Artículos

“Deep Vulnerability”: Identifying the Structural Dimensions of Climate Vulnerability through Qualitative Research in Argentina, Canada and Colombia*

How to cite this article: Fletcher, A. J., Musseta, P., Turbay, S., & Acevedo Mejía, E. C. (2021). “Deep vulnerability”: Identifying the structural dimensions of climate vulnerability through qualitative research in Argentina, Canada and Colombia. *Cuadernos de Desarrollo Rural, 18*. https://doi.org/10.11144/Javeriana.cdr18.dvis

Amber J. Fletcher [a]
University of Regina, Canadá
amber.fletcher@uregina.ca
ORCID: https://orcid.org/0000-0001-5965-2925

Paula Mussetta
National University of Cuyo, Argentina
ORCID: https://orcid.org/0000-0002-8128-5524

Sandra Turbay
Universidad de Antioquia, Colombia
ORCID: https://orcid.org/0000-0001-5903-0499

Erika Cristina Acevedo Mejía
Universidad de Antioquia, Colombia
ORCID: https://orcid.org/0000-0001-8912-4795

DOI: https://doi.org/10.11144/Javeriana.cdr18.dvis
Received: 31 May 2019 | Accepted: 10 October 2020 | Published: 25 August 2021

[a] Corresponding author. E-mail: amber.fletcher@uregina.ca

Abstract:

Extreme climate events are becoming more frequent and severe due to climate change. Vulnerability to extremes is the result of three components: exposure to hazards, sensitivity of the system, and capacity to adapt. A large-scale qualitative study of rural vulnerability to climate extremes in Argentina, Canada, and Colombia demonstrates the political-economic root causes of vulnerability in each context. Structural causes are difficult to identify using quantitative indices and deductive metrics alone, but qualitative approaches can help identify key drivers of vulnerability at a deeper level. Technology and diversification are insufficient to address such structural or "deep" vulnerability.

Keywords: climate change, climate extremes, vulnerability, agriculture, neoliberalism, qualitative research, technocratic solutions.

"Vulnerabilidad profunda": identificación de las dimensiones estructurales de la vulnerabilidad climática a través de la investigación cualitativa en Argentina, Canadá y Colombia

Resumen:

Los acontecimientos climáticos extremos se están haciendo cada vez más frecuentes y severos debido al cambio climático. La vulnerabilidad a las condiciones extremas es el resultado de tres componentes: exposición a los peligros, sensibilidad del sistema y capacidad para adaptarse. Un estudio cualitativo a gran escala de la vulnerabilidad rural a las condiciones climáticas extremas en Argentina, Canadá y Colombia demuestra las causas político-económicas de fondo de la vulnerabilidad en cada contexto. Las causas estructurales son difíciles de identificar usando índices cuantitativos y métricas deductivas solas, pero los enfoques cualitativos pueden ayudar a identificar elementos clave que generan vulnerabilidad a un nivel más profundo. La tecnología y la diversificación son insuficientes para abordar esa vulnerabilidad estructural o "profunda".

Palabras clave: cambio climático, condiciones climáticas extremas, vulnerabilidad, agricultura, neoliberalismo, investigación cualitativa, soluciones tecnocráticas.

Social Dimensions of Vulnerability

In the context of climate change, the concept of vulnerability has been applied to both natural and social systems. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) defined vulnerability broadly as "the propensity or predisposition to be adversely affected" by climate events (2014, p. 128). This definition includes three components of vulnerability: *exposure* to climate hazards, *sensitivity* of the system, and *capacity to adapt*.

Many social vulnerability models are concerned with the relationship between these three components, which ultimately determines the vulnerability of a social or a socio-ecological system (e.g., a household, community, institution, region, or country) (Himes-Cornell & Kaspersky, 2015; Maiti et al., 2017; Yenneti et al., 2016). While exposure and sensitivity cause vulnerability, adaptive capacity reduces it; thus "to be vulnerable to the effects of global change, human-environment systems must not only be exposed and sensitive to the effects, but also must exhibit limited ability to adapt" (Polsky et al., 2007, p. 477).

Three general trends can be found in the literature on climate vulnerability and social systems. First, components of sensitivity and/or adaptive capacity are often drawn from pre-existing literature or models, then are applied deductively to analyze the system. For example, such approaches measure how access to resources or capitals (human, social, economic, technological, and natural) affects sensitivity or adaptive capacity (Cutter et al., 2003; Luers, 2005), or how climate change will affect specific economic variables (Akram & Hamid, 2015).

Second, and relatedly, social aspects of sensitivity/adaptation are often understood through observable and measurable factors, such as agricultural management practices and levels of poverty, health, or education (Henríquez et al., 2016; Luers, 2005; Weis et al., 2016). Less attention has been paid to social and economic factors that are more difficult to trace and quantify, or which are sometimes seen as peripheral to the climate stressors —factors Wisner et al. described as "remote root causes" of vulnerability (2004, p. 7). Similarly, Ribot (2014; 2017) emphasized the importance of identifying the generative social, historical, and political-economic structural factors that cause social precariousness in a determined context. For example, beyond poverty as a cause of vulnerability, we must also examine how poverty itself is produced (Ribot 2014; 2017).

A third trend in the existing vulnerability literature is that a vulnerability level is often attributed to an entire system (often a community or region), which has a homogenizing effect inside it. Less attention is paid to power differentials that increase vulnerability in certain people or groups within a community. Vulnerability in social systems is almost always unequally distributed. Social differentiation and inequality on the basis of gender, race, socioeconomic class, and age, among other factors, can create different experiences of a climate event (Cutter et al., 2003; Enarson & Morrow, 1997; Fletcher, 2018; Yadav & Lal, 2018). These inequalities are linked to broader social, economic, and political structures (Fletcher, 2018; IPCC, 2014; Smit & Wandel, 2006; Turner et al., 2003) existent in the system. All these social factors determine how a system may be affected, but the way these effects actually manifest depends on various contextual conditions (Handmer et al., 1999).

Vulnerability assessment is highly context-specific; thus, applying pre-determined vulnerability criteria in a deductive fashion may result in a somewhat circular process of "discovery". Similarly, focusing only on measurable aspects of vulnerability or adaptation may miss out important cultural, social, political, or economic determinants seen as less relevant to climate change (Ulloa, 2011; Correa, 2012). Even researchers using only a composite vulnerability index to express the aggregation of biophysical exposure, sensitivity, and adaptive capacity recognize the limitations of their method. For example, Zhang et al. (2020) in a climate change vulnerability assessment of the Shenzhen coast in China, highlight that the index is calculated based on a single-time period of datasets although vulnerability is not static; they emphasize that societies respond to hazards in a nonlinear and complex ways.

Other difficulties that some quantitative studies present for the study of vulnerability are of scale: they are usually available for regional or national scales that do not necessarily reveal local vulnerabilities (Krishnamurthy et al., 2014). Another problem is that the weighting of the most relevant components of vulnerability relative to each case may be disregarded (Ashan & Warner, 2014). Previous studies have found that the indicators representing the most methodological difficulties for the study of vulnerability in the cases analyzed herein are those related to the economy, access to water, and infrastructure, technical assistance, associationism, and educational level (Mussetta et al., 2017).

Climate change vulnerability assessment requires methodologies that reveal the differentiated vulnerability patterns of communities and, therefore, help inform appropriate coping and response strategies (Mwangi et al., 2020). Qualitative research methods (which include techniques such as social cartography, oral history, semi-structured interviews, participant observation, and focus groups) allow us to recognize vernacular explanations about climate change, identify local conceptions of space, capture representations about disasters, understand the social, cultural, and environmental context of spontaneous adaptation strategies and understand the reasons for resistance to intervention measures designed by institutions loaded with authority and power (Salinas et al., 2020). Hybrid methodologies combine top-down and bottom-up approaches: they are based on easily quantifiable available data but they also obtain stakeholders' opinions and values through qualitative methods. A challenge for these hybrid methods is the integration of multiple metrics from dissimilar sources in the final assessment compensated, however, with benefits such as the possibility to reach a fuller community spectrum, the production of more spatially detailed assessments, and potential community empowerment in the planning of adaptive strategies (van Aalst et al., 2008; Cains & Henshel, 2019; Espíndola & Valderrama, 2016). While such hybrid or mixed methods are an important area for future research, this paper aims to help develop the qualitative component of vulnerability analysis, which we suggest has been underemphasized to date. We demonstrate the use of qualitative methods in a community-based research project to help reveal structural aspects of vulnerability in rural communities facing climate extremes.

Qualitative and Community-Based Research on Vulnerability: Challenges and Benefits

The fifth IPCC report (2014) briefly recognized the usefulness of qualitative research on climate vulnerability and risk, stating that "useful approaches for managing risk do not necessarily require that risk levels can be accurately quantified. Approaches recognizing diverse qualitative values, goals and priorities, based on ethical, psychological, cultural or social factors, could increase the effectiveness of risk management" (p. 36). This statement reflects the growing acceptance of qualitative, community-based, and participatory approaches to vulnerability research, which offer an important complement to quantitative studies in the literature (Cadag & Gaillard, 2012; Wright et al., 2014). Qualitative and participatory approaches usually focus on stressors and priorities identified by communities, rather than the application of pre-defined criteria by researchers.

Despite this shift, challenges remain for qualitative and community-based approaches. The first challenge is that qualitative approaches to climate research may be viewed by some as "unscientific" (van Aalst et al., 2008, p. 174) and in need of quantification to be taken seriously as "data". For climate researchers and policymakers operating within a positivist paradigm, community members' own interpretations and experiences of vulnerability may not be considered a reliable evidentiary base. However, we argue that understanding the meanings people attribute to their experiences can point toward the larger causes of those experiences. Critiques of solely quantitative assessments include the risk of oversimplification due to aggregation (Fernandez et al., 2017) and their inability to reveal the complex relations between actors and resources that shape vulnerability (Montaña & Mussetta, 2016; Retamal et al., 2011). Qualitative approaches, in contrast, have the power to identify deep structural causes of vulnerability that otherwise may not be noticed.

