (state, private, mixed, etc.); definition of responsibility-sharing with respect to management; arrangement of responsibility-sharing with respect to the delivery of services belonging to public policy; and establishment of the policy for evaluating public policy" [67, p. 18]. "The co-construction of public policy is tied to the idea that it can become more democratic if the state agrees not to construct it all on its own" [67]. And the more the co-construction process tends to be democratic, the greater will be its likelihood to target a participatory reform according to [42]. This reform means that "the state's strength derives from its capacity to call on the resources of all segments of society with a view to achieving collective goals and meeting the collective interest" [42, pp. 8–9].

The co-construction of agricultural policies is an ambitious collaboration between different actors, public and private, for the definition of these policies and their application [67]. In addition, [54] defines planned adaptation of a sensitive system (or unit, business, industry, community, or region of interest) to the current and future effects of climatic changes as a result of deliberate policy on the part of public bodies (or governments) together with other actors of civil society (e.g. the farmers and agricultural companies involved); hence, from this perspective the co-construction approach can be considered to be a planned adaptation.

To summarize, co-construction is not just a bottom-up approach. Co-construction started mainly between government and high-level organizations (e.g. UPA or the farmers' union in Québec), but increasingly it starts from the bottom-up. In other words where possible higher levels ought to be involved particularly so that the bottom-up perspective can have an impact on the upper levels of government.

Co-construction can also be used to construct planning processes and specific projects. Co-construction has some features in common with collaborative research (such as that pursued in Québec in Gaspésie and New Brunswick when a team of researchers spent close to 4 years accompanying and supporting a set of coastal communities in the development of community resilience and appropriate plans of action by municipal and regional governments to reduce their vulnerability to climate change impacts, tidal surges and storms [1]). On the other hand, co-construction does not necessarily involve researchers; for instance the co-construction of strategic planning processes have been constructed by local actors and citizens (in some of the coastal communities in Gaspésie and New Brunswick [1]) and in some cases the process has led to major actions and initiatives (e.g. Haliburton County in Eastern Ontario where the process has been in place for almost 20 years [25]). Furthermore, co-construction (and some collaborative research) can also be considered part of action research; while some action research involves researchers accompanying groups of farmers and other local actors in developing a collective project [3, 6], it is also the case that some action research involves other actors including some farmers who take on the role of the research in developing a co-constructed project [3].

Origin of the Adaptation Concept

According to [75], the concept of adaptation is rooted in population biology and evolutionary ecology, which are considered as natural or biological sciences. Its applications are concentrated on the survival of species and ecosystems, and not necessarily on the viability of individuals within them [51]. Tolerance, stability and resilience are ecological concepts that have been used to describe the tendency of biological systems to adapt to changed conditions, including the processes by which these changes occur.

In the social sciences, adaptation is a paradigm (even stated again recently and more specifically in the IPCC report (2014) in terms of incremental and transformational adaptation) under which interaction between humans and their natural environment occurs, leading in turn to a broader meaning. Many scholarly fields, such as human and cultural ecology, natural hazards research, ecological anthropology, cultural geography, ecological economics and, more recently, climate impact research, include social science applications and extensions of the adaptation

paradigm. Furthermore, in social and economic systems, since human systems adjust in pursuit of goals other than mere survival, individuals have a high potential to adapt to changing environmental circumstances. However, it is noteworthy that while the response of biological systems is totally reactive, the responses of human systems (e.g. agriculture) are both reactive and anticipatory, integrating environmental perception and risk evaluation as essential elements of adaptation.

Characteristics of Adaptations

Distinguishing adaptation can be undertaken by identifying its characteristics. Among the distinguishing characteristics are intent and purposefulness, timing and duration, scale and responsibility, and form.

Intent and Purposefulness

Intent and purposefulness differentiate between autonomous or spontaneous adaptations and planned or anticipatory adaptations. In socio-economic systems, planned or anticipatory adaptations are undertaken by the public sector in concert with other actors. However, under the private sector, without the intervention of the public sector, adaptations can be autonomous or planned or both. An example of the latter are the decisions of a producer who, over several years, gradually phases out one crop variety in favour of another that seems to cope better under current climatic conditions, and this might be considered autonomous and planned. It is noteworthy that even in autonomous adaptations, private actors plan for adaptation without deliberate intervention from the government, but they do not act in isolation from the existing cultural, political, social and market institutions.

Timing and Duration

Timing distinguishes between responses that are proactive or reactive. On the other hand, duration differentiates adaptation according to their temporal scopes, such as tactical (short-term) responses versus strategic (long-term) responses. It is noteworthy that if farmers are only involved in tactical responses, strategic responses constrain, to a larger extent, the tactical responses of farmers; hence, it is wrong to consider that farmers alone are the decision makers.

