CENTER FOR U.S.-MEXICAN STUDIES
UNIVERSITY OF CALIFORNIA, SAN DIEGO

RESEARCH SEMINAR SERIES

2002-2003

Rural Responses to Climatic Variability and Institutional Change in Central Mexico

by

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Working Paper #10/2002

INTRODUCTION

In recent years, policy-makers, academics, international agency administrators and development practitioners have become preoccupied with two related, but somewhat independent processes: first, an observed increase in global economic integration and second, changes in the global environment and its variability. We are increasingly aware that our local and national economies are deeply integrated into economic processes that take place at a supra-national level and involve institutional structures that supercede national authority or accountability (Romero Polanco 1996; Goodman and Watts 1997). We are also confronting the uneasy reality that our production and consumption habits are collectively having an irreversible effect on the planet, and that this may be related to a perceived increase in the frequency of extreme climatic events. Economic and climatic change are not only linked in cause and effect at the planetary scale, but also interact in unpredictable and complex ways in the context of regional political and trade relationships, national economic and social programs, and in the decision-making of institutions, enterprises and individuals. As O'Brien and Leichenko argue, while occurring on different temporal and spatial scales, the simultaneity of the processes of globalization and climatic change result in populations that are "doubly exposed" and thus particularly vulnerable (O'Brien and Leichenko 2000).

Small-scale farmers in developing countries are one such social group. In a world where there is increasing pressure for countries to drop agricultural subsidies and open their markets to free trade, smallholders are increasingly left without infrastructure, political and institutional support. These farmers often lack the organization and political clout of agricultural groups in more industrialized countries that would facilitate their participation in more competitive international and domestic markets. Transportation costs and reductions in state support for agricultural research and technology compound the difficulties these farmers face. Insurance industries and disaster management institutions are often absent or inadequate, and the nature of climatic variability in the tropics and sub-tropics can result in frequent and intense extreme events. These conditions are painfully evident in rural Mexico, where the proximity of the agricultural powers of United States and Canada has made the market failures and inefficiencies in Mexican agriculture all the more obvious, and has accentuated the negative implications of globalization for Mexico's farmers. In order to elaborate policies to address rural poverty and agricultural development, we need an improved understanding of how households cope simultaneously with different sources of uncertainty and adjust their

livelihoods to accommodate newly evolving environmental, political and economic realities.

Unfortunately, adaptation to climate and adaptation to economic change are typically considered as independent and unrelated processes. While scientists are becoming increasingly skilled at modeling the physical and even biological relationships that characterize the world's ecosystems, to date these models have failed to account for the dynamism and variability of the social systems that provide both the context for and human meaning of climatic variability and change (Liverman 1994; Downing, Watts et al. 1996; Smit, McNabb et al. 1996). As Bebbington writes, "The socio-economic environment in which peasant farmers operate is at least as troublesome a source of instabilities and pressures as the bio-physical environment, instabilities whose incidence farmers are often unable to predict" (Bebbington 1990: 206). These "instabilities" affect the range of choice any farm household faces as well as the resources on which a household depends in its response to change (Chiotti, Johnston et al. 1997).

In recognition of the inadequacies of climate change models to account for the full complexity of social systems, increasingly the global change research agenda is incorporating the theoretical contributions from political-ecological, structural and behavioral studies of "natural" hazards (Kelly and Adger 2000; Ribot et al. 1996). Amartya Sen's concepts of resource entitlement, political empowerment and enfranchisement, developed through his economic analyses of famine and food insecurity, have given rise to more complex theories of vulnerability that look for explanations in institutional structures, political-economic realities and resulting livelihood choices (Watts and Bohle 1993; Downing, Watts et al. 1996; Burton 1997; Liverman 1994; Smithers and Smit 1997; Kelly and Adger 2000).

Using ethnographic data collected in three agricultural communities in the states of Tlaxcala and Puebla, this paper explores the intersection of institutional change and climatic uncertainty in the production process and livelihood decisions of small-scale farm households. The research focuses on household response to the neoliberal reforms in Mexico's agricultural sector of the 1990s and to the series of climatic events that were experienced in central Mexico in 1997, 1998 and 1999. These latter events have been associated with an observed increase in the occurrence of the El Niño-Southern Oscillation phenomenon. The experience of smallholder farmers with these two parallel processes of exogenous change serves as a rough analogue of the more abstract processes of economic globalization and climatic change. The paper argues that ultimately a farm

household's vulnerability to climatic changes will depend on the series of livelihood decisions the household takes, from season to season, over the course of decades. Those decisions, in turn, are not in any way a simple product of climatic factors, but rather are the result of what Kelly and Adger have called "the architecture of entitlements, the social, economic and institutional factors that influence levels of vulnerability within a community or nation and promote or constrain options for adaptation" (Kelly and Adger 2000: 326). Documenting *adaptation in practice* to concrete events allows us to see the difficult competition between non-climatic and climatic risks in decision-making and the important role of institutions in structuring adaptation capacity.

The paper is divided into four sections. First, I provide a brief introduction to the concepts of vulnerability and adaptation. Second, I summarize some of the principal changes in Mexico's agricultural policy that occurred in the 1990s that have affected the flexibility of smallholder production strategies. Third, I discuss the results of field research in Central Mexico, focusing on four principal livelihood strategies farmers are pursuing in the case study communities and the ways in which these strategies appear to address both socioeconomic and climatic risk. The final section concludes by presenting the key attributes of adaptive capacity of the smallholders of the study and outlines an approach to social vulnerability that explicitly addresses the dynamic institutional context of production.

VULNERABILITY AND ADAPTATION

Current definitions of vulnerability continue to reflect the relatively long theoretical history of the concept and interdisciplinary debates about its meaning. Geography has served as the disciplinary forum for much of this discussion, given the discipline's strong traditions of human-environment research. Although initially vulnerability was defined largely by measures of the physical impact and extent of climatic hazards (White 1973; Burton, White et al. 1978), today most definitions of vulnerability applied to climate impacts research recognize to some extent the contributions of historical processes, structural inequalities and problems in resource access as significant factors in creating vulnerability (Dow 1992; Watts and Bohle 1993; Blaikie, Cannon et al. 1994; Liverman 1994).

In the 1990s, the climate change research community's interest in vulnerability and progress in theorizing hunger and famine coalesced in the development of definitions of vulnerability that drew heavily on political-economic and structural explanations of

poverty, marginalization and risk exposure, yet did not abandon the critical importance of the environmental hazard and its biophysical and social impacts on exposed populations (Blaikie, Cannon et al. 1994; Downing, Watts et al. 1996; Ribot 1996). Poverty, as a primary indicator of inequality in resource endowments and resource access, is now often equated with vulnerability (Chen 1994; Ribot, Najam et al. 1996). Drawing from Robert Chamber's conceptualization of how rural populations manage risk, vulnerability is now commonly defined in three dimensions: the exposure of a population to hazards, stresses and shocks; the capacity of the population to manage and make adjustments to these shocks; and the ability of the population to regain previous standards of living, or maintain the integrity of their activities, in the aftermath of the period of stress or shock (Dow 1992; Blaikie, Cannon et al. 1994; Downing, Watts et al. 1996). In this way, the concepts of adaptation and vulnerability are essentially two sides of the same coin: vulnerable populations are inhibited in their capacity to adapt, and because of this constraint, are more vulnerable.

In his research on social vulnerability to climate in Vietnam, Neil Adger returns to Amartya Sen's concepts of entitlements--the different "commodity bundles" that a person or household can access, exchange or otherwise use via their rights and opportunities (Sen 1981)--to argue that vulnerability is perhaps best understood through an analysis of livelihood resources and poverty, and the evolving policies, rules and institutions that structure resource use (Adger 1999). In this conceptualization of vulnerability, the household, or the decision-maker, becomes the appropriate unit of analysis. As Ribot argues, vulnerability analysis thus "builds outward from the household..." and "…includes the multiple temporal, spatial and social scales that impinge on the production and reproduction of everyday life" (Ribot 1996: 9). Such vulnerability analyses revolve around household decisions about the use of key resources, the institutions that frame those decisions and structure resource use and access, and the meaning of the decisions' outcomes for the household's future. Although this approach recognizes that vulnerability arises from a broad range of both immediate and root causes at different temporal and spatial scales (Ribot 1996), this approach also brings focus to the analysis by emphasizing only the institutional, historical and socio-economic processes that appear to be the most relevant to the decision-making of the household. Without such a focus, vulnerability analyses run the risk of having no analytical bounds and losing any hope of being useful for policy.

The challenge has been in operationalizing such an approach. Both political-economic and the climate impact models generally operate on macro-levels: they address broad structural features in the physical environment and social system that change slowly, yet that will undeniably have impacts on households and economies in the short to medium terms. Not only do these approaches need to be integrated such that political-economic and climatic changes are considered together, but also they require far more spatial and temporal "resolution" in order to understand vulnerability and adaptation at the level of the household or decision-maker.

Over the last decade, the climate change research agenda has shifted from a concerted focus on the technical, legal and political aspects of climate change mitigation to defining opportunities for adaptation. Farmers in Latin America already have a long history of ecological adaptation (see for example, Denevan 1980; Whitmore and Turner II 1992). A wide diversity of climatic-risk mitigation strategies, involving soil moisture conservation techniques, tillage practices, seed selection for stress tolerance, inter-cropping and other forms of micro-climate adjustments, can still be observed in many traditional agricultural systems in Mexico (see for example Altieri and Trujillo 1987; Wilken 1987; Brush, Bellon Corrales et al. 1988; Doolittle 1989; Trujillo 1990; Bellon 1991). While it would be erroneous to suggest that these methods are always effective, these practices represent a wealth of knowledge and experience that conceivably could be used as the foundation of more resilient and adaptive agricultural systems (Richards 1985; Toledo 1990; DeWalt, Rees et al. 1994).

