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ONE DECADE OF DROUGHT AND TWO OF NEOLIBERAL REFORMS IN THE SIERRA SONORENSE: RESPONSES BY THE RURAL POOR*

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ABSTRACT

Since the mid-1990s, Northwest Mexico has been experiencing drought conditions. As Mexico's number one irrigator, the state of Sonora's agricultural sector is particularly concerned about the availability and distribution of surface and ground water. Drought has contributed to a sharp decline in cultivated area, the abandonment of land, and permanent out migration of a large sector of the rural population. This paper examines the vulnerability to drought of small farmers in the Santa Cruz and Magadalena basins, south of the Sonora-Arizona international border. Farmer's ability to respond to drought is considered within the larger context of neoliberal reform policies, social inequality, and free trade between Mexico and the U.S. By focusing on the most vulnerable, the paper argues that informal social networks and collective organization are key strategies to improve adaptive capacity, particularly for those who do not have access to state sponsored adaptations.

> The vegetation is drying up and most people blame the excessive heat and the lack of water. In the ranch we used to have springs that had been there our entire lives and five years ago they started to dry up. I was born here 61 years ago, my grandparents were born here, never had we seen trees drying, the old *alamos* (poplars) are dying, the oaks, mesquites, everything, even undesireble weeds, the ash trees, the weeping willows . . . everything is drying up (Resident of Imuris, Sonora, 2004).

Mexico's northwestern state of Sonora, in the northern hemisphere desert belt, is a semiarid region where precipitation is low and highly erratic, where water is scarce, and where multi-year droughts can have devastating social and environmental consequences. Despite the challenges presented by a semiarid environment, Sonora produces one-third of Mexico's wheat and is one of the country's top five agricultural producers. High productivity in a desert environment

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requires a steady flow of water from rivers and underground aquifers to irrigate 650,000 hectares (ha), out of a total of 700,000 ha that constitute the state's approximate land surface under cultivation (Vásquez-León and Bracamonte Sierra 2005). This places Sonora as the country's number one irrigator. The availability, distribution, and use of surface and ground water are thus fundamental concerns, which relate to the region's long-term sustainability and to the viability of those livelihoods that depend on the natural environment (Wilder and Romero Lankao 2006).

Since the mid-1990s, the state of Sonora, like much of northwest Mexico, has been experiencing a prolonged and relentless drought. For much of the past decade precipitation has been well below the 437 millimeters (mm) average (Magaña and Conde 2000) affecting water availability and agricultural production. In this paper I examine the vulnerability to drought of small farmers in several rural *municipios* (roughly equivalent to U.S. counties) of the Santa Cruz and Magadalena basins, at the northern end of the state, just south of the Sonora-Arizona international border. Like in the rest of Sonora, the region has been greatly affected by the current drought, which has contributed to a sharp decline in cultivated area, the abandonment of land, and permanent out migration of close to 30 percent of the rural population. A good indicator of the severity of the drought and its impact on agriculture in the region is a dramatic reduction in the number of groundwater wells in use for irrigation, as wells either dry up or water tables decline to the point where it becomes too expensive to irrigate. In the Magdalena Basin, Mexico's Ministry of Agriculture registered a decline of 67 percent (from 629 to 426) in the number of wells used for agricultural purposes from 1991 to 1999 (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación* 2003). A corresponding decline of 46.5 percent in cultivated area was registered from 1998 to 2004 (from 3,042 to 1,627 hectares).

Drought, however, is not the only culprit. Along with lower annual precipitation and higher temperatures, farmers also note the role of the North American Free Trade Agreement (NAFTA), lack of access to state support programs, and land privatization. Drought must then be considered in the larger context of neoliberal reform policies by the state, social inequality at the regional and local levels, and the influence of the U.S. as Mexico's gigantic trading partner to the north. The degree to which farmers and ranchers in the region are vulnerable to drought varies according to the socioeconomic conditions under which producers operate and make decisions. Differential welfare levels and access to adaptive resources (water, technology, financial resources, government programs, marketing

and institutional networks) as well as national and international agricultural policies have had major impacts on producers' abilities to respond to the drought.

In this paper I focus on the most vulnerable, the small-scale farmers who constitute most producers in the state and whose strategies to deal with drought are becoming increasingly ineffective. I assess their vulnerability to severe and prolonged drought and examine the different ways in which they are confronting and dealing with its impacts. I argue that informal social networks and collective organization are key strategies to improve adaptive capacity, particularly for those who do not have access to state sponsored adaptations. Participation in collective strategies and networks can make a difference between improving resiliency and remaining in agriculture, or going bankrupt to perhaps join the ranks of "illegal" workers in the U.S. or the urban poor that struggle to make a living in already crowded cities.

The research presented in this paper is based on fieldwork conducted in 2004. The study used a participatory ethnographic approach to conduct a community-level assessment of climate-related vulnerability. In-depth interviews were conducted with a variety of stakeholders, including government officials, extension agents, small and large farmers, *ejidatarios* and *comuneros*[1] (communal land holders), private landowners, and water managers. Existing secondary information also was collected and analyzed from such agencies as the *Instituto Nacional de Estadística Geografía e Informática* (INEGI), the *Secretaría de Agricultura, Ganadería, Recursos Hidráulicos, Pesca y Alimentación* (SAGARPA), and the *Comisión Nacional de Agua* (CNA).

I begin by presenting a brief description of the study region, its socioeconomic and physical characteristics, highlighting the problems and dilemmas faced by the agricultural sector in the study area in relation to drought, land privatization, and NAFTA. I then focus on the strategies used by producers to deal with these multiple problems, including migration, the search for off-farm work, as well as changes in productive activities within the farm. The last part of the paper focuses on two case studies of producers that operate in two very different socioeconomic contexts. Their responses illustrate that it is possible to develop a long-term strategy that takes into account the likelihood of drought, the reality of diminishing

[1] *Ejidatarios* and *comuneros* are both communal landholders. *Ejidatarios* can hold individual parcels of land within an *ejido* and also have access to the *ejido's* communal lands. Comuneros belong to agrarian communities where all land is held communally.

water resources, and the unequal socioeconomic context that the most vulnerable farmers must confront.