A second and related challenge with qualitative approaches is the dominant "technocratic" approach to adaptation. In this approach, a variety of (usually technological) options are presented as solutions to reduce vulnerability. Infrastructure changes and new crop varieties are often amongst the solutions promoted, regardless of whether these solutions are feasible or acceptable to farmers or communities. Infrastructures designed to reduce community vulnerability to climate change are potentially not reliable for the future if they do not take into account the increase in frequency and intensity of climate extremes, the inner uncertainty of climate change, and the intersections of community, livelihoods, and governance of those infrastructures (McMartin et al., 2018). Without community engagement and input into the research, such technical solutions may ignore communities' own concerns (Wright et al., 2014). Structural factors may render some "solutions" unusable —or even worse, as maladaptations that exacerbate problems (Barnett & O'Neill, 2010). As our findings demonstrate, for example, technological solutions are not always affordable and over-reliance on these solutions may strengthen social inequalities.

The third challenge is that qualitative community-based studies may be considered contextually limited and only locally useful (Cameron, 2012). Existing literature has drawn attention to structural causes of climate vulnerability in particular areas, for example, HIV/AIDS in Uganda (Niyibizi et al., 2013), colonization in Canada (Cameron, 2012), and poverty in Latin America (Manzanal, 2016). In these cases, vulnerability is shaped by deeper factors that go beyond the climate extreme itself. Although vulnerability will manifest differently in different places, its root causes can be found in broader structures —such as political economy (Ribot, 2014), past and present forms of colonization (Whyte, 2017), and gender inequality (MacGregor, 2010) —that are relatively persistent across time and space.

Broad political, economic, and social conditions that determine vulnerability may be *a priori* unknown to researchers (Smit & Wandel, 2006), but may become visible in participants' everyday lives and problems (van Aalst et al., 2008). In the sections below, we present the findings from an intercontinental study using qualitative community vulnerability assessments (CVAs) with over 300 participants in Argentina, Canada, and Colombia. After providing an overview of the conceptual framework and methods of the project, we present key findings from each of the three countries. Beyond simply identifying the features of vulnerability within each region, we identify structural causes of vulnerability that operate *across* these diverse contexts. Specifically, we find that the most significant vulnerabilities experienced by farmers in each country are linked to unequal access to resources, which is exacerbated by neoliberal macro-level political-economic structures affecting agriculture (Mussetta & Hurlbert, 2020).

Our analysis of structural causes of vulnerability is informed by a particular philosophy of science, Critical Realism (CR) (Archer, 1995; Bhaskar, 2015; Collier, 1994; Danermark et al., 2002). CR suggests that social events and experiences are driven by structurally rooted mechanisms that may not be immediately obvious at the surface. Observable events, such as the social effects of a climate extreme, are interconnected with causal mechanisms operating at a deeper level of reality (Bhaskar, 2015). However, as social phenomena exist in open social systems (i.e., not lab conditions), specific conditions in each context may cause the mechanism to manifest differently. This approach suggests the importance of analyzing everyday experiences for causal roots that may extend across specific contexts but may take slightly different forms in each place.

The VACEA Project

The intercontinental research project "Vulnerability and Adaptation to Climate Extremes in the Americas" (VACEA) was funded by the International Development Research Centre (IDRC) and conducted by a team of natural and social scientists with the goal of integrating climatological and social determinants of climate vulnerability. This paper draws upon one key component of the project: community vulnerability assessments (CVAs) conducted in three countries of the project. Similar to other types of participatory research —e.g., "practical analysis" (Smit & Wandel, 2006), "participatory vulnerability assessment" (Fazey et al., 2010), "place-based analysis" (Turner et al., 2003), and "bottom up" analysis (van Aalst et al., 2008; Smit & Wandel, 2006) —we used an inductive approach to identify key issues through the participation of stakeholder groups and individual participants. Each CVA focused on rural communities, with attention to agricultural producers.

Methods

Each country team used a semi-structured interview method, beginning with open-ended questioning that allowed participants to identify and discuss their greatest stressors rather than using categories imposed by the researchers (van Aalst et al., 2008); these questions were followed by more specific questions about climate extremes in each region. In each study area, researchers partnered with local organizations on fieldwork, interpretation, and knowledge mobilization. Interview data were transcribed verbatim and coded using a flexible directed technique (Hsieh & Shannon, 2005; Gilgun, 2011) that identified very general aspects of vulnerability (e.g., social, economic, environmental) while also capturing other ideas outside these categories. Key findings were later evaluated and discussed in follow-up workshops with participants and community members in each country. During these workshops, participants were also asked to comment on climate scenarios generated as part of the research project.

To compare emerging themes and facilitate cross-case analysis, the researchers met annually for in-person international team meetings. For this paper, we identified and compared the key vulnerability themes (e.g., climatic, economic, social) in each of the three study areas. Although the precise form of vulnerability varied across these countries, we noted the prominence of economic and financial issues as a dominant theme *causing* producers' vulnerability in all three contexts. As we describe below, in each case financial precarity of producers can be linked to the broader political economic structure.

The Mendoza River basin was the study area selected in Argentina. The region is in central-west Argentina. The river is mainly snowfed and agriculture is only possible through a complex system of irrigation infrastructure. The research team conducted two focus groups of ten participants each, along with 41 interviews with farmers throughout the districts of the basin and 25 interviews with representatives of national, provincial, and local governance institutions.

In Canada, ethnographic community-based research was conducted in four rural communities in two different watersheds of the South Saskatchewan River Basin: Taber and Pincher Creek in Alberta and Rush Lake and Shaunavon in Saskatchewan. Study areas included towns and their surrounding rural municipal (RM) district(s). All four communities are part of the semi-arid Palliser's Triangle region —an area known for its history of severe drought (Marchildon et al., 2009; Warren & Diaz, 2012). In-depth interviews were conducted with 160 farmers, ranchers, rural residents, and local governance representatives (e.g., RM councillors, representatives of local watershed groups).

The Colombian research was conducted in the Chinchiná River Basin in the Andes, which exhibits a steep topography and a marked altitudinal gradient from 5,300 to 800 meters above sea level. The basin covers five municipalities: Manizales, Villamaría, Neira, Chinchiná, and Palestina. Coffee cultivation, the most important economic activity, is developed in the steep hill slopes, thus it is highly prone to erosion and highly vulnerable to climate extremes. In-depth interviews (n = 44) were conducted with potato growers living in the moorlands, coffee farmers living in the middle basin, and cattle ranchers, citrus fruit growers, and miners who extract sand and stones from the riverbed near the mouth of the Chinchiná River. Twenty additional interviews were conducted with managing directors of water and energy companies, public environmental authorities, leaders of risk management systems, reforestation company heads, and researchers on coffee and climate change.

Results

Argentina

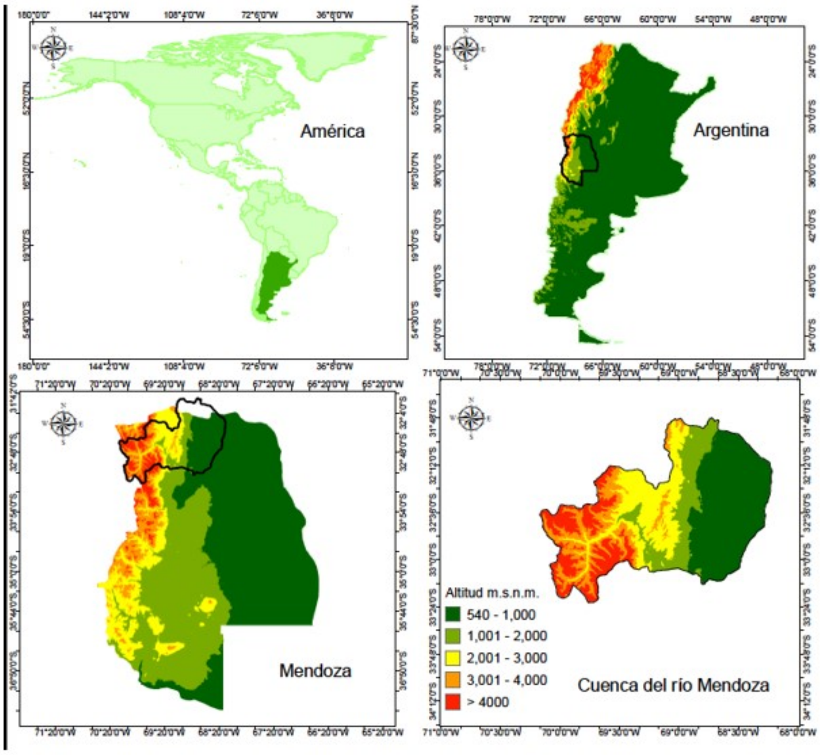

FIGURE 1.
Location of the Mendoza River Basin
Source: Mussetta et al. (2017)

The Mendoza region (figure 1), at the foothills of the Andes mountain range, is characterized by an arid climate with 224 mm of average annual precipitation; projected climate change for the region points to an increase of 2-4°C from mean annual temperature and a decrease in winter snowfall in the Andes with consequent lowering of the Mendoza River runoff and a rise in summer rainfall in the plains (Deis et al., 2015; McMartin et al., 2018; Villalba et al., 2016). Water scarcity is an ongoing historical phenomenon in the basin but is still the main climate change impact (figure 2). For producers, water scarcity manifests in decreased stored and circulating water and in a considerable shortening of irrigation shifts that are insufficient to irrigate the whole cultivated area. Less water means less quality and quantity of production.