Scale and Responsibility

Regarding adaptations, decisions are undertaken at several scales, mainly spatial (i.e. plant, plot, field, farm, region and nation) and by several actors (i.e. private or public agencies and actors).

Where these adaptations are consciously planned, whether by individuals (private adaptation) or public agencies (public adaptation), there is an interest in assessing the performance of such strategies.

To summarize what has been said above thus far and since commonly used distinctions of adaptations are purposefulness and timing [53, 55], autonomous adaptation is undertaken by private agents and it is generally reactive, but it can also be proactive. On the other hand, planned collective adaptation is undertaken by the public in concert with other actors, and it is anticipatory in general, but it can also be reactive.

Form

[12, 13, 60], among other authors, have also distinguished adaptations according to their form. Such studies consider adaptations according to their administrative, financial, institutional, legal, managerial, organizational, political, practical, structural and technological characteristics.

Types

This section is drawn particularly from Canadian literature and experience. It is also based on the spatial scale, the stakeholders involved, private or public, and their responsibilities. As noted earlier, it divides the main adaptation types into four, often interdependent, categories: (1) technological developments; (2) government programmes and insurance; (3) farm production practices; and (4) farm financial management. The first two categories are mainly undertaken by public agents and agribusiness (which is private), and they are pursued at a broader scale (or macro-scale). The last two categories are undertaken by the producers at the farm level.

To summarize all the above, adaptation is under the best of circumstances a continuous process. At one end is the pure spontaneous adaptation by private agents; at the other end is the pure planned adaptation by government. Between these extremes, there are many forms of adaptation that involve both the private agent and the government (Fig. 2).

The Co-construction Approach: Methodological Steps

By focusing on the bottom-up perspective, the co-construction approach is similar to the grounded theory approach in terms of data collection (and hence in analysis). According to [23], theory emerges from a process of data collection through primary data (i.e. interviews and/or focus groups) and secondary data (collected from literature review and data from organizations such as Statistics Canada and other websites) (Fig. 3).

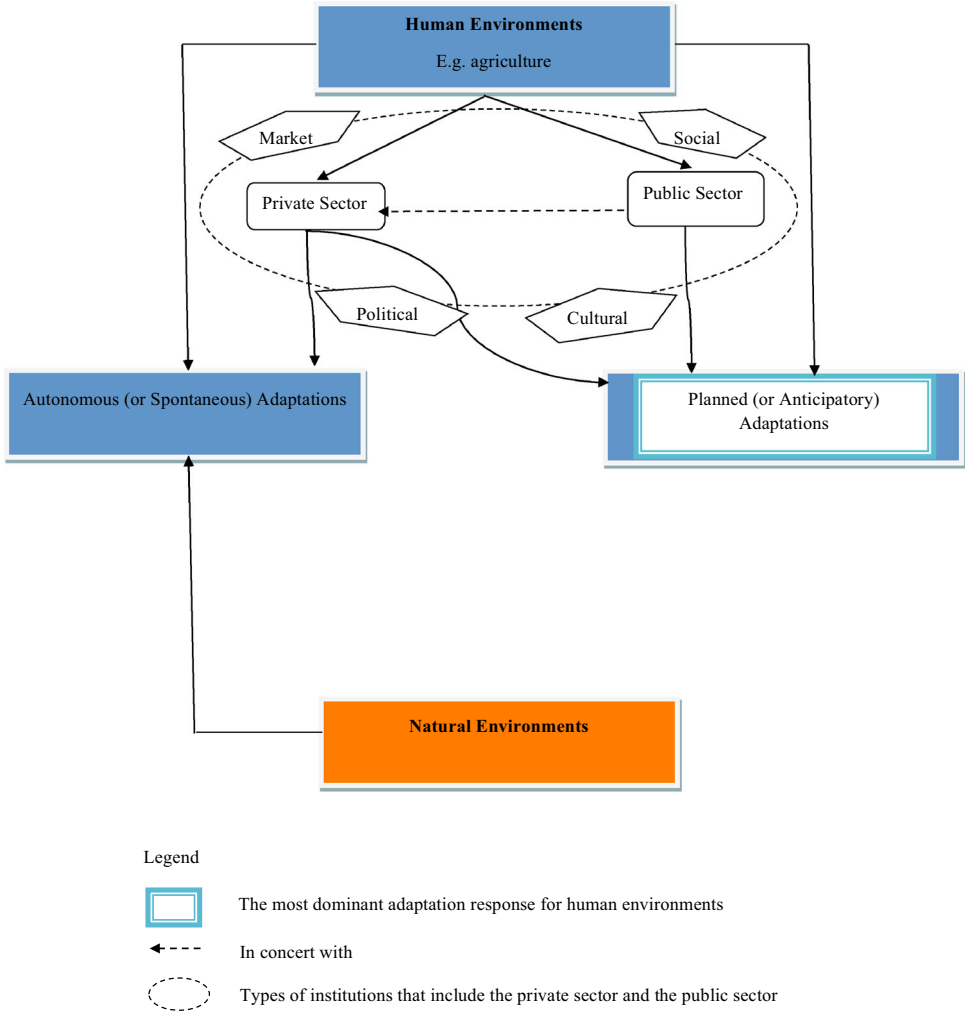

Fig. 2 Types of adaptation according to human and natural enviroments. *Source*: Cherine Akkari, 2014