DROUGHT AND VULNERABILITY

The literature on vulnerability to climate variability and change increasingly recognizes that the social system creates the conditions by which a drought or any other extreme event can become a socioeconomic and environmental disaster (Kelly and Adger 2000). Drought is a relative notion and must be considered from a physical and a socioeconomic perspective. As defined by Mexico's Drought Research Center (*Centro de Investigación Sobre Sequía* 2004), drought is a period when annual precipitation is below average, which persists through time, and may lead to marked hydrological disequilibrium in a specific region. The severity of drought from a socioeconomic perspective depends not only on its intensity (the degree of dryness) but also on its duration (the length of time of a dry period), on the surface area affected by it, and on the degree of dependence on water resources. For agricultural livelihoods a drought is present when there is a marked deficit in precipitation to the point where the humidity of the soil is below the level required to undertake productive activities and when irrigation water is either not available or too costly to extract. This leads to a significant reduction in total crop production or to a significant decline in cattle herds (*Centro de Investigación Sobre Sequía* 2004). There are several reports (Govaerts and Sayre 2008) that assess the impact of drought on the productivity and economic profitability of the agricultural sector as a whole. These often focus on mechanized export commodity producers from the large irrigated regions in the state. Even though their losses from drought may be the largest in monetary terms, their livelihoods are not threatened, as is the case with Sonora's small rain-fed farmers (Vásquez-León and Liverman 2004).

Whereas assessments of total crop loss provide important data to understand the impacts of drought on a specific region, a sectoral approach hides the rich detail that emerges when examining different types of producers and regions. Variability is critical to a better understanding of not only the impacts of drought, but of the multiple strategies, both failed and successful, that rural populations build on to adapt, increase resiliency to drought, and find a path toward the development of sustainable livelihoods.

Because drought is an expected phenomenon in Mexico's northwest, humans have adapted to periodic droughts through generations and have been generally able to respond to short-term events. The development of small scale, highly diversified agriculture in combination with hunting and gathering, or, in more

recent times, with off-farm work and ranching (Spicer 1962; Sheridan 1988; Vásquez-León and Liverman 2004), are strategies designed to improve adaptive capacity in an environment where water is a scarce resource. An intricate policy arena shaped by socioeconomic and political pressures at the local, regional, and global levels, however, exacerbates the uncertainty that drought and other extreme events generate. It is within these multiple contexts that the feasibility for developing sustainable strategies must be assessed. Just as a long-term drought may eventually erode the capacity to deal with drought and force those most dependent on water resources to abandon their livelihoods, it may also result in more permanent adaptations, which require substantial investment in technological, institutional, and social change (Nelson and Finan 2000; Vásquez-León, West, and Finan 2003).

Holling, Gunderson, and Ludwig (2002:8) provide a useful definition of sustainability that refers to "the capacity to create, test, and maintain adaptive capability." From a systems approach to resource management, adaptive capability implies the ability and knowledge necessary to respond to environmental and human-caused fluctuations in local resources, in a way that overexploitation of critical resources is avoided. In a semiarid environment like northwestern Mexico, that critical resource is water. Understanding how climate and hydrology create conditions of vulnerability, how different types of farmers deal with drought and affect the natural environment, and how the larger policy arena facilitates or hinders adaptation strategies requires us to look beyond the sectoral assessments of drought impacts.

Social scientists are increasingly looking at the differential impact of climatic events on society, highlighting the socioeconomic and environmental contexts that influence people's daily lives, including larger structural inequalities, access to critical resources, and public policy (Schipper and Pelling 2006; Ray et al. 2007). Wealth, technology, education, and access to institutional resources are all factors that greatly influence the capacity of a particular group or sector to adapt to climate variability (Peacock and Girard 2000; Dixon, Smith, and Guill 2003). In turn, power-based relations help explain how and why some groups in society are more vulnerable to climate than others (Denton 2002; Oliver-Smith 2006). With Mexico, several authors tackle the complex current policy scenario that is leading to an emphasis on short-term adaptation and difficulties for the most vulnerable to deal with drought and other extreme events (Bracamonte Sierra 2001; Eakin 2006). Wilder and Romero Lankao (2006) focus on the decentralization of water resources as part of Mexico's neoliberal reform strategies. They present two case studies from

large irrigation districts in Sonora that clearly indicate that the privatization of land and water assets has been "less an instrument aimed at improving efficiency than a channel for preferred treatment for capital accumulation by private entities" (Wilder and Romero Lankao 2006: 1977). Water policies have disproportionately affected ejidatarios, many of whom, given the current drought, have decided to abandon their land altogether. As these studies indicate, the experiences of marginalized populations are rooted in socially constructed ways of living that make those that are most destitute persistently vulnerable in their everyday life. By focusing on the most vulnerable, Paavola and Adger (2006) and Tschakert (2007) also demonstrate the importance of paying attention to the question of resilience and adaptation with an emphasis on how, by ignoring the poor, society risks downplaying adaptations that might be critical to encourage adaptive capacity and long-term sustainable livelihoods.

Within the climate vulnerability literature more attention is given to the implications of informal social networks and social capital in reducing risk for most vulnerable groups (Adger 2003). These studies pay close attention to how well established networks of exchange within a defined socioeconomic group allow for the sharing of knowledge, risk, information, and capital resources during times of crisis. Informal social networks are particularly important in reducing exposure to climatic and other risks in a context where social trust in mainstream society is problematic (Bebbington and Perreault 1999; Pelling and High 2005).

This paper attempts to contribute to the emerging vulnerability literature that focuses on the most vulnerable by highlighting individual and collective adaptations of farming livelihoods both at the household level and at the level of communities. Although the paper does not focus on the role of formal collective organizations—be it as cooperatives or associations—on vulnerability reduction, the case study indicates that strategies to develop adaptive capacity seem more promising among small-scale resource-poor farmers who have resorted to forming more formal organizations. Collective organization may allow individual farmers to adapt to a changing climate, new agricultural policies, and market liberalization better. Because smallholder rural societies often represent values that center on place and community where the goal is not so much to maximize profit but to achieve a viable and stable livelihood in the community and on the land (Netting 1993), grassroots organizations may play a fundamental role in allowing rural populations to develop adaptive capacity and reduce vulnerability in the long-term.