Yet it is also true that under the accelerated process of economic and cultural globalization, the context in which smallholders obtain their livelihoods has dramatically changed, and the persistent resilience of "peasant" agriculture in Latin America is now threatened by domestic and international policies that appear bent on making the smallholder farmer obsolete. Whereas previously food production and consumption policies were determined largely by national political and socio-economic objectives in concert with international trade commitments, now national agricultural policies are being driven by transnational conditions, such as multilateral regulations on food product quality, regulations on trade and protectionism, quality and quantity demands of transnational agro-industries and cosmopolitan consumer tastes and preferences (Friedmann 1994; Marsden 1997; Nigh 1997). Adjusting to the new globalized context of national production has required countries to focus on increasing economic competitiveness across all sectors and orienting agriculture more narrowly towards export

production at the expense of any previously held goals of food self-sufficiency (Goodman and Watts 1997). Suddenly, agricultural populations that were protected and supported for diverse reasons are "non viable" and essentially dismissed as economically unproductive (Bebbington 1999).

Under these conditions, it is very difficult to generalize about what factors might facilitate agricultural adaptation to climatic risk. While broad-scale economic models may illustrate that in the long run, changes in market prices and new technology will allow agricultural systems to adapt so that aggregate global food security is never truly threatened (Rosenzweig and Parry 1993; Helms, Mendelsohn et al. 1996), the reality is that these results mask important social and cultural costs within regions, nations and communities (Chen 1994; Reilly and Schilmmelpfenning 1999). Even without consideration of climatic variability, the numerous case studies of farmers' adaptation to economic change have illustrated the potentially high social costs entailed for Mexico's smallholders, particularly when these changes have occurred in a policy environment that offers little in the way of financial, technical, or institutional support (de Janvry, Chiriboga et al. 1995; Appendini 1998; Cornelius and Myhre 1998). Under these circumstances, the adaptive choices that may be available to producers in more industrialized systems—irrigation, alternative (yet lucrative) crops, capital investments to enhance temperature or moisture control, or market orientation—are unrealistic for the majority of Mexico's producers. Given current patterns of social change in rural Mexico, the most viable adaptation strategies may be *outside* the agricultural sector entirely—entailing long-distance migration, peri-urban wage employment, shifts in the meaning and purpose of rural land use and basic education. Such adaptations do not necessarily mitigate future climate impacts, but rather complicate our understanding of vulnerability by creating the necessity for cross-sectoral and cross-scalar research as well as sophisticated policy coordination.

NEOLIBERALISM AND MEXICAN AGRICULTURE

While in academic circles the debate continues about how much importance to give climate change in national and sector planning, the path of economic development in most of Latin America has undergone a dramatic shift in recent decades. Neoliberalism—the suite of policies designed to unfetter markets and minimize governments' regulation of resource distribution—has swept Latin America, and few countries in Latin America have surpassed Mexico in the enthusiasm of its

implementation. The deep penetration of neoliberalism in Mexico has been the subject of considerable research and analysis, particularly in relation to the implications of the economic ideology for the country's agricultural sector (Escalante and Redón 1987; Gledhill 1995; Rello and Pérez 1996; Kelly 1999; Snyder 2001). It is not the purpose of this article to review the history and implementation of the agricultural reforms, as that has been done elsewhere. Here I will highlight only some of the institutional changes that have had the most substantial impact on smallholder farmers' adaptive capacity.

Mexico's aggressive move towards facilitating processes of economic integration in the late 1980s and early 1990s followed a severe economic crisis that involved a re-negotiation of its national debt obligations and a strict program of financial restructuring under the tutelage of the International Monetary Fund (Myhre 1994; Gerber and Kerr 1995). The shock of structural adjustment was particularly difficult for the agricultural sector, which had traditionally served as an instrument for political control and legitimacy for the dominant political party, the *Partido Revolucionario Institucional*, and as a result, had developed an unhealthy dependency on the state apparatus.

This dependency had become particularly intense in the period immediately following the structural reforms of the 1980s and 1990s. In the 1970s, the government had attempted to recuperate national food self-sufficiency by revitalizing the production of Mexico's smallholders: the *ejidatarios* and *comunitarios* who had essentially been by passed by the technological improvements of Mexico's Green Revolution. Subsidized technological packages and extension advice were channeled to farmers with credit through BANRURAL, the public agricultural bank, along with insurance from ANAGSA, the state crop insurance institution. The intervention brought results in the field—yields did improve—but at the cost of institutionalizing a heavy dependence of smallholder farmers on the state.

The contrast between the heavy-handed interventions of the late 1970s and the neoliberal reforms of the 1980s could not have been more marked. In the late 1980s, the Salinas de Gotari administration (1988-1994) continued the reforms initiated by the de la Madrid administration, launching a systematic program of privatization for the state-owned agricultural inputs and service agencies (e.g., PRONASE, ANAGSA, FERTIMEX) and deregulation of prices for agricultural inputs and farm products (Escalante and Redón 1987; de Janvry, Gordillo et al. 1997). The national budget for agricultural services and investment was slashed by more than half (Ochoa and Lorey 1994; OECD 1997). Prices supports for all crops but maize and beans were withdrawn.

CONASUPO, the public grain marketing agency, closed its doors in 1998 in the midst of a corruption scandal, leaving farmers with small production volumes with few marketing options. In the early 1990s, BANRURAL was restructured to meet the needs of farmers identified as "commercially viable"— eliminating all but a handful of Mexico's 27,470 *ejidos* from its portfolios (Appendini 1998; Myhre 1998). By the mid-1990s, only 6.7% of the area planted in Mexico's ten principal crops was covered with public insurance, down from 44% a decade earlier (Zedillo 1996: 107).

One of the most discussed and more radical reforms during this period was the amendment of Article 27 of the Constitution of 1917 (DeWalt, Rees et al. 1994; Appendini 1998; Cornelius and Myhre 1998). The fact that the land in the nation's *ejidos* was owned by the state, and that the sale or rental of *ejidal* land was illegal, was targeted by the "technocrats" of the Salinas administration as a significant source of inefficiency in the sector (Cornelius and Myhre 1998). In 1991, Salinas brought an end to the agrarian reform period by instituting a land-privatization program (PROCEDE) in which each *ejidatario* would be given title to his or her land thus enabling the rent, sale, or use as collateral of that land. The program has now granted titles to approximately 75% of Mexico's *ejidos*, although to date there little evidence that the program has either revitalized national production or been a source of new foreign investment in agriculture (Cornelius and Myhre 1998; Dussel Peters 2000).

In 1994, Salinas finished his *sexenio* by signing the North American Free Trade Accord (NAFTA) with the United States and Canada, and effectively ended any hope that Mexico would be able to fulfill its identity as a country of *maiceros* in globalized markets. Mexico was allowed under the NAFTA to continue to protect its maize market for 15 years through a gradual annual increase in importations of tariff-free corn (Fritscher Mundt 1999: 151; Dussel Peters 2000: 58). Yet Mexico has opted not to enforce this protective policy and U.S. corn imports have entered Mexico *without* the application of the allowed tariff (Fritscher Mundt 1999:142; Dussel Peters 2000). This, and the fact that the price offered for domestic maize in Mexico is set as an "indifference price"[1] in relation to U.S. yellow maize (although most of the maize produced by Mexico's farmers is a higher quality white maize), has meant that maize producers now face prices that make marketing their production nearly impossible (Nadal 1999: 129).

[1] The "indifference price" is the international price of yellow maize #2, plus the cost of domestic transport, etc. to point of sale. For Mexico's farmers, this price was lower than what was formerly offered via CONASUPO.

Today Mexico's farmers today face a production environment quite different from the one that they were accustomed to at the beginning of the 1980s—an environment in which in many cases the traditional ways they were able to accumulate resources have been severely constrained, thus limiting the flexibility of their productive activities within the agricultural sector. As Appendini persuasively argues, without credit, support for fertilizer use, and technical assistance, the state has effectively written off smallholders as potential contributors to the future of Mexico's agricultural sector (Appendini 1998). In the current context of producer support, common assumptions about agricultural adaptation to climatic change that focus on crop choice, technology use, irrigation access, crop insurance and credit, and research and extension support make little sense. In fact, the "choice set" of *agricultural* adaptations appears to be narrowing for many farmers.

This does not mean, however, that new opportunities as well as vulnerabilities will not be forthcoming as Mexico's new commercial openness and political democratization brings changes in rural and urban industry and migration patterns. Income diversification in response to risk can, under some circumstances, provide access to new resources and facilitate the development of different capacities that can help mitigate vulnerability. In other circumstances, such diversification can amplify exposure to other risks—economic shocks and recessions, for example—that will complicate our understanding of vulnerability to climatic hazards and change. The next sections will elaborate on how these institutional changes were structuring the risk perceptions, livelihood options and adaptive capacities of households in three communities in central Mexico.