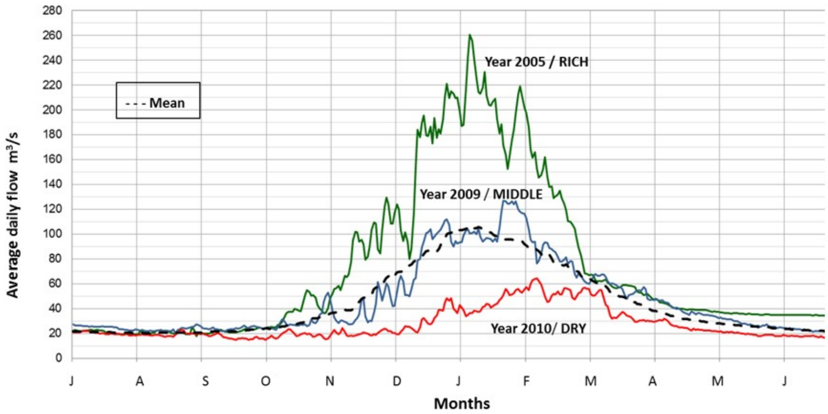

FIGURE 2.
Mendoza River Flows in Years Classified as Rich-Middle-Dry
Source: Adapted from Departamento General de Irrigación (DGI) Balance hídrico río Mendoza (2017, p. 403)

The shortage of irrigation water impacts all producers but is less relevant under the framework of other economic processes. As one producer puts it: "I once thought about putting drip irrigation, but it was unaffordable for me. My main problem is not lack of water, but the market and the price of my crops... I lose a lot of production". Particularly relevant are changes in agri-food trade, economic concentration, importance of foreign capital, and new requirements of competitiveness. This all results in a strong loss of profitability that deepens pre-existing socio-economic inequalities. The low price paid to producers creates a spiral of causes and consequences with the water-climate vulnerabilities: the lack of profitability prevents producers from adapting to climate risks and lack of water; this inability to adapt influences lesser quality products that, together with other factors, determine profitability.

Producers' vulnerability is, therefore, differentially manifested in the coexistence of two trends: accumulation versus subsistence (Altschuler, 2009). The accumulation trend is represented by those who can meet the new standards required by local and international markets. The subsistence trend is seen in those who, cycle by cycle, are on the borderline of being pushed out of the system. As a viticulturist described: "Six or seven years ago, a family with five hectares could live and could send their children to school and university. Today, a family which has five hectares, does not live on the farm. I had 30 hectares, and I was almost big, now I am small. There was an impressive concentration".

After an uninterrupted succession of cycles of zero profitability, hardest hit producers are forced to leave the land, concentrating the local agri-food system in few hands. This situation is not circumstantial; it is part of a macro policy of deregulation and opening of the economy in favor of a specific modality of capital circulation and accumulation in the agricultural production (Vergara-Camus & Kay, 2017). This scheme highlights the role of transnational corporations and gives them the power to impose the parameters under which other agents of the production chain must operate (Delgado Cabeza, 2010), especially because small producers do not have any ability to negotiate the price of the crops and are captives of oligopolistic markets. As an example: in 2016 the price of bottled wine was approximately seven times higher than the price of grapes. The interviewees are accustomed to this situation, as a grape farmer explained:

This concentration has led corporations to lobby along with the institutions, then generate prices for the raw material. We are producers of raw material, we are not winemakers and that has made unprofitable our farms and, therefore, we have not been able to do the technical conversion, which makes the maintenance of our farms. (Coffe farmer, personal interview)

Some data illustrate the concentration in the wine production chain, not only in its primary link of grape producers but also in the last link of industrialization and sales. In the last 20 years, the total cultivated area in

Mendoza increased by 7.5%, but the number of vineyards decreased by 27.7% (Instituto Nacional de Estadística y Censos [INDEC], 2019). In other words, the cultivated area increased (i.e., the business continues to grow) but was concentrated into a smaller number of owners. Currently, 75% of the domestic market is in the hands of 20 companies and four companies concentrate half of exports (Asociación de Cooperativas Vitivinícolas Argentinas [ACOVI], 2018).

In this abyss between the raw material (grapes) and the final product (wine) pricing, producers are the least well-paid. In such scenarios, only the large economic groups survive and the gap between the most and the least vulnerable widens. The lack of state regulation is one of the fundamental factors that allowed economic concentration in the agro-industrial sector, and the existing regulations are not sufficient to improve the position of small producers. Although there are regulatory and governing bodies for wine policies, they hardly intervene to seek solutions to the problem of economic concentration and abuse of dominant position (Palazzolo, 2017).

In the absence of profitability over a number of years, many producers are forced to diversify their incomes as a survival strategy rather than adaptation to the impacts of climate and the economy. In the last 10 years, more than 25,000 farms in the periurban areas requested permission for land use change, to move to real estate as tourism (Secretaría de Ambiente y Ordenamiento Territorial, 2015). Producers whose farms are in other areas of the oasis sell their lands to big companies, triggering a process of land concentration. This way, changing the business does not make producers resilient, but demonstrates that the current model of agricultural development is strongly oriented to industrial agriculture for the export market, which is moving away from agricultural production aimed at small-scale food production.

Institutions in Argentina strive to implement adaptation policies, but these efforts respond to an industrial agriculture model designed to favor large and powerful producers. In the case of water adaptation policies, they are aimed at modernizing regional agriculture based on irrigation technology and efficient use of water: reservoirs, animal watering, domestic storage, and irrigation canals and conveyance systems (McMartin et al., 2018). This modernization also involves an extension and training framework that challenges producers to adopt technological packages to reach that efficiency (Ferrer et al., 2015). These policies assume that technology increases productivity and is the best strategy for addressing climate change impacts. However, far from becoming alternatives to overcome vulnerability and poverty, they deepen vulnerability (Trottier, 2008) because actors become technology dependent.

Technical proposals classify producers as "viable" or "unviable" according to their capacity to incorporate technologies provided by the market. The "viable" are those who adapt to the strategies of agriculture managed by and for the big corporations of the agri-food chain (Cáceres, 2015). The "unviable" are those who do not have access to technological adaptations as a part of a development model and are left out of the system. Additionally, McMartin et al. (2018, p. 1040) highlight that "pre-existing infrastructure supporting water accessibility was not designated for flood control and often fails under high intensity and duration precipitation events and may create more devastating outcomes that if no infrastructure has been in place".

Canada

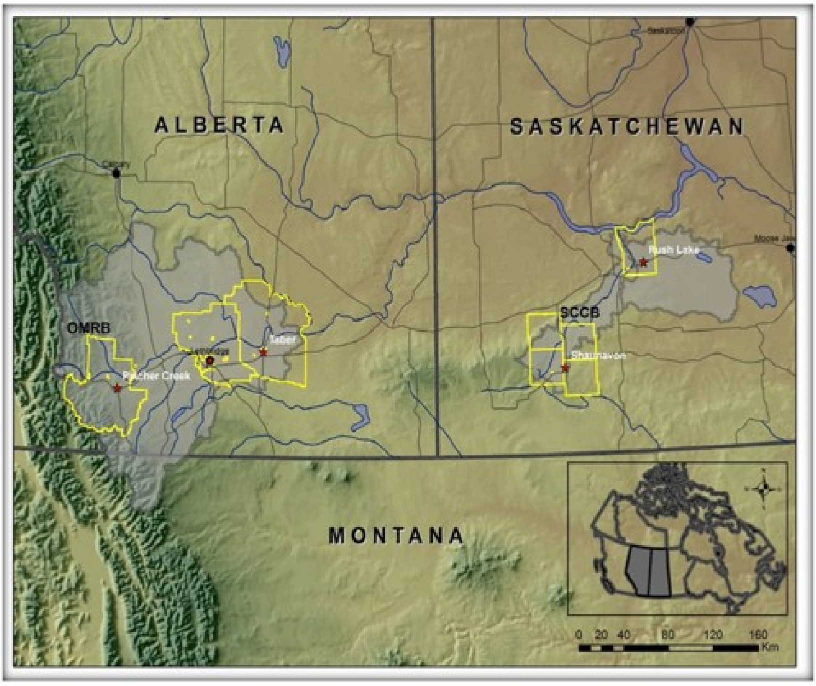

FIGURE 3.
Location of the Swift Current Creek Watershed and the Oldman River Basin.
Source: Fletcher et al. (2020)

The Canadian study area of southern Alberta and Saskatchewan is known for its history of drought (Diaz et al., 2016; Sauchyn et al., 2010). The Swift Current Creek Watershed (figure 3) is very vulnerable to drought due to extremely low average total annual precipitation (367 mm; 247 mm as rainfall) (McMartin et al., 2018). The Oldman River Watershed (figure 3), also in proximity to the Rocky Mountains, is more adapted to water scarcity through irrigation (McMartin et al., 2018), but access to irrigation is not universal and is governed by a system of water rights. Crop and cattle production now thrive due to a long history of adaptation, such as adoption of drought-resistant crops and minimum-tillage practices that reduce soil erosion (Warren, 2016). Such adaptation will be particularly important in the future, as climate scenarios for the region include changes in mean annual temperature by the 2080s ranging from 4° to 6°C, longer and warmer summers, anticipated precipitation changes, an increase in overall variability between dry and wet extremes, as well as a risk of longer and deeper droughts (Bonsal et al., 2017; Hurlbert et al., 2020; McMartin et al., 2018; Tanzeeba & Gan, 2012; Wheaton et al., 2016). Climate data already show trends of increasing temperature (figure 4) and decreasing total annual precipitation (figure 5).

