Vulnerability Studies in the Americas

Vulnerability Studies in the Americas:

Extreme Weather and Climate Change

Edited by

Paula Mussetta and Margot Hurlbert

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INTRODUCTION

HARRY POLO DIAZ, DAVID SAUCHYN AND PAULA MUSSETTA

Today the fundamental issue about climate change is no longer whether the climate is changing. Rather, the debate is related to the many uncertainties that characterize this transformation of climate conditions. It is a controversial topic, with many different voices that provide distinct explanations of the phenomenon, different predictions of how it will impact on us and natural systems, and diverse solutions to ameliorate the rate of change and the potential impacts. In spite of these differences, there is a strong scientific and political consensus about the inevitability of climate change and its global impact. Climate change is expected to bring variations in local climate patterns, disturbing ecosystems and soil landscapes, as well as impacting on economic production and social conditions, such as health. Climate change, however, could also bring new opportunities, such as the expansion of cultivated areas. In these terms, it is a crucial and urgent task to expand our knowledge about climate change and its potential impacts on ecosystems and society, and about our capacity to manage the risks and opportunities associated with climate change.

Despite the consensus regarding global warming and its impacts, there is a limited understanding of the possible solutions. Most governments have adopted, with varying degrees of commitment, a mitigation policy in the context of international agreements, such as the Kyoto Protocol and the Paris Accord. However, these policies will not significantly alter the processes of climate change and its near-term impacts without an in-depth knowledge of local social and environmental vulnerabilities and existing adaptive capacities. Effective anticipatory adaptation strategies, based on sustainability principles and the ability to deal with opportunities and threats from climate change, are also required. The development of adaptive capacity—the capacity of governments and civil society to combine their strengths and resources to manage risk—increases the

ability of people, communities, and regions to reduce the adverse impacts of climate change and maximize its benefits.

This book deals with the impacts of present and future extreme climate conditions on the rural regions of five countries in the Americas: Argentina, Brazil, Canada, Chile, and Colombia. It presents and discusses the results of the Vulnerability and Adaptation to Climate Extremes in the Americas (VACEA) project, a collaborative, comparative and interdisciplinary investigation of vulnerable rural agricultural communities in the five countries. The research team comprised of investigators and research assistants from different disciplines: Geography, Geology, Engineering, Agronomy, Sociology, Law, Economics, and Anthropology.

The VACEA project took place between 2011 and 2016. Its main goal was "to improve the understanding of the vulnerability of rural agricultural and indigenous communities to shifts in climate variability and to the frequency and intensity of extreme climate events, and to engage governance institutions in Canada, Argentina, Brazil, Chile and Colombia in enhancing their adaptive capacity to reduce rural community vulnerability." Thus, it addressed the consequences of global climate change for both regional climate variability and extremes, and the associated vulnerabilities and adaptive strategies of rural communities. The project was focused on rural populations that are highly vulnerable, either because their lives take place on the social and economic margins of society or because the nature of their livelihoods makes them highly exposed and sensitive to climate variability and extremes.

The project's focus was extreme weather events, one of the most serious sources of climate change risk. The most common and robust projections of future climate are climate model outputs averaged over decades and over large areas. For example, the IPCC (2007) projected a 1.5 to 4 degrees increase in global average temperature in the 21st century. In turn, most assessments of climate change impacts and vulnerability have relied on these scenarios of shifts or trends in an average climate. However, at local and regional scales the major climate hazards are extreme conditions rather than shifts or trends in the means: "variability is more important than averages" (Katz and Brown, 1992, p. 289). In this context, changes in the extremes and range of variation are the most problematic due to an increase in water scarcities, more intense precipitation, heat and cold periods, and other consequences. When extremes go beyond our range of experience we will face more serious climate hazards than ever, making rural regions of Canada and South America highly sensitive to climate change (Santibañez et al., 2008).

The book discusses the physical phenomena and the social processes that inform both the impacts of extreme weather events and the capacity of rural people to reduce those impacts, a discussion based on the research insights produced by both natural and social scientists in the course of their investigations. The book adopts an interdisciplinary approach with the goal of integrating the insights of the different scientific disciplines involved in the project in order to produce a comprehensive knowledge of a complex phenomenon. This integrated knowledge of current social vulnerabilities in the context of projected shifts in climate variability and the frequency and intensity of extreme events has produced important insights into future rural risks and opportunities and informed the adoption of more appropriate local practices and adjustments to governance policies. In these terms, the book is distinctive, not only because it offers a depth of analysis and breadth of coverage that is highly useful, but also because it highlights the complementary roles of scientific disciplines in explaining a complex new phenomenon. A comparative chapter compares the main findings of the case study chapters and draws critical inferences for consideration when thinking of climate change and vulnerability.

