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Chapter One

A Vulnerable Society

Introduction

28 June 1692 was a very wet day in Celaya, Guanajuato. Unusually heavy rains began falling late in the afternoon and continued all through the evening, causing a rapid increase in the level of the River Laja which ran adjacent to the town. Finally, just after 10 o’clock that night, the river burst its banks. The flood caused ‘terrible panic among all the inhabitants of the city’ and took place when the people of Celaya were at their most vulnerable.

With the darkness of the night no one knew where the most danger lay and much less how to escape this ... men, women and children were desperately shouting and crying ... and the turbulent waters invaded everything with impetuous force ... no one believed there was any possible escape from this and all began begging for mercy.

Daylight revealed the scale of the devastation. ‘The whole city was left like an immense field covered in mud, uprooted trees and branches, rubbish, debris, bodies of all kinds of animals and ... all the other remnants of the near destruction.’ Volunteers from local communities joined forces with army troops to clear the debris in search of flood victims, some of whom had died trapped in their houses. In total it was estimated that close to three thousand families lost their houses and livelihoods (Zamarroni Arroyo, 1960: 141; Marmolejo, 1967).

But this calamitous event could not have come at a worse time. Repeated droughts in 1690 and 1691, followed by crop blights, had already led to harvest losses across a broad area. Famine and epidemic disease had then gripped this, and other, regions of the country, causing massive life loss, especially among the disenfranchised indigenous population, some of whom
were left without access to even the most basic provisions (Orozco y Berra, 1938; Berthe, 1970). The subsistence crisis that followed resulted in social unrest and the emergence of popular uprisings across central Mexico.

Dramatic as this period was, it was in no way unique. Extreme and unusual weather events and natural hazards, including earthquakes and volcanic eruptions, have continually tested the resilience and resourcefulness of Mexican society. Droughts have regularly destabilized agricultural production and have affected food security and social and economic well-being in various parts of the country throughout history and prehistory (Florescano, 1980; Hodell et al., 1995; Conde et al., 1997; Liverman, 1999) and remain a problem today. Successive droughts in the 1930s, 1950s and 1990s, for example, contributed to water scarcity, harvest failure, illness, livestock disease, land abandonment and water conflict in the north of the country (Sandoval, 2003). Catastrophic flood events, some associated with hurricanes, have also killed thousands of people across southern and central Mexico, have left tens of thousands homeless and caused billions of dollars of damage, both directly and through rainfall induced land sliding. In short, over three hundred years after the devastating events of the 1690s, the impacts of climate change still rank among the most significant threats to social and economic well-being and environmental security in Mexico.

Current climate models all indicate that ‘it is likely that all land regions will warm in the 21st century’ (IPCC, 2007: 850). It is thought that significant potential increases in temperature will be accompanied by changes in precipitation, with the possibility of more frequent and intense extreme weather events (Fraser et al., 2003; Bogardi, 2004; IPCC, 2007). While it should be acknowledged that such changes could bring opportunities for some, they will increase the vulnerability of others, especially those already socially, environmentally or politically marginalized sectors of society (Tompkins and Adger, 2004). In Mexico, where a substantial proportion of the population works in an agricultural system that relies on relatively low and variable rainfall, and whose prosperity is critical to the nation’s debt burden economy, such conditions could prove particularly disastrous (Liverman, 1999). It is anticipated that most of central America in fact will warm over the next century in line with global mean warming, but annual precipitation is likely to decrease (IPCC, 2007: 892). There are fears that higher temperatures and reduced precipitation could increase the competition for water and falling ground water levels which could in turn exacerbate existing tensions over this most vital resource.