THE STUDY REGION

The study region encompasses the Santa Cruz and Magdalena River Basins and includes the *municipios* of Imuris, Magdalena, Nogales, and Santa Cruz (see Figure 1). It is part of the Magdalena Rural Development District (DDR 140), which includes four more *municipios*.[2] The region has a total population of 195,868 of which about 25% of those who are categorized as economically active depend on ranching and farming. Given the current drought, rapid population growth is a concern as increasing urbanization and industrialization compete with agriculture for scarce water resources. The study region has an average annual demographic growth rate of between 1% and 4.66%, depending on the *municipio*. The average growth rate for the region is higher than the national average of 1% (*Instituto Nacional de Estadística Geografía e Informática* 2005).

Figure 1. The Study Region: Northern Sonora

Source: Vásquez-León and Bracamonte Sierra 2005

The region is in Sonora's mountainous area, known as the *sierra*, which, due to its varied topography, contains the smallest proportion of surface area dedicated to agriculture in the state—7% as opposed to 28% in the central-northern zone, and 65% in the southern zone. Agriculture has traditionally been highly diversified, with fruit orchards and vegetables produced during the spring and fall cycles, as well as sorghum, corn, beans, and forage crops such as rye grass and hay for cattle feed. In

[2]A Rural Development District (DDR) is the unit through which the agricultural sector is administered by SAGARPA. A DDR encompasses regions that have similar ecological and socioeconomic characteristics in relation to the agricultural sector. DDR 140 also includes the municipios of Trincheras, Santa Ana, Cucurpe and Benjamin Hill.

the past decade there has been a significant shift in the types of crops grown. As discussed below, there has been a gradual shift away from fruits and vegetables and toward increased production of forage crops. Another recent trend in the region is the establishment of greenhouses. Ranching is also economically important. Most ranching operations are cow-calf, where a breeding herd is maintained and calves are sold to feedlots in the U.S. or other parts of the state. Three fourths of the cattle in the region is *pardo suizo*, ideal for the production of milk and cheese. Most producers in the region integrate farming and cattle ranching, and cattle are often perceived as a form of insurance in case crops fail.

The sierra's uneven terrain has not permitted the development of large-scale farming. Thus, most operations are small. According to 1999 data from the Ministry of Agriculture (*Secretaría de Agricultura, Ganadería y Recursos Hidráulicos* 1999),[3] 47% of total agricultural land in the study region was held by private sector farmers, known as pequeños propietarios, and 42% of the land was held by ejidatarios. In the study area, pequeños propietarios have an average land holding of 8 ha and an average number of cattle that fluctuates between 150 to 200 head. The largest may have 40 ha under cultivation and 300 head of cattle. *Ejidatarios* usually have 10 ha of land and anywhere between 20 and 80 head of cattle.[4] Some *ejidatarios* are also small private owners. These often use communal lands for cattle grazing and their private parcel for the production of subsistence and commercial crops. Of all producers, those *ejidatarios* that do not own individual parcels of land are the most vulnerable of all producers.

THE PHYSICAL ENVIRONMENT

Low and erratic precipitation in the region has not allowed for the development of rain fed farming. Agriculture depends on irrigation from surface and groundwater sources provided by the Santa Cruz and the Magdalena rivers basins. The Santa Cruz River basin is shared with the state of Arizona. The river begins on the Mexican side at the Sierra of San Antonio near the border at an altitude of 1,400 meters above sea level. It advances in a U-shape touching the basin's southern limit to return north, crossing the border at an altitude of 1,140 m near the city of Nogales. The river extends about 60 km and covers a hydrological region of around 1000 km^2. The Magdalena River begins north of Imuris and has an approximate length of 139 km. It belongs to the Concepcion-Arroyo Cocospera River basin,

[3]The last report for each DDR was done in 1999; more recent data is not available.

[4]In the case of *ejidatarios*, cattle are individually owned, but grazing lands are communal.

which has two important dams: *El Comaquito*, with a capacity of 32 million m^3, and the smaller dam of *El Yeso*. Both are critical for irrigators in the region. River water use depends on flow volumes, which vary seasonally and annually. Water management has been traditionally done through user associations. The water is equally distributed to individual producers through canals. An irrigation plan is drawn up by the water judge every six months, for each agricultural cycle. Depending on the quantity of water available, each farmer will irrigate for a set amount of time per parcel of land. Irrigation time declines when there is not enough water. Groundwater is used for irrigated agriculture to supplement surface water from the rivers, especially during dry years when river flows are low. The Magdalena groundwater basin covers an area of 131 km^2. Aquifer levels vary between 2 and 17 meters. The Santa Cruz groundwater basin covers an area of 203 km^2 with aquifer levels that fluctuate between 1 and 25 meters (Vásquez-León and Bracamonte Sierra 2005).