Both approaches—the co-construction approach and the grounded theory approach—represent a way to develop tools or agricultural policies or recommendations in the fields of adaptation of agriculture to climate change and variability at the farm level in a decentralized (bottom-up) manner involving a group of actors. This type of approach is used for connecting indicators and integrating and managing interaction between individuals, and collective and scientific knowledge. It is no longer the optimum which is sought but a compromise, not only a compromise between the actors involved, but a compromise between practise and theory; and this is reached by a dynamic process of progressive adjustment and learning. It is more likely to suit the diversity of actors' values or visions. During the application of a grounded theory approach, data analysis and interpretation and theory building occur at the same time as data collection. It is a pro-active approach. What makes it original is the regional nature of the approach. The theory is formed based on actors' issues and representations, thereby encouraging their appropriation. In other words, it is an approach where adaptation takes place as a bottom-up process, with the possibility of government stepping into provide incentives.

Implementation of the Co-construction Approach in the Context of Agricultural Adaptation to Climate Change and Variability

Actions of co-construction (e.g. of relevant adaptation strategies) should be integrated with the different roles of stakeholders, which requires strategic decisions by different government agencies, farm communities and institutions.

Implementing the co-construction approach (Fig. 4) is a way to develop new tools (or toolkits) in the fields of adaptation of agriculture to climate change and variability at the farm level in a decentralized (bottom-up) manner by a group of actors. This type of approach can be used for connecting indicators and integrating and managing interaction between individual, collective and scientific

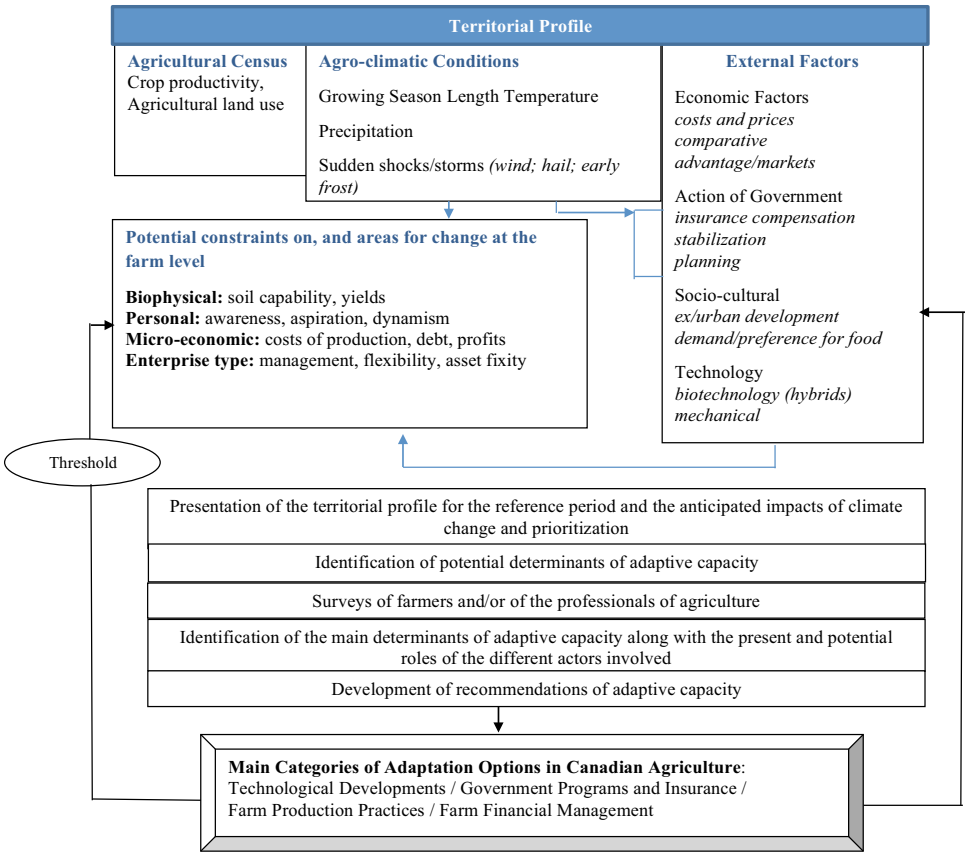

Fig. 3 Steps of the methodology used in grounded theory as well as in the Co-construction Approach. *Source*: Cherine Akkari, 2014