Considerable insight into the specific regional social and economic implications of predicted climate changes can be gained by analysing the spatial vulnerability of society, agriculture and other resources to current and predicted variations in temperature and precipitation (Magaña et al., 1997; Liverman, 1999). The way in which human activities and the natural environment have
been affected by and have responded to climate changes and weather perturbations in the past, however, provides another invaluable guide to where the most critical vulnerabilities to possible future climate changes may lie. The purpose of this study is to explore the complex interaction between climate and society in historical perspective across Mexico, by investigating the nature and scale of the impacts of climatic variability and unusual and extreme weather events on different agricultural communities in colonial Mexico between 1521 and 1821. Attention focuses on the variety of responses to climate changes and weather events and how these responses varied according to the changing social, political and economic circumstances throughout the colonial period. The degree to which these impacts and responses were a function of differential social and environmental vulnerabilities will be considered.

### Changing Vulnerabilities

Vulnerability can be broadly defined as the potential for loss (Cutter, 1996: 529) or ‘the degree to which human and environmental systems are likely to experience harm due to a perturbation or stress’ (Luers et al., 2003: 255). Though frequently referred to and widely used in the risk, hazards and disaster literature (see, for example, Burton et al., 1993; Blaikie et al., 1994; Kasperson and Kasperson, 2001), vulnerability is becoming an increasingly important concept in the fields of environmental and climate change (Cutter, 2006). Vulnerability is not static. The temporal context of vulnerability is of critical importance. Yet there have been relatively few historical treatments of vulnerability (Cutter, 1996: 533) and less still of how vulnerability to climate variability may have changed and may be changing over time (Parry, 2001: 258).

To some extent, this relative neglect is a function of three key problems: first, the multiplicity of definitions of and approaches to vulnerability and a general lack of consensus on the meaning of the term (Luers et al., 2003: 255); second, vulnerability is a concept, not an observable or tangible phenomenon per se, rendering it difficult to identify in the historical record; and third, we still possess only an imperfect knowledge of how the climate has changed over the historical period.

Adopting Cutter’s terminology, there is certainly a ‘confused lexicon’ of meanings, interpretations and approaches to understanding vulnerability (Cutter, 1996: 530), reflecting a suite of epistemological orientations and contrasting frameworks. Various genres of literature, for example, have focused on vulnerability from the perspective of biophysical threats and hazards (Hewitt and Burton, 1971; Gabor and Griffith, 1980; Ambraseys and Jackson, 1981; Burton et al., 1993; Blaikie et al., 1994). Many ‘unapologetically naturalist’, physicalist explanations of disasters, for example, place
total blame on ‘the violent forces of nature’ (Frazier, 1979; Foster, 1980; Blaikie et al., 1994: 11). These approaches position people as being implicitly vulnerable, owing to their presence in particular fragile or precarious environments. Adopting this perspective, those societies considered most vulnerable to drought, for example, would be those living in areas of low rainfall and sandy soils (Liverman, 1999).

Some more subtle biophysical based assessments have also incorporated demographic factors, such that concern focuses on the capacity of a particular environment to support a population. In recent years there has been a move away from attention on the stressors in vulnerability studies to the stressed system and its component parts and its ability to respond (Ribot, 1995; Clark et al., 2000). Social vulnerability, for instance, focuses on the ‘susceptibility of social groups or society at large to potential losses’ (Cutter, 2006: 72) from hazardous events and disasters. In these approaches, as Macnaghton and Urry (1998) suggest, ‘cultural criteria are implicated in the definition and trajectories of even the most apparently physical environmental issues’ (cited in Jones, 2002: 248). The nature of a hazardous event is taken as a given or at the very minimum viewed as a social construct, not a biophysical condition (Cutter, 1996). This perspective thus highlights human coping strategies and responses, including societal resilience to environmental hazard, and positions biophysical threats as socially constructed phenomena. The most extreme of such approaches have been criticized for environmental denial (Burningham and Cooper, 1999: 306) and for fostering political quietism with respect to pressing environmental issues (Milton, 1996: 54; Demeritt, 2001).