THE CASE STUDIES

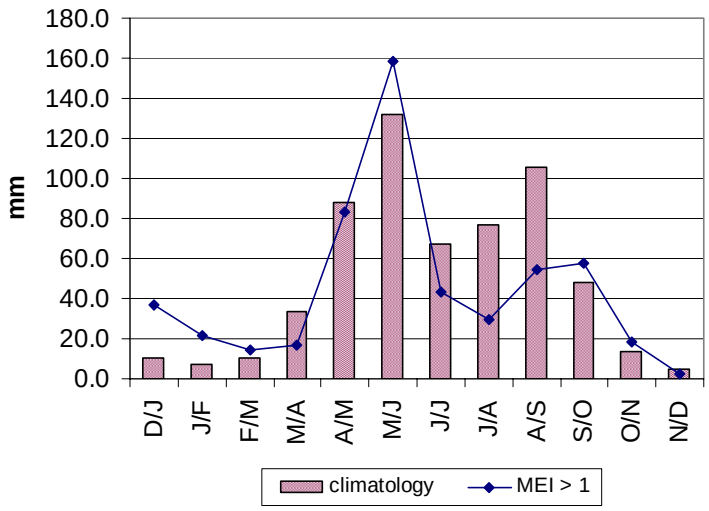
Study Area

The three case study communities were located in the neighboring states of Puebla and Tlaxcala, in the *altiplano* of Central Mexico. Although the complex topography of the region gives rise to considerable local climatic variability, all three communities share a temperate sub-humid climate with a summer (May through September) rainfall regime characterized by a mid-summer "drought" called the

canícula.[2] The dry climate and altitude (2400 m to 2600 m above sea level) of the Puebla-Tlaxcala valley exposes the region to frequent frosts that serve to limit the agricultural growing to five months. Recently, anomalous frosts have occurred in June and July with serious consequences for rainfed crop yields. Rainfall is also highly irregular and atypical dry spells frequently affect yields, particularly in the northern and eastern parts of Tlaxcala and in central-south Puebla.

Furthermore, the region has been identified as relatively sensitive to the effects of El Niño - Southern Oscillation (ENSO), although the topography of the region complicates the relationship (Magaña R. 1999). Composite analyses of precipitation anomalies in El Niño years show that both Puebla and Tlaxcala suffer a general reduction in precipitation (mm/day) during the summer rainy season (Figure 1).

Figure 1: Average Monthly Precipitation, El Niño Years vs. Climatology, Tecamachalco, Pue.



El Niño also appears to be associated with a higher frequency of early and late frost events, particularly in the eastern Puebla stations analyzed in this study. La Niña events (anomalous cooling in the Central Pacific) appear to have less impact on the regional climate, however particularly intense events such as the 1998/1999 La Niña can

[2] The *canícula* is technically not a drought, but rather a decline in the number of rainy days during the months of July and August, resulting in a rainfall pattern characterized by two peaks, one in June and one in September. The region in which the *canícula* is observed extends from the northeast down towards the south-central coast. Variability in the *canícula's* timing and duration may be related to ENSO, via the influence of the position of the Intertropical Convergence Zone on Mexico's summer rainfall patterns.

result in excessive rainfall in the area (Magaña R. 1999). Paradoxically, climate change simulations for the Tlaxcala-Puebla region actually project more favorable production conditions in the future, as higher temperatures are expected to extend the length of the growing season. However, the region's recent experience with ENSO suggests that should ENSO events increase in frequency or intensity (as some scientists expect under climate change), the negative implications of increased climatic variability may largely outweigh any projected benefits of changes in average conditions.

The Communities

Three different agricultural communities were chosen for this study: In Puebla, the *ranchería* Jesús Nazareno, in the *municipio* of Palmar de Bravo and in Tlaxcala, the *ejido* Plan de Ayala, in the *municipio* of Tetla, and the *ranchería* Los Torres, in the *municipio* of Huamantla. The communities were selected to be representative of the region in terms of climate and general agricultural characteristics, yet different in terms of the type of agriculture pursued and the degree of integration into agricultural markets (Table 1).

Table 1: The Case Studies in Comparison

	Los Torres	**Plan de Ayala**	**Nazareno**
Landholding size	4 ha	9 ha	3.5 ha
Principal crops	Maize, beans	Maize, beans, wheat, barley, oats	Maize, beans, vegetables
Harvest destination	Subsistence	Subsistence, local	Subsistence, regional, national
Access to urban areas	Moderately difficult	Easy access	Easy access
Irrigation	No	No	Yes

Source: Household Survey, 2000

Nazareno was the most commercially integrated community, producing irrigated vegetables for the market of southeastern Mexico, along with maize and beans for subsistence purposes. Approximately two-thirds of the community's households had access to land irrigated with well water; the remaining households had access only to rainfed fields. Landholdings averaged approximately 3.5 ha, and it was common for

households' land tenancy to be a mix of *ejidal* and *pequeña propiedad*. Sharecropping was widely practiced. Production tended to be highly input intensive and year-round. Despite the community's commercial orientation, in 1995 Mexico's National Population Council (CONAPO) classified the village as "highly marginal" based on its lack of basic services and infrastructure and the material poverty of its population (CONAPO 1998).

Plan de Ayala is an *ejido* in central Tlaxcala where the *ejidatarios* planted rainfed grains (maize, wheat, barley, oats and beans) for their own consumption as well as for local seed markets. Land was evenly distributed among the community's 32 *ejidatarios*, with each having access to approximately 9 ha. Only 10 minutes from the busy commercial town of Apizaco, the *ejido* also had relatively easy access to the services and institutions of the urban area including secondary and preparatory schools. Soon after the *ejido*'s founding in 1975, Tlaxcala laid the foundation for its largest "industrial city," Xicoténcatl I, on the *ejido*'s borders. The presence of the factories has meant the *ejido* has benefited from frequent public transportation and improved roads as well as access to a regional source of employment. The industries' presence has also raised concerns about pollution as well as new pressures on the *ejido*'s land to accommodate the industries' expansion.

Los Torres was the most physically isolated and least commercial of the three communities. Los Torres was located in the far northeastern corner of Tlaxcala, in the foothills of the Sierra de Tlaxco-Huamantla. Households tended to have a mixture of *ejidal* and *pequeña propieded* tenancy and at an average of 4 ha per household, landholdings were on average less than half what was available in Plan de Ayala. Transport to the community was infrequent, and although the city of Huamantla was only twenty minutes away by car, access to the schools and employment of the area was difficult. Until the mid-1990s, the community had partially related on the sale of *aguamiel* —the primary ingredient in the production of *pulque*, Tlaxcala's traditional alcoholic beverage made from *maguey*—for supplementary income. The growing popularity of commercial beer in the region had caused the market for *pulque* to collapse, denying households this locally derived source of income.

CLIMATE IMPACTS AND COPING STRATEGIES

The 1999 season was uniformly cited as the worst "*año malo*"[3] in recent memory for over 80% of the surveyed farmers in Plan de Ayala and Los Torres, and by 39% of respondents in Nazareno. In all three communities that year almost farmers had suffered form an unlikely combination of late and early frosts (in May, September and October) and excessive rain in the fall (October). In Plan de Ayala and Los Torres, the two rainfed communities, 1999, 1998 and 1997 had all been particularly difficult seasons. The area lost to climatic hazards and crop disease in 1999 in Los Torres amounted to 89% of the total area planted by surveyed farmers. In Plan de Ayala, respondents reported losses totaling 74% of the total area planted. The availability of irrigation in Nazareno partially buffered yields in the community from the climatic events of 1999, however households also cited 1999 more often than any other year as having been difficult for production. Overall, 38% of area planted by the surveyed households in Nazareno was damaged in 1999.

Although the households in the three communities tended to draw from a similar resource base– livestock, seed reserves, and their own labor—to cope with losses to hazards, there were important differences in the range of strategies pursued in the three communities, illustrating a far from uniform pattern of vulnerability to impacts and resilience in face of loss. Although it might be assumed that the households that are forced to implement the broadest range of coping strategies may be those that are particularly vulnerable, the three case studies illustrated that the households that were most affected by climate hazards were also characterized by the narrowest range of response. The households of Plan de Ayala reported engaging in the greatest diversity of activities. There, household reported selling livestock, intensifying their participation in non-farm activities, seeking financial support through informal loans and, when possible, replanting their fields (Figure 2). There was also widespread participation in public emergency work programs and emergency food distribution campaigns.