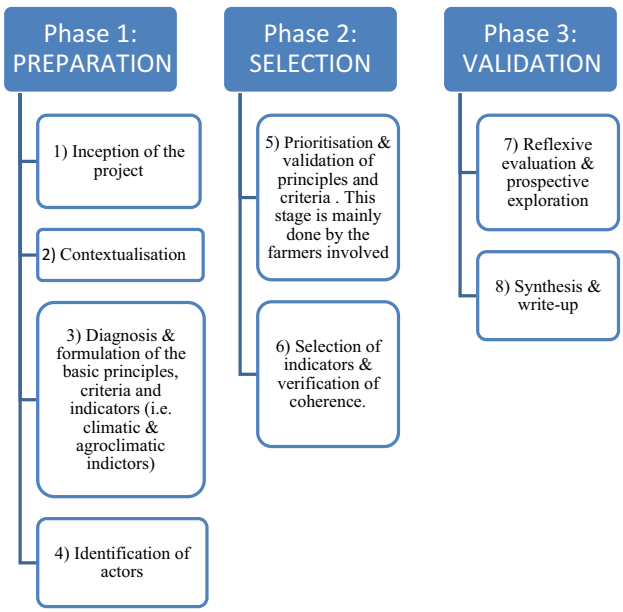

Fig. 4 Implementation process of the co-construction approach. *Source*: Cherine Akkari, 2014

knowledge. It is no longer the optimum which is sought but a compromise, and this is reached by a dynamic process of progressive adjustment. This type of approach where practices which are considered to be positive or innovative are institutionalized is more likely to suit the diversity of actors' values [15]. The approach combines action research (progressive and collective learning) and grounded theory (beginning with data collection and then formulating a hypothesis or theory by comparative analysis). It is a pro-active approach. What makes it original is not only the participatory nature of the construction, but also the regional nature of the approach. It is based on a selection process that nests principles, criteria and linking indicators to the actors' issues and representations, thereby encouraging their appropriation. In other words, it is an approach where adaptation takes place as a bottom-up process, with government stepping into provide incentives.

The use of this approach is based on a generic foundation established in three phases and eight chronological stages which, depending on the case under study, follow from specific work by the pioneering group or from participatory work by the stakeholders. The pioneering group refers to the team (often small in size, and sometimes a single person) in charge of facilitating and coordinating the development of indicators, either as the initiator of the approach or because they have been allocated the task. As specified previously, the co-construction approach suggested here is based on a mode of interaction between the

members of the pioneering group and the stakeholders involved, which is deliberately flexible and light. Hence, it is possible to imagine closer action research partnerships in the future. The figure below (Fig. 4) illustrates a procedural and interactive process, particularly when the learning function is determinant. It also shows the links between phases and stages. Three phases set the pace for the implementation of the suggested approach:

- a preparatory phase (four stages) which tends to be cognitive and comprehensive
- a principle and criteria selection phase, which is at the heart of the approach (two stages) and tends to be comprehensive and participatory
- a validation phase (two stages) which may be described as participatory, reflexive and cognitive.

The co-construction approach is a decision-making process, which consists of the following (4) four sequential steps: (1) problem recognition; (2) specification of strategies; (3) specification of the decision criterion or criteria; and (4) selection of the optimum strategy. Each alternative to solve a recognized problem is a strategy. So while decision-making is largely a matter of selecting one of the strategies available, it is pointless to consider alternatives that cannot possibly be implemented. Therefore, the need for a decision criterion that evaluates each strategy and expresses the desirability of the outcomes obtained from each strategy. Managing the policy process involves the actors, a policy dialogue, the right timing and appropriate communications.

The involvement of players is and should be undertaken at the various stages of the policy process. Though the actors differ from one situation to another, the common theme is that those who are actively involved in the process are those who will have to diagnose, design, implement, monitor, evaluate, or significantly change their behaviour or are financially personally affected by a policy. The active participation of a broad spectrum of stakeholders is important because it contributes to the legitimacy of policy and may engender higher acceptance among stakeholders even if implementing agencies lack the resources or authority to effectively monitor and enforce compliance. Dialogue is an important management tool that is applied to all stages of the policy process and that varies from one stage of the process to another. It facilitates the exchange of ideas, information, analytical results and policy options, approaches and tools, and it ultimately contributes to the transparency and effectiveness of decision-making in the policy arena, especially at the stage of design. Moreover, getting the timing right is another key element for managing a policy. For instance, the timing of participation of key players is particularly important to achieving successful policy formulation, enactment and reform. And, because time horizons vary, knowing when to press forward and when to relent are complementary—not contradictory qualities—in achieving success. Therefore, both persistence and patience are required. The final management element in the policy process is communication. Communication is the final management element in the policy process. It is closely linked to the other elements: actors involved in the policy process communicate and interact with other participants in an attempt to reach consensus, sharing information, and informing and educating the public. Policy dialogue is an important mechanism for communicating information; and getting the timing right implies an awareness of the pace and steps involved in the policy process, which are gleaned through communication. As for the implementation costs of the co-construction approach, the costs are highly variable. When researchers are involved, their own costs would not get counted. And it is not the costs that are so very important as the point that it often takes a long time to develop a co-constructed project, programme or plan.