1. The Vulnerability Study of VACEA

The VACEA study consisted of a set of regional case studies in two provinces within Canada (Alberta and Saskatchewan) and four countries within South America (Chile, Argentina, Brazil, and Colombia) with similar geographical and climatic characteristics, but very different social, political and economic contexts. Table 1 below outlines the watershed in each case study area forming the basis of the study and its basic characteristics. Figure 1 below depicts the study countries which are also presented in other chapters. Despite differences in agricultural commodities, all the study areas are rural and agricultural and characterized by communities and economic activities sensitive to deviations in climate from normal conditions and to extreme events. Drought and floods are serious threats in these water basins, threatening the water supply for human consumption as well as agricultural production and irrigation. Sufficient similarities and contrasts among the chosen river basins enabled a multi-national comparative study of the human and environmental dimensions of the impacts of climate change and adaptive responses to short-term climate variability and extreme events.

Country	River basin	Location	Size (km2)	Extreme climate events	Agricultural production
Brazil	Ararangua	Southern Brazil	3,020	Hurricanes, hail, tornadoes, and heat stress	Rice, fruits, vegetables, and cattle
Colombia	Chinchina	Central Andes	1,135	Droughts, floods, storms, avalanches	Coffee, sorghum, maize, rice, and cattle
Argentina	Mendoza	Eastern Andes	17,821	Droughts, hailstorms, and heat stress	Fruits, horticulture, and goats
Chile	Choapa	Northern Chile	8,124	Droughts, floods, mudslides, frost, and heat	Fruits, horticulture, flowers, and goats
Canada	Oldman	Southern Alberta	26,700	Droughts and floods	Grains, pulses, forage, vegetables, and cattle
	Swift Current	Southern Saskatchewan	5,592	Droughts and floods	Grains, pulses, forage, and cattle

Table 1: The study composition (Source: Diaz, Sauchyn and Mussetta, 2017)

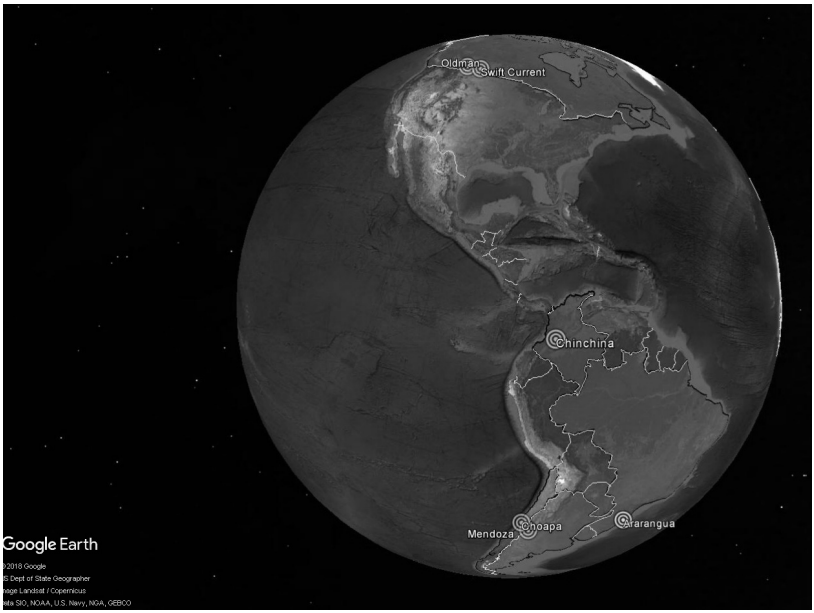

Figure 1: The study areas (Source: Google Earth, 2017)

2. The Wickedness of Climate Change

The interdisciplinary perspective of the VACEA project and of this book emerges from a conception of climate change as a complex subject that no single discipline is capable of understanding and explaining in all its multiple dimensions. Indeed, climate change is a "wicked" problem (Batie, 2008; Brown et al., 2010; Conklin, 2006). It is a problem for which there is no single or simple solution and which requires an increasing proximity between researchers, decision-makers, and local people; as well as an effort to bring together a multiplicity of perspectives in order to deal with it (Brown et al., 2010). The complexity of the phenomenon requires us, as a minimal condition, to understand how the natural and social dimensions come together in shaping the problem and directing solutions.

