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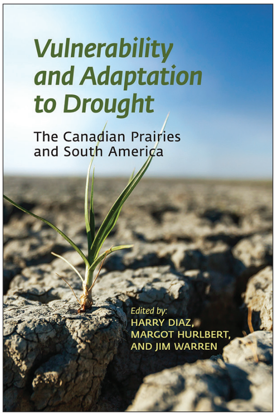

VULNERABILITY AND ADAPTATION: The Canadian Prairies and South America Edited by Harry Diaz, Margot Hurlbert, and Jim Warren

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PART 1

FRAMING THE BOOK

CHAPTER 1

DROUGHT AND VULNERABILITY: A CONCEPTUAL APPROACH

Johanna Wandel, Harry Diaz, Jim Warren, Monica Hadarits, Margot Hurlbert, and Jeremy Pittman

The fundamental message of this book is the need to discuss and understand drought—not just in terms of climatic parameters such as timing, duration, intensity, and geographic scope, but also relative to human exposure-sensitivity. A holistic understanding of the socio-economic conditions that define human sensitivity, vulnerability, and adaptive capacity is fundamental to grasp the implications of drought. This chapter provides the conceptual framework that contextualizes the interdisciplinary perspective informing this book and its chapters. It reviews some of the traditional approaches to drought, ranging from hydrological to socio-economic droughts, and argues for the need to understand drought in terms of contextual vulnerability and its components. By adopting this contextual approach, we are able to identify how social and economic conditions influence exposure, sensitivity, and adaptive capacity to droughts, allowing for a better understanding of how people experience and live with this hazard. Contextually based approaches are generally rooted in local cases and facilitate a comprehensive understanding of problems from a "bottom up" perspective; however, there is a need to couple this understanding with macro-scale drivers of change to devise appropriate strategies for managing drought. This perspective, with an emphasis on vulnerability, is an internationally recognized conceptual framework for assessing and understanding the social dimensions of drought and other natural hazards (see Smit and Wandel 2006 for a discussion of the conceptual framework. For examples of its application, see Turbay et al. 2014; Diaz et al. 2011; Hadarits et al. 2010).

The "Wickedness" of Droughts

Understanding droughts and their impacts has always constituted a challenge. Similar to other climate events, droughts are phenomena that take place at the centre of human-environment interactions. Droughts are natural events that have ramifications for society, affecting people, social activities, and social processes in different forms and with different consequences. Having a comprehensive understanding of droughts involves embracing all their complexities in both human and natural systems. In this way, droughts are intricate, broad, and multifaceted phenomena.

Droughts are not a simple, tame problem that can easily be explained from a single disciplinary perspective or dealt with through a simple decision-making approach. Rather, to the extent that it is difficult and complex to define and deal with their impacts, they could be considered "wicked" problems (Brown et al. 2010; Batie 2008; Conklin 2006; Rittel and Webber 1973). A wicked problem "is a complex issue that defies complete definition, for which there can be no final solution, since any resolution generates further issues, and where solutions are not true or false or good or bad, but the best that can be done at the time" (Brown et al. 2010: 4). These kinds of problems do not exist as naturally wicked events, but rather they seem to be related to our attempts to define and explain them using traditional modes of inquiry, which tend to overemphasize some aspects of these wicked problems and ignore others. The possibility of an increase in the intensity and duration of extreme climate events due to climate change or other natural drivers makes it even more urgent to expand our understanding of drought. In this perspective, there is an identified need for developing and strengthening an interdisciplinary approach to understanding these climate events (e.g., Bhaskar et al. 2010).

Droughts are climate events with characteristics that make them significantly different from other climate hazards. In comparison to other extreme weather events, such as torrential rains or tornados, droughts are known as "creeping" hazards because they tend to accumulate more slowly and over longer periods of time and may also recede at a slow pace, they have differentiated and accumulative impacts, and their spatial coverage is heterogeneous (Sheffield and Wood 2011; Kallis 2008: 3–4; Wheaton 2007).