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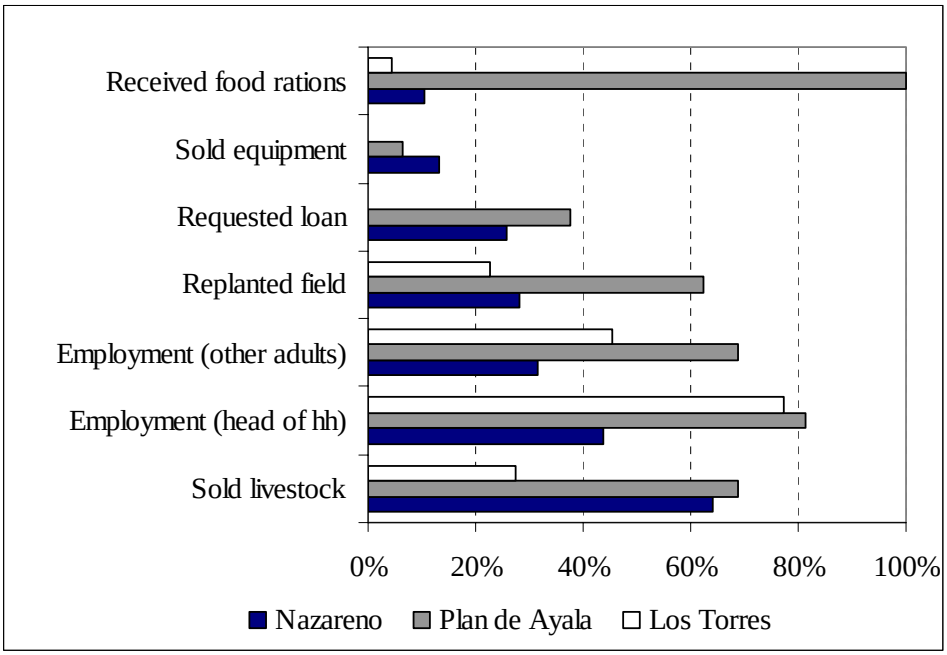
[3] How each farmer interviewed defined a "bad year" was specifically explored in each survey. This was done to determine to what extent climate-related hazards (drought, frost, hail, flood) were related to perceptions of "bad years". In all three communities, with only few exceptions, climate factors were determinant in farmers' definitions of bad years, although it was significant that lack of alternative employment options together with crop losses were important in the definitions of the more marginal households in Los Torres, and in Nazareno 17% of households associated "bad years" with periods in which producer prices were low and investment costs particularly high.

Figure 2: Coping Strategies Employed
(% of Households)



Source: Household Survey, 2000.

In contrast, households in Los Torres reported pursuing essentially two strategies: searching for employment off-farm (typically entailing temporary migration to Puebla to work in cement block manufacturing) and selling small livestock in order to acquire sufficient funds to purchase their maize needs. Few households had the resources to replant, more distant migration was economically infeasible and not one household reported participating in public assistance programs.

Although losses were reportedly far less extensive in Nazareno, the households involved in irrigated agriculture were faced particularly difficult challenges in coping with losses because of the intensive labor demands of their production process and the fact that the high investment required in irrigated production often meant that debt accompanied crop losses. The year-round nature of production meant that many households experienced subsequent crop losses without a period of fallow in which to recuperate through alternative activities. It was not uncommon for households to find themselves caught in a downward spiral of increasing hardship and more drastic coping measures, as explained by one farmer interviewed:

> "First you sell of any animals you have to pay for household expenses. Second, you look for someone to share the land. You plant vegetables

> but "*a medias*" with the hope that you will get sufficient income to recover. You can plant short-cycle crops because these will bring income faster . . . Third you plant basic grains. You migrate only if you are in debt and you can't think of any other way to get out of it. And if you migrate, you go to the U.S. where you have the chance of getting enough to make up for your losses."

The differences in the range of choice available to households as they responded to the crop losses of 1999 are indicative of not only the households' resource endowments at the time of those losses, but also the households' relationships to intra-community and national institutions and their capacity to simultaneously address climatic variability and political-economic change through their livelihood decisions. The next sections explore how the reforms of the agricultural sector appear to be affecting the adaptive capacity of the households in the three communities. The household survey data were classified to reveal four different livelihood orientations of farm households: 1) subsistence maize production under conditions of land scarcity, 2) crop diversification and livestock investment, 3) irrigated vegetable production and 4) economic diversification into non-farm income.

LAND SCARCITY AND ADAPTATION THROUGH CROP CHOICE

One of the documented responses of rural households to economic and agricultural reforms of the 1990s has been an increase in the area planted with maize, despite the fact that under NAFTA domestic maize production cannot compete with cheaper U.S. imports. The increase in planted area has been explained by some researchers as an unexpected consequence of the direct subsidy program PROCAMPO, which pays farmers a fixed sum for every hectare that was planted in one of nine basic crops when they registered their land in the program in 1994 (Nadal 1999). In face of declining producer prices and volatile crop markets, some researchers have speculated that PROCAMPO payments may serve as an incentive to continue to plant maize because PROCAMPO is the only source crop income commercial farmers can count on. [4] For smallholder farmers, the increase in maize area appears to be a response to increased

[4] Although PROCAMPO was ostentatiously designed to help smallholder farmers of basic grains transition into more viable commercial alternatives, Appendini found that 70% of PROCAMPO payments went into the hands of producers with more than 5 ha. Appendini, K. (1998). Changing agrarian institutions: Interpreting the contradictions. The Transformation of Rural Mexico: Reforming the Ejido Sector. W. Cornelius and D. Myhre. San Diego, Center for U.S.- Mexican Studies..

economic insecurity: no other crop or accessible economic activity provides households with sufficient income to guarantee that they can meet their subsistence needs through exchange (de Janvry, Gordillo et al. 1997; Davis 2000).

The data collected in the three communities largely confirm the latter hypothesis. In all three of the communities, regardless of the degree of commercial orientation of the household, subsistence maize production was the core of households' livelihood strategies. For households engaged in a diversity of economic activities subsistence maize essentially served as an insurance strategy against failures in exchange entitlements and the prevalent uncertainties associated with commercial agricultural and non-farm activities. Yet ironically, maize was identified in all three communities as "most risky crop" to plant, and the households surveyed also reported far more extensive losses on fields planted in maize than on fields planted in other crops. With a relatively long growing season (averaging 180 days), maize yields are highly sensitive to early and late frosts, as well as to the mid-summer drought.

This contradiction between adaptation to economic uncertainty and management of climatic risk was most acute for households who, because of limited land, felt obligated to plant all their land in maize in order to do as much as possible to secure their subsistence needs. These households—that represented the majority surveyed (86% of households) in the community of Los Torres—were thus constrained in their ability to adjust to seasonal climatic variations through their crop choice and land use.

This was illustrated clearly in households' explanations of the determinant factors in their key production decisions. As Table 2 shows, meeting subsistence needs was the primary determinant of crop choice among Los Torres households. Climate factors were significant in crop choices for less than 10% of the households surveyed. In comparison, over 80% of Plan de Ayala households (who had an average of 9 ha) reported altering their crop mix to reflect the timing of the onset of the rainy season and the perceived risk of frost events.

In face of declining purchasing power and rising consumer prices, *not* planting maize (and investing the land in a more climatically suitable crop, or abandoning agriculture to venture into alternative non-farm activities) represented a higher risk to food security for Los Torres households than planting maize with the risk that their crop would be damaged or destroyed by frost or drought. By planting some of the more traditional local varieties of maize and intercropping, households could mitigate some of their sensitivity to climatic variability. In the event that yields fell to less than 500 kg/ha

(as they did in 1998 and 1999) households could use the maize stalks as fodder for domestic livestock. Aside from these measures, the Los Torres households had little flexibility in managing the climatic risk they faced through cropping decisions.

Table 2: Factors Determining Crop Choice.
Percent of Households (Frequency)

Factors	Los Torres n = 22	Plan de Ayala n = 16	Nazareno n = 43
Family consumption	59 (13)	13 (2)	14 (6)
Crop rotation	27 (6)	13 (2)	9 (4)
Livestock needs	23 (5)	25 (4)	0 (0)
Land availability	14 (3)	0 (0)	0 (0)
Climate	9 (2)	81(13)	28 (12)
Finances	9 (2)	13 (2)	23 (10)
Market viability	5 (1)	13 (2)	30 (13)
Tradition	5 (1)	0 (0)	5 (2)
Seed availability	0 (0)	13 (2)	0 (0)
Crop water & labor req.	0 (0)	0 (0)	7 (3)
No choice (sharecrops)	0 (0)	0 (0)	2 (1)
Irrigation availability	N/A	N/A	19 (8)

Note: Percentages do not add to 100 because several respondents in each community named several influencing factors in their crop choice.

FROM MAIZE TO MILK

For households that have sufficient land to not only meet their subsistence requirements in maize and beans but also to diversify into alternative crops, planting crops with growing cycles of 80 to 100 days was an effective way to mitigate climatic risk. After several years of severe crop damage from anomalous frost events, the state of Tlaxcala had begun to promote oats and barley as alternatives in regions of the state where maize was considered to be an (climatically) inappropriate crop (INIFAP 1998). Through the program "Kilo por Kilo," as well as through oats seed distribution programs, agricultural officials hoped that traditional maize farmers would "convert" to producing oats and barley. Both these crops were considered more robust in face of a perceived

increase in climatic variability as well as more economically viable under newly liberalized markets (INIFAP 1998).[5]

The adaptive advantages of oats and barley were well known among all the farmers interviewed. The Plan de Ayala farmers consistently ranked oats and barley as the most "rapid" and resilient of the crops they were accustomed to planting. Households that planted these crops in 1998 and 1999 also reported far less extensive damages from climate events in comparison to those households who planted only maize.[6]

Despite the apparent advantages of these crops in mitigating the households' sensitivity to climate risk, in economic terms neither barley nor oats represented viable alternatives. As a result of the price liberalization policies of the late 1980s, producer prices for barley or oats were no longer regulated and had declined in real terms. The *ejidatarios* of Plan de Ayala had formerly sold their barley harvests to IMPULSORA, a malt manufacturing plant. By the mid 1990s, however, IMPULSORA was no longer interested in the quality and volume of barley produced by the *ejido*. In order to receive the prices advertised by IMPULSORA and other grain processors, the households needed to invest in the fertilizers, herbicides and the hybrid seeds to meet strict commercial standards. Without access to affordable credit (the *ejido* had lost its access to BANRURAL loans with the bank's restructuring in the late 1980s) and with no crop insurance, the households were unwilling to risk such investments.