Interdisciplinary research teams have now begun to explore vulnerability as a function of exposure, sensitivity and adaptive capacity, manifested within interactions of social and ecological systems (Turner et al., 2003). Vulnerability in this body of literature is conceived both as a biophysical risk as well as a social response (Cutter, 1996: 533). The impacts of an extreme climate event for a community, for example, would then be influenced ‘as much by the level of technological, economic and political development as by the severity of the meteorological event itself’ (Liverman, 1990: 49). The complex interaction between the environment and human society, however, represents a constraint that not only influences how livelihoods in a region may be vulnerable to disruption, and the way in which environmental change or an environmental or climate event is experienced, but also how different social systems and groups can respond or adapt to such events (Oliver-Smith and Hoffman, 1999: 73; Ohlsson, 2000).

Kasperson et al. (1988) and Kasperson and Kasperson (1996), for example, suggest that risks and hazards interact with cultural, social and institutional processes in such as way as to temper or aggravate public response (Cutter, 2006). Vulnerability, and hence adaptability, may thus change
according to different scenarios and over time. Trajectory analysis can go some way to revealing these regional dynamics of change and, it follows, changing vulnerabilities (Kasperson et al., 1995). Messerli et al. (2000), for example, have suggested that the vulnerability of a particular society changes over time in conjunction with adaptive mechanisms and adjustments, some of which may in fact render society more vulnerable in the long run. They argue that there is a historical ‘trajectory of vulnerability’ through which all societies pass as they develop, economically, socially and technologically. The position of a society on this trajectory influences its relative vulnerability. ‘Nature dominated’ hunting and gathering societies, for example, are considered to be the most vulnerable to environmental and climatic changes. Societies who have modified their environments in order to buffer themselves from these changes, however, and who have developed productive agrarian-urban systems based on these adaptations are thought to be more resilient. With population expansion, however, and the overexploitation of and reliance upon these buffer systems, it is thought that the vulnerability of these societies once again increases. There has been considerable debate as to whether modern society is effectively becoming more or less vulnerable as a result of technological innovation and adaptation over time (see Meyer et al., 1998: 240–241; Messerli et al., 2003). Only through regionally focused, historical analysis of vulnerability, however, can such questions be adequately addressed.

Climate Change and the ‘Double-Sided’ Structure of Vulnerability

There is now little doubt that the global climate is changing and human activities are exacerbating natural climatic variability. That the climate to which the world is currently accustomed will undergo further significant change is also indisputable. The details and implications of these changes, however, are less clearly understood. Such changes in climate are likely to pose new and significant challenges for society at large (Adger, 2003: 387) and for this reason climate change and its implications are increasingly being recognized as the most important influences on both biophysical and social vulnerability (O’Brien and Leichenko, 2000).

Unusually severe or prolonged drought, for example, ranks among the most devastating and calamitous of all extreme climate events, contributing to wildfires, crop failure, livestock death, food shortages and famine. Yet the vulnerability to extreme droughts is also thought to be increasing in many parts of the world (Baethgen, 1997), judging by escalating economic losses and a greater number of fatalities due to such events (Meyer et al., 1998; Kundzewicz and Kaczmarek, 2000; Easterling et al., 2001). Understanding
why vulnerabilities are changing and how and why certain sectors of the population are disproportionately affected by drought, and investigating how people respond to its effects, are considered critical steps toward designing appropriate drought preparedness, mitigation and relief policies and programmes (ISDR, 2002).