Most definitions of drought refer to limited availability of water, relative to normal conditions, with negative consequences for humans and ecosystems. Droughts can be variable in duration, can last several weeks to several years, and can affect very small to very large areas. Water deficits have significant negative implications for human activities that are highly dependent on access to water, such as agriculture, especially when the reduction is below critical thresholds that define water requirements for plants, animals, and humans. Moreover, droughts can become self-sustaining in that the "dryness" of droughts can reduce water vapour in an area, thereby exacerbating drought conditions (Wheaton 2007: 49). Over the long term, droughts can degrade the environment and foster desertification. This notion of drought, however, is too simple. As discussed in the next section, more complex notions of drought emerge depending on the nature of the water deficit and its impacts (Sheffield and Wood 2011: 11–13). Together, they enhance our understanding of drought and improve preparedness and adaptation.

Approaching and Understanding Droughts

Defining drought is more than a semantic exercise; the lack of agreement on a common definition has hampered proactive drought management (Paulo and Pereira 2013; Wilhite et al. 2005). As indicated above, the common metric for identifying drought is a deficiency of precipitation relative to "average" conditions (Wilhite and Glantz 1985). Early discussions of the term separated definitions into two broad categories—meteorological and agricultural—with the former considering a departure from long-term mean precipitation and the latter considering the timing of precipitation relative to crop development (Glantz and Katz 1977). In recent decades, a typology based on four broad categories of drought, as first set out by

Table 1. A typology of broad conceptualizations of drought

Conceptualization	Common definitions	Metrics	Non-climatic considerations
Meteorological	Departure from the long-term mean moisture supply (Paulo and Pereira 2006)	Long-term precipitation records, precipitation indices (e.g., SPI), cumulative precipitation shortages	None
Agricultural	Timing of precipitation relative to crop needs (Glantz and Katz 1977) Declining soil moisture and precipitation failure (Mishra and Singh 2010) Availability of soil moisture to support crop growth (Wilhite and Buchanan-Smith 2005) Moisture supply below climatically appropriate moisture supply and crop production negatively affected (Quiring and Papakyriakou 2003)	Crop water stress indices (e.g., PDSI, CMI)	Crop moisture needs, soil characteristics (infiltration, moisture holding capacity)

Hydrological	Departure from average conditions in surface and subsurface supplies (Wilhite and Buchanan-Smith 2005) Inadequate surface and subsurface water resources for established water uses (Mishra and Singh 2010)	Streamflow data, surface water supply indices (e.g., SWSI)	Upstream water availability, water storage capacity, institutional allocation, legal agreements between jurisdictions (e.g., Master Agreement on Apportionment)
Socio-economic	The interplay of human activity and meteorological, agricultural, and hydrological drought (Wilhite and Buchanan-Smith 2005) Failure of water resource systems to meet demands or demand exceeds supply (Mishra and Singh 2010)	Highly contextual descriptions	Access and entitlement to water resources, perception of water availability

Note: SPI = Standardized Precipitation Index; PDSI = Palmer Drought Severity Index; CMI = Climate Moisture Index; SWSI = Surface Water Supply Index.

Wilhite and Glantz (1985), has been used to distinguish different forms of droughts. They are meteorological, agricultural, hydrological, and socio-economic droughts (Table 1).

Meteorological approaches define drought as a deficit in precipitation over a particular time period relative to the long-term mean (Mishra and Singh 2010). While metrics vary (e.g., monthly precipitation data), the meteorological approach to drought lends itself to long-term quantitative analysis of precipitation in a given region (e.g., Sauchyn et al. 2003). Frequently, drought indices are derived to evaluate duration and intensity.

For example, the Standardized Precipitation Index (SPI) uses the mean and standard deviation of precipitation over various time periods to compute probability, percentage of average, and accumulated precipitation deficits (McKee et al. 1993). Outputs of indices such as the SPI are useful for identifying statistically anomalous conditions, but they do not give insight into how much precipitation is necessary to meet the needs of stakeholders in a given area.