In order to make crop diversification a successful strategy, the households of Plan de Ayala turned to livestock. Over the 1990s, the *ejidatarios* had built up small herds of milk cows that they supported with their oats and barley harvests. These milk cows not only provided the households with milk but also with a small but important source of income, which according to the data collected through group interviews, was critical in households' investment in education. In other circumstances households might have relied on selling small quantities of maize for paying school costs, but in face of poor market conditions and low yields milk was now a more attractive alternative. Perhaps partly for this reason, these households also tended to be more highly educated

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[5] Interestingly, an increase in the frequency of ENSO events is explicitly discussed in the policy documents promoting the "crop conversion" program as a justification for the initiative. This may represent one of the few examples in Tlaxcala of adaptation to perceived changes in climatic patterns through policy.

[6] Of the fields planted in maize, 76% suffered near complete or total loss compared to only 13% of fields planted in barley. The majority of fields planted in barley suffered minimal losses (65%), while only 20% of maize fields were relatively unaffected.

than households with similar landholdings but that had not invested in livestock (averaging more than 3 household members with secondary education, compared to none or just one member with secondary school education in other households).

Those households in the community with the largest livestock holdings were also those that planted the largest proportion of their total area in oats and barley, and thus also reported the least extensive losses to climatic hazards (averaging 28% of the total area planted in comparison to losses of 68% to 86% in other households in the community). The cows and calves also served to buffer households from the full economic impact of climatic hazards, as illustrated by the sale of livestock by many households after the crop losses of 1998 and 1999. Those households with significant numbers of livestock also tended to report the highest levels of material wealth — although their monetary incomes were not significantly different from other households in the three communities.[7] This type of material wealth accumulation suggests a certain degree of economic stability that was lacking in less economically diversified households.

IRRIGATION AND MARKET RISK

Irrigation is one of the oldest methods employed by farming populations to adapt their production to otherwise inhospitable climate conditions. Theoretically, in the context of "globalizing" agriculture and environmental change, production under irrigation in semi-arid central Mexico might represent a "win-win" solution to agricultural risk. Not only should irrigation substantially reduce the sensitivity of crops to climatic variability, but also access to irrigation should facilitate the entry of smallholders into commercial agricultural markets by permitting their diversification into higher-value high-yielding crops. When Mexico entered into the NAFTA in 1994, there was also some expectation that farmers who specialized in non-traditional crops would benefit from a comparative advantage in off-season production and cheap labor (de Janvry, Sadoulet et al. 1995; Marsh and Runsten 1998; Nadal 1999). Yet ironically, the involvement of Nazareno farmers in vegetable markets appears to have exacerbated their vulnerability and restricted their capacity to adapt.

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[7] Material wealth was estimated according to an index of ownership of selected household goods. Monetary income was estimated from both on and off-farm activities, excluding remittances.

The decision-making environment for the Nazareno households was one of extreme uncertainty. The prices farmers received for their harvests were extremely volatile and the regional market was easily saturated. In choosing what crop to plant in any particular field, farmers reported that they essentially "played the lottery," guessing what crop would be in highest demand at the time of harvest, or alternatively, trying to second-guess the regional supply of vegetables by eyeing their neighbor's fields. Farmers reported that prices could drop so precipitously within the space of an hour that a crop they harvested in the morning, with the expectation of at least a "break even" price, could be unmarketable by the time it was washed and packed for sale. As Table 3 illustrates, approximately 25% the households surveyed reported plowing under at least one harvest per year, largely as a consequence of unviable market conditions.

Although the direct climate impacts on yields were far less extensive than what households reported rainfed communities, climate hazards, crop pests and fungal diseases and market risk combined had a synergistic impact on household vulnerability. Relatively light damage to a vegetable field from frost or an unexpected dry spell typically increased the susceptibility of crops to disease, and the combined impact of climate and disease on the quality of the harvest made it even more unlikely that households would be able to commercialize their crops in the highly competitive vegetable markets.

Table 3: Households Reporting Plowing Under Harvests

	2000*	**1999**	**1998**	**1997**
% Of households turning under one or more harvest	19%	30%	23%	25%
Reason for turning under crop				
Price	- - -	62%	70%	70%
Climate	- - -	23%	30%	20%
Disease	- - -	15%	0%	10%

* partial count, as of interview date, mid-July, 2000.

The impact of crop losses — whether from poor prices, climatic events or disease —was exacerbated by the high investment required in irrigated production. With cuts in public support for agricultural extension, most (42%) of Nazareno farmers who reported seeking technical advice turned to private sector input supply stores.[8] The farmers were aware that they were often sold more pesticides and fungicides than their crops required,

[8] Only 11% of households sought advice from public sources, 38% turned to neighbors or relatives, and 8% to NGOs.

yet felt that they lacked the ability to diagnose the problems they observed. The agricultural chemicals sold to the farmers were also typically imported and farmers reported that their input prices were escalating with the declining value of the peso.

While this dependence on the private sector should not in theory contribute to farmers' vulnerability, in the context of minimal formal education, the complexity of crop disease diagnosis, and the volatility of crop and input prices, it was common for farmers to purchase and apply both excessive quantities and inappropriate chemicals in attempts to eradicate the observed problem (Aguirre Alvarez, Salcido Ramos et al. 1999). Rather than saving the harvest, this practice often caused further damage to the crop while considerably augmenting the households' investment and thus their risk of significant economic loss and debt from either climatic impacts or market failures. The year-round, intensive nature of irrigated production meant that not only the households risked experiencing more than one harvest loss per calendar year, but they also lacked an extended fallow period in which they could allocate labor to other, less risky activities. For households who experienced significant losses, ultimately migration to the United States was one of the few options that allowed them to rapidly recuperate their losses.

"DE-AGRARIANIZATION" AND HOUSEHOLD VULNERABILITY

Those who research climate hazards and their social impacts have long recognized the importance of non-farm activities and rural-urban migration in the coping strategies of agricultural households. Recently, scholars and practitioners of rural development in Latin American and Africa have noted a surge in the participation of rural households in non-farm wage activities, apparently indicative of a defined shift in the orientation of rural livelihoods towards a more diversified income base (Bryceson 1996; Ellis 2000; de Janvry and Sadoulet 2001; Reardon, Berdegué et al. 2001; Bryceson 2002). Bryceson argues that in face of declining producer subsidies, rising production costs and obstacles to participation in commercial agricultural markets, households have initiated a process of converting their former "temporary" coping strategies into committed adaptations to changing social conditions (Bryceson 2002: 731). According to a recent analysis by de Janvry and Sadoulet, non-farm income accounts on average for 55% of rural incomes in Mexico, and of this income, non-farm wages surpass self-employment income, agricultural wage income and remittances (de Janvry and Sadoulet 2001).

The NAFTA was sold to Mexico with the promise of increased foreign investment and jobs, and as part of the domestic development program designed to facilitate the realization of these promises, industrial corridors and parks have materialized throughout central Mexico, contributing to the economic productivity of states such as Tlaxcala and Puebla (Table 5) (Dussel Peters 2000). Many of these parks contain the more traditional textile *maquilas* and other forms of simple assembly plants. However, increasingly these parks also contain representatives of the chemical, paper, electronics and transport sectors that demand relatively higher-skilled labor. Wages are still low: In 2000, the average wage in the industrial park that bordered on the *ejido* of Plan de Ayala was $35 pesos/day, $15 pesos less than the average farm worker wage in the region of $50 pesos/day. The families of Plan de Ayala reported, however, that access to employment in the factories was competitive. Few industries accepted employees with less than a complete secondary school education or who were older than 32 years old.

Table 5: *Maquila* Establishments in Tlaxcala

	1990	1999
Establishments	1703	3297
Employment (thousands)	446	1141

Source: (INEGI 2002)

As you can see from the table below, 27% of the adults in the surveyed households of Plan de Ayala had completed secondary school, compared to 7% in Los Torres and 15% in Nazareno. Plan de Ayala also had the highest percentage of households with non-farm income (75%), compared to 45% and 38% in the other two communities respectively. Frequent public transport and the immediate proximity of Plan de Ayala to Tlaxcala's largest industrial park (Xichoténcatl I) as well as the accessibility of opportunities in the nearby commercial town of Apizaco also greatly facilitated the *ejido*'s access to factory and peri-urban employment.

During periods of good harvests, subsistence maize and beans production essentially subsidized the wages of those members of the Plan de Ayala households that were engaged in non-farm activities. During years of crop losses, the non-farm contributions to the households assumed greater importance in meeting both agricultural and non-agricultural investments and expenses. The households most seriously engaged in non-farm activities in Plan de Ayala also exhibited relatively high levels of material

wealth (equivalent to the households specializing in livestock) despite three years of significant crop losses from climatic hazards.

In contrast, acquiring non-farm income in Los Torres required seasonal migration. The community lacked a secondary school within easy walking distance. The village also lacked frequent public transport to urban and peri-urban areas where non-farm wages might be obtained. The households surveyed reported that the primary source of non-farm income came from the younger adult men in their households who sought work in cement block manufacturing near Cholula in the state of Puebla. These men left the households for 3-6 months, returning for the next year's planting and field preparation. The material poverty of the Los Torres households suggested that this strategy was barely letting households "get by" from year to year and thus not enabling them to develop an economic buffer to mitigate against future economic and climatic shocks.