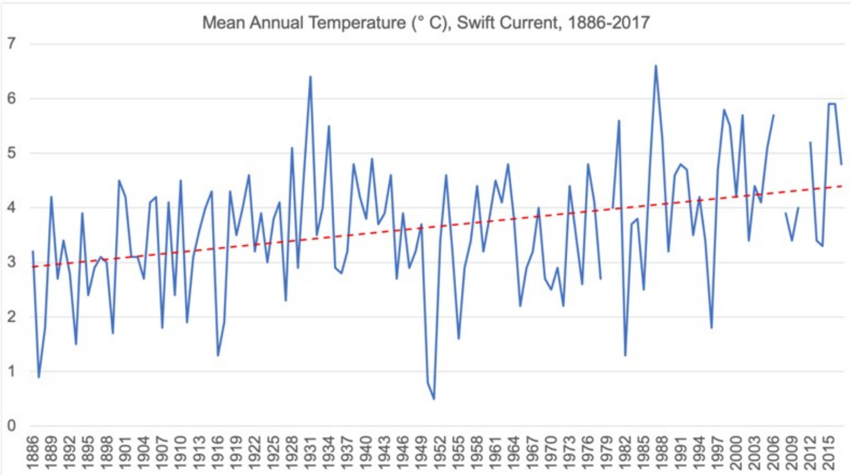

FIGURE 4.
Mean Annual Temperature (ºC), Swift Current, 1886-2017
Source: VACEA data; provided by Dr. David Sauchyn

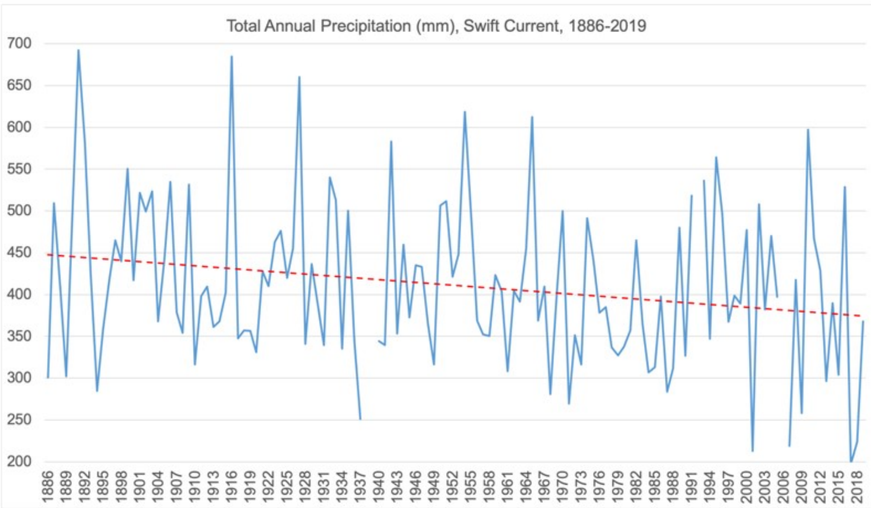

FIGURE 5.
Total Annual Precipitation (mm), Swift Current, 1886-2019
Source: VACEA data; provided by Dr. David Sauchyn

Despite these climatic challenges, financial challenges were the most commonly mentioned source of vulnerability for producers in the study. Farmers in the basin continue to face the "cost-price squeeze" as they are caught between fluctuating commodity prices for their products and the high cost of seed, fuel, and machinery inputs. One Rush Lake farmer said: "Well, our inputs are too high and our outputs are too low. That is probably the biggest challenge." The vagaries of international markets were top of mind for many participants, especially cattle producers whose prices were just starting to recover from global market closures due to the BSE (*bovine spongiform encephalopathy*) crisis of the early 2000s.

Producers also described the ongoing reduction in farm supports and market control programs as governments emphasize a free-market approach to agriculture. For example, some participants were concerned with the 2012 loss of the Canadian Wheat Board (CWB), a single-desk marketer of Canadian grains. Rush Lake producers were concerned about the federal government's decision to divest from irrigation infrastructure in the area, which had been supported through a government drought-response program for decades but was being eliminated.

As the power of vertically integrated agricultural corporations grows throughout the food chain (Fletcher, 2013) and financialization increases the market power of corporate retailers and grain traders (Isakson, 2014; Magnan, 2015), some participants questioned the role of large corporations —particularly in the agricultural input and export markets. "The companies are getting bigger; the world is getting smaller. That seems to be the way it is going," said one Pincher Creek producer. A Shaunavon farmer expressed a similar view that, "...between seed companies with herbicide-tolerant seed programs and chemical companies, any chance of profitability [for farmers] is very quickly eaten up."

Many farmers have responded to these political-economic pressures by increasing the size of their operations to create economies of scale. As smaller farmers are forced to leave the industry altogether, competition for the newly available land creates tensions between neighbours. A Pincher Creek producer described the phenomenon:

Land used to be $100 or $150 and you had 20 years to pay for it. Now they want to generate that just in fertilizer and chemical every year. It's hugely expensive and you've got to generate that every year. So, everybody's taking more out and the poor primary guy, the little guy doing the farm, he's working his tail off and can't keep up, he can't do enough to stay alive.

Off-farm work has become another major adaptive strategy to ensure stability in the face of price volatility and weather uncertainty. Farmers in oil-producing areas may also rely on rents from oil companies wishing to pump oil from farmers' lands. Unfortunately, these diversification strategies may contribute to longer work hours, stress, and further environmental depletion.

Although increasing farm size has become a major adaptation, it would be inaccurate to suggest that larger farmers are uniformly less vulnerable than smaller farmers. Increased farm size is often premised on increased debt, paradoxically increasing vulnerability on some large operations as flood or drought renders some people unable to service their debts (Fletcher and Knuttila, 2016). Discussing drought survival, one Pincher Creek farmer said, "It all depends financially on your debt load. If you are loaded up and then you miss a payment, then that is when you can get into trouble." Farmers are also encouraged (by both public and corporate agronomists) to spend money on new seed varieties and agrochemicals that promise increased yield or resistance to drought, weeds, and pests. This leads to large profits for the companies that make these products; however, for farmers facing drought and flooding, a more expensive crop can mean a more expensive crop lost. A few participants reported that they could no longer afford crop insurance due to high premiums. Climate extremes will likely cause insurance premiums to increase even further in the future, making more farmers dependent on government disaster assistance rather than producer-pay programs.

Colombia

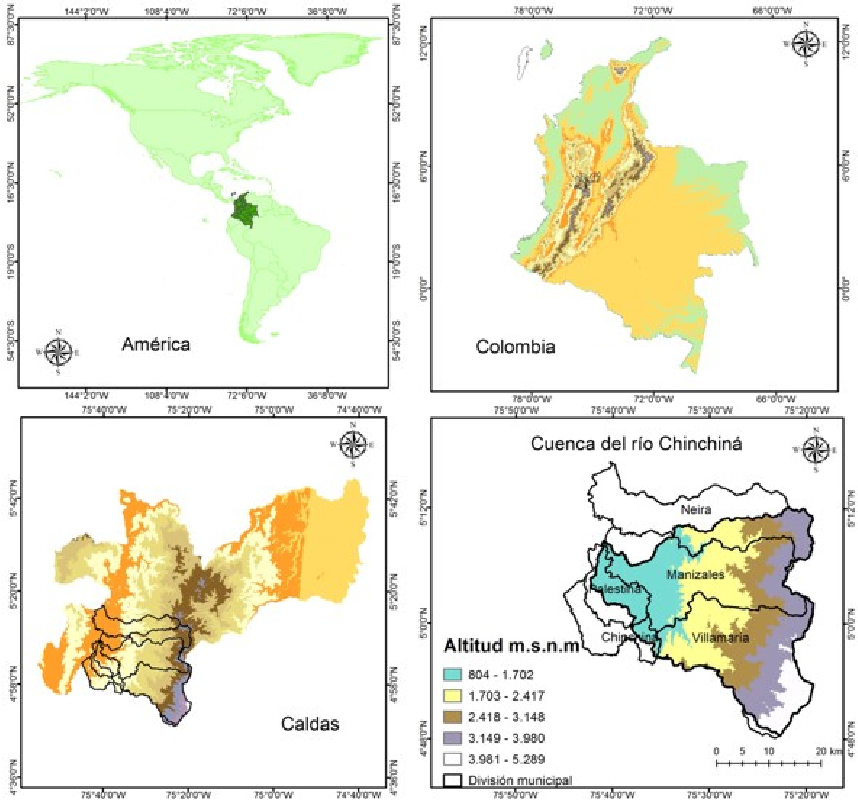

FIGURE 6.
Location of the Chinchiná River Basin
Source: Mussetta et al. (2017)

The Colombian coffee-growing axis covers the departments of Caldas, Risaralda, and Quindío, in the central mountain range of the Andes (figure 6). The coffee growers have coffee cooperatives, which in turn are linked to the National Federation of Coffee Growers of Colombia (FNCC), a union entity created in 1927. For thirty years, coffee farmers benefited from the International Coffee Agreement that established export quotas and ensured reasonable prices for farmers in producing countries. However, the theories that promoted trade liberalization were imposed leading to the rupture of the Agreement in July 1989 and the subsequent fall in international coffee prices (Urán et al., 2013). Other internal factors made the situation of the Colombian coffee growers worse, such as the process of decentralization derived from the 1991 Constitution, the change in the national economic structure to promote an open economy model (1990-1994), and the 1999 earthquake in the Coffee-Growing Triangle.

A study conducted by Perfetti del Corral and Hernández Ortiz (2003) analyzed living conditions in the coffee-growing axis during the 1990s based on four different measures[1] of well-being and found that in this period, and particularly between 1994 and 2000, there was a clear deterioration in household income, a decrease in human capital due to the abandonment of studies by the school-age population, an increase in unemployment, a loss of job quality, greater economic dependence, an increase in the number of people in poverty status, an increase in illiteracy rates, and an increase in child malnutrition.