Conclusions

To conclude, co-construction is not just a bottom-up approach. Co-construction started mainly between government and high-level organizations (e.g. UPA—the farmers' union in Québec), but increasingly it starts from the bottom-up. In other words where possible higher levels should be involved particularly so that the bottom-up perspective can have an impact on the upper levels of government. In addition, a form of territorialization of public and collective intervention, and policies, is necessary when it comes to agricultural adaptation to climate change and variability. In the Canadian context, this essentially requires forming partnerships between the federal and especially provincial level, on the one hand, and regional and local actors on the other hand including farmers and their local associations. However, one should note here that it is difficult to obtain social quality and public policy by relying only on state intervention [67]. And that is where the distinction between co-construction and co-production of policy is helpful. Besides, at the local level, it is critical to provide training for actors in the use of various tools for helping farmers and groups of farmers, and as well in the whole field of climate change. For instance, developing a credible and respected local presence, depending on each region, is in effect equivalent to developing a form of an extension network.

Further, adaptation is a necessary complement to mitigation measures. Moreover and while adaptation has many characteristics and types [8, 30, 58], there are plenty of forms of adaptation that involve both the private agent and the government.

One of the most important results of the project on which this article is based is how the research process has complemented the series of other projects undertaken by research teams involving the co-author as principal or co-principal investigator since the early 1990s. In particular, it has become much easier now when dealing with groups of farmers in the regions where these research projects were carried out to present the climate scenarios and potential impacts in ways that help the farmers readily appropriate the significance of climate change and variability for their own farming operations. This was also helped significantly by the crop insurance data (factors behind crop insurance claims, total amounts of annual insurance claims made by farmers by municipality or region in which the research was being undertaken, and for periods of up to 25 years depending on the region and crops) provided to the researchers since the late 1990s by the FADQ (Financière Agricole du Québec or the Agricultural Financial Corporation of Québec). The many graphs and tables presented to farmers were rapidly appropriated by the farmers for showing how real the increasingly recurrent extremes of climate conditions had been since the late 1990s, emphasizing the reality of the phenomenon of climate change and variability for them.

Acknowledgments The authors are thankful to Natural Resources Canada for funding this study through project Grant number (A1332, CCIAP). And more directly, I would like to thank my supervisor Christopher Robin Bryant for supporting me financially in this project.

Authors' contribution C.A. acquired, cleaned and analysed the data; wrote and edited the manuscript. C.R.B. edited the manuscript and supervised the entire study.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no competing interests.