Hydrological approaches to drought, like meteorological ones, define the event by a departure from the long-term normal in a given area. In this case, however, the determining variables are surface and subsurface moisture availability, including lakes, reservoirs, streamflows, and soil moisture (Wilhite and Buchanan-Smith 2005), which distinguishes hydrological approaches from meteorological ones both spatially and temporally. For example, in the case of the South Saskatchewan River basin, water supplies largely depend on rivers that are affected by precipitation upstream in the Rocky Mountains (spatial variation). Both surface water and groundwater may have a lag time in response to precipitation deficits, meaning a hydrological drought can continue to have impacts after a meteorological drought has been declared over (temporal variation). Finally, hydrological approaches indirectly consider some human systems, given that upstream withdrawals from river systems or prolonged over-allocation of ground and surface water supplies can affect the severity of a drought. Common metrics for measuring hydrological drought are similar to those measuring meteorological drought in that they rely on indices. For example, the Surface Water Supply Index considers deviations from long-term conditions in reservoir storage, streamflow, snowpack, and precipitation (Mishra and Singh 2010), but it does not consider the needs of stakeholders in an area.

Agricultural approaches to drought indirectly consider stakeholder needs by analyzing deviations from long-term conditions in soil moisture to support crop and forage growth (Wilhite and Buchanan-Smith 2005). Agricultural drought is not measured as a direct function of precipitation and hydrological availability of water, because soil types vary in their water uptake and holding capacity, and crops have different moisture needs. These types of conceptualizations are thus relative not only in time and space but also to particular production systems. Agricultural drought indices range from those that use water availability and potential evapotranspiration as dominant inputs, such as the Palmer Drought Severity Index, to complex satellite-based models, such as the Integrated Surface Drought Index, which combines moisture and temperature variables with remotely sensed vegetation conditions and thus can include irrigation effects in drought definition (Wu et al. 2013).

It is also important to recognize that subsidiary categories of drought experience exist within the wider classification of agricultural drought. Recent interdisciplinary research on the adaptive capacity of Prairie farmers and ranchers demonstrates that sensitivity to drought conditions can vary considerably between production models. For example, the success of irrigated crop production can be affected by hydrological drought conditions, which may or may not coincide with localized precipitation levels (Warren and Diaz 2012; see also Chapter 6 by Warren on irrigation in southwestern Saskatchewan in this volume). Similarly, research demonstrates that the timing of precipitation events can affect field crop production differently than it does the growth of domestic forage crops and native grasses. Dry conditions early in a growing season can adversely affect forage production. However, if precipitation increases later in the season, it might still be possible to produce crops. In addition, ranchers reliant on surface water sources for cattle can be affected by hydrological drought conditions to a greater extent than farmers producing dryland crops.

The four conceptualizations of drought mentioned above are all based on variability in natural conditions (with some human modification in the case of irrigation or water withdrawals) over a given temporal and spatial extent. All of these definitions are primarily based on departures from "average" conditions and lend themselves to the identification of drought, primarily for decision makers to react and make changes to their management approaches. While objective quantification of drought is useful (and necessary) for the allocation of drought relief (e.g., for agricultural producers), it does not provide insights into how stakeholders live with and experience this hazard or how they make decisions under drought conditions, nor does it consider human perception as a factor in drought response. Furthermore, the wider social, economic, and political context is important for creating management strategies that reduce overall drought hazard. Alternative conceptualizations of drought, which include diverse considerations of human-environment systems, have been grouped in the category of *socio-economic drought*, although it should be noted that conceptualizations captured under this approach are not as homogenous as the previous ones.

The assessment of the spatial and temporal impacts of droughts on the supply and demand of water-dependent economic goods has been a significant line of work in this area (Lindesay 2003: 38–39; see also O'Meagher 2003). More recently, and in the context of climate change, efforts have focused on evaluating the costs of climate change on agricultural activities based on biophysical-agroeconomic models (Kallis 2008).

The category of socio-economic drought has also included what Wilhite and Buchanan-Smith (2005: 10) term "human-induced" drought, where "development demands exceed the supply of water available [and] may exceed supply even in years of normal precipitation." This type of drought leads to considerations of equity and differential vulnerability; for example, upstream over-allocation in the case of the southern Colorado River basin has contributed to inequities for downstream Mexican users (see Maganda 2005). Another example of how water and power come together to produce conditions of drought for those producers downstream of the river or at the bottom of the social hierarchy is provided by Montaña and Boninsegna in Chapter 14 (this volume) for the Mendoza River basin in Argentina.