The FNCC survived the breakdown of the World Coffee Pact, helping coffee growers to cope with the crisis. In the department of Caldas there are five coffee cooperatives, linked to the FNCC, that offer programs in four areas —environmental, social, economic and governmental— which support 22,482 associated coffee growers. These programs provide farmers with a range of important supports, including a purchase guarantee for their products, technical assistance, access to agricultural inputs and information, and marketing support.

Despite these supports, coffee farming families continue to live on the edge of poverty due to three main political-economic factors: 1) Intermediation in the marketing of coffee; the volatility of international coffee prices that depend on the prices on the New York Stock Exchange and the exchange rate of the Colombian peso against the dollar that leaves a little profit margin to producers (Steiner et al., 2015); 2) Inequity in the distribution of land that leads peasant families to live on smallholdings of less than four hectares, which is insufficient for the reproduction of the family group and is a reason for the emigration of rural youth to the cities (Mendez-Sastoque, 2016, p. 3). The coffee monocultures promoted by the FNCC as a path to increase productivity and gain profit in the international market disadvantages food security, the conservation of soils, forests, and water sources (FNCC, 2014; García Pineda, 2013; Satran, 2014).

In these circumstances, any extreme weather condition destabilizes the economy of small farmers. Coffee crops in the Chinchiná River Basin, our study region, grow from 1000 m to 1800 m a. s. l. with temperatures from 24°C to 18°C and total annual precipitation from 2000 mm to 2730 mm (Turbay et al., 2014). The historical data from 1981 to 2010 in the Chinchiná River Basin reflects an increase in mean temperatures by 0.5°C (Poveda et al., 2014). This has forced the farmers who live in the lower areas to change their activity. Some are planting fruit trees or have sold their small farms, which are now part of larger cattle ranches. Those who still grow coffee are more aware that coffee crops are extremely sensitive to changes in temperature, precipitation, and solar brightness during the warm and the cold phases of El Niño / Southern Oscillation, i.e., ENSO (figure 7). During the last years, the FNCC has increased actions aimed at promoting what has called "climate-smart" coffee growing, which includes scientific research, planting varieties resistant to rust, technologies to save water and avoid contamination, management of shadow, reforestation, protection of water sources and soils, daily weather bulletins, an early warning system, etc. (FNCC, 2018). Nevertheless, the main support of the Federation is for sun-grown coffee monocultures, which increase productivity but can have negative environmental impacts and weaken the response capacity of rural families against climate extremes because they cannot afford the labor and the financial costs of technified sun-grown coffee crops. A coffee farmer described the transition to sun-grown coffee:

During the bonanza, coffee prices were exceptionally good, productivity was excellent, and labor was very cheap. At that time, we had Arabica coffee, you only had to pass the machete once. There were no pests. In addition, we had many guamos trees in the coffee plantations, it was only necessary to remove some twigs for the sun to enter. The soil had a particularly good organic layer. One walked in the middle of the decomposing leaf litter. That was a beauty. The production costs were nothing because the chemical fertilizer was not used. But then there was an ecological crime, the fault lies with the National Federation of Coffee Growers. They said that they were going to make loans to us to plant and renew coffee plantations on the condition that it had to be in full sun exposure. You ask an agronomist from the National Federation of Coffee Growers how a banana plant is planted, and they cannot tell you anything ... they cannot speak if it is not coffee. That is the reality, it makes me sad. (Coffe farmer, personal interview)

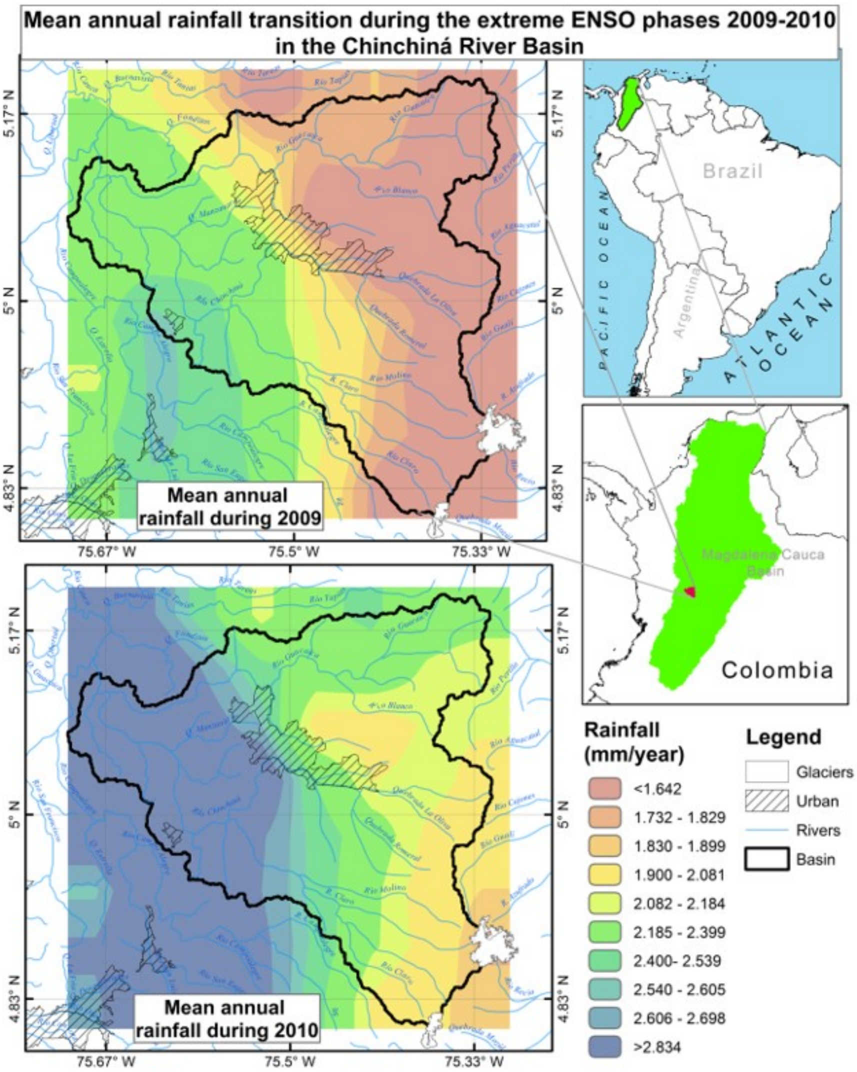

FIGURE 7.
Mean Annual Rainfall Transition During the Extreme ENSO Phases (2009-2010), Chinchiná River Basin
Source: VACEA project; provided by Juan Mauricio Bedoya

The technification of coffee culture and the generalization of sun-grown coffee monocultures transformed the landscape of the Colombian coffee-growing axis during the 1990s. Guhl (2008) indicated that, between 1990 and 1997, the area with coffee crops in Colombia decreased 18.5%, but in the same period the production doubled (cited by Chait, 2015). However, there are some diversified agro-ecological systems with shade-grown coffee, which has environmental benefits and reduced production costs (Chait, 2015). A woman who runs a coffee farm said:

When I was a kid, the farms had coffee but also many fruit trees. Nowadays, the big producers only have coffee, they look like green deserts on the slope of the mountain. I do not know to what extent such coffee industry is sustainable. In addition, any monoculture is exposed to pests. I believe more in self-sufficient farms, where expenses are lower because you don't have to buy as much food in town. (Coffe farmer, personal interview)

Some interviewed producers had invested all their energy, resources, and knowledge into polycultures including shade coffee; they are protecting the environment and selling their coffee well in alternative markets that appreciate the quality of coffee and the environmental services provided through this form of production. A small coffee roaster that sells an excellent quality product in the local market said:

The price of the product depends on how the business is done; you see that I sell my coffee at a higher price because the business is in adding value. But it is exceedingly difficult to export. It is easier to bring 30 tons of coffee from Vietnam on a mule than I as a coffee producer to send 5 pounds of coffee to London. Eight days ago, I could not send them, because I don't have an export license. To achieve this, it is necessary to break the monopoly, there are many powerful economic groups that take coffee from Colombia, and they are not interested in the producers starting to take out each one of their pounds of coffee. (Coffe farmer, personal interview)

In the Colombian case, climate change adaptation efforts have been primarily directed toward risk management of climatic events, civil engineering projects, and agronomic measures. Scientific knowledge about climate and agriculture is strong, but technical solutions are not accessible to all producers and could have unwanted results. Little progress has been made to address the structural aspects that cause vulnerability and reduce adaptive capacities; for example, inequity of land distribution, the monoculture model derived from the Green Revolution, and the structure of the coffee market that allows more benefits to coffee roasters abroad than to rural producers in Colombia.

Discussion

The findings from this intercontinental study illustrate the potential of qualitative research to identify causal structures of vulnerability, even across very different contexts. Taken together, these findings clearly reveal how a particular political-economic paradigm constitutes a major source of vulnerability in all three places. Climate extremes interact with existing inequalities to create different levels of vulnerability between producers (e.g., small versus large; highly indebted versus low indebted). These vulnerabilities are further exacerbated by neoliberal policy changes and market rationalities and by worsening climate extremes.

Findings from the three countries converge on neoliberal political-economic trends as a major cause of farmers' vulnerability to climate extremes. Neoliberalism has been defined as "a theory of political economic practices that proposes that human well-being can best be advanced by liberating individual entrepreneurial freedoms and skills within an institutional framework characterized by strong private property rights, free markets, and free trade" (Harvey 2005, p. 2). Neoliberal political-economic paradigms are often marked by deregulation, financialization, and corporatization. In Argentina, deregulation has facilitated economic concentration and capital accumulation into an oligopoly system, causing financial precarity for grape farmers who are pushed out. A similar trend is occurring in Canada, where farmers are increasing the size of their farms to stay profitable amidst rising costs due to strong corporatization and financialization in the agri-food sector. Such growth, however, is often premised on debt and more expensive inputs, thus increasing farmers' vulnerability when crops are lost due to climate extremes. For some Canadian farmers, off-farm employment offers stability and increased adaptive capacity, while in Argentina many have moved into tourism. In both cases, such adaptive efforts do little to address the deeper unsustainability of the agri-food system itself.