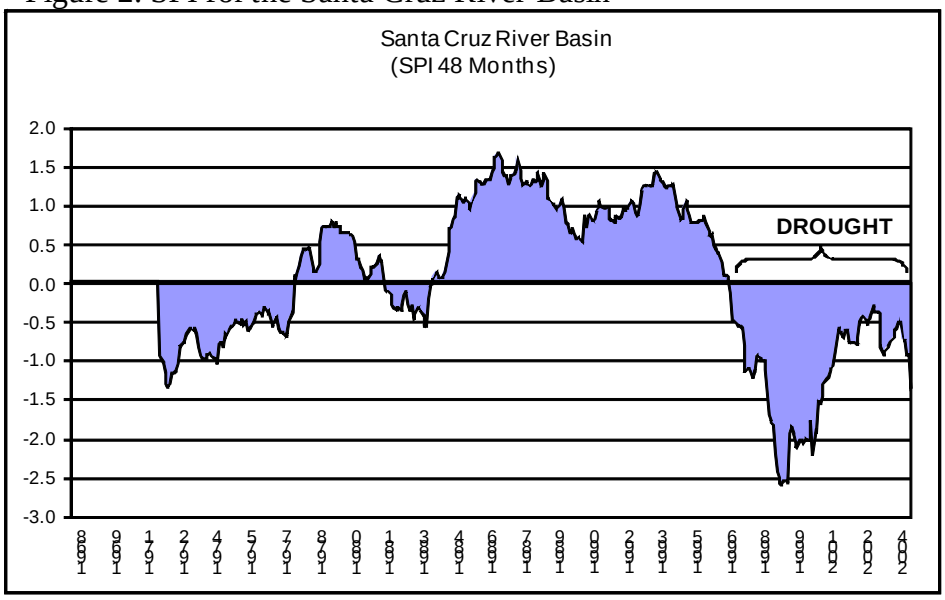
Water availability depends on precipitation, which, when lacking, creates considerable anxiety. Climatically, the region is characterized by a bimodal distribution of annual rainfall and high year-to-year variability. The region receives an annual average precipitation of 413.1 mm, of which 50% fall in the months of July and August. Summer or monsoon rains are strong, highly localized and last for short periods. Average annual temperature for the region is 18.7° C, with summer temperatures that go as high as 28.1° C in the valleys. More gentle winter rains, known as *equipatas*, fall in the winter months of December and January, when minimum temperatures reach 10.5° C. These more persistent and mild rains are critical as they contribute to groundwater recharge, increased flow volumes in rivers, and increased snowpack in the mountains, which feeds the rivers as it melts during the spring.

Multi-year droughts represent the most significant climate-related hazard, having major long-term impacts on the viability of irrigated farming. The severity of the drought in the region during the past decade is evident when looking at the Standardized Precipitation Index (SPI). As shown in Figure 2, according to the CNA, the long-term SPI for the Santa Cruz River Basin has been below the average range from 1996 to 2005 (Vásquez-León and Bracamonte Sierra 2005).

Besides lower annual precipitation, farmers also observe excessive summer temperatures and erratic summer rains that are often stronger, of short duration and more localized, greatly contributing to erosion. In addition, farmers also talk about a greater incidence of late summer rains and stronger and localized tropical storm precipitation.

The region also has suffered from periodically devastating floods. The last flood occurred in 1993 and was so severe that it destroyed crops and took with it several old prune trees. All these climatic factors affect farmers' abilities to plant and harvest crops.

Figure 2. SPI for the Santa Cruz River Basin



Source: CNA, Hermosillo Delegation

THE IMPACT OF DROUGHT ON FARMERS AND RANCHERS

The consequences of the drought have been devastating for most producers in the region. Below average precipitation results in low availability of pastures and vegetation in natural grazing areas, which are often at higher elevations. This forces cattle to stay in the valleys where they have to be provided with water, forage, and supplemental feed, significantly increasing production costs. As one producer points out, "a cow can eat in one year more than what is worth in food, but people continue buying feed because we always have hope that the rains will start again." As costs of production increase, the quality of cattle decreases and with that, household income declines. As most producers indicate, ten years ago their cows produced twice the milk that they produce today, thus income from milk and cheese, from which a significant proportion of annual income is derived, has declined. High quality studs and breeding cows are more difficult to achieve because cattle weights are declining and the quality of meat is deteriorating. Income from calf sales, which constitute the most important source of earnings in the region, is also declining. A calf that would have been sold at 200 kg is now being sold at 150 kg. For those who

do not have access to wells from which to extract groundwater, the situation is more critical because they cannot produce forage crops and must buy forage to sustain their cattle.

Those who do not own cattle and specialize in the production of vegetables are also at increased risk when the availability of irrigation water declines. Such is the case of Don Sebastián,[5] who has been farming in the region for 14 years. In 2000 he began to export squash, chile, and cucumber to the U.S. However, during the year that our study was carried out, he had decided not to plant at all because of lack of water. Too little water will result in a low quality crop that commands a low market price. For vegetable farmers, in addition to drought, heavy late summer rains have been particularly damaging. Torrential rains at the end of the summer will often rot or waterlog chiles and increase the incidence of pests and insects, fungal disease, and weeds.

The drought has also led to an increase in conflict over water resources. The *Comaquito* and *Yeso* dams have been well below capacity through most of the drought years. Upstream farmers use much of the already scarce water to irrigate their fields. Whereas most upstream users are *pequeños propietarios*, *ejidatarios* are mostly located downstream and receive a substantially lower amount of water. The drought has also led to direct competition with urban areas for water use. Such is the case of five wells built in the municipio of Imuris to provide water for the urban center of the *municipio* of Nogales. This has created considerable conflict, as producers feel that they were neither consulted nor compensated for the loss of water.

STATE POLICIES AND THE ABILITY TO DEAL WITH DROUGHT

Structural adjustment reform policies that started at the beginning of the 1990s have negatively affected farmers' abilities to develop viable long-term adaptation strategies in response to drought and water scarcity. Changes in the Agrarian Reform Law have contributed to uncertainty and heightened the sense of vulnerability at the regional and at the local level. In Imuris, officials calculate that 305 of the original landowners have sold their land in the last 20 years. For *pequeños propietarios*, land privatization immediately opened the option of selling, mortgaging, transferring or renting the land when it no longer meets subsistence needs. For *ejidatarios* and *comuneros*, the experience of privatization has brought a level of conflict and uncertainty that increases their vulnerability to drought (see

[5]The names of those interviewed have been changed in order to protect their privacy.

also Vásquez-León and Liverman 2004). Many have lost access to communal lands or have new neighbors whose help they cannot count on during times of crisis. Given the localized nature of precipitation in the region, dividing communal lands means that farmers lose the flexibility provided by having access to a more extensive territory in different areas, thus increasing their chances of losing all of their production to drought or heavy summer rains and fall storms.