In the perspective of socio-economic droughts, the issue of perception has long been recognized as a key factor in understanding and responding to drought (i.e., the way drought is perceived). Glantz and Katz (1977) noted that recent weather conditions, particularly abnormally wet conditions, influence decision making in arid and semi-arid environments more heavily than the long-term record or drought periods. This can lead to management practices being adopted that are suited only to higher-than-average moisture and result in perceived drought conditions when the wet period ends. This situation was described for the Sahel in the 1960s by Glantz and Katz (1977) and was further evaluated for northern Ethiopia by Meze-Hausken (2004). In the latter case study, farmers' perceptions of drought—that is, when they felt that a drought had occurred—were relatively poorly matched to the long-term precipitation records and were closely tied to satisfactory harvests and returns for these harvests. As livelihoods changed, so did what were considered optimal moisture conditions, and drought was determined through this lens (Meze-Hausken 2004). A related situation also applies to the Canadian Plains during the early twentieth century: an abnormally wet period relative to the long-term record led to the establishment of land claims and associated survey systems, which were maladapted to long-term conditions, including periodic drought, contributing to the failure of a wheat-based economy during the 1930s (Wandel and Marchildon 2010; see also Chapters 5 and 6 by Warren on min till and irrigation in this volume). In this case, a failure of human perception to match the long-term record captured in the indicator approaches (at scales ranging from individual to institutions) actually increased drought hazard beyond what existed in pre-settlement range-based agriculture, illustrating the importance of considering livelihoods and their exposures and sensitivities to climatic conditions. On the other hand, the perception of drought as a normal condition of the landscape contributes to a shared experience of drought among local producers that helps reduce the impacts of dry conditions. This latter argument is reinforced by Hewitt (1983), who argues against the viewpoint that a natural hazard such as a drought is an "extreme" condition, as it primarily leads to what he terms "technocratic" (i.e., engineering, science, and technological development approaches); if we accept drought as a natural part of the landscape that is considered a hazard because of human reliance on precipitation (i.e., the view that a drought is "normal"), we develop routine adaptations and consequently higher adaptive capacity to drought. For example, a recent study of the Palliser Triangle in western Canada shows that farmers in areas normally exposed to droughts tend to have higher resilience than producers residing in areas where droughts are rare (Diaz and Warren 2012). Farmers living in the core of the Palliser Triangle have greater capacity to survive long droughts relative those living outside the area, who tend to show very limited coping capacities (Diaz and Warren 2012; Warren and Diaz 2012; Wandel et al. 2009).

Under socio-economic considerations of drought, "good years" and "bad years" are not solely defined by climatic variables. For example, using the case of climatic conditions in the Okanagan grape industry, Belliveau et al. (2006) found that good years were those where both yields and market prices were high, and a year with acceptable yields may still have been considered a bad year if crop prices were low. Similarly, producers may experience a decrease in crop yields under agricultural drought but not actually see a reduction in net farm income if commodity prices are sufficiently high to compensate for lost yield. This example illustrates the importance of considering macro-economic variables and net farm returns.

Beyond perceptions and economics, we must also consider the institutional conditions that can reduce (or increase) the drought hazard. Marchildon et al. (2008) describe the development of the Special Areas of southeast Alberta as an institutional adaptation to drought. In this case, changing land-use policy has significantly reduced exposure to drought hazards. In most cases, land administered by the Special Areas Board only allows for extensive cattle grazing (Wandel et al. 2009), which has much lower moisture requirements than crop farming, meaning that the area is drought-proofed to conditions that, under a different institutional environment, would have perhaps led to a collapse in the environmental system. Hurlbert and Diaz's (2013) analysis of water governance in Chile and Canada shows a different situation, in which the adoption of a neo-liberal framework reduces the capacity of government to alleviate exposure to drought and other forms of extreme climate events.