In Colombia, union entities do provide supports for coffee growers. Unfortunately, however, even the FNCC promotes the dominant discourse of sun-grown coffee monocultures as key to productivity. In the midst of this monoculture model, inequity of land distribution and international market fluctuations render peasant farmers particularly vulnerable to climate extremes that threaten their survival. Reflecting trends in the other two countries, Colombian youth choose off-farm employment due to the precarity of the dominant system.

Climate scenarios indicate increased risk of future extremes in each basin. In all three countries, farmers are exposed not only to climate extremes, but also to financial insecurity and uncertainty as a result of neoliberal economic trends, which then increases their sensitivity to climate events. Loss of producer supports and increased corporate market power exacerbate this exposure and contribute to reduced adaptive capacity.

In response to these structural factors, Colombian and Canadian farmers are pushed toward individualized and technocratic solutions like genetically modified seeds and chemicals to maintain their productivity. In Colombia and Argentina, climate adaptation measures are oriented to technological efficiency and market solutions (e.g., climate-smart agriculture), which depoliticize vulnerability and involve an excessive reliance on technological solutions to environmental damage caused by the economic model. Some authors have described this phenomenon as the "ecotechnocracy" of climate change, a bureaucratic apparatus in which socio-environmental problems produced in the framework of capitalist development have a technical-based solution, and positivist science becomes the only way to produce valid knowledge about climate change and adaptation (Sevilla-Guzmán, 2006). At the same time, ecotechnocracy promotes market solutions that accommodate globalization and associated patterns of rural development. Technology then is not only a proposal to tackle climate change, but the bastion of a development model.

In response to political-economic pressures, individual farmers may also pursue financial adaptation strategies. In Canada, the shift to specialized (sometimes patented) seed and chemical combinations and more sophisticated machinery has pushed some farmers further into debt. Large vertically integrated agricultural corporations seek to increase their profit both upstream (e.g., patented seeds) and downstream (processing, marketing and exporting) in the agri-food sector. As farms grow ever larger to adapt, larger farms and more expensive crops may not necessarily decrease vulnerability to climate risks.

This situation is similar in Argentina where, together with limitations in the availability and access to water, producers are affected by the pricing and marketing system imposed by the neoliberal model of agribusiness. The dominant model of rural development and agribusiness excludes those farmers who fail to integrate into the marketing chains. Ensuring water access will not be sufficient to modify vulnerabilities of less powerful producers, if it does not go hand-in-hand with policies that support small producers. In Colombia, farmers traded traditional polycultures for monocultures of genetically modified coffee varieties to increase productivity and resistance to pests and diseases. These cultures require more investment in fertilizers, but coffee prices at the New York Stock Exchange are not high enough to cover production costs —a similar issue to the "cost-price squeeze" reported in Canada. In both countries, international markets generate large profit to intermediaries, corporations, and foreign roasters.

The cases analyzed in this paper clearly reveal that vulnerabilities to climate change are produced under the framework of broad political-economic structures.

Global changes in agri-food systems exacerbate farmers' vulnerabilities to climate change, especially in certain sectors or for some groups already experiencing inequality. This inability is manifested in unequal power over domestic market prices and trade dealings in general and makes the most vulnerable farmers fight for minimum subsistence levels. While in some cases, adaptation strategies challenge the dominant system (e.g., producers of shade-grown coffee in Colombia), in other cases, they may reinforce the very structures that produce vulnerability in the first place (e.g., Canadian farmers turning to costly biotechnological inputs to increase production; Argentinian producers abandoning agricultural activities under pressures from other sectors).

In this analysis, a Critical Realist approach helps us see commonality across contexts. In the midst of contextual specificity, CR encourages the search for "demi-regularities" (i.e., identifiable trends or patterns, but not causal laws) that can be found in complex "open" social systems (Danermark et al., 2002). Demi-regularities point toward pervasive structures that are relatively perseverant over time, although they may manifest differently depending on context and local conditions. Neoliberal political economic structures have led to similar patterns in each country, although institutional and individual responses may differ, and social differentiation means that some groups are affected differently than others. The structures we identify across contexts may ultimately be *internally necessary* to farmers' current vulnerability (Danermark et al., 2002). In other words, in a completely different political-economic system, vulnerability might manifest differently or not at all. Moving beyond the proximal causes of vulnerability to the structural ones (Ribot, 2014) also helps us question the shortcomings of superficial solutions that focus only on the surface level of vulnerability (e.g., livelihood diversification, climate-smart solutions) and are not sufficient for addressing deeply rooted vulnerability.

Our findings suggest future actions that reduce the extent of corporatization or facilitate fairer international trade relations. Nonetheless, one caveat to our approach is that although such solutions help struggle against "deep vulnerability", they are, by virtue of their depth, much more difficult to achieve. Thus, more short-term and context-specific solutions remain important but should be combined with structural critique. While the current analysis has relied primarily on qualitative data to identify relevant structures, future research in this area may seek to integrate quantitative data into structural critiques.

Conclusion

Drawing on the findings of an intercontinental study in Argentina, Canada, and Colombia, this paper has illustrated the usefulness of qualitative analysis for identifying deeply rooted causes of vulnerability amongst agricultural producers facing climate change. Interviews and group discussions with over 300 community members reveal that neoliberalism —as a deeply engrained political-economic structure that emphasizes trade liberalization, deregulation, corporatization, and a reduction in state supports for farmers— has been a major cause of vulnerability for agricultural producers in each country, exacerbating existing inequalities and reducing adaptive capacity to climate change. Identifying structural causes of vulnerability helps us move beyond individualized or technocratic solutions (for example, income diversification or expensive technological inputs that promise higher yields). In all three countries, over-reliance on such solutions has actually proved to be maladaptive for many farmers, in some cases pushing them further into the very structures that cause their vulnerability. Individualized responses are mostly reactive, and although they may work in some contexts or for some groups, deeper solutions are needed to address vulnerability at its very roots.

Declarations

The authors declare no competing interests. Funding for this research was provided by the International Development Research Centre (IDRC) and the Tri-Councils, grant number 106372-008, 009.

Acknowledgments

This article is based on an intercontinental research project entitled "Vulnerability and Adaptation to Climate Extremes in the Americas" (VACEA). The authors gratefully acknowledge the work of the VACEA research team. We are thankful to Dr. David Sauchyn and Juan Mauricio Bedoya-Soto for their assistance with the graphs in this article.

References

Akram, N., & Hamid, A. (2015). Climate change: A threat to the economic growth of Pakistan. *Progress in Development Studies, 15*(1), 73-86. https://doi.org/10.1177/1464993414546976

Altschuler, B. (2009). El trabajo y los trabajadores en América Latina: perspectivas históricas y problemáticas actuales. La travesía de la libertad ante el bicentenario. *IV Congreso Interoceánico de Estudios Latinoamericanos, X Seminario Argentino Chileno y IV Seminario Cono Sur de Ciencias Sociales, humanidades y relaciones internacionales*. Mendoza.

Archer, M. S. (1995). *Realist social theory: The morphogenetic approach*. Cambridge University Press.

Ashan, N., & Warner, J. (2014). The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risk— A case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction, 8*, 32-49. https://doi.org/10.1016/j.ijdrr.2013.12.009

Asociación de Cooperativas Vitivinícolas Argentinas (Acovi). (2018). *Análisis de la concentración en el mercado vitivinícola*. Observatorio de Economías Regionales.

Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change, 20*(2), 211-213. https://doi.org/10.1016/j.gloenvcha.2009.11.004

Bhaskar, R. (2015). *The possibility of naturalism: A philosophical critique of the contemporary human sciences* (4th ed.). Routledge.

Bonsal, B. R., Cuell, C., Wheaton, E., Sauchyn, D. J., & Barrow, E. (2017). An assessment of historical and projected future hydro-climatic variability and extremes over southern watersheds in the Canadian Prairies. *International Journal of Climatology, 37*(10), 3934-3948. https://doi.org/10.1002/joc.4967

Cáceres, D. M. (2015). Tecnología agropecuaria y agronegocios. La lógica subyacente del modelo tecnológico dominante. *Mundo Agrario, 16*(31). http://sedici.unlp.edu.ar/bitstream/handle/10915/48398/Documento_completo.pdf?sequence=1&isAllowed=y

Cadag, J. R. D., & Gaillard, J. C. (2012). Integrating knowledge and actions in disaster risk reduction: The contribution of participatory mapping. *Area, 44*(1), 100-109. https://doi.org/10.1111/j.1475-4762.2011.01065.x.

Cains, M. G., & Henshel, D. (2019). Community as an equal partner for region-based climate change vulnerability, risk, and resilience assessments. *Current Opinion in Environmental Sustainability, 39,* 24-30. https://doi.org/10.1016/j.cosust.2019.06.005

Cameron, E. S. (2012). Securing Indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. *Global Environmental Change, 22*(1), 103-114. https://doi.org/10.1016/j.gloenvcha.2011.11.004

Chait, G. (2015). Café en Colombia. Servicios ecosistémicos, conservación de la biodiversidad. En F. Montanini, E. Somarriba, E. Murgueitio, H. Fassola y B. Eibl (Eds.), *Sistemas Agroforestales. Funciones productivas, socioeconómicas y ambientales* (pp. 349-364). Serie Técnica. Informe Técnico 402, CATIE, CIPAV, Turrialba.

Collier, A. (1994). *Critical realism: An introduction to Roy Bhaskar's philosophy*. Verso.