Part of the wickedness of climate change is that its complexity does not yield to the perspectives and methodologies of individual disciplines. In fact, investigations of climate change from narrow disciplinary perspectives have typically produced results that are not particularly relevant or useful. For example, and in general, natural scientists typically take a 'remote'

approach to modeling earth and atmospheric systems, this methodology does not require that they consult the natural or social systems to determine how they are affected. The results are the outcome of rigorous science, based on robust methods and sophisticated models, but have little relevance for a community, ecosystems or local government. Conversely, studies of social vulnerability to climate change have, in some cases, not considered the nature of the exposure to climate change. In this way, disciplinary understandings tend to transform a wicked problem into a tame issue, an artificial simplification of complexity.

The wicked nature of climate change emerges to a certain extent from our definition of the problem. Defining a phenomenon is not only a statement about its fundamental characteristics but also about its scope. A definition clearly imposes limits on what is being defined, and a definition of climate change is no different. Climate change can be understood in a narrow technical way; what natural scientists mean when they use the terminology climate change, that is, a trend in the average or variation of weather conditions, such as temperature, precipitation and atmospheric pressure. If the variation of any of these meteorological conditions is consistent over a long period of time, then we infer the existence of climate change.

This understanding of climate change, based on insights from the natural sciences, defines the problem in terms of an increase in the global average temperature as a result of an accumulation of greenhouse gases. From this perspective, the solution to the problem is to reduce the production of these gases—the mitigation approach—or to absorb some of the already existing gases in the atmosphere by storing them in places where they cannot escape—the sequestration of gases. This type of fast and simple solution is unable to deal with the wickedness of climate change. Minimal solutions do not properly resolve the problem. Rather, these solutions tend to ensure the persistence of the problem.

A different understanding of the causes that have created climate change is to contextualize the phenomenon in a larger setting. For at least 150 years we have witnessed a constant process of economic globalization which has brought significant social, economic, and political changes to most societies and their citizens. This process of economic global integration has been characterized by an increasing flow of goods, technology, services, and money among countries and regions, a process in which the free market and private enterprise have played a predominant role. This process, it is argued, has fostered competition and continuous economic growth (Robbins, 1999). As a result, many of the things we buy in our everyday life have been produced thousands and thousands of miles

away, while the production of our own regions satisfies people in other areas of the world.

The process of economic globalization has been accompanied by significant increases in world population and consumption. The increase in population has accelerated over the last decades, reaching seven billion people at this moment in time. An increase in consumption has accompanied this rapid rise in the rate of population growth. People are not only purchasing goods to satisfy their basic needs—clothing, household utensils, basic foodstuff—but also an even larger number of goods that are not always essential. Currently, human beings consume more than ever, not only because the number of people living on the planet has increased but also because they have redefined their cultural patterns of consumption, consuming more non-essential products and services. These three developments combine into what has been called the "treadmill of production" (Schnaiberg et al., 2003), a process of continuous and increasing production aimed at both satisfying the expanding consumer needs of a larger population and increasing the profits of industry. It is these three interrelated processes that have introduced significant changes into the environment. We produce more and more, we have more people living on this planet, and we consume more per capita than our grandparents did.

In their long history, human beings have been able to satisfy their needs to the extent that they have been able to use a variety of services provided by ecosystems existing in the vicinity. The ecosystems, in order to provide these services and sustain their structure and functions, have adapted to the demands imposed by humans. In these terms, both natural and social systems have been adaptive systems that have the ability to change themselves in order to secure their sustainability, a situation that promotes some degree of internal stability to both systems (Marten, 2004). The recent history of social systems has been transformed, however, by significant qualitative and quantitative changes. We produce more for a larger number of people who are increasingly adopting a "consumerist" cultural ethos. The result is a larger demand for ecosystem services, which is clearly exceeding the carrying capacity of these ecosystems to reproduce the services and support the increasing requirements of society.

Dunlap and Catton (2003) affirmed that the Earth has a more and more limited carrying capacity. According to them, the natural systems provide three general services to people: a living space, a supply of natural goods and services needed by humans, and a waste repository, a space that is used to accumulate all the material produced by the social systems and which is unwanted by society. Increasing production, population, and

consumption have increased the demand for these services to the point that natural systems are not able to adapt to the new circumstances and are starting to have unpredictable changes, which have been defined as global environmental change.