Floods are also considered to be among the most common and yet most damaging of all extreme events. No other natural hazard occurs as frequently around the world or causes as much collateral damage (Kunkel et al., 1999; Kundzewicz and Kaczmarek, 2000; Changnon et al., 2000; Berz et al., 2001: 458; Kohle and Dandekar, 2004). The frequency and magnitude of floods from unexpected and unusual rainfall, but also associated with hurricanes and windstorms, is expected to increase in the next few decades in a context of predicted global warming and sea level rises (Kundzewicz and Kaczmarek, 2000; Changnon et al., 2000; Yin and Li, 2001; IPCC, 2007: 6). Yet vulnerability to floods and, it follows, flood losses, is also a product of anthropogenic change. Increasing deforestation, urbanization and river regulation and decisions to settle floodplains either through choice or due to land pressure, have rendered people in some locations effectively more vulnerable to flood risk. Moreover, although changes in technological development and agricultural practices can help to create a society that is effectively better able to survive the impacts of such events, they can also lead to over-dependence upon these systems. Indeed, it has been argued that a reliance on existing flood alleviation schemes has actually encouraged people to settle, build on or exploit lands in even higher risk zones (Kundzewicz and Kaczmarek, 2000). As suggested above, combined with population expansion, such developments can and will effectively increase the level of social vulnerability to the impacts of flooding over longer timescales (Messerli et al., 2000).

Climate change and weather events could also have important health implications. Climate can constrain the range of infectious diseases and can also influence pathogens, vectors, host defences and habitat, and many diseases are thought to be influenced by weather conditions or show strong seasonality (Patz et al., 2000, 2005). Global warming, however, is thought to be playing an increasingly important role in driving the global emergence and redistribution of infectious diseases, while extreme weather events may influence the timing and intensity of infectious disease outbreaks (Epstein, 1999, 2001, 2002; Patz et al., 2005). Variation in the incidence of vector borne diseases, for example, has been strongly associated with extreme weather events and annual changes in weather conditions (Zell, 2004). El Niño Southern Oscillation (ENSO) events in particular are often accompanied by weather anomalies that have been strongly associated with disease outbreaks over time (Epstein et al., 1997; Epstein, 1999; Pascual et al., 2000; Kovats et al., 2003). There is considerable debate about the precise
nature of the health impacts of climatic changes, the nature and timing of the effects and their possible beneficial or adverse consequences (McMichael et al., 2006). Identifying the causal associations between climate, extreme events and disease outbreaks remains a major challenge (Kovats et al., 2003: 1482) and a better comprehension of the linkages between climate variability and disease should be seen as imperative if predictive models to guide public health responses are to be devised (Parmenter et al., 1999: 814).

Climatic changes will thus disrupt the way people live and interact with their environment and with each other (Chen and Kates, 1994: 3) and will pose challenges to future livelihood strategies for everyone (Bohle et al., 1994). Of course, unpredicted changes or extreme weather events, ‘when climate surprises occur in unexpected places or with unexpected frequency’ (Streets and Glantz, 2000: 99), have the potential to affect, and indeed disrupt, even the most robust of environmental, social and economic systems. It is anticipated, however, that the impacts of future climate changes are most likely to be felt more severely by natural resource dependent communities (Adger, 2003), and particularly by those societies in the developing world (Liverman, 1999). Agricultural economies are indeed thought to be more vulnerable to climatic hazards than industrialized ones, while conditions are most critical for environmentally, politically, socially or economically marginalized communities (Meyer et al., 1998; Cutter, 1996; Liverman, 1999), whose ability to adapt to and recover from environmental changes and biophysical events can be limited or constrained by limited access to natural resource or financial capital (Fraser et al., 2003; Mirza, 2003). People who live in arid or semi-arid lands, in low lying coastal zones, in water limited or flood prone areas, or on small islands are obviously especially vulnerable to climatic variability and any changes therein. The very young and very old are also often regarded as especially vulnerable, while differences in health, or access to health facilities, ethnicity, education, and learned experience with the hazard in question can all influence vulnerability (Meyer et al., 1998). Moreover, women in some parts of the world might also be differentially more vulnerable than men to environmental changes, particularly in developing countries where they are often responsible for agriculture, fuel wood and water management and hence are disproportionately affected by drought, deforestation and water pollution (Liverman, 1999).