References

1. Alliance Recherche Université-Communautés (ARUC) (2014) Défis des communautés côtières. UQAR (Université du Québec à Rimouski), Rimouski, Québec. http://www.defisdescommunautescotieres.org/
2. Borenstein S (2013) Climate talk shifts from curbing CO_2 to adapting. The Associated Press, New York. http://globalnation.inquirer.net/77731/climate-talk-shifts-from-curbing-global-warming-to-adapting#ixzz2WWvPzvwd. Accessed 27 June 2013
3. Bousbaine AD, Bryant CR (2015) The integration of action research and traditional field research to provide sustainable solutions to maintaining periurban agriculture. Geogr Res (eventually for the Special Issue: Rural Action Research), 1–11
4. Brklacich M, McNabb D, Bryant C, Dumanski J (1997) Adaptability of agriculture systems to global climate change: a Renfrew County, Ontario, Canada pilot study'. In: Ilbery B, Chiotti Q, Rickard T (eds) Agricultural restructuring and sustainability: a geographical perspective. CAB International, Wallingford, pp 351–364
5. Bryant CR (1994) Strategic management and planning for local and community economic development: I. The organization. Econotrends limited St, Eugène
6. Bryant CR, Chahine G (2015) Action research and reducing the vulnerability of peri-urban agriculture: a case study from the Montreal Region. Geogr Res (eventually for the Special Issue: Rural Action Research), 1–11
7. Bryant CR, Johnston TRR (1992) Agriculture in the city's countryside. Pinter Press, London, p 226
8. Bryant CR, Smit B, Brklacich M, Johnston TR, Smithers J, Chiotti Q, Singh B (2000) Adaptation in Canadian agriculture to climatic variability and change. Clim Change 45(1):181–201. doi:10.1023/A:1005653320241
9. Bryant CR, Singh B, DesRoches S, Thomassin P, Baker L, Madramootoo C, Délusca K, Savoie M (2005) Climate variability in Quebec: lessons for farm adaptation from an analysis of the temporal and spatial patterns of crop insurance claims in Quebec. In: National conférence on: adapting to climate change in Canada 2005: understanding risks and building capacity, Natural Resources Canada, Montréal. May 4–7, 2005
10. Bryant CR, Singh B, Thomassin P, Baker L, Délusca K, Savoie M, Doyon M, Seyoum E (2008) Evaluation of agricultural adaptation processes and adaptive capacity to climate change and variability: the co- construction of new adaptation planning tools with stakeholders and farming communities in the Saguenay-Lac-Saint-Jean and Montérégie Regions of Quebec. Université de Montréal and McGill University Research Team. Submitted to Natural Resources Canada, Climate Change Impacts and Adaptation Program (CCIAP), Project A1332
11. Burton I (1997) Vulnerability and adaptive response in the context of climate and climate change. Clim Change 36(1–2):185–196. doi:10.1023/A:1005334926618
12. Burton I, Kates RW, White GF (1993) The environment as hazard. The Guilford Press, New York, p 290
13. Carter TR, Parry ML, Harasawa H, Nishioka S (1994) IPCC Technical guidelines for assessing climate change impacts and adaptations, Department of Geography, University College London, London
14. Castel R (1985) L'expert mandaté et l'expert instituant. In: Situations d'expertise et socialisation des savoirs, C.R.E.S.A.L. Saint-Étienne, 14–15 mars 1985
15. Chéron M, Ermisse L (2008) Repères sur l'évaluation au regard du développement durable. Cahier no. 2, octobre 2008, Observatoire national des Agenda 21 et des pratiques territoriales de développement durable, p 84. http://www.observatoire-territoires-durables.org/spip.php?article1055
16. Chiotti Q, Johnston TRR, Smit B, Ebel B (1997) Agricultural response to climate change: a preliminary investigation of farm-level adaptation in southern Alberta'. In: Ilbery B, Chiotti Q, Rickard T (eds) Agricultural restructuring and sustainability: a geographical perspective. CAB International, Wallingford, pp 167–183
17. Délusca K (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-Saint-Jean-Est. Thèse présentée à la Faculté des études supérieures en vue de l'obtention du grade de Philosophiae Doctor (Ph.D.) en géographie. Dissertation, Faculté des arts et sciences, Département de géographie, Université de Montréal
18. Desjarlais C, Chaumont D, Larrivée C, Lease N, Allard M., Bourque A, Gosselin P, Houle D, Roy R, Savard J-P, Turcotte R,