Global environmental change involves a significant number of changes to natural systems. Some of the manifestations of this global environmental change are the destruction of the atmosphere's ozone layer as a result of the production of chlorofluorocarbons; acid rain, which has damaged ecosystems and lakes, the destruction of forests, especially of the tropical rain forest, with serious consequences for local populations and the global climate; the decline of fish stocks; the increasing pollution of rivers, lakes, and ground water, and so on. Climate change is a concrete manifestation of this global environmental change. It involves a disruption of the climate system as a result of human intervention in the earth's energy balance and biogeochemical cycles. Together with the other forms of global environmental change, global warming is producing significant alterations to the fabric of nature in the short term, and society in the long term.

In these terms, a more comprehensive understanding and definition of climate change, beyond the scientific construct, present climate change as the product of a process of "bad development" that has redefined the interactions between social and natural systems centered on anthropocentric needs. As Hulme (2009) argues, climate change is both an environmental and cultural process. Climate change, from this perspective, is an alteration of the climate systems due to the excessive production of waste from anthropogenic activities, an alteration that rebounds in the social system by affecting many of its activities.

To add more complexity, climate change is not a phenomenon with a specific space within which it takes place, like an oil spill or an earthquake. It affects the whole planet, there are no corners in this world where we could escape climate change and its impacts. At the same time, however, the impacts of climate change are not homogeneous but rather varied, according to local environmental and natural conditions. Global climate conditions and processes have local consequences. They affect local conditions, altering the delicate balance of local ecosystems and the livelihoods of people. The relevance of climate change lies in the reciprocal impacts of both natural and social systems, and the interchange between global and local processes as is illustrated in Figure 2.

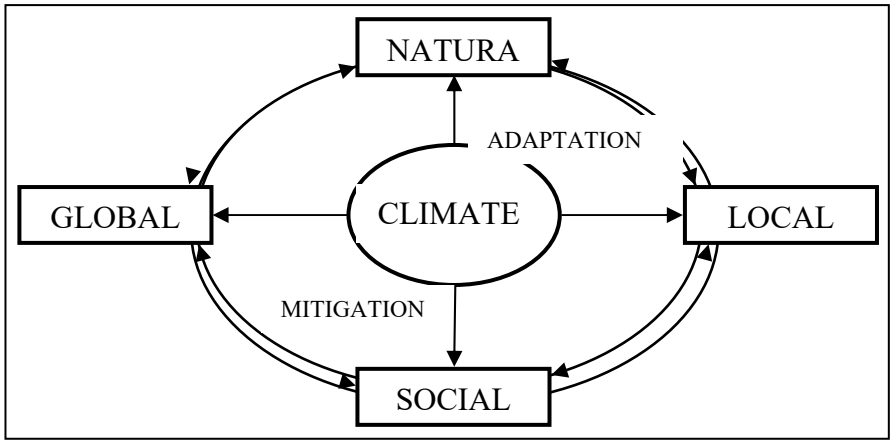

Figure 2. The Nature of Climate Change

This definition of climate change requires a more comprehensive approach, able to understand the dynamics of the social and the natural systems and their interrelationships and, at the same time, develop robust responses from both governments and civil society. Thus, central to this complex conception of climate change is an important point—the need for an interdisciplinary approach able to support the climate decision-making of government agencies and civil society organizations (Bhaskar et al., 2010).

3. Interdisciplinarity and Integration

A process that emphasizes the use of multiple perspectives, in order to develop a comprehensive understanding of a given phenomenon, is a research alternative that resolves some of the issues created by the narrowness of the disciplinary approach. There are, of course, different "multiple perspectives" that could be implemented, such as multi-disciplinarity, interdisciplinarity, and transdisciplinarity, where the differences are related to the degree of integration that is sought among the perspectives. Whereas multi-disciplinarity involves a degree of collaboration between scientific disciplines, each one of them maintains its own approach to the study and explanation of the phenomenon, engaging with the issue in parallel ways. Interdisciplinarity, on the other hand, involves not only collaborations among the scientific disciplines but also an integration of the approaches and explanations of the issue under study.

Finally, transdisciplinarity transcends scientific disciplinary approaches by incorporating and integrating into the research work the insights provided by different sectors of the non-scientific communities, such as policymakers or civil society organizations (for a deeper discussion of the differences among these approaches see Leavy, 2011, 13-35; Lawrence, 2010; Tress et al., 2006).