Wilhite et al. (2005) argue for a risk management approach to drought via a ten-step planning process that incorporates stakeholder participation (and thus perception), inventories of resources, identification of needs and institutional gaps, and direct integration of science and policy with associated awareness and education programs. This sort of highly contextualized approach to drought, which is rooted in place and time, and whose primary purpose is to reduce overall drought hazard, is consistent with current approaches to vulnerability and adaptation in the climate change field.

Understanding the socio-economic impact of droughts is part and parcel with classifying droughts as natural hazards, which is a perspective assumed in this book. There is a long tradition of approaching environmental conditions that are problematic for human systems as natural hazards. Under a hazards perspective, environmental events such as flooding do not themselves represent hazards, but they become so when coupled with human occupancy and the degree to which human systems are able to manage the impacts of the event (Kates 1976). When this perspective is applied, defining drought becomes a function of both natural water availability relative to long-term normals and human activity within the region of interest (Wilhite and Buchanan-Smith 2005; see also Kallis 2008).

Adopting a hazards perspective to drought naturally leads to considerations of vulnerability and adaptation. Conceptualizations of vulnerability draw extensively on earlier environmental hazards work and maintain the view that vulnerability is a function of both natural conditions and sensitivity, as well as the ability of systems to adapt (Smit and Wandel 2006).

The hazards perspective contrasts with meteorological, hydrological, and agricultural approaches to drought, which view the event in terms of precipitation, surface and subsurface water availability, and soil moisture, respectively (Mishra and Singh 2010). These conceptualizations of drought lend themselves primarily to quantitative analyses, including indices, and foster the view of drought as an unusual circumstance as opposed to a naturally occurring hazard that is part of the long-term climate regime (Wilhite and Buchanan-Smith 2005). Treating drought as an exceptional circumstance fosters reactive and crisis-based management solutions to deal with the impacts of a particular event without necessarily decreasing the overall drought hazard, a situation termed the "hydro-illogical cycle" by Wilhite et al. (2005: 95). In impacts, vulnerability, and adaptation to climate change scholarship, similar conceptualizations occur when vulnerability is viewed as the outcome, end-point, or residual of the adaptation process—that is, the portion of the impact due to a climatic event that could not be adapted to (Smit and Wandel 2006). Similar to the hydro-illogical cycle, this lends itself to reactive management solutions rather than proactive adaptation.

Defining drought and vulnerability as naturally occurring properties, which are a function of both human and environmental systems, changes the nature of research on drought vulnerability assessment by shifting the lens to how humans interact with the environment on an ongoing basis. This in turn can help break Wilhite et al.'s hydro-illogical cycle by adopting policies of drought-preparedness that decrease overall vulnerability to drought.

Living with Drought: Vulnerability and Adaptive Capacity

Early conceptualizations of vulnerability to climate change have been categorized variously as "vulnerability as an end point," "outcome vulnerability," or "residual impact" (Fussel and Klein 2006; Smit et al. 2000; Kelly and Adger 2000). These conceptualizations grew out of first-order climate impact assessments and take the methodological approach of first projecting future climate, then modelling impacts of future conditions, and then identifying adaptations to moderate the harm (or exploit beneficial opportunities). In this case, "vulnerability" becomes those impacts that cannot be compensated for by adaptation. This early conceptualization, although still in use in narrowly defined crop yield models (e.g., Osborne et al. 2013), has been criticized for its lack of consideration of a full suite of flexible adaptation strategies beyond those that respond to a projected impact (Ortiz-Bobea and Just 2012; Schneider et al. 2000).