Villeneuve C (2010) Learning to adapt to climate change. Ouranos, Montreal, p 128. ISBN: 978-2-923292-04-5
19. Easterling WE, Rosenberg NJ, Lemon KM, McKenney MS (1992) Simulations of crop responses to climate change: effects with present technology and currently available adjustments- The "smart farmer" scenario'. Agric Forest Meteorol 59:75–102
20. Easterling WE, Crosson PR, Rosenberg NJ, McKenney MS, Katz L, Lemon KM (1993) Agricultural impacts of and responses to climate change in the Missouri-Iowa-Nebraska-Kansas region. Clim Change 24(1–2):23–62
21. Environment Canada (2002) Les dix principaux évènements météorologiques canadiens de 2000. Retrieved from: http://www.msc.ec.gc.ca/media/top10/2000_f.html. Accessed on 1 July 2013
22. Fankhauser S (1996) The potential costs of climate change adaptation. In: Smith J, Bhatti N, Menzhulin G, Benioff R, Budyko MI, Campos M, Jallow B, Rijsberman F (eds) Adapting to climate change: an international perspective. Springer, New York, pp 80–96
23. Glaser BG (1963) Retreading research materials: the use of secondary data analysis by the independent researcher. Am Behav Sci 6(10):11–14
24. Goldenberg S (2013) Scientists call for overhaul of UN 'block-buster' climate reports. The Guardian http://www.theguardian.com/environment/2013/sep/04/scientists-overhaul-un-climate-report-ipcc. Accessed 5 Sept 2013
25. Haliburton County (2015) Community-driven strategic plan. https://haliburtoncounty.ca/services/planning-and-gis/strategic-plan/. Consulted August 21st 2015
26. Ilbery B (1985) Agricultural geography: a social and economic analysis. Oxford University Press, Oxford
27. Ilbery B (1991) Farm diversification as an adjustment strategy on the urban fringe of the West Midlands. J Rural Stud 7(3):207–218
28. IPCC (2014) Part A: global and sectoral. Aspects. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds) Climate change 2014: impacts, adaptation, and vulnerability. Contribution of Working Group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge
29. Jetté C, Levesque B, Mager L, Vaillancourt Y (2000) Économie sociale et transformation de l'État-providence dans le domaine de la santé et du bien-être: une recension des écrits (1990–2000). PUQ, Sainte-Foy, p 202
30. Kandlikar M, Risbey J (2000) Agricultural impacts of climate change: if adaptation is the answer, what is the question? Clim Change 45(3):529–539
31. Kane SM, Shogren JF (2000) Linking adaptation and mitigation in climate change policy. Clim Change 45(1):75–102
32. Klein RJT, MacIver DC (1999) Adaptation to climate variability and change: methodological issues. Mitig Adapt Strateg Global Change 4(3–4):189–198. doi:10.1023/A:1009690729283
33. La Financière agricole du Québec (FAQ) (2006) Statistiques annuelles, Assurance récolte. Retrieved from: http://www.fadq.qc.ca/index.php?id=826. Accessed 28 Sept 2014
34. Marsden T, Munton R, Whatmore S, Little J (1989) Strategies for coping in capitalist agriculture: an examination of the responses of farm families in British agriculture. Geoforum 20(1):1–14
35. Mendelsohn R (1998) Climate-change damages. In: Nordaus WD (ed) Economics and policy. Issues in Climate Change for the Future
36. Ministère des Ressources naturelles et de la Faune du Québec (MRNF) (2006) Ressources et industrie forestière, portrait statistique, édition 2005–2006, Ministère des Ressources naturelles et de la Faune du Québec
37. Molin C (2008) Guide de la co-construction des politiques agricoles périurbaines d'agglomération. Terres en Villes: http://www.terresenvilles.org/upload/pubdoc/pdc_20081128034756_guideco-construction.pdf
38. Nordhaus WD (1991) To slow or not to slow: the economics of the greenhouse effect. Econ J 101(407):920–937
39. Oumarou D (2014) L'adaptation de l'agriculture au changement et à la variabilité climatiques au Québec: un processus de diffusion des innovations. Thèse présentée à la Faculté des études supérieures en vue de l'obtention du grade de Philosophiae Doctor (Ph.D.) en géographie. Dissertation, Faculté des arts et sciences, Département de géographie, Université de Montréal
40. Patino L (2010) Understanding climate change adaptation and adaptive capacity. Synthesis Report. PRI Project. Sustainable Development.Ottawa, ON. Policy Horizons Canada. ISBN: 978-1-100-16609-4. PDF format: http://www.horizons.gc.ca/sites/default/files/Publication-alt-format/2010-0041-eng.pdf
41. Pielke RA (1998) Rethinking the role of adaptation in climate policy. Glob Environ Change 8(2):159–170
42. Pierre J (2005) ¿Poder para… o poder sobre?: repensando la fuerza del Estado. Reforma y Democracia, 32
43. Reilly JM (1994) Crops and climate change. Nature 367:118–119
44. Reilly J (1995) Climate change and global agriculture: recent findings and issues. Am J Agric Econ 77:727–733
45. Risbey J, Kandlikar M, Dowlatabadi H, Graetz D (1999) Scale, context, and decision making in agricultural adaptation to climate variability and change. Mitig Adapt Strateg Global Change 4:137–165
46. Rosenberg NJ (1992) Adaptation of agriculture to climate change. Clim Change 21(4):385–405. doi:10.1007/BF00141378
47. Rosenzweig C, Parry ML (1994) Potential impact of climate change on world food supply. Nature 367:133–138
48. Saucier J-P, Grondin P, Robitaille A, Bergeron J-F (2003) Vegetation zones and bioclimatic domains in Québec. Ministère des Ressources naturelles et de la Faune, Québec, Canada. http://www.mrnfp.gouv.qc.ca/english/publications/forest/publications/zone-a.pdf
49. Scheraga JD, Grambsch AE (1998) Risks, opportunities, and adaptation to climate change. Clim Res 11:85–95
50. Singh B, El Mayaar M, André P, Bryant CR, Thouez JP (1998) Impacts of a GHG- induced climate change on crop yields: effects of acceleration in maturation, moisture stress and optimal temperature. Clim Change 38:51–86
51. Slobodkin LB, Rapoport A (1974) An optimal strategy of evolution. Quart Rev Biol 49:181–200
52. Smit B (ed) (1993) Adaptation to climatic variability and change: report of the task force on climate adaptation. Canadian Climate Program. University of Guelph, Ontario
53. Smit B (1994) Climate, compensation and agriculture. In: Proceedings of a workshop on improving responses to atmospheric extremes: the role of insurance and compensation, Theme papers. Environment Canada, Toronto, pp 29–37
54. Smit B, Pilifosova O (2007) Adaptation to climate change in the context of sustainable development and equity. In: Climate change 2001: working group II: impacts, adaptation and vulnerability
55. Smit B, Skinner WM (2002) Adaptation options in agriculture to climate change: a typology. Mitig Adapt Strateg Global Change 7:85–114
56. Smit B, McNabb D, Smithers J (1996) Agricultural adaptation to climatic variation. Clim Change 33:7–29
57. Smit B, Blain R, Keddie P (1997) Corn hybrid selection and climatic variability: gambling with nature? Can Geogr 42:429–438
58. Smit B, Burton I, Klein RJT, Wandel J (2000) An anatomy of adaptation to climate change and variability. Clim Change 45:223–251