In addition, selling *ejido* lands to outsiders has brought a level of conflict that was absent in the past. Such is the case of those who buy land for investment to gain access to government programs. As one *ejidatario* complained, "we have been working our butts off for generations in the *ejido*, working 365 days per year, struggling to obtain enough food, with cars that are falling apart. And all of a sudden you see these people coming in huge, brand-new trucks, treating us like if we were scum . . . that really makes you lose hope."

Some buyers are involved in illegal activities and are not interested in producing. As one *ejidatario* explained, "one cannot compete with those people, they bring money and are only interested in money laundering activities. One goes to their rancho to ask them to behave according to the norms of the *ejido* . . . to clean their portion of the irrigation canals or else their water has to be cut off, as the rule goes, and they point a gun at you. That kind of corruption makes relationships very difficult and without the help of fellow *ejidatarios* during difficult times, it is impossible to recover from a bad year."

NAFTA and market liberalization policies have also contributed to the heightened level of insecurity. The marketing of crops has become harder because quality standards and bureaucratic prerequisites are difficult to meet. Produce imported from the U.S. sells better at local and regional markets because it comes in packages that are more attractive to consumers or because prices are so low that local farmers simply cannot compete. For example, lettuce producers at the local level complain that U.S. producers often flood local markets with lettuce that they are not allowed to sell in the U.S. At the time of our study, a former lettuce producer pointed out that the price of lettuce in the regional market was at 30 pesos[6] per box of 24 lettuces, which is the actual cost of the box itself. As he said, "the government does not protect us here, everything that comes from the U.S. can get through, and here in Mexico, well, everyone wants American lettuce, even when its quality is lower. We ask for support from the state and all we hear is that the market was liberated and it is now liberated, there is nothing else to do."

[6]At the time of the research, 1 U.S. dollar was roughly equivalent to 10 Mexican Pesos

Despite the geographic proximity, the option to sell in the U.S. is not any easier. To sell their products across the international border, farmers must meet standards that, particularly for the small farmer, are extremely difficult to achieve, let alone understand. In addition, as several farmers stated, there is a sense of distrust toward those small farmers who want to create associations to export their products collectively to increase their ability to compete. Small producers also are aware that they cannot compete with farmers in the U.S. and Canada whose production is partly subsidized by government programs (Bracamonte Sierra 2001).

The dramatic reduction in the region's production of fruits and vegetables, which have traditionally been the most important income generator in the region, is largely attributed to NAFTA, although, as explained below, part of the explanation is also related to the drought. According to a SAGARPA extension agent, before NAFTA there were 1,400 ha in vegetables and 700 ha in fruit orchards in the study region. At the time of our research there were only 634 ha in vegetables and the production of apples and quince had declined by more than 50%.

Although there are state-sponsored agricultural programs designed to help producers compete in international markets and also to deal with the consequences of drought, aid is often more accessible to those who are wealthier, better connected, and better educated. Programs such as the *Programa de Apoyos Directos al Campo* (PROCAMPO), a crop subsidy for specific grains given on a per hectare basis, have focused on the state's southern coastal zone, the center of Sonora's large-scale industrial irrigated farming. Information about programs and application forms are often available to those who have better access to various sources of information, such as those who have computers and navigate the Internet. Computer literacy is a major barrier to most producers in the study region. Access to credit is another major constraint. As the president of the local cattle association indicated, the association applied for credit two years prior to our research. They had not heard back. Bank managers are more interested in large-scale commercial producers and have no interest in negotiating agricultural credits with small producers, as the latter represent a higher risk for the bank. Lack of credit and access to government programs has precluded farmers from adopting water conservation technologies, which are, as explained below, fundamental to small-scale farming in a semiarid environment beset by drought.

Finally, producers have also been negatively affected by water conservation policies issued and implemented by the CNA. Whereas the CNA has not allowed for the opening of new wells since the early 1990s, in the past there were no restrictions in terms of how much water could be extracted from a registered well.

In 2004, however, the CNA implemented a restriction by which each well must have a meter to determine water volume pumped and only a certain amount of cubic meters can be extracted. For local producers this measure makes sense from the point of view of conservation, particularly in areas where aquifer levels are too low. The measure, however, imposes an unbearable burden for those producers who are at the brink of bankruptcy. For some, this measure has been the breaking point that has led them to abandon their land.

ADAPTATION STRATEGIES

Although small farmers in the *sierra* may lack access to the various forms of state-sponsored programs, they, in the words of Fordham (1999:20), "are never simply victims, but also survivors and active agents." Producers in the study region have developed a variety of strategies to deal with drought. These can be divided into a) those that allow farmers to cope in the short-term and involve incremental, low-input, and short-term investments that help farmers "get by" during droughts, and b) those that are more permanent and imply a significant transformation in their agricultural operations. For those that have limited access to institutional adaptations, more permanent adaptations also include the strengthening of social networks and collective organization.

In the first case, there are preventive measures such as the storage of forage crops during years of good rain; the buying of supplementary feed during critical years; and the sale and reduction of livestock. Farmers may also reduce the amount of hectares under cultivation to lower water use. In 2004, of the 15,000 ha available for agricultural production in the study region, only 6,000 ha were cultivated (SAGARPA 2003). Farmers may also switch to less water demanding crops, or temporarily reduce the land dedicated to food crops to increase the production of forage crops that will allow them to keep some cattle. This is becoming an increasingly important trend. While in 1998 there were 589 ha cultivated in hay, by 2004 the volume had gone up to 1,138 ha.

Those who can plant drought resistant grass, such as buffel, consider this as an important strategy. A few farmers have received resources from the *Programa de Estímulos a la Productividad Ganadera* (PROGAN)—a federal program designed to encourage extensive cattle ranching—to plant buffel grass and build water storage tanks and fences. Because land size is relatively small in the region, however, the amount of funds received is also very small. Combining strategies allow farmers to persist in spite of drought. As one local producer stated, "one searches here and there, making small changes to be able to keep some cattle and also making changes

in the *milpa* (parcel), looking for ways to reduce water use or to take the most advantage out of the few hours of water that we receive, so one uses the best land in the *milpa* and everything else is left alone because there is no water."