In Nazareno, the labor demands of irrigation represented the major constraint to the participation in non-farm activities. The households surveyed who had a substantial portion of income from non-farm activities tended to be those who had too little irrigation to farm commercially, or who lacked irrigation entirely. In contrast, the households that were committed to vegetable production required all of the available family labor to help manage the financial burden of irrigated production, and without a fallow period, their production process rarely liberated sufficient labor for alternative activities. Thus once again, the commitment to irrigation appeared to limit the flexibility of households' strategies rather than to improve their security.

CONCLUSION

Other research on vulnerability has illustrated that economically marginal populations—those with limited access to resources and limited capacities to exchange their few endowments in order to enhance their livelihood security and protect themselves from harm—are typically also the most vulnerable to climate hazards, and thus often assumed to be the most vulnerable to climatic change (Chen 1994; Downing, Watts et al. 1996; Ribot 1996). The research presented in this paper does not contest this assumption, but rather highlights the complexity of poverty and vulnerability at the local level in the context of a rapidly changing agricultural sector and national economy. The case studies illustrate that within generally "marginalized" populations, not all resources

and assets are equal, location matters, and the particular ways households relate to the institutions that govern their economic activities make a difference in their vulnerability.

It is not so much average income that appears to be making the difference in the adaptive capacities of the households, but rather the flexibility and range of choice that particular resources provide, and the overall stability of livelihoods, as reflected in their material wealth and assets. The farmers in the three communities are all considered resource-poor and small-scale in comparison with the diversity of farm systems in Mexico. They are all struggling to find their place in Mexico's neoliberal economy, and were all affected by drought and frost in the last three years of the 1990s. The production systems in which the households are involved, however, varied between the three communities, each based on particular sets of endowments, each entailing different constraints and risks as well as opportunities.

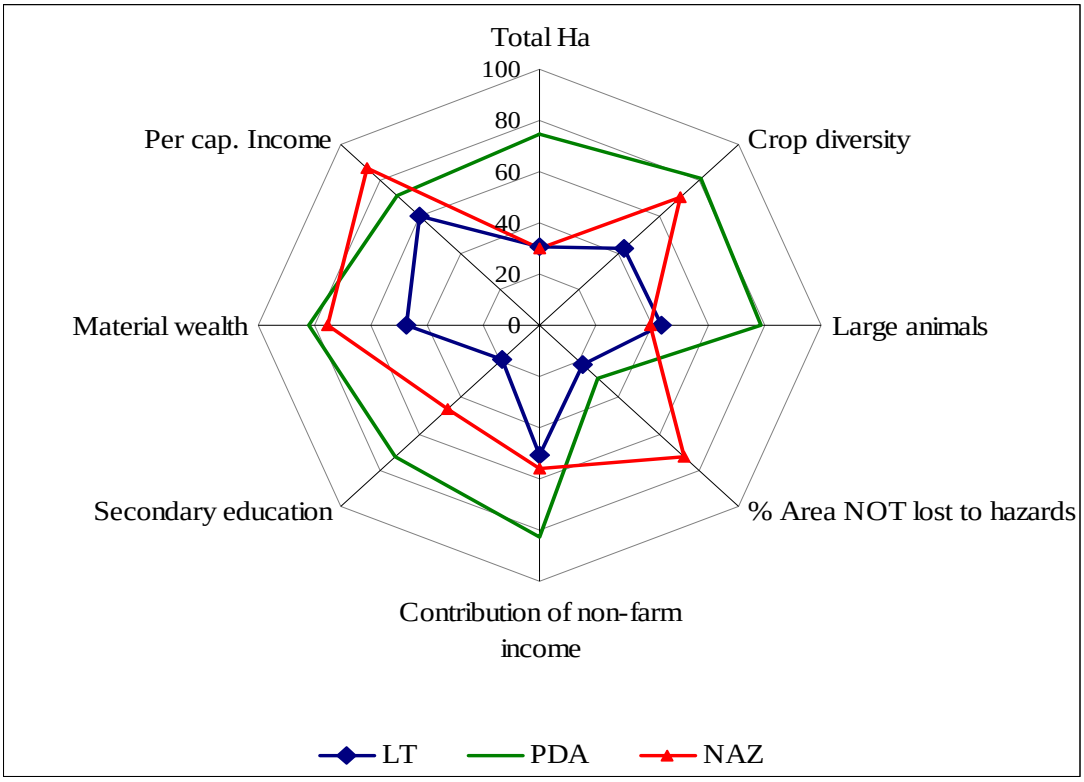
These three concepts—resource access and livelihood flexibility and stability—are key indicators of adaptive capacity. These three factors are also similar to those that have been recently identified as central to understanding the persistence of rural poverty and the potential for sustainable development, illustrating the strong conceptual links between "sustainability" and adaptation (c.f.Scoones 1998; Bebbington 1999; Mortimore and Adams 1999; Ellis 2000). Adaptation is less likely to be successful where choices are limited by lack of available technology, limited land, failures in research, inaccessible credit or insurance, poor transport or simply such a high degree of livelihood insecurity that the quickest and most secure route to survival is the only option. Livelihood stability offers households the capacity to plan, and with planning, the potential to adjust to future risks or mobilize to take advantage of new challenges.

In circumstances where there is no assured market for staple crops (although consumer prices have steadily risen), where access to the markets for commercial alternatives is difficult if not impossible, and where the government's rural development policy focuses not on agricultural production but rather "*maquilization*," being adaptive in the Puebla-Tlaxcala valley means having the capacity both to intensify agricultural activities and to diversify economically into activities that are, by definition, less sensitive to the variability and uncertainties of the agricultural sector. This is not to say that abandoning agriculture is the solution to rural uncertainty—although in the very long run this may be a solution for many households—but rather that in the current policy environment, and in the context of high climatic variability, the more diversified a household is both in terms of its on-farm *and* non-farm strategies, the better.

The analysis of the strategies pursued by households in Los Torres, Plan de Ayala and Nazareno shows that adaptive capacity is associated with a particular suite of key resources: having sufficient land for one's own subsistence, livestock to provide stability and access to cash, and the education, social connections and support to take advantage of one's resources to engage in diversified and occasionally innovative livelihood arrangements. When an index of these resources is plotted on an "amoeba" diagram, one can see that on average, households in the community of Los Torres not only report the most extensive crop losses, but are also lacking in the capacity to effectively manage these risks (Figure 3).[9] As Bebbington argues, assets "are not simply resources... they are also the basis of agents' power to act and to reproduce, challenge or change the rules that govern the control, use and transformation of resources" (Bebbington 1999: 2022). If a household is not able to use its assets to transform its strategies and re-invent its relationship to the institutions that structure its activities, then it is far less likely to be able to pro-actively negotiate and adapt to environmental and social change.

Figure 3: Comparison of Resources For Adaptation

[9] The axes represent a uniform scale of 1 – 100 where each point represents the distance of the absolute value in relation to a maximum value, here defined as the greatest value of the variable in all of the three communities plus the standard deviation.



Source: Household Survey, 2000.

There is a growing consensus among development practitioners and scholars of rural areas that "diversification matters" not only for household survival but also for poverty alleviation, rural resilience and sustainability (Mortimore and Adams 1999; Ellis 2000; Francis 2000; Batterbury 2001; Bryceson 2002). The cases Plan de Ayala, Nazareno and Los Torres further support this research by suggesting that a certain amount of agricultural flexibility and intensification is necessary in order for households to diversify in a pattern that offers households not simply a survival strategy, but a way forward towards increasing stability and security.

The larger landholding size and the institutional framework of the *ejido* in Plan de Ayala distinguished the community in this respect. The combination of having more than enough land for subsistence production, access to communal pasture and a tax-free zone for urban settlement (the *ejido's* urban area) —in addition to being located next to a source of non-farm employment— substantially reduced the economic and social costs of economic diversification, and thus enhanced the adaptive benefits of this strategy.

If one were to extrapolate these findings to research on agricultural vulnerability and adaptive capacity more generally, it is clear that analyses that focus solely on biophysical impacts, or that assume invariable risk profiles and decision rules among

producers of similar scales, will be problematic. According to this analysis, it is not simply a household's income or landholding size, the type of crop it produces or even the degree of exposure to climatic risk that is determinant of its vulnerability. It is rather a combination of physical, financial and human resources within a context of changing policy, variable or stagnant prices, uncertainties in labor markets and environmental variability that identifies what populations are vulnerable, and how they may respond. In the context of economic globalization and neoliberal reform the relationships of peasant households to markets—whether input markets, markets for agricultural harvests or for labor and other goods and services produced—becomes central. Tracing the links from farmers' livelihoods outwards to prices, policies, public programs and private development provides a structure through which the important and relevant cross-scalar and inter-sectoral linkages in vulnerability can be empirically documented.

The three communities selected for this project cannot be considered representative of all Mexico's smallholder farmers; the significant differences between the three communities illustrate that it is unrealistic to assume that smallholders in Mexico are a homogeneous group. Yet together, the results from the three communities begin to show the diversity of production systems in Mexico, and the findings suggest plausible hypotheses about other farm systems that one might find not only in Mexico, but also in Latin America and in other regions of the world where smallholder farming has persisted. Through the careful comparison of case studies of actual decision-making under uncertainty, it may be possible to construct models of farmers' management of risk and capacity to adapt that reflect the important differences in institutional contexts and resource access that have been shown to affect vulnerability.