Correa, S. (2012). Procesos culturales y adaptación al cambio climático: la experiencia en dos islas del Caribe colombiano. *Boletín de Antropología Universidad de Antioquia, 27*(44), 204-222. https://revistas.udea.edu.co/index.php/boletin/article/view/15621

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly, 84*(2), 242-261. https://doi.org/10.1111/1540-6237.8402002

Danermark, B., Ekström, M., Jakobsen, L., & Karlsson, J. C. (2002). *Explaining society: An introduction to critical realism in the social sciences*. Routledge.

Deis, L., de Rosas, M. I., Malovini, E. Cavagnaro, M., Cavagnaro, J. B. (2015). Climate change impact in Mendoza. Climate variation on the last 50 years. A view to grapevine physiology. *Revista Facultad Ciencias Agrarias, 47,* 67-92. https://ri.conicet.gov.ar/handle/11336/39851

Delgado Cabeza, M. (2010). El sistema agroalimentario globalizado: Imperios alimentarios y degradación social y ecológica. *Revista Economía Crítica, 10,* 32-61. http://revistaeconomiacritica.org/sites/default/files/revistas/n10/3.pdf

Departamento General de Irrigación. (2017) *Balance Hídrico Rio Mendoza*. Gobierno de Mendoza. Mendoza.

Diaz, H. P., Hurlbert, M., & Warren, J. W. (2016). *Vulnerability and adaptation to drought: The Canadian prairies and South America*. University of Calgary Press.

Enarson, E., & Morrow, B. H. (1997). A gendered perspective: The voices of women. In W. G. Peacock, B. H. Morrow, & H. Gladwin (Eds.), *Hurricane Andrew: Race, gender and the sociology of disaster* (pp. 116-140). Routledge.

Espíndola, C., & Valderrama, J. O. (2016). AbaniCO2: Un método simple y efectivo para la toma de decisiones sobre la adopción de la huella del carbono en la gestión sustentable de emisiones en las empresas. *Información tecnológica, 27*(3), 35-52. http://dx.doi.org/10.4067/S0718-07642016000300005

Fazey, I., Kesby, M., Evely, A., Latham, I., Wagatora, D., Hagasua, J.-E., Reed, M. S., Christie, M. (2010). A three-tiered approach to participatory vulnerability assessment in the Solomon Islands. *Global Environmental Change, 20*(4), 713-728. https://doi.org/10.1016/j.gloenvcha.2010.04.011

Federación Nacional de Cafeteros de Colombia (FNCC). (2014). *Comportamiento de la industria cafetera colombiana 2013*. FNCC. https://www.federaciondecafeteros.org/static/files/Informe_Industrial_2013_Web.pdf

Federación Nacional de Cafeteros de Colombia (FNCC). (2018). *Comportamiento de la industria cafetera colombiana 2018*. FNCC. https://federaciondecafeteros.org/app/uploads/2019/10/Informe_de_la_Industria_Cafetera_20182.pdf

Fernandez, M. A., Bucaram, S., & Renteria, W. (2017). (Non-) robustness of vulnerability assessments to climate change: An application to New Zealand. *Journal of Environmental Management, 203*, 400-412. https://doi.org/10.1016/j.jenvman.2017.07.054

Ferrer, C., Carballo, O., Barrientos, J., & Mussetta, P. (2015). Políticas públicas, desarrollo rural y cambio climático en la provincia de Mendoza, Argentina. *IX Jornadas Interdisciplinarias de Estudios Agrarios y Agroindustriales argentinos y latinoamericanos*. Buenos Aires.

Fletcher, A. J. (2013). *The view from here: Agricultural policy, climate change, and the future of farm women in Saskatchewan*. University of Regina.

Fletcher, A. J. (2018). More than women and men: A framework for gender and intersectionality research on environmental crisis and conflict. In C. Fröhlich, G. Gioli, R. Cremades, & H. Myrttinen (Eds.), *Water Security Across the Gender Divide* (pp. 35-58). Cham. https://doi.org/10.1007/978-3-319-64046-4

Fletcher, A. J., Akwen, N. S., Hurlbert, M., & Diaz, H. P. (2020). "You relied on God and your neighbour to get through it": Social capital and climate change adaptation in the rural Canadian Prairies. *Regional Environmental Change, 20*(2), 61. https://doi.org/10.1007/s10113-020-01645-2

Fletcher, A. J., & Knuttila, E. (2016). Gendering change: Canadian farm women respond to drought. In H. Diaz, M. Hurlbert, & J. Warren (Eds.), *Vulnerability and adaptation to drought: The Canadian prairies and South America* (pp. 159-177). University of Calgary Press.

García Pineda, A. F. (2013). Vulnerabilidad y adaptación al cambio climático en la caficultura colombiana. En A. Ulloa & A. I. Prieto-Rozo (Eds.), *Culturas, conocimientos, políticas y ciudadanías en torno al cambio climático* (pp. 107-142). Universidad Nacional de Colombia, Sede Bogotá, Facultad de Ciencias Humanas.

Gilgun, J. (2011). Coding in deductive qualitative analysis. *Current Issues in Qualitative Research: An Occasional Publication for Field Researchers from a Variety of Disciplines, 2*(1), 1-4.

Guhl, A. (2008). *Café y cambio de paisaje en Colombia, 1970-2005*. Fondo Editorial Universidad EAFIT.

Handmer, J. W., Dovers, S., & Downing, T. E. (1999). Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change*, 4(3-4), 267-281. https://doi.org/DOI:10.1023/A:1009611621048

Harvey, D. (2005). *A brief history of neoliberalism*. Oxford University Press.

Henríquez, C., Aspee, N., & Quense, J. (2016). Zonas de catástrofe por eventos hidrometeorológicos en Chile y aportes para un índice de riesgo climático. *Revista de Geografía Norte Grande, 63*, 27-44. http://dx.doi.org/10.4067/S0718-34022016000100003

Himes-Cornell, A., & Kasperski, S. (2015). Assessing climate change vulnerability in Alaska's fishing communities. *Fisheries Research, 162*, 1-11. https://doi.org/10.1016/j.fishres.2014.09.010

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277-1288. https://doi.org/10.1177/1049732305276687

Hurlbert, M., Fletcher, A., Sauchyn, D., & Diaz, H. P. (2020). Climate change, agriculture and communities in the South Saskatchewan River Basin. In P. Mussetta and M. Hurlbert (Eds.), *Vulnerability studies in the Americas: Extreme weather and climate change* (pp. 22-52). Cambridge Scholars Press.

Instituto Nacional de Estadística y Censos (Indec). (2019). *Censo Nacional Agropecuario. Resultados Preliminares*. Gobierno de Argentina. https://www.indec.gob.ar/ftp/cuadros/economia/cna2018_resultados_preliminares.pdf

Intergovernmental Panel on Climate Change (IPCC). (2014). *Climate change 2014: Synthesis report. Contribution of working groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (R. K. Pachauri & L. A. Meyer, Eds.). IPCC.

Isakson, S. R. (2014). Food and finance: The financial transformation of agro-food supply chains. *The Journal of Peasant Studies, 41*(5), 749-775. https://doi.org/10.1080/03066150.2013.874340

Krishnamurthy, P., Lewis, K., & Choularton, R. J. (2014). A methodological framework for rapidly assessing the impacts of climate risk on national-level food security through a vulnerability index. *Global Environmental Change, 25*, 121-132. https://doi.org/10.1016/j.gloenvcha.2013.11.004

Luers, A. L. (2005). The surface of vulnerability: An analytical framework for examining environmental change. *Global Environmental Change, 15*(3), 214-223. https://doi.org/10.1016/j.gloenvcha.2005.04.003

MacGregor, S. (2010). A stranger silence still: The need for feminist social research on climate change. *The Sociological Review, 57*, 124-140. https://doi.org/10.1111/j.1467-954X.2010.01889.x

Magnan, A. (2015). The financialization of agri-food in Canada and Australia: Corporate farmland and farm ownership in the grains and oilseed sector. *Journal of Rural Studies, 41*, 1-12. https://doi.org/10.1016/j.jrurstud.2015.06.007

Manzanal, M. (2016). Acumulación, crisis y la problemática del hambre y de la desnutrición en América Latina. *Revista Latinoamericana de Estudios Rurales, 1*(1), 27-50. http://www.ceil-conicet.gov.ar/ojs/index.php/revistaalasru/article/view/154/36

Maiti, S., Jha, S. K., Garai, S., Nag, A., Bera, A. K., Paul, V., Upadhaya, R. C., Deb, S. M. (2017). An assessment of social vulnerability to climate change among the districts of Arunachal Pradesh, India. *Ecological Indicators, 77*, 105-113. https://doi.org/10.1016/j.ecolind.2017.02.006

Marchildon, G. P., Pittman, J., & Sauchyn, D. J. (2009). The Dry Belt and changing aridity in the Palliser Triangle, 1895-2000. In G. P. Marchildon (Ed.), *A dry oasis: Institutional adaptation to climate on the Canadian Plains* (pp. 31-44). Canadian Plains Research Center Press.

McMartin, D. W., Hernani Merino, B. H., Bonsal, B. Hurlbert, M., Ocampo, O. L., Upegui Vélez, J. J., Poveda, G. & Sauchyn, D. (2018). Limitations of water resources infrastructure for reducing community vulnerabilities to extremes and uncertainty of flood and drought. *Environmental Management, 62,* 1038-1047. https://doi.org/10.1007/s00267-018-1104-8

Mendez-Sastoque, M. (2016). Factores de expulsión y retención en la decisión migratoria de jóvenes rurales de Manizales, Colombia. *Intersedes, 17*(36), 2-38. http://dx.doi.org/10.15517/isucr.v17i36.26943

Montaña, E., & Mussetta, P. (2016). Vulnerabilidad al cambio ambiental global en los Andes Centrales: Enunciados para un enfoque hacia la justicia climática. *LASA Forum, XLVI*, 17-21. http://lasa.internationa l.pitt.edu/forum/files/vol47-issue4/Debates3.pdf

Mussetta, P., Barrientos M. J, Acevedo, E., Turbay, S. & Ocampo, O. (2017). Vulnerabilidad al cambio climático: Dificultades en el uso de indicadores en dos cuencas de Colombia y Argentina. *Empiria. Revista de metodología de ciencias sociales, 36*, 119-147. https://doi.org/10.5944/empiria.36.2017.17862

Mussetta, P., & Hurlbert, M. (Eds.). (2020). *Vulnerability studies in the Americas: Extreme weather and climate change*. Cambridge Scholars Press.