Because lack of water is a main concern, producers are conscious that they must look for more permanent solutions that will allow them to continue their way of life and better prepare them for future droughts. More permanent measures at the farm level involve the construction and deepening of wells, an option that is no longer relevant in the region given new regulations issued by the CNA; the adoption of water efficient irrigation technologies; and the construction of green houses. The adoption of water-efficient irrigation technologies has been the most important adaptation for larger, wealthier producers. Sprinkler and drip irrigation systems have a higher field irrigation efficiency (80 to 90 percent respectively) than the traditional gravity furrow system (60 percent), where up to 50 percent of the water may be lost to deep percolation, runoff, and evaporation (Ayer and Hoyt 2001). It is estimated that only 15 percent of producers in the region have adopted water efficient technologies. Wealthier farmers have also built greenhouses, dramatically increasing production per hectare and reducing water use. At the time of our study there were 29 ha of greenhouse tomatoes and 4 ha of cucumbers. Greenhouses, however, are not an option for most producers in the region. Not only do they require a considerable monetary investment, but also a great deal of expertise.

Strategies to cope with water shortages are not limited to the farm or ranch. Households, for example, diversify their sources of income. To supplement household income, men often migrate during the off season to work as farm laborers in the state's southern zone or find temporary employment outside agriculture. Many agricultural families in the region have young adults who migrate permanently in search of work outside the region and once employed send remittances to help. As one *ejidatario* recounted, "we have 5 kids, they all went to the other side [U.S.], the girls all got married, our two sons are single but also working. None of the kids stayed at the farm because frankly it does not produce enough. And they send a little help here and there, the girls always send more, and all in all, it is enough for us to survive and keep the *milpa* for self consumption and also out of pride." Although not quantified, the region's federal deputy estimates that after tourism, remittances from relatives are the second most important source of income in rural areas.

Although women have traditionally worked at home and on the farm, it is now common to find that they work elsewhere. This trend began at the beginning of the 1990s and today women's contributions to household income is substantial.

Sometimes female household heads contribute 50% or more toward household expenses. Working in the *maquila* (factory or assembly plant) industry, cleaning houses north of the border, or small commerce are common occupations. Some women have organized to access resources from the *Instituto Sonorense de la Mujer* (ISM).[7] Those able to secure loans have opened small shops like bakeries, beauty salons, or *abarrotes* (neighborhood general stores). One of the most successful examples is the case of a women's cooperative that produces and markets cheese and quesadillas. All of the women in the cooperative are married to cattle ranchers who provide the milk that the women then process into cheese and quesadillas. With credit from the ISM, the cooperative built the structure and bought the industrial unit for milk processing.

For the most vulnerable, who lack access to critical resources (government loans, credit from private banks, remittances from relatives, or some cattle), the inability to recover leads to a vulnerability that is incremental, leading to a downward spiral where livelihoods are threatened. These are often small farmers whose wells have dried up, who use gravity irrigation but do not have enough surface water to cultivate all of their land, and who after several difficult years are forced to sell their cattle. For this group of farmers, the last recourse is to sell or abandon the land to find permanent employment outside agriculture. Local residents estimate that about 30 percent of the land has been abandoned. In these cases, the entire household relocates settling in urban areas, like Hermosillo or Nogales, or moving "to the other side," to Tucson, Phoenix or Los Angeles to face the tribulations of becoming "illegal aliens."

Promising Adaptations: Two Case Studies

The case studies presented in this section tell the story of two producers and their strategies to deal with drought. Although their experiences are shaped by entirely different socioeconomic circumstances, both have continued farming despite difficulties and has been able to adopt strategies that reduce their vulnerability in the long-term.

Case study 1: Don Fermín

Don Fermín has always been a farmer, a comunero who also represents a rural association formed by six members. Together, association members have 1,200 ha

[7]The Sonoran Institute for Women is a state organization created in 1998 with the objective of increasing women's economic, political, and cultural participation (ISM 2005).

of land and 100 *vientres* (breeding cows). They have artisan springs and a well with an electric pump that they dug to a depth of 50 meters. In the past they used river water and gravity irrigation, but due to water scarcity they have now been forced to completely rely on groundwater from the well. Association members belong to a *comuna* (collective) that had 66 original *comuneros* and 15,000 ha of communal natural grasslands. Of the 66 *comuneros*, only 33 remain, the rest sold or abandoned their land to find work elsewhere. The ones who sold their land are no longer *comuneros* and if they sell to an outsider that is not accepted by the *comuna*, the land becomes private property. Of the *comuneros* left, aside from having access to communal lands, most, like Don Fermín, are also *pequeños propietarios* and have a few hectares of privately owned land.

The drought has affected everyone to the point where natural springs in the sierra have all dried up, each of which used to sustain between 20 to 30 head of cattle. Now they must bring the cattle down to the wells in the valley, so they have had to build paths through which to transit with the animals and build water tanks and fences.

To be able to continue in agriculture, Don Fermín as an individual, but also as part of the association, has followed several strategies. In his individually owned land, Don Fermín used to plant 15 ha in vegetables and 5 ha in grasses, but the drought forced him to stop planting vegetables for three consecutive years (from 1999 to 2003). Because natural vegetation had dried up, his cattle were no longer going up the hills in search of wild grasses, so he decided to plant the 20 ha in ray grass and buy hay from middlemen that arrived from San Luis and Caborca. His wife opened a small store where she sells clothes and shoes, but their main income continues to come from ranching.

With remittances from their children and some profits from his wife's store, Don Fermín deepened wells and installed drip irrigation on four hectares. In 2004 Don Fermín was extremely proud of the 60 tons of jalapeño peppers that he harvested in those four hectares.

For Don Fermín the fact that he belongs to a *comuna* and to a rural association means a great deal. As part of the association, Don Fermín and the other association members where able to secure assistance from PROGAN and *Alianza Para el Campo* (Alliance for the Countryside), a federal program designed to increase the overall productivity of the rural sector. During a period of two years, each association member received 350 pesos for 20 animals and used the money toward fencing. The money received was not a lot, but Don Fermin is grateful because he knows how difficult it is to get anything at all. In numerous occasions he has been trying,

individually and as part of the association, to get a loan from the bank, but they have gotten nowhere.