For example, in Figure 3 the aggregate vulnerability of the three communities is graphed to illustrate that while agricultural systems can be considered on a continuum of commercial orientation and scale, and in terms of the potential for producing agricultural income, their vulnerability cannot be mapped linearly on the basis of these indicators. In this diagram, the vulnerability of the Nazareno households is mapped on par with that of the Los Torres households, despite—indeed, because of—substantial differences in commercial orientation and market involvement. In order to understand the complexity of the interaction of market risks, political-economic change and climatic variability, this schematic representation of vulnerability could be extended to new case studies of still different production systems. One might hypothesize that large-scale commercial farmers who produce one or two crops in large volumes would be particularly vulnerable

to both market risk (particularly in relation to changes in specific commodity policies) and climatic hazards, but perhaps would have the formal institutional support to mitigate impacts and share risks. In contrast, small-scale coffee farmers who are inextricably tied to the fluctuations of a particular international commodity market are unlikely to have the same institutional support or market contracts that might help them manage risk, yet are similarly exposed to market and climatic volatility. When these characteristics of scale, institutional context and market relations are considered together with environmental risks, it is clear that vulnerability is neither static nor obviously linear in nature and thus assumptions about the uniformity of agricultural risk and the capacity of rural populations to adapt must be made with considerable caution.

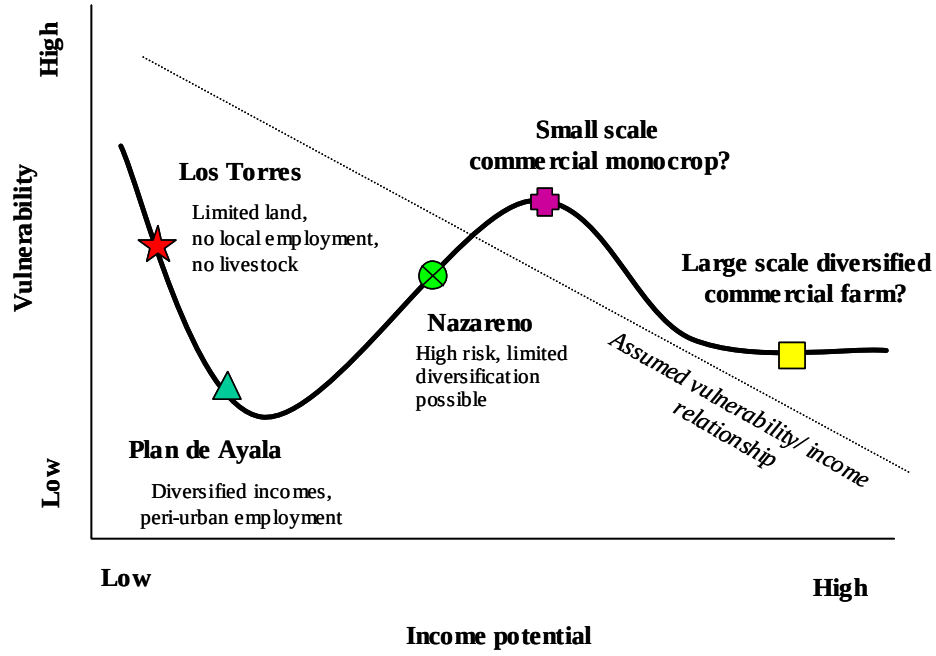


Figure 4: Vulnerability at the level of the community

One of the challenges in addressing climatic change and variability through development policy is that the question "to what are we adapting?" remains ambiguous. Not only does this ambiguity present us with a moving target, but also even the direction of change can be the subject of considerable debate. In fact the projections of increased climatic variability that are embedded in climate change scenarios imply that we may be needing to adapt to a variety of climate outcomes simultaneously. This suggests that perhaps our best hope is in pursuing development policies that encourage a diversity of alternative paths towards growth and stability based on what is already working rather than what is predicted to work by optimization models.

In the Mexican context, this means that instead of searching for the ideal or "optimal" agricultural adaptation to projected change—be it oats instead of maize, earlier planting, or more efficient irrigation—perhaps the goal should be to create "adaptive policies." These would be policies that evolve over time with the changing goals and vulnerability of populations, while maintaining the overall objective of improving the range of choice available, and the long-term sustainability of rural livelihoods. In other words, although it may be difficult—even unwise—to propose specific adaptations to climate and socio-economic circumstances not yet known or experienced, it may be possible to use analyses of climate trends and simulations of climate change to avoid making decisions that will result in a narrower range of choice for the future.

Ironically, although the aims of neoliberalism are to increase choice and opportunity through removing "obstacles" to the efficient functioning of markets, "actually existing neoliberalism" (Brenner and Theodore 2002) in Mexico may be having the opposite effect for farmers. The persistence of the belief that one model of production—capital-intensive, large-scale and run as part of the global food industry— is the future of agriculture leads naturally to policies that ease the functioning of such agribusinesses, although it does so at the expense of rural economic security for farmers following more "traditional" agricultural models. It is important to recognize that the policy decision to orient public support for production only for farmers who fall within a narrow definition of "commercially viable" has significant welfare and economic consequences for those who are by definition excluded.

The evidence from the central Mexican case studies described in this study suggests that in the near future small-scale agriculture still has a role to play—perhaps not as an economic force in its own right, but as potential springboard into other activities for the younger generations in rural areas. Facilitating processes of economic diversification while not undermining the fundamental viability of family farm production not only helps households deal with the environmental uncertainties that have persistently faced agriculture, but also conversely provides rural households the subsistence security (maize, beans and livestock) to mediate survival in the evolving economy. In this light, public policy that marginalizes small-scale producers and aggressively "de-develops" (Yapa 1996) alternatives for the rural economy would seem, in face of the vast social and environmental uncertainties of Mexico's future, shortsighted.

References

Adger, N. W. (1999). "Social Vulnerability to Climate Change and Extremes in Coastal Vietnam." World Development 27(2): 249-269.

Aguirre Alvarez, L., B. A. Salcido Ramos, et al. (1999). Planificación de actividades de desarrollo para productores de hortalizas en el centro este del estado de Puebla. Puebla, SAGAR/Colegio Postgraduados/ICRA/RIMISP: 67.

Altieri, M. and J. Trujillo (1987). "The Agroecology of Corn Production in Tlaxcala, Mexico." Human Organization 15(2): 189-220.

Appendini, K. (1998). Changing Agrarian Institutions: Interpreting the Contradictions. The Transformation of Rural Mexico: Reforming the Ejido Sector. W. Cornelius and D. Myhre. San Diego, Center for U.S.- Mexican Studies, University of California San Diego.

Batterbury, S. (2001). "Landscapes of Diversity: A Local Political Ecology of Livelihood Diversification in South-Western Niger." Ecumene 8(4): 437-464.

Bebbington, A. (1990). "Farmer Knowledge, Institutional Resources and Sustainable Agricultural Strategies: A Case Study from the Eastern Slopes of the Peruvian Andes." Bulletin of Latin American Research 9(2): 203-228.

Bebbington, A. (1999). "Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty." World Development 27(12): 2021-2044.

Bellon, M. R. (1991). "The Ethnoecology of Maize Variety Management: A Case Study from Mexico." Human Ecology 19(3): 389-418.

Blaikie, P., T. Cannon, et al. (1994). At Risk: Natural Hazards, People's Vulnerability and Disasters. London, Routledge.

Brenner, N. and N. Theodore (2002). "Cities and the Geographies of "Actually Existing Neoliberalism" " Antipode 34(3): 349-379.

Brush, S., M. Bellon Corrales, et al. (1988). "Agricultural Development and Maize Diversity in Mexico." Human Ecology 16(3): 307-328.

Bryceson, D. F. (1996). "Deagrarianization and Rural Employment in sub-Saharan Africa: A Sectoral Perspective." World Development 24(1): 97-111.

Bryceson, D. F. (2002). "The Scramble in Africa: Reorienting Rural Livelihoods." World Development 30(5): 725-739.

Burton, I., G. White, et al. (1978). Environment as Hazard. New York, Oxford University Press.

Chen, R. (1994). The Human Dimension of Vulnerability. Industrial Ecology and Global Change. R. Socolow, C. Andrews, F. Berkhout and U. Thomas. Cambridge, Cambridge U.P.: 85 - 105.

Chiotti, Q., T. Johnston, et al. (1997). Agricultural Response to Climate Change: A Preliminary Investigation of Farm-level Adaptation in Southern Alberta. Agricultural Restructuring and Sustainability. B. Ilbery, Q. Chiotti and T. Rickard. Oxon and New York, CAB International: 201-218.

CONAPO (1998). Índice de Marginación por Localidad, 1995. Mexico City, Consejo Nacional de Población.

Cornelius, W. and D. Myhre, Eds. (1998). The Transformation of Rural Mexico: Reforming the Ejido Sector. San Diego, Center for U.S. - Mexican Studies, University of California San Diego.

Davies, S., P. Bhargava, et al. (1998). Making Livelihoods Work: Women, Men and Children in Rajasthan. London/Brighton, Department for International Development/Institute of Development Studies.