The VACEA project assumed a policy and community-oriented interdisciplinary approach. The project has encompassed natural and social science and engineering researchers in five countries, and an integration process that links the different perspectives and disciplinary approaches to research, knowledge translation and adaptive decision-making. This broad scope was required by the complexity of the issue of vulnerability and adaptation to climate change variability and extremes, and very much facilitated by the emphasis and thought given to explicit frameworks for the successful conceptual, methodological and administrative integration of the research activities and new knowledge. Many of the members of the VACEA research team have considerable experience with interdisciplinary research in the field of adaptation to climate change, including extensive collaborations with decision-makers and stakeholders engaged in relevant programs, policies and practice (Diaz et al., 2009; Montaña, 2008; Poveda and Pineda, 2009; Santibañez, 2008; Sauchyn and Kulshreshtha, 2008). The project was designed both to shape policy and inform practice, with a focus on local/sub-national scales, and to improve understanding of the adaptation of social and natural systems to climate change, and the interrelated social, physical, political and structural drivers/constraints. In collaboration with our project partners, the project sought to achieve a heightened inter-jurisdictional awareness and an exchange of practices and tools for adapting to the climate, including vulnerability and risk assessment, interventions that respect traditional knowledge, and communication to enhance public understanding of climate change adaptation strategies and their benefits.

There are several assumptions that have informed the development of the research process in the VACEA project. The first is that the impacts of extreme climate events are highly complex processes, where a multiplicity of dimensions are interconnected and interdependent, making it necessary to understand not only the dimensions in themselves but also the linear and nonlinear links among them. In these terms, the different disciplines in isolation are not the most adequate tools to understand this complexity, but disciplinary approaches are fundamental to the development of a deep understanding of these dimensions. And finally, there is a need for a process of integration of the different disciplinary insights in order to map

the connections between the dimensions and define their degree of importance (Repko and Szostak, 2017).

An important step in the process of integrating the different disciplinary insights was the formulation of a common conceptual framework to inform the activities of the project. Since the impacts of climate change are many and varied, and no region, community or sector of the rural economy is immune, we need to impose a framework to organize and describe the varying degrees of exposure and vulnerability to a changing climate. Vulnerability is understood as the degree to which a system, such as a rural community or agricultural producer, is susceptible to the adverse effects of stressors and change (Smit and Wandel, 2006; Wisner et al., 2004). Vulnerability to climate change is a function of (1) exposure to climate hazards and their impacts; and (2) social conditions that determine sensitivity—the degree to which a system is affected by climate-related stimuli—and adaptive capacity, the ability of a system to adjust to climate risks and opportunities by increasing its coping range. The adaptive capacity of communities depends on their access to a variety of resources (economic, social, and natural) and, no less relevant, the availability of institutional resources provided by governance and policies, the management of current and past stresses, and the ability of institutions and individuals to learn from experience and to anticipate and plan for future change (Armitage, 2005). Thus, a vulnerable community or industry could have high exposure to climate change and a relatively low adaptive capacity. The sensitivity of human activities to variations in climate ranges from relatively low, for built and controlled environments like modern cities, to high, for industries that required large amounts of natural resources, with agriculture being the best example. The natural resources themselves can be more or less sensitive, where some soils and ecosystems, for example, can be easily degraded if not properly managed during periods of prolonged dry conditions. Like the climate itself, there is complexity in the cascade of interconnected impacts, such that an industry, a community or a region can suffer adversity or realize benefits as a consequence of prior or remote climate-induced changes, or as a result of being affected by other non-climatic factors.

In the VACEA project, exposure was considered a characteristic of a climate system referring to climate hazards, i.e. droughts, storms, and others—and their attributes—such as intensity, duration, and coverage—that define the magnitude of their impact on social systems. This was the domain of the natural scientists and Theme 2 as illustrated in Figure 2. Sensitivity and adaptive capacity, on the other hand, are defined as characteristics of the different social groups and are defined by access and

control of resources. In this perspective, vulnerability emerges from the interactions between the human and natural systems. A social system that is characterized by limited resources is more vulnerable and, consequently, more conditioned to be impacted by climate hazards. These resources are based on what the IPCC calls the "determinants of adaptive capacity" (IPCC 2001, p. 893) and include economic, technological, human, natural, technological, and institutional resources as outlined in Table 1. Access and control of these resources are important to reduce vulnerabilities, but it is the capabilities of actors to organize them into adaptive activities that define the balance between sensitivity (determined by lack of, or limited resources) and adaptation (defined by the existence of resources that could be mobilized to reduce sensitivity).