Inasmuch as many climate change predictions have tended to be at best pessimistic and at worst apocalyptic (Liverman, 1999: 112), the predicted impacts for all these different sectors of society are similarly gloomy. Past climate impacts research, for example, and much of the continuing policy discussion has viewed climate change as something of a Malthusian threat to the world’s overall ability to produce enough food and support a rapidly expanding population (Chen and Kates, 1994: 4). Vulnerability to climate change has been considered to be the very ‘key to human security’ (Bogardi,
Indeed, climate change, and an increasingly ‘weaponized’ world, have been identified as the two most important challenges facing the world in terms of international security (McBean, 2004: 183). Environmental security discourses, for instance, have drawn links between climate change, environmental degradation, economic decline and the debt crisis, and have positioned climate change as a high priority security concern, with the potential to stimulate or aggravate conflict and tension both within and between nations (Homer-Dixon, 1991, 1995). Moreover, by extension, the implications of climate change have also been highlighted as a potential cause of environmental migration, contributing to the movement of thousands of ‘environmental refugees’ across borders (Barnett, 2003).

Although climate change undoubtedly poses risks to human welfare and as such represents a security concern, literature on such themes has been criticized for being more theoretically than empirically driven and for being motivated by predominantly northern geostrategic interests (Barnett, 2003: 8). Furthermore, the overemphasis on pessimistic prediction has tended to overshadow any net benefits that might be derived from climatic changes measurable through increased agricultural productivity, improved availability of key resources such as water, a reduction in some risks, such as those associated with flooding or decreased climate related expenditures. There has been a general reluctance among both scientists and policy makers to discuss the existence of any such positive outcomes lest they undermine efforts to secure global consensus on the implications of climate change (O’Brien and Leichenko, 2000: 223; 2003) and rightly so. This general pessimistic stance, however, has also, to some extent, obscured the fact that vulnerability to climate change does have an orienting function and that human societies are adaptable and have developed institutions and cultural coping strategies to deal with the impacts of environmental changes (Hassan, 2000; Fraser et al., 2003). This is particularly true of extreme or ‘surprise’ events which can, under certain circumstances, provide a ‘window for positive change and impetus for remedial action’ (Streets and Glantz, 2000: 100).

On this theme, Vogel (2001) has suggested that greater emphasis needs to be placed on the ‘double sided structure’ of vulnerability, that is to say, studies of vulnerability that also pay attention to adaptive capacity. Adaptation in this sense can be defined ‘as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects or impacts in order to alleviate adverse impacts of change or take advantage of new opportunities’ (Adger et al., 2005). While most adaptation is reactive, in response to past or current events, it can also be anticipatory and planned (Smithers and Smit, 1997; Smit et al., 2000; Pelling and High, 2005: 1). Moreover, societies have an inherent capacity to adapt to climate change and these capacities are often bound up in an ability to act collectively (Adger, 2003: 388). Recent work
focusing on ‘social capital’ responses has highlighted that environmental problems may be as likely to promote community co-operation as much as conflict between communities (Liverman, 1999: 112). Community engagement may thus offer a means of reducing vulnerability to natural hazards associated with climate change (Abramovitz et al., 2001). Although there has been an ‘explosion of interest’ in such studies of adaptation to climate change in recent years (Adger et al., 2005), there is still a need for a more comprehensive understanding of the pathways through which social resources are accumulated, on the influence of political structure on decision-making processes within communities and on the role of institutions and culture in shaping adaptive capacity and action (Pelling and High, 2005: 2).

Vulnerability is thus a composite and dynamic concept which means different things to different people (Cutter, 2006). It can be discussed in ecological terms, in relation to political economy or class structure and as a reflection of social relations and, in as much, represents a multi-layered and multidimensional social space defined by the determinate political, economic and institutional capabilities of particular groups of people in specific places at specific points in time. It follows that assessments of vulnerability need to be capable of mapping the historically, spatially and socially specific realms of choice and constraint that determine risk exposure, coping and adaptive capacity and recovery potential (Bohle et al., 1994). Such complex mosaics inevitably cast doubt on attempts to describe any general patterns and trends at global scales (Liverman, 1990) and justify the need for regionally or locally focused studies which are necessarily likely to be much more revealing. Yet, to date, relatively few studies have adopted such a multi-factor regionally based approach and fewer still compare the changing vulnerability of one place to another (Cutter, 2006: 116).