Davis, B. (2000). "Las políticas de ajuste de los ejidatarios frente a la reforma neoliberal en México." Revista de la CEPAL 72(Diciembre): 99-118.

de Janvry, A., M. Chiriboga, et al. (1995). Reformas del Sector Agrícola y el Campesinado en México. San José, Costa Rica, Fondo Internacional de Desarollo Agrícola y Instituto Interamericano de Cooperación para la Agricultura.

de Janvry, A., G. Gordillo, et al. (1997). Mexico's Second Agrarian Reform: Household and Community Responses. San Diego, Center for U.S. - Mexico Studies, University of San Diego.

de Janvry, A. and E. Sadoulet (2001). "Income Strategies Among Rural Households in Mexico: The Role of Off-farm Activities." World Development 29(3): 467 - 480.

de Janvry, A., E. Sadoulet, et al. (1995). "NAFTA and Mexico's Maize Producers." World Development 23(8): 1349-1362.

Denevan, W. M. (1980). Latin America. World Systems of Traditional Resource Management. G. A. Klee. New York, Halsted Press: 217-256.

DeWalt, B., M. W. Rees, et al. (1994). The End of the Agrarian Reform in Mexico. San Diego, Center for U.S. - Mexican Studies, University of California San Diego.

Doolittle, W. (1989). Arroyos and the Development of Agriculture in Northern Mexico. Fragile Lands in Latin America: Strategies for Sustainable Development. J. O. Browder. Boulder, Westview Press.

Dow, K. (1992). "Exploring Differences in Our Common Future(s): the Meaning of Vulnerability to Global Environmental Change." Geoforum 23(3): 417-436.

Downing, T. E., M. J. Watts, et al. (1996). Climate Change and Food Insecurity: Towards a Sociology and Geography of Vulnerability. Climate Change and World Food Security. T. E. Downing. Berlin, Springer-Verlag.

Dussel Peters, E. (2000). El Tratado de Libre Comercio de Norteamérica y el Desempeño de la Economía en México, United Nations/CEPAL.

Ellis, F. (2000). Rural Livelihoods and Diversity in Developing Countries. Oxford, Oxford University Press.

Escalante, R. and T. Redón (1987). "Neoliberalismo a la Mexicana: Su Impacto Sobre el Sector Agropecuario." Problemas del Desarrollo 75: 115-151.

Francis, E. (2000). Making a Living: Changing Livelihoods in Rural Africa. London and New York, Routledge.

Friedmann, H. (1994). Distance and Durability: Shaky Foundations of the World Food Economy. The Global Restructuring of Agro Food Systems. P. McMichael. Itaca, Cornell University Press.

Fritscher Mundt, M. (1999). "El Maíz en México: Auge y Crisis en Los Noventa." Cuadernos Agrarios(17-18): 142 - 163.

Gerber, J. and W. A. Kerr (1995). Trade as an Agency of Social Policy: NAFTA's Schizophrenic Role in Agriculture. NAFTA in Transition. S. J. Randall and H. W. Konrad. Calgary, University of Calgary Press: 93-111.

Gledhill, J. (1995). Neoliberalism, Transnationalization and Rural Poverty. Boulder, Westview Press.

Goodman, D. and M. Watts, Eds. (1997). Globalising Food: Agrarian Questions and Global Restructuring. London, Routledge.

Helms, S., R. Mendelsohn, et al. (1996). "The Impact of Climate Change on Agriculture." Climatic Change 33: 1-6.

INEGI (2002). Estadística de la Industria Maquiladora de Exportación. Banco de Información Económica. http://www.inegi.gob.mx/difusion/espanol/fecono.html

INIFAP (1998). Conversión Productiva del Temporal para el Estado de Tlaxcala. Tlaxcala, INIFAP-Tlaxcala.

Kelly, T. (1999). The Effects of Economic Adjustment on Poverty in Mexico. Aldershot, Ashgate Publishing Ltd.

Liverman, D. (1994). Vulnerability to Global Environmental Change. Environmental Risks and Hazards. S. L. Cutter. Englewood Cliffs, New Jersey, Prentice Hall.

Magaña R., V. O., Ed. (1999). Los Impactos de El Niño en México. Distrito Federal, SEP - CONACYT.

Marsden, T. (1997). Creating Space for Food: The Distinctiveness of Recent Agrarian Development. Globalizing Food: Agrarian Questions and Global Restructuring. D. Goodman and M. Watts. London, Routledge.

Marsh, R. and D. Runsten (1998). Smallholder Fruit and Vegetable Production in Mexico: Barriers and Opportunities. The Transformation of Rural Mexico: Reforming the Ejido Sector. W. Cornelius and D. Myhre. San Diego, The Center for U.S. - Mexico Studies.

Mortimore, M. and W. M. Adams (1999). Working the Sahel: Environment and Society in Northern Nigeria. London, Routledge.

Myhre, D. (1994). The Politics of Globalization in Rural Mexico: Campesino Initiatives to Restructure the Agricultural Credit System. The Global Restructuring of Agro-Food Systems. P. McMichael. Ithaca and London, Cornell University Press.

Myhre, D. (1998). The Achilles' Heel of the Reforms: The Rural Finance System. The Transformation of Rural Mexico: Reforming the Ejido Sector. W. Cornelius and D. Myhre. San Diego, The Center for U.S. - Mexican Studies, University of California San Diego.

Nadal, A. (1999). Maize in Mexico: Some Environmental Implications of the North American Free Trade Agreement (NAFTA), Commission on Environmental Cooperation.

Nigh, R. (1997). "Organic Agriculture and Globalization: A Maya Associative Corporation in Chiapas, Mexico." Human Organization 56(4): 427-436.

O'Brien, K. L. and R. M. Leichenko (2000). "Double Exposure: Assessing the Impacts of Climate Change Within the Context of Economic Globalization." Global Environmental Change 10: 221-232.

Ochoa, E. C. and D. E. Lorey, Eds. (1994). Estado y Agricultura en México: Antecedentes e Implicaciones de las Reformas Salinistas. Distrito Federal, México, Universidad Autónoma Metropolitana.

OECD (1997). Review of Agricultural Polices in Mexico. Paris, OECD.

Reardon, T., J. Berdegué, et al. (2001). "Rural Nonfarm Employment and Incomes in Latin America: Overview and Policy Implications." World Development 29(3): 395-409.

Reilly, J. M. and D. Schilmmelpfenning (1999). "Agricultural Impact Assessment, Vulnerability and the Scope for Adaptation." Climatic Change 43: 745-788.

Rello, F. and A. Pérez (1996). Liberalización Económica y Política Agrícola: El Caso de México. La Agricultura Mexicana y la Apertura Comercial. A. Barrón and J. M. Hernández Trujillo. D.F., México, UNAM: 15-50.

Ribot, J. C. (1996). Introduction: Climate Variability, Climate Change and Vulnerability: Moving Forward by Looking Back. Climate Variability, Climate Change and

Social Vulnerability in the Semi-arid Tropics. J. C. Ribot, A. R. Magalhaes and S. S. Panagides. Cambridge, Cambridge University Press: 1-10.

Ribot, J. C., A. Najam, et al. (1996). Climate Variation, Vulnerability and Sustainable Development in the Semi-arid Tropics. Climate Variability, Climate Change and Social Vulnerability in the Semi-arid Tropics. J. C. Ribot, A. R. Magalhaes and S. S. Panagides. Cambridge, University of Cambridge Press: 13-51.

Richards, P. (1985). Indigenous Agricultural Revolution. London, Hutchinson & Co.

Romero Polanco, E. (1996). "Globalización Económica y Agricultura en México." Problemas de Desarrollo 27: 7-15.

Rosenzweig, C. and M. Parry (1993). Potential Impacts of Climate Change on World Food Supply: A Summary of a Recent International Study. Agricultural Dimensions of Global Climate Change. H. Kaiser and T. E. Drennen. Delray Beach, St. Lucie Press.

Scoones, I. (1998). Sustainable Rural Livelihoods: A Framework for Analysis. IDS Working Paper.

Sen, A. (1981). Poverty and Famines. Oxford, Clarendon Press.

Smit, B., D. McNabb, et al. (1996). "Agricultural Adaptation to Climatic Variation." Climatic Change 33: 7-29.

Snyder, R. (2001). Politics after Neoliberalism. Cambridge, Cambridge University Press.

Toledo, V. (1990). The Ecological Rationality of Peasant Production. Agroecology and Small Farm Development. M. Altieri and S. B. Hecht, CRC Press.

Trujillo, J. A. (1990). "Adaptación de Sistemas Tradicionales de Producción de Maíz a las Condiciones 'Siniestrantes' de Tlaxcala." Historia y sociedad en Tlaxcala Octubre: 67-70.

Watts, M. J. and H. G. Bohle (1993). "The Space of Vulnerability: the Causal Structure of Hunger and Famine." Progress in Human Geography 17(1): 43-67.

White, G. (1973). Natural Hazards Research. Directions in Geography. R. J. Chorley. London, Methuen: 193-216.

Whitmore, T. M. and B. L. Turner II (1992). "Landscapes of Cultivation in Mesoamerica on the Eve of the Conquest." Annals of the Association of American Geographers 82(3): 402-425.

Wilken, G. (1987). Good Farmers: Traditional Agricultural Resource Management in Mexico and Central America. Berkeley, University of California Press.

Yapa, L. (1996). Improved Seeds and Constructed Scarcity. Liberation Ecologies. R. Peets and M. Watts. New York, Routledge.

Zedillo, P. d. L. (1996). Segundo Informe de Gobierno. México, D.F., Presidencia de la República.