Determinants	Description
Economic	Monetary capital, financial means, wealth, productive resources, and other forms that could contribute to the development of adaptive capacity.
Technological	Availability and access to technology, such as irrigation systems, flood control measures, warning systems, and others—as well as the existence of a capacity to develop new technologies that could contribute to a more robust adaptive capacity.
Human	Educational and knowledge levels, as well as expertise in a system. Including traditional knowledges about nature, and especially climate and weather, their relationships with agricultural practices. The capacity to produce, disseminate and store information (high educational levels or efficient communication among producers to disseminate successful practices) has a better ability to understand and predict climate hazards, reducing their vulnerability to climate and climate-related events.
Natural	Availability and access to basic environmental services (water, soil, seeds) fundamental to the viability of rural livelihoods.
Infrastructure	Proper housing conditions, drainage systems, weather-resistant roads, coastal defense, and other forms of infrastructure that allow regions and populations not only to cope with extreme weather events but also recuperate more quickly from their impacts.

Institutional	Established institutions facilitate the management of climate-related risks such as the existence and availability of insurance services, water conservation programs, and others thus reinforcing the adaptive capacity of the population.

Table 2. Determinants of Adaptive Capacity (Source: Diaz, Sauchyn and Mussetta, 2017)

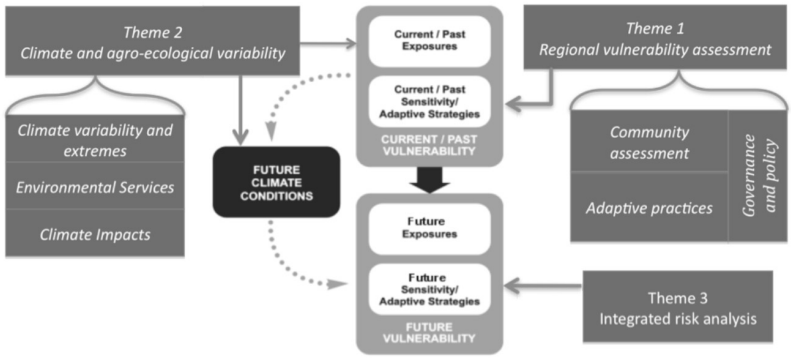

Figure 3. Vulnerability Assessment Model and Research Themes

This vulnerability model, characterized as a "bottom-up" approach, offers a consistent framework for interdisciplinary and comparative research employing various methodologies, incorporating climate science, integrating structural institutional conditions and agency, and actively engaging stakeholders and decision-makers. Moreover, it is a framework that facilitates the integration of not only the disciplinary insights about present vulnerability conditions but also contributes to integrating insights about present and future vulnerability conditions, a very important task in projects dealing with climate change. Figure 3 illustrates how the concept of vulnerability and its present and future forms were integrated into the VACEA project.

3. Method—the Vulnerability Nodes

In the VACEA project, interrelated research activities were organized under three major Research Themes: Regional Vulnerability Assessment (Theme 1), Climate and Agro-Ecological Variability (Theme 2), and Integrated Risk Analysis (Theme 3).

Theme 1 fundamentally followed a social science approach. It involved an assessment of the vulnerabilities of communities and their institutional context by assessing factors determining sensitivity (the degree to which a system is affected by climate-related stimuli) such as droughts and floods, and adaptive capacity (the system's ability to adjust to climate risks and opportunities by increasing its coping range). Initially it consisted of a review of secondary sources and the implementation of interviews and/or focus groups with key informants. These activities allowed the establishment of initial ties, the refining of the data collection instruments and the establishment of sampling procedures. In a second stage the teams conducted semi-structured interviews with rural residents, as well as with government officials and representatives of private companies involved in climate governance processes. The interviews with local people were guided by a set of open topics that inquired into the different dimensions of vulnerability: experienced exposures, sensitivities, and adaptive capacities, while those with public officials explored the dimensions of adaptive governance, including the ability to cope appropriately and in a timely fashion with climate events, the willingness to learn from past experiences and modify practices to promote adaptation to unexpected events. Most of the questions used in both interviews were common to all the countries to secure some degree of comparison, although space was allocated for questions related to the particularities of each region. The VACEA project developed a guide for all countries to follow the same methodology. While the general lines were respected, the process in each country acquired its own particularities through the imprints of each team and by the research contexts (administration and receipt of funds, human resources, and access to the subject of study).