There are also benefits to being a *comunero*. Three years ago all the *comuneros* acquired individual land titles, but as long as they remain together as group, they have each other. If it rains in someone's piece of land, but others receive no rain, then those better off will help because in the following year they know they can be in the same situation. As a group, they are also well respected by neighbors and local authorities, do not have to pay taxes, and if someone invades their lands, officials listen and respond to their complaints faster than if they were alone.

Case study 2: Gabriel

Gabriel feels that he is more of a farmer than a rancher. He started farming in the 1980s. He has 30 ha of which 20 are planted with vegetables and 10 are for forage crops. Part of his land is located in the lower valley where he has wells and cultivates vegetables—during the spring cycle he plants onion, cilantro and spinach, and during the fall he plants lettuce, cilantro, potatoes, spinach and cabbage. Gabriel is one of the few farmers that uses drip irrigation and was among the first to install the system in 2002. He also has land located upstream, where he has access to river water and where he had his forage crops, which he stopped cultivating in mid-2004 due to the lack of water. Gabriel and his two brothers have a 4,000 ha cattle ranch and sell calves for export to the U.S. During years of normal precipitation, the ranch can sustain 600 head; today they only have 200.

Drip irrigation has been Gabriel's salvation. The decision to switch technologies was not an easy one due to the high capital investment required. However, thanks to an experimental field and demonstrations by extension agents from the *Centro de Investgaciones Agrícolas del Noroeste* (CIANO) and SAGARPA, he could see the benefits clearly. He received a low-interest rate agricultural loan from the federal government through *Fideicomisos Instituidos en Relación con la Agicultura* (FIRA), which provides loans through private banks. He obtained a long-term loan for a two-year period to install the new irrigation system. In addition, Alianza covered 30% of the investment. He also received direct support from PROCAMPO.

The benefits have been substantial. As Gabriel explains, his water costs have declined by more than half. Besides that, he does not need to hire workers for weeding or applying pesticides and fertilizer, which simply go through the irrigation hoses directly to the plant. He is also producing more per hectare. As he explains, "with gravity irrigation you can only have two lines, that is, you can only produce 40 tons of onion per hectare or 8 to 12 tons of garlic. With drip, you

produce between 70 to 80 tons of onion per hectare or 20 tons of garlic per hectare because you can place up to 4 lines. Double production, half the costs." In 2004 Gabriel produced 550 tons of onion and 200 tons of garlic. Despite the drought, production has been good and Gabriel and his family can enjoy their upper-/middle-class lifestyle, which allows them to undertake frequent shopping trips to the U.S. during the holidays.

CONCLUSIONS

In this paper I have attempted to show the impact of drought on small producers in four rural *municipios* of northern Sonora, as well as their efforts to adjust their livelihoods to deal with current climatic challenges and the differential degree to which they are vulnerable to drought. The problems that small producers confront have multiple causes and are not just linked to the physical consequences of the drought. Isolating the impact of climatic events on producers and production from the larger policy context and from the socioeconomic conditions under which producers operate and make decisions is impossible. Vulnerability is determined by the drought as much as by a multiplicity of additional factors related to differential welfare levels and access to adaptive resources. The most vulnerable, mainly ejidatarios, have disproportionately bore the brunt of land privatization policies, water decentralization, subsidy reductions, and NAFTA. They are those whose ability to compete with large sophisticated producers in Sonora and the U.S. has been rapidly diminishing because they lack access to credit, government assistance, technology, enough water to assure production, and the means to maintain fertile lands. These multiple factors determine the capacity to generate short-term responses to drought as well as to develop farming systems capable of maintaining a viable production from the perspective of economic and environmental sustainability.

Farming households have responded to drought and policy pressures in a variety of ways. These range from the abandonment of land and out-migration to urban centers or to the U.S. for the most vulnerable; diversification through the incorporation of women in productive activities, an increase in off-farm work, and increasing reliance on remittances from family members for those who persist and hope that the drought will go away; and continuous reliance on agriculture through a combination of individual and collective adaptive strategies, plus some reliance on off-farm income. For small producer households, particularly for those who do not have access to state-sponsored adaptations, collective organization appears to be a promising strategy for generating adaptive capacity to the current and future

drought events. Through the formation of a cooperative organization, a group of women has increased the value of the milk produced by participating households. Being part of an association has helped Don Fermín to install drip irrigation in a small piece of land. Because he lacks access to credit, income from his wife's shop and remittances from his children have been critical. For Don Gabriel, although his socioeconomic level gives him access to state programs and credit, his adoption of drip irrigation has improved his ability to respond to drought and point to the importance of this technology in long-term vulnerability reduction.

Farming practices that emphasize collective organization, diversification by combining the production of high-value crops with livestock and off-farm work, plus the adoption of drip irrigation could in fact turn out to be viable operations with minimal support from the state. By supporting small-scale farmers in their desire to change from gravity irrigation to drip irrigation, state agencies would promote water conservation, increase the adaptive capacity of farmers, and encourage the continuation of an agricultural system capable of adapting to changes in the natural environment.

The variety of responses outlined in this paper illustrate that it is possible for the region to develop a long-term strategy for the agricultural sector that takes into account the likelihood of drought, the reality of diminishing water resources, and the unequal socioeconomic context that the most vulnerable farmers must confront. In addition, the preliminary analysis presented in this paper points to the importance of conducting future research on the role of formal collective organizations—be it cooperatives or associations—in vulnerability reduction and the development of adaptive capacity among small-scale resource-poor farmers. Collective organization may allow individual farmers to better adapt to a changing climate, new agricultural policies, and market liberalization.

REFERENCES

Adger, N.W. 2003. "Social Capital, Collective Action, and Adaptation to Climate Change." *Economic Geography* 79(4):387–402.

Ayer, H. and P. Hoyt. 2001. "Arizona Water Use." *Arizona Water Series: Number 11.* The University of Arizona, College of Agriculture: Tucson, Arizona. Retrieved January 20, 2002 (http//hermes.ecn.purdue.edu/ gopher_dir-index/wq_pub/ARIZONA% 20WATER%20-%20USE).