59. Smith JB (1996) Using a decision matrix to assess climate change adaptation. In: Smith JB, Bhatti N, Menzhulin G, Benioff R, Budyko MI, Campos M, Jallow B, Rijsberman F (eds) Adapting to climate change: an international perspective. Springer, New York, pp 68–79
60. Smithers J, Smit B (1997) Human adaptation to climatic variability and change. Global Environ Change 7(2):129–146
61. Smithers J, Smit B (1997) Agricultural system responses to environmental stress. In: IIbery B, Chiotti Q, Rickard T (eds) Agricultural restructuring and sustainability: a geographical perspective. CAB Direct International, Wallingford, pp 167–184. ISBN: 0-85199-165-3
62. Tol RSJ, Fankhauser S, Smith JB (1998) The scope for adaptation to climate change: what can we learn from the impact literature? Global Environ Change 8(2):109–123
63. UNFCC (2006) Handbook. Bonn, Germany: Climate Change Secretariat. ISBN: 92-9219-031-8. PDF format: http://unfccc.int/resource/docs/publications/handbook.pdf
64. United Nations Environment Program (UNEP) (1998) Handbook on Methods for Climate Impact Assessment and Adaptation Strategies, 2. Institute for Environmental Studies, Amsterdam
65. United Nations Framework Convention on Climate Change (UNFCCC) (1992) United Nations Framework Convention on Climate Change: Text. World Meteorological Organization and United Nations Environment Program, Geneva
66. University of Southern Denmark (2013) Unexpected interaction between ocean currents and bacteria may weaken ocean's ability to absorb carbon dioxide. ScienceDaily. Retrieved June 29, 2014 from www.sciencedaily.com/releases/2013/09/130913101817.htm
67. Vaillancourt Y (2008) Social Economy in the co-construction of public policy: La démocratisation des politiques publiques: Une vision canadienne et québécoise. Occasional Paper Series, 3
68. Vaillancourt Y, Aubry F, Jetté C (2003) L'économie sociale dans les services à domicile. Presses de l'Université du Québec, Quebec City, p 341
69. Vaillancourt Y, Aubry F, Kearney M, Thériault L, Tremblay L (2004) The contribution of the social economy towards healthy social policy reforms in Canada: a Quebec viewpoint. In: Dennis R (ed) Social determinants of Health. Canadian Perspectives. Canadian Scholars' Press Inc., Toronto pp 311–329
70. Wang YP, Jr Handoko, Rimmington GM (1992) Sensitivity of wheat growth to increased air temperature for different scenarios of ambient CO_2 concentration and rainfall in Victoria, Australia: a simulation study. Clim Res 2:131–149
71. Wang QJ, Nathan RJ, Moran RJ, James B (1999) Impact of climate changes on the security of the water supply of the Campaspe System. In: Proceedings of the 25th hydrology and water resources symposium, vol 1, 6–8 July 1999, Brisbane, Institution of Engineers, Australia, Water 99 Joint Congress, pp 135–140
72. Watson RT, Zinyoera MC, Moss RH (1996) Climate change 1995: impacts, adaptations and mitigation of climate change: scientific-technical analysis. In: Contribution of working group II to the second assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge
73. Wheaton EE, McIver DC (1999) A framework and key questions for adapting to climate variability and change. Mitig Adapt Strateg 4:215–225
74. White C (2013) The other job. The Carbon Pilgrim. http://carbonpilgrim.wordpress.com/2013/03/27/the-other-job/. Accessed on 1 April 2013
75. Winterhalder B (1980) Environmental analysis in human evolution and adaptation research. Human Ecol 8(2):135–170
76. World Bank (2010) Development and climate change. World development report. The International Bank for Reconstruction and Development, Washington, DC. http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1226014527953/WDR10-Full-Text.pdf