Theme 2 involved the work of natural scientists and engineers. This theme determined rural community and agricultural producer exposure. It included assessments of past, present and future climate and of their implications for agriculture and natural resources based on scenarios, modeling and forecasting. In this context, biophysical data and models were developed to build probabilistic scenarios of water shortages in the future, and extreme weather events for each region. These two themes generated significant insights of (a) the past and present vulnerability of

rural agricultural communities and households, the effectiveness of land and water adaptive practices, and the institutional adaptive capacity of governance organizations; (b) climate impacts on agricultural productivity and environmental services; (c) adaptation barriers and opportunities; and (d) scenarios of shift in regional climate variability and the frequency of extreme events. Theme 3 involved the integration of these different insights, an integration that allows for the understanding of vulnerability within the context of past, present, and future climate conditions.

Chapters 2 through 5 seek to provide an evaluation of the main vulnerability aspects and insights of the rural communities and agricultural producers of the study areas of each case study country, identifying causes, consequences, adaptive capacities and adaptations (practices and policies that are actual and potential). These insights—identified as vulnerability nodes—identify and discuss the multiple vulnerabilities in each study area. These nodes involve not only climatic vulnerabilities but also other forms of social, political, and institutional vulnerabilities that set up the general conditions of vulnerability in the study areas; they blur both the exposures of Theme 2 as well as the sensitivities and adaptive capacity of Theme 1, integrating the separate analysis dimension of assets outlined in Table 1. In this way, the authors seek to advance a holistic approach integrating the structural processes that merge all dimensions of the analysis. Thus, the nodes facilitate a cross-sectional analysis of the problem by means of qualitative statements that refer to a narrative strategy (rather than focused on the quantification of a static phenomenon), an analysis that provides an account of the dynamic nature of the vulnerability, and offers the possibility of assessing future vulnerabilities considering the present circumstances in the context of the expected climate scenarios. This is possible thanks to the evaluation of the different types of adaptation strategies; preventive and reactive, spontaneous and planned, as well as in terms of their contributions to sustainability. The nodes also facilitate the evaluation of strategies with the potential to transform the social conditions that structure the vulnerability. Additionally, this scheme lays the groundwork for a socialization process and co-production of knowledge between scientists, government officials, producers and other social actors, from the spaces of analysis of the current adaptation capabilities.

Each country's team identified 'vulnerability nodes' describing the present multiple vulnerabilities (economic, political, social, environmental, and climatic) in each study area. The vulnerability nodes describe present vulnerabilities not only related to climate conditions but to all conditions. For the construction of the nodes of vulnerability, the determinants of

vulnerability, their consequences, both today with current adaptations or practices/adaptive capacities, as well as in the future, given climate exposure, were taken into account. Thus, future climate conditions were considered in order to reflect future scenarios of vulnerability. Recommendations were made based on this.

The vulnerability nodes represent those social, economic, environmental, agricultural, climatic and political processes and changes that are critical for establishing vulnerability in each respective study area. Vulnerability nodes facilitate a cross-sectional analysis of the problem by means of qualitative statements that refer to a narrative strategy (rather than a focused strategy on the quantification of the statistical phenomenon). The vulnerability nodes also give an account of the dynamic nature of the vulnerability of agricultural producers and their communities, and shed light on possible future vulnerabilities considering the adaptations to current and predicted climate scenarios. This analysis of vulnerability nodes was possible thanks to the evaluation of the different types of adaptation strategies, including the preventive and reactive, the spontaneous and planned, and those that strengthened the sustainability and those that destroyed the long-term bases that guarantee the reproduction of social and natural systems. Vulnerability nodes also facilitated the evaluation of strategies with the potential to transform the social conditions that structure vulnerability. The schema of vulnerability nodes also allows the groundwork for a socialization process and the co-production of knowledge between scientists, government officials, producers and other social actors, from the spaces of the analysis of current adaptation capabilities.

4. The Contents of the Book

The book focuses on the process of integrating the different insights produced by researchers in the five countries that participated in the VACEA project. It is organized around five chapters, each one of them focused on one of the five countries. Each one of these chapters presents and discusses the main insights produced by natural and social scientists in explaining the varied impacts of extreme weather events and the capacity of local communities to reduce the risks associated with the impacts utilizing the vulnerability node approach outlined in this chapter. An additional chapter discusses, from a comparative perspective, the main lessons learned from each one of the national cases and their relevance for future climate studies.