Mwangi, M., Kituyi, E., Ouma, G. & Macharia, D. (2020). Indicator approach to assessing climate change vulnerability of communities in Kenya: A case study of Kitui County. *American Journal of Climate Change, 9*, 53-67. https://doi.org/10.4236/ajcc.2020.92005

Niyibizi, A., Mpeirwe, A., & Ajambo, S. (2013). Vulnerability assessment for rural settings: Applicability to developing countries. In W. L. Filho (Ed.), *Climate change and disaster risk management* (pp. 273-92). Springer. (h ttp://link.springer.com/chapter/10.1007/978-3-642-31110-9_17).

Palazzolo, N. E. (2017). Concentración económica en el circuito productivo vitivinícola en Mendoza. *Plataforma de información para políticas públicas de la Universidad Nacional de Cuyo*. http://www.politicaspublicas.uncu.edu .ar/articulos/index/concentracion-economica-en-el-circuito-productivo-vitivinicola-en-mendoza

Perfetti del Corral, M., & Hernández Ortiz, J. F. (2003). Cambio en las condiciones de vida en el eje cafetero en la Década de los Noventa. *Estudios Regionales, 10*, 1-25 https://crece.org.co/wp-content/uploads/2016/11/Con dicionesdeVida_paper_No_10.pdf

Polsky, C., Neff, R., & Yarnal, B. (2007). Building comparable global change vulnerability assessments: The vulnerability scoping diagram. *Global Environmental Change, 17*(3-4), 472-485. https://doi.org/10.1016/j.gloenv cha.2007.01.005

Poveda, G., Turbay, S., Vélez, J. J., Ocampo, O. L., Acevedo, E. C., & Bedoya, M. (2014). *Vulnerabilidad y adaptación a las variaciones climáticas extremas en la cuenca de la quebrada Los Cuervos, afluente del río Chinchiná*. Universidad Nacional de Colombia, Universidad de Antioquia, IDRC-CIHR-NSERC.

Retamal, M. R., Rojas, J., & Parra, O. (2011). Percepción al cambio climático y a la gestión del agua: aportes de las estrategias metodológicas cualitativas para su comprensión. *Ambiente & Sociedade, 14*(1), 175-194. https://doi.org/10.1590/S1414-753X2011000100010

Ribot, J. (2014). Cause and response: Vulnerability and climate in the Anthropocene. *The Journal of Peasant Studies, 41*(5), 667-705. https://doi.org/10.1080/03066150.2014.894911

Ribot, J. (2017). Causa y responsabilidad: Vulnerabilidad y clima en el antropoceno. *Acta Sociológica, 73*, 13-81. https://www.sciencedirect.com/science/article/pii/S018660281730049X

Salinas, V., Cevallos, W., & Levi, K. (2020). Afrodescendientes e indígenas vulnerables al cambio climático: desacuerdos frente a medidas preventivas estatales ecuatorianas. *Iconos. Revista de Estudios Sociales, 66,* 107-129. https://doi.org/10.17141/iconos.66.2020.4012

Satran, J. (2014). The coffee industry is worse than ever for the environment. *The Huffington Post*. http://www.huffingtonpost.com/2014/04/29/sustainable-coffee_n_5175192.html

Sauchyn, D. J., Diaz, H. P., & Kulshreshtha, S. (2010). *The new normal: The Canadian Prairies in a changing climate*. CPRC Press.

Secretaría de Ambiente y Ordenamiento Territorial. (2015). *Agencia provincial de ordenamiento territorial.* Gobierno de Mendoza. http://www.ambiente.mendoza.gov.ar/organismos/ordenamiento-territorial/agencia-provincial-de-ordenamiento-territorial/

Sevilla-Guzmán, E. (2006). Agroecología y agricultura ecológica hacia una reconstrucción de la soberanía alimentaria. *Agroecología, 1*, 7-18. http://helvia.uco.es/xmlui/bitstream/handle/10396/2221/4.pdf?sequence=1&isAllowed=y

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Steiner, R., Salazar, N., & Becerra, A. (2015). La política de precios del café en Colombia. *Coyuntura Económica: Investigación Económica y Social, xlv*(2), 101-136. http://hdl.handle.net/11445/3166

Tanzeeba, S., & Gan, T. Y. (2012). Potential impact of climate change on the water availability of South Saskatchewan River Basin. *Climatic Change, 112*(2), 355-386. https://doi.org/10.1007/s10584-011-0221-7

Trottier, J. (2008). Water crises: Political construction or physical reality? *Contemporary Politics, 14*(2), 197-214. https://doi.org/10.1080/13569770802176929

Turbay, S., Nates, B. Jaramillo, F., Vélez, J. J. & Ocampo, O. L. (2014). Adaptación a la variabilidad climática entre los caficultores de las cuencas de los ríos Porce y Chinchiná, Colombia. *Investigaciones Geográficas, 85,* 95-112. https://doi.org/10.14350/rig.42298

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley N., Kasperson J. X., Luers A., Martello M. L., Polsky C., Pulsipher A. and Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences, 100*(14), 8074-8079. https://doi.org/10.1073/pnas.1231335100

Urán, A., Acevedo, E., & Piedrahíta, I. (2013). Café de Colombia: Escenarios de la cafeticultura colombiana tras la liberalización del mercado mundial. En *Del Sabor A Café Y Sus Nuevas Invenciones. Escenarios Cafetaleros En América Latina* (pp. 1-30). Universidad Nacional Autónoma de México.

Ulloa, A. (2011). *Perspectivas culturales del clima*. Universidad Nacional de Colombia.

van Aalst, M. K., Cannon, T., & Burton, I. (2008). Community level adaptation to climate change: The potential role of participatory community risk assessment. *Global Environmental Change, 18*(1), 165-179. https://doi.org/10.1016/j.gloenvcha.2007.06.002

Vergara-Camus, L., & Kay, C. (2017). Agribusiness, peasants, left-wing governments, and the state in Latin America: An overview and theoretical reflections. *Journal of Agrarian Change, 17*(2), 239-257. https://doi.org/10.1111/joac.12215

Villalba, R., Boninsegna, J., Masiokas, M., Cara, L., Salomon, M., & Pozzoli, J. (2016). Cambio Climático y recursos hídricos en las tierras secas del oeste argentino. *Ciencia Hoy*, June, 48-55. https://cienciahoy.org.ar/cambio-climatico-y-recursos-hidricos-el-caso-de-las-tierras-secas-del-oeste-argentino/

Warren, J. W. (2016). The "min till" revolution and the culture of innovation. In H. P. Diaz, M. Hurlbert, & J. W. Warren (Eds.), *Vulnerability and adaptation to drought: The Canadian prairies and South America* (pp. 107-132). University of Calgary Press. http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1284686

Warren, J. W., & Diaz, H. P. (2012). *Defying Palliser: Stories of resilience from the driest region of the Canadian prairies*. Canadian Plains Research Center Press.

Weis, S. W. M., Agostini, V. N., Roth, L. M., Gilmer, B., Schill, S. R., Knowles, J. E., & Blyther, R. (2016). Assessing vulnerability: An integrated approach for mapping adaptive capacity, sensitivity, and exposure. *Climatic Change, 136*(3), 615-629. https://doi.org/10.1007/s10584-016-1642-0

Wheaton, E., Sauchyn, D., & Bonsal, B. (2016). Future possible droughts. In H. Diaz, M. Hurlbert, & J. Warren (Eds.), *Vulnerability and adaptation to drought: The Canadian prairies and South America* (pp. 59-76). University of Calgary Press.

Whyte, K. (2017). Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene. *English Language Notes, 55*(1-2), 153-162. https://doi.org/10.1215/00138282-55.1-2.153

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters* (2nd ed.). Routledge.

Wright, H., Vermeulen, S., Laganda, G., Olupot, M., Ampaire, E., & Jat, M. L. (2014). Farmers, food and climate change: Ensuring community-based adaptation is mainstreamed into agricultural programmes. *Climate and Development, 6*(4), 318-328. https://doi.org/10.1080/17565529.2014.965654

Yadav, S. S., & Lal, R. (2018). Vulnerability of women to climate change in arid and semi-arid regions: The case of India and South Asia. *Journal of Arid Environments, 149*, 4-17. https://doi.org/10.1016/j.jaridenv.2017.08.001

Yenneti, K., Tripathi, S., Wei, Y. D., Chen, W., & Joshi, G. (2016). The truly disadvantaged? Assessing social vulnerability to climate change in urban India. *Habitat International, 56*, 124-135. https://doi.org/10.1016/j.habitatint.2016.05.001

Zhang, Y., Ruckleshaus, M., Arkema, K. K., Han, B., Lu, F., Zheng, H., & Ouyang, Z. (2020). Synthetic vulnerability assessment to inform climate-change adaptation along an urbanized coast of Shenzhen, China. *Journal of Environmental Management, 255,* 109915. https://doi.org/10.1016/j.jenvman.2019.109915

Notes

* Research article

1 The Human Development Index, the Quality-of life Index, the Unsatisfied Basic Needs Index and the Poverty Line Index.