The Intergovernmental Panel on Climate Change's Third Assessment Report argued for the consideration of vulnerability as a system property and drew on environmental hazards and international development work to define the concept as the product of both physical exposure to climate stresses and ability to cope with the impacts of that exposure (Smit and Pilifosova 2001). Associated terms such as sensitivity, susceptibility, coping ability, adaptability, and adaptive capacity, among others, were proposed to capture what others have termed "social vulnerability." Since then, conceptualizations that have variously been framed as "vulnerability as a starting point" or "contextual vulnerability" (O'Brien et al. 2007) have gained traction. In this framing of the concept, an understanding of vulnerability goes beyond its treatment relative to a narrow suite of climatic stimuli to "the context of political, institutional, economic and social structures and changes, which interact dynamically with contextual conditions associated with a particular 'exposure unit'" (O'Brien et al. 2007: 76). This alternate framing guides how questions are asked about vulnerability, and in turn the methods used for vulnerability assessment, providing us with an understanding of the "lived experience" of drought. Frequently, empirical analyses are conducted at the scale at which multiple stresses in the context of climate change are experienced, and a growing body of scholarship on community-based case studies has emerged (e.g., Westerhoff and Smit 2009; Brouwer et al. 2007; Ford et al. 2006; Stehlik 2003). However, as recognized by Adger et al. (2005), adaptation occurs across scales, and thus contextual vulnerability can be seen as a nested hierarchy where local adaptation actions are made within a broader set of determinants of exposure, sensitivity, and adaptive capacity. Contextual vulnerability has been applied by the Intergovernmental Panel on Climate Change (IPCC), in conjunction with its efforts to enhance community sustainability in response to the challenges presented by climate change, including the prospect of more severe and prolonged droughts on the Canadian Prairies and other world regions.

Most chapters in this book (see Chapters 4–14) are based on empirical studies framed within the contextual vulnerability approach. In many of these analyses, the "exposure unit" for empirical analysis is the rural community or the agricultural production unit, with an implicit recognition that adaptation decisions are made within a broader institutional, governance, and political environment (see Chapters 5, 6, 8, 9, 10, and 12 on institutional context).

Following the IPCC, vulnerability is defined in this volume as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al. 2001: 6). In this volume, we use a socio-economic conceptualization of drought as a lens for analyzing climate variability, extremes, and change, and examine the various perceptions, values, and enabling and constraining factors by scaling out from community-based vulnerability assessments.

An important point of departure for most chapters in this volume is the recognition that all agricultural producers are exposed to the extremes of climate variability, but not all of them are vulnerable to the same degree. Differences in vulnerabilities are closely related to a variety of social, economic, and political conditions and capacities, which either facilitate or constrain, for example, the ability of farmers and ranchers to cope with harsh climate conditions. However, it is important to remember that even in those situations in which producer communities have adopted practices that increase their capacity to cope with drought, their resilience is based on experience with past droughts. Should future droughts exceed the thresholds for severity and duration of those experienced in the past, as climate change science suggests is likely, current levels of adaptive capacity may no longer be sufficient to sustain current practices (see Chapter 3 by Wheaton et al. in this volume). Understanding the processes associated with successful adaptations in the past can provide insights into how communities might adapt to future conditions (see Chapter 5 by Warren on "min till" (minimal tillage) and see Chapter 8 by Marchildon in this volume). Similarly, observing and assessing how communities in other regions of the world have adapted to drought conditions can provide useful lessons for other localities. Chapters 13 and 14, which discuss adaptation to drought in Latin America, reflect this principle.

As indicated in IPCC's definition, vulnerability combines two dimensions: first, exposure to climate hazards and its impacts on social systems; and second, social conditions that determine the sensitivity of a ranch or a farm—the degree to which they are affected by climate-related stimuli—as well as the system's adaptive capacity (i.e. the ability of the system, such as a production unit, to adjust to climate risks and opportunities by increasing its adaptive range). Figure 1 represents these two dimensions of vulnerability. Exposure is a characteristic of a climate system, and it refers to climate hazards—that is, droughts, storms, and others—and their attributes—such as intensity, duration, and coverage—that define the magnitude of their impact on social systems. Sensitivity and adaptive capacity, on the other hand, are characteristics of the social system defined by access to and control of a variety of resources. In this perspective, vulnerability is a characteristic of a social system that emerges when a natural hazard impacts human systems. In very simple terms, a social system that is characterized by limited resources is more vulnerable and consequently more susceptible to being impacted by climate hazards. Figure 1 lists these resources, defined by the IPCC as "the determinants of adaptive capacity" (McCarthy et al. 2001: 893). Access to 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).