There are, therefore, still considerable gaps in our knowledge of climate changes themselves, but also exposure, sensitivity, adaptability and vulnerability of social and environmental systems to any possible changes in the future (Parry, 2001: 258). We have only an incomplete understanding of differential social vulnerability in different places through time and are only partially aware of the ways in which adaptations at different scales of human organization may interact and in some cases lead to differential or unexpected effects. Moreover, we do not know the extent to which adaptation might help overcome or exacerbate the diverse threats climate change poses in a more crowded and demanding world. Further work is needed to identify and integrate information about exposures, sensitivity and adaptability in the past in order to provide more detailed information about the potential impacts and responses associated with future climate changes (Parry, 2001: 258).
Exploring Climate and Society in Mexico

Mexico represents one of the most climatically sensitive areas of the world (Wallen, 1955; Kutzbach and Street-Perrott, 1985; Liverman, 1993). The country lies in a latitudinal belt that is sensitive to fluctuations in atmospheric circulation and has, accordingly, experienced climatic change on the long (Heine, 1988; Bradbury, 1989; Metcalfe et al., 1991) and short timescales (García, 1974; Jáuregui and Kraus, 1976; Jáuregui, 1979; Metcalfe, 1987; O’Hara and Metcalfe, 1995). Such changes can be explained by present day climatic mechanisms.

The Mexican climate is influenced by two dominant atmospheric circulation systems. These are the trade winds, which deliver summer rainfall to the central and southern regions of the country when the Intertropical Convergence Zone (ITCZ) shifts northwards, and the subtropical high pressure belt, which brings stable dry conditions to the country during the northern hemisphere winter, when the ITCZ is displaced equator-wards. The northern part of the country is climatically distinct from the central and southern regions and tends to be marginal to the summer trade winds, though the northwest of the country is affected by the westerlies during the boreal winter, which can bring rainfall to this region.

The distribution and total annual rainfall across the country are determined by shifts in the strength and location of these dominant atmospheric circulation systems. Seasonality of precipitation, and variations therein, and the incidence of tropical storms also dictate changes in the temporal and spatial distribution of precipitation. Some drought events may relate to summer high pressure which can disrupt the flow of moist air, creating a mid wet season drought or canicula (Liverman, 1999).

A number of other climatic features play an influential role in the distribution of rainfall and annual precipitation totals. These include hurricanes and tropical cyclones, which typically affect both Caribbean and Pacific coasts between May and November, with September having the greatest frequency. Mid-latitude cyclones can bring rain, hail, sleet and snow. Severe thunderstorms, which form along or ahead of cold fronts, are also common during the spring and summer months and are often accompanied by hailstorms (Mosiño Alemán and García, 1974). ENSO events are thought to represent the most significant cause of inter-annual climate variations across the country. Evidence of ENSO related rainfall anomalies for the instrumental period, for example, suggests that during warm ENSO (El Niño) events, an enhancement of the mid-latitude westerlies brings above normal rainfall to northern Mexico in the normally dry season between November and April, while a reduced flow of air across the country with the ITCZ well
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Climate History and Vulnerability in Mexico

Climate changes on a range of timescales have had implications for social and economic well-being throughout Mexican history and prehistory. Yet by the time Hernando Cortes and the first Spanish conquistadores arrived in Mexico in 1519, the region had been the site of some of the most advanced civilizations of the western hemisphere. A number of scholars have investigated the nature and diversity of landscape changes associated with the climate risk avoidance strategies of such ‘traditional’ and pre-Hispanic agrarian societies (Wilken, 1987; Whitmore, 1992). The most significant