Bebbington, A., and T. Perreault. 1999. "Social Capital, Development, and Access to Resources in Highland Ecuador." *Economic Geography* 75:395–418.

Bracamonte Sierra, A. 2001. *Análisis de los efectos de las políticas económicas en comunidades rurales, mediante modelos multisectoriales: el caso de El Júpare, Sonora.* PhD Dissertation, UAM-Iztapalapa, México.

Centro de Investigación Sobre Sequía (CISS). 2004. Definición de la Sequia. Instituto de Ecología, A.C. Retrieved January 5, 2004 http://www.sequia.edu.mx/

Denton, Fatma. 2002. "Climate Change Vulnerability Impacts, and Adaptation: Why Does Gender Matter?" *Gender and Development* 10 (2):10–20.

Dixon, R., J. Smith and S. Guill. 2003. "Life on the edge: Vulnerability and Adaptation of African Ecosystems to Global Climate Change." *Mitigation and Adaptation Strategies for Global Change*, 8 (2):93–113.

Eaken, H. 2006. Weathering Risk in Rural Mexico: Climatic, Institutional, and Economic Change. Tucson: The University of Arizona Press.

Fordham, M. 1991. "The Intersection of Gender and Social Class in Disaster: Balancing Resilience and Vulnerability." *International Journal of Mass Emergencies and Disasters*, 17(1):15–36.

Govaerts, B. and K. D. Sayre. 2008. "Agricultura de Conservación, Hacia un Procedimiento Integrado de Agricultura Sostenible y Rentable en México". Sistemas de Manejo de Cultivos, CIMMYT, México.

Holling, C.S., L.H. Gunderson, and D. Ludwig, 2002. "In Quest of a Theory of Adaptive Change." Pp. 3–24 in *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by L.H. Gunderson and C.S. Holling. Washington: Island Press.

Instituto Nacional de Estadística Geografía e Informática. 2005. "Tasa de Crecimiento Media Anual de la Población por Entidad Federativa, 1990 a 2005". Retrieved January 5, 2005 (http://www.inegi.gob.mx/est/contenidos/espanol/rutinas/ept.asp?t=mpob09&c= 3186).

Instituto Sonorense de la Mujer. 2005. *Quienes Somos*. Retrieved January 10, 2009 (http://www.ism.gob.mx/quienes.asp).

Kelly, P. W. and W.N. Adger. 2000. "Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation". *Climatic Change* 47(4):325–52.

Magaña, V. and C. Conde. 2000. "Climate and Freshwater Resources in Northern Mexico: Sonora, a Case Study" Environmental Monitoring and Assessment 61:167–85.

Nelson, D. R. and T.J. Finan. 2000. "The Emergence of a climate anthropology in Northeast Brazil.: *Practicing Anthropology* 22(4):6–10.

Netting, R. 1993. Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture. Stanford, Calif.: Stanford University Press.

Oliver-Smith, A. 2006. "Disasters and Forced Migration in the 21st Century." In *Understanding Katrina: Perspectives from the Social Sciences* edited by the Social Science Research Council. Retrieved September 3, 2007 (http://understandingkatrina.ssrc.org/).

Paavola, J. and W.N. Adger. 2006. "Fair Adaptation to Climate Change." *Ecological Economics.* 56:594–609.

Peacock W.G. and C. Girard. 2000. "Ethnic and Racial Inequalities in Hurricane Damage and Insurance Settlements. Pp. 171–90 in *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*, edited by W.G. Peacock, B.H. Morrow, and H. Gladwin. New York: Routledge.

Pelling, M. and C. High. 2005. "Understanding Adaptation: What Can Social Capital Offer Assessments of Adaptive Capacity?" *Global Environmental Change* 15: 308–19.

Ray, A. J., G. Garfin, M. Wilder, M. Vásquez-León, M. Lenart, and A. Comrie. 2007. "Applications of monsoon research: Opportunities to inform decision making and reduce regional vulnerability." *Journal of Climate* 20(9):1608–27.

Secretaría de Agricultura, Ganadería y Recursos Hidráulicos. 1999. *Distrito de Desarrollo Rural 140-Magdalena: Carpeta Básica de Información 1997–1999*, Gobierno de Sonora, Sonora, México.

Secretaría de Agricultura, Ganadería, Recursos Hidráulicos, Pesca y Alimentación. 2003. *Programa de Desarrollo Rural Sustentable—DDR 140,* México.

Schipper, L. and M. Pelling. 2006. "Disaster Risk, Climate Change and International Development: Scope for, and Challenges to, Integration." *Disasters* 30 (1):19–38.

Sheridan, T. 1988. Where the Dove Calls: The Polictical Ecology of a Peasant Corporate Community in Northwest Mexico. Tucson: University of Arizona Press.

Spicer, E.H. 1962. Cycles of Conquest: The Impact of Spain, Mexico, and the United States on the Indians of the Southwest, 1533–1960. Tucson: University of Arizona Press.

Tschakert, P. 2007. "Views from the Vulnerable: Understanding Climate and other Stressors in the Sahel." *Global Environmental Change.* Vol. 17(3-4): 381–96.

Vásquez-León, M, C. T. West, and T. J. Finan. 2003. "A Comparative Assessment of Climate Vulnerability: Agriculture and Ranching on Both Sides of the US–Mexico Border." *Global Environmental Change*, 13 (3):159–73.

Vásquez-León, M. and A. Bracamonte Sierra. 2005. "Indicadores Ambientales para la Agricultura Sustentable: un Estudio del Noreste de Sonora" Final Report for CONAHEC. El Colegio de Sonora, Sonora, Mexico.

Vásquez-León, M. and D. Liverman. 2004. The Political Ecology of Land-Use Change: The Case of Affluent Ranchers and Destitute Farmers in the Mexican Municipio of Alamos. *Human Organization* 63(1):21–33.

Wilder, M. and P. Romero Lankao, 2006. "Paradoxes of Decentralization: Water Reform and Social Implications in Mexico." *World Development* 34(1):1977– 95.