These determinants of adaptive capacity—also called assets or "capitals" (Department of International Development 2000)—are resources that could be used to ensure the sustainability of farms and ranches in

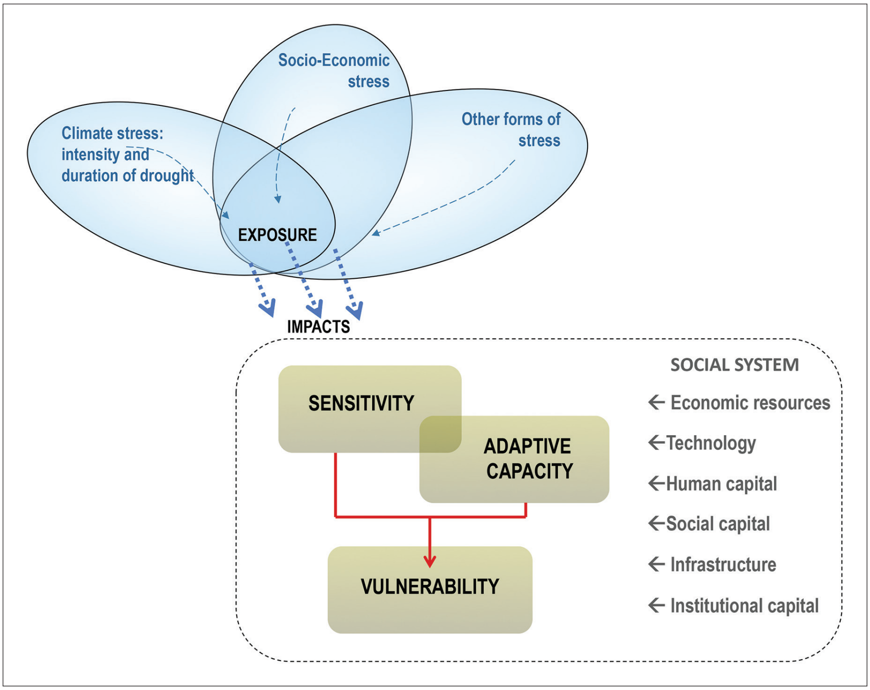

Figure 1. The dimensions of vulnerability.

contexts other than climate change. Economic assets refer to financial resources, such as cash, credit, productive resources (machinery, buildings), and other forms of economic capital, that could be mobilized to sustain a livelihood. These resources are undoubtedly central to secure the conditions that enhance the sustainability of a farm or ranch, but there are other resources no less significant. Access to good infrastructure (proper housing conditions, drainage systems, weather-resistant roads, coastal defence, and others forms of infrastructure) and to technology (irrigation systems, flood control measures, warning systems, and others) is fundamental to sustain productivity in the face of increasing climate-related risks. No less relevant is access to natural capital—those basic ecosystem services, such as water and soil, which are fundamental to the viability of rural livelihoods. The quantity and quality of these natural resources are, obviously, two important aspects that secure the success of agricultural activities.

Also relevant are other elements such as human capital—the educational experiences, knowledge, skills, and expertise of a person. This capital includes not only knowledge obtained in the formal educational system but also local knowledge and experiences that could be used to employ, modify, and develop other types of resources. In this context of human capital, the capacities to wisely manage materials and human resources, the ability to learn from experience, and the ability to gain access to and process information are important.

In the same perspective, institutional capital, defined as those resources that exist at the level of local, regional, and national institutions, is important. The process of generating and maintaining an adaptive capacity at the level of the farm or the ranch is always related to the existence of collective resources and capacities that support and multiply individual efforts. Established institutions, such as government agencies, facilitate the management of a variety of risks—such as the existence and availability of insurance services, water conservation programs, and others—which reinforce the adaptive capacity of the population. Previous studies in the area of climate vulnerability have shown that adaptation of communities is nested in larger institutional contexts, from where a myriad of resources, programs, and policies are provided to individuals and local communities (Hurlbert and Diaz 2013; Diaz et al. 2011; Diaz et al. 2009; Hurlbert et al. 2009; see also Chapter 8 by Marchildon and Chapters 9 and 10 by Hurlbert in this volume). How this institutional capital interacts, or how governments, organizations, producers, and other entities make decisions and share power, exercise responsibility, and ensure accountability, is the essence of governance (Cundill and Fabricius 2010) and an important component of adaptive capacity (Gupta et al. 2010; Folke et al. 2005). In the same vein, institutional capacities are not limited to formal agencies and organizations that exist beyond the local community. Local institutional capital—whether in the form of local government or local organizations—is also relevant as a form of capital that could be mobilized to reduce sensitivities to a variety of stressors (Wandel et al. 2009). There is also increasing evidence that informal local institutions—such as social capital based on friendship or kinship—strengthen the capacity to reduce the stress of natural and economic hazards (learning from experience, capacity for innovation, flexibility) and are important for organizing these assets into adaptation actions (Warren and Diaz 2012).