This book was conceived with an understanding of climate change as the product of interacting natural and social processes. This approach

requires an interdisciplinary perspective, natural scientists and social scientists concerned with the relationships between the environment and society, and supporting the adaptation decision-making of government agencies and civil society organizations. The book attempts to offer insights that are drawn from both the natural and social sciences which are fundamental to a comprehension of climate change and its ramifications for both ecosystems and nature.

Chapter 1, Climate Change, Agriculture and Communities in the South Saskatchewan River Basin analyzes the vulnerability of four agricultural study communities in southern Alberta and Saskatchewan in relation to climate change, droughts, and floods. The activities of dryland farming, irrigated agriculture, and raising livestock dominate the area, in addition to agri-business (intensive livestock operations and food processing, as examples) and oil and gas mining. As in the past, agricultural producers and their communities are subject to double exposure. The double exposure is predominantly that of climate (extreme drought and more recently flood) and economics (international market prices for products and rising production costs). Participants referred to the drought of the 1930s and resulting adaptations, including seed and technological adaptations, institutional adaptations such as the formation of the Prairie Farm Rehabilitation Administration (PFRA), and assistance for displaced producers leaving unproductive lands, some of which had reverted to sand dunes. The double exposure to climate and economics continues to dominate this region, and technology remains a means of adaptation for those with proper resources. Two current trends are occurring in relation to economics. Either producers are increasing the size of their operations (with its associated high debt level) or remaining small while relying on good management techniques. In more recent years, flooding has become a concern of communities and governments, but reduced institutional programs as a result of government austerity threaten adaptive capacity in relation to both flood and drought. Producers have exhibited great adaptation to the drying conditions, but vulnerability exists to future droughts that may be similar to the multi-decadal drought of the 1850s. Reducing vulnerability in the future requires attention to reductions in institutional support and funding, and climate change education and information.

Chapter 2, Rural Vulnerability in Mendoza: Social gaps, Development Model, and Irrigation Districts Transformation concerns the ancient desert oasis and wine-producing region of Mendoza, Argentina, the case study area of this ethnographic vulnerability analysis of agricultural producers and the impacts of climate change. Increasingly arid conditions are already

being experienced and more are anticipated in the future, together with reduced winter rains and potentially increasing spring rains. Significant fragmentation was discovered in relation to laws and policies in three areas: 1. Those managing and developing land and those related to water; 2. Laws and policy surrounding access to and management of surface versus groundwater; 3. Laws and policies surrounding the supply of water and the demand for water. Not all agricultural producers are experiencing the impacts of climate changes equally; larger agricultural producers with better access to resources have greater adaptive capacity and less vulnerability. Small and medium-sized producers not only have less economic capital but also have less access to the necessary workforce for the operation as well as information and knowledge. This differential access to resources is exacerbated by differing prices for product. The hegemony of knowledge, information and technology are resulting in the expulsion of small producers from their lands, and the fate of these producers is not known. More research is required into these producers as well as supportive policies surrounding equitable pricing. The vulnerability nodes of this analysis inspire politically-oriented action to help bridge the gap and address poverty and inequality.

Chapter 3, Vulnerability Nodes in the Commune of Salamanca (Choapa Valley, Chile): A Look at the Interaction Between Water, Mining, Agriculture, and Society in the Context of Climate Change analyzes past and present rural vulnerabilities associated with climate change in a basin located in a desert area of northern Chile, the Choapa River Basin. Historically, agriculture and goat raising have been the main productive activities; however, in the last decade mining has emerged as a very important economic activity. The extended drought, due in part to a prolonged process of desertification and decreasing precipitation, has had a long-term negative effect on water resources and agricultural activity, making rural communities increasingly sensitive and their viability increasingly problematic. The study pinpointed four critical nodes of vulnerability: a) Drought—the decrease in precipitation and overuse of water resources by the mining industry; b) Economy—the mining-based economy and the reduction in agricultural activity which cause unresolved political tensions within the community; c) Health sector—the serious deficiencies of and the limited support from the government; and d) Social tensions that surround the conflict over water use and ownership. The findings of this research consider how to better structure water governance in order to define actions to manage water resources more effectively, taking into account future projections regarding climate change and a progressive desertification process. Inhabitants of the communities living