Figure 1 also shows that climate is not the single determinant of a system's vulnerability. Rather, climate and water stresses are part of a suite of stresses that individual producers and rural communities must manage in their everyday lives. Rural people are exposed to several non-climatic stressors—such as market conditions, political processes, domestic catastrophes, and others—which are frequently more relevant to them than extreme climate events. Particularly problematic for them is the combination of climatic and non-climatic vulnerabilities at a single moment in time, such as the case of a drought at a moment in which market crop prices are low. It is this combination of stressors that multiplies the negative impacts of risks leading to double exposures (Leichenko and O'Brien 2008; see also Chapter 4 by Kulshreshtha et al. and Chapter 13 by Hadarits et al. in this volume). In addition, the nature of production systems creates specific conditions of vulnerability for different types of agricultural producers. For example, water demands vary between farmers and ranchers, as well as among different production units. No less relevant is the localization of the production units within a region. Non-existent or limited access to irrigation is a fundamental issue for agricultural producers in the context of increasing water scarcities (see Chapter 6 by Warren on irrigation in this volume). Similarly, having a farm in certain areas of a region or water basin may limit access to water (the case of the Mendoza River basin is a good example of this situation; see Chapter 14 by Montaña and Boninsegna in this volume).

As expected, vulnerabilities—and associated adaptive capacity—tend to be unequally distributed. These unequal conditions are associated with processes of economic differentiation, which allow some producers to have access to more and better resources than others. This differentiation results not only from the economic conditions generated by competition and a process of globalization but also from institutional failures, which result in an unequal distribution of resources vital to adaptive capacity (Hurlbert and Diaz 2013). In other words, some rural people have greater adaptive capacity than others because of greater access and control of the different forms of capital discussed above.

Vulnerability is not an unalterable condition but rather is subject to change depending on the intensity of the stressor and the quality and quantity of resources that are available to rural people. In other words, vulnerability must be considered as a fluid process. In the case of resources, they are obviously subject to change depending on the intensity of the stressor and the quality and quantity of the different forms of capital available to the local community. In other words, vulnerabilities, and adaptive capacities, are not a given condition but rather are subject to a myriad of processes that could increase or reduce the quantity and quality of resources. Thus, when resources are limited and they are used unwisely, the capacity of a farm or ranch to face future risks declines (Pelling 2011). The wise management of resources is therefore essential to the sustainability of livelihoods.

Conclusion

This chapter has presented a case for considering both human and natural systems—and their interactions—when assessing vulnerability to drought. Both socio-economic definitions of drought and conceptual approaches to contextual vulnerability, by definition, incorporate this dynamic. Moreover, they allow researchers to approach and understand droughts and other climate events from a people-centred focus, providing an opportunity to grasp how rural people live and experience droughts, and how differential access to resources promotes or reduces the resilience of producers.

This knowledge is fundamental to developing appropriate climate governance approaches that could facilitate a move beyond the assumptions of homogeneity which characterize the policy landscape. In facing the increasing threat of climate change, drought policies and programs need to incorporate a deeper understanding of local vulnerabilities to develop and implement more focused, targeted, and relevant drought management strategies. This so-called "bottom-up" knowledge also helps expand our scientific understanding of the complexities of droughts and adds to our existing knowledge of the biophysical elements that contribute to and characterize droughts. By adding new dimensions to our knowledge, we move another step forward in taming the wickedness of droughts.

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