Crop Choice as Adaptation to Climatic Risk in Central Mexico

Hallie Eakin
Department of Geography, University of Arizona, Tucson, AZ 85721
heakin@u.arizona.edu

Prepared for presentation at the Open Meeting of the Global Environmental Change Research Community, Rio de Janeiro, Oct. 6-8, 2001

The sensitivity of crop production to climate has put agriculture at the center of research on the vulnerability of human systems to climate change. Not only is production inextricably linked to climatic parameters, but also the capacity of households to adapt to changes in these parameters is a critical concern for assuring world food security and maintaining stable livelihoods for the world’s large rural population (Parry 1990; Chen and Kates 1994).

Research on the vulnerability of the agricultural sector to climatic change and variability has tended to be based on the outputs of models that link simulations of climatic change to physiological models of crop growth and productivity, such as the EPIC or CERES models (Liverman et al. 1992; Crosson 1993; Conde et al. 1997; Magrin et al. 1997; Izaurralde et al. 1999). These analyses can be useful in illustrating possible scenarios of climate effects on crop performance, and can indicate the sensitivity of particular aspects of the crop production process to climatic changes. They are also used as a “first approximation of adaptability”, by simulating how changes in cultivar, technology and inputs or even in crop type might mitigate the impact of climate changes on yields (Easterling et al. 1996, 42).

In recent efforts to improve the applications of El Niño – Southern Oscillation forecasting in agriculture, for example, scientists have used crop models to identify “alternative crops” that are better adapted to the swings in regional climatic conditions that often occur in relation to El Niño or La Niña events. The hope is that those crops whose yields prove less sensitive to anticipated changes in climate patterns (whether interannual changes, as in ENSO, or decadal shifts related to climate change) can be promoted as “optimal” agricultural adaptations, particularly when coupled with a long-lead forecast based on ENSO signals.

In central Mexico, climatologists at the National Autonomous University of Mexico (U.N.A.M.) have been working with colleagues in the state of Tlaxcala to produce such forecasts. The government of Tlaxcala has expressed interest in this research, and is using the threat of rainfall irregularities associated with strong El Niño events to promote barley as an alternative to
maize, the dominant crop in Tlaxcala (INIFAP 1998). The shorter growing cycle of barley (120 - 130 days vs. 130 –160 days for maize) is thought to be better adapted to drought periods associated with El Niño. The state is also motivated to encourage farmers to switch to barley production because maize is no longer seen as having any commercial advantage in central Mexico, while barley can be used as an input into malt processing.

In this paper, I will use data collected in a broader study of agricultural vulnerability and adaptation in Tlaxcala to “unpack” some of the complexity in households’ crop choices, particularly in relation to crops presented as “alternatives” under adverse climate conditions. The paper is based on findings from two case studies of small-scale rainfed farming systems in the state of Tlaxcala: the ejido Plan de Ayala, in the county of Tetla, and the rancheria Los Torres, in the county of Huamantla. Ethnographic methods (individual interviews, focus group discussions and participant observations) and a household survey were used to discern how recent changes in Mexico’s agricultural programs and general economic policies are influencing households’ production strategies, and the implications of their responses for their vulnerability to climatic risk. This paper focuses on one part of that research: household decisions regarding crop choice.

I will argue that any study of farm-level adaptation that is limited to options in crop management, such as crop choice, will fail to address the vulnerabilities of many of Tlaxcala’s rural households, and will ignore the full range of adaptation options available to such households. Important changes in economic and agricultural policies do not make barley as attractive an option as agricultural officials may hope, and, under these circumstances, maize actually may provide more household security and greater livelihood flexibility than other crops. Furthermore, the most effective adaptation options available to farm households in Tlaxcala may have little to do with cropping systems, and more to do with non-agricultural or inter-sector livelihood strategies.

1 This broader study included a third case study in Puebla, Mexico that will not be discussed in this paper. The research was undertaken in close collaboration with the National Autonomous University of Mexico’s Center for Atmospheric Sciences (UNAM – CCA), which is interested in promoting long-lead forecast use among households in Tlaxcala, Mexico.

2 Ejidos are legally constituted farm communities in which the land is held communally, although typically farmed in individually distributed plots. Until recently, ejidatarios did not hold individual title to their land although the land was inalienable. Rancherias are communities that are not officially incorporated as towns with their own administration. They are not ejidos, although some of a rancheria’s residents may be ejidatarios in near by ejidos.
Policy Overview

Before exploring in detail the nature of crop decisions in Tlaxcala, it is important to understand the broader political and economic context of those decisions. The dramatic changes in agricultural policy that have occurred in the last decades can be traced back to the initiation of neo-liberal reforms under the de la Madrid administration (1982-1988). Soon after de la Madrid took office, the government began to withdraw from its role of being the primary source of investment and provider of agricultural services for both small and large-scale agriculture. From 1982 – 1988, the government’s spending on agriculture was slashed by 62%. The agricultural finance sector was re-vamped to fit a primate sector model, and, as a result, funding for the public agricultural finance institution BANRURAL declined by 76% in real terms (Ochoa 1994, 11).

By 1991, the area credited through BANRURAL had fallen from 7.2 million ha in 1988 to 1.2 million ha as all “high risk” borrowers were dropped from its lending program (Myhre 1998). Subsidies for agricultural inputs and technology were also cut. Although support prices for maize and other crops were initially maintained, they declined in real terms between 4% and 9% annually (de Janvry 1995, 74).

When Mexico entered into the North American Free Trade Agreement in 1994, the new orientation of agricultural policy was solidly in place. The sector had been divided into two groups of farm households: the small proportion of large-scale commercial enterprises that might be able to compete internationally, and the rest: the smaller scale farm households who were either marginally commercial or subsistence oriented, and thus thought not likely to survive in the globalized economy. The smallest-scale farm households, particularly those in regions of high climatic risk and low productivity, were no longer entitled to credit from BANRURAL, nor were they to be offered crop insurance. Thus, while nationally the insured cropped area was increasing, a smaller percentage of farm households – those with substantial property and “commercial potential” – were benefiting. Tlaxcala’s small-scale maize producers were among those excluded (Figure 1).

The input parastatal, FERTIMEX (fertilizers) was privatized in 1990 and PRONASE (the national seed company) was forced to share the market with foreign competitors in 1991 (Appendini 1994). Input subsidies, particularly for fertilizer, water and electricity, were also reduced dramatically (Figure 2) and households experienced a sudden escalation in the cost of production just as the system of offering guaranteed producer prices was being abandoned (de Janvry 1995). CONASUPO, the state-run marketing agency for basic grains (including barley, maize and beans), was downsized and given a reduced mandate to market only maize and beans, the only two crops with a remaining price support (Appendini 1994). By 1999, CONASUPO had
closed and households no longer had a guaranteed buyer. Although maize and beans currently continue to enjoy some price support, in real terms corn prices have continued to fall (de Janvry 1997).

At the end of the 1990s rural households faced a very different and highly uncertain policy environment. They no longer had the patronizing interference of the BANRURAL extension agents, monitoring their production decisions, however now few households had any access to extension. Crop prices had stagnated, and without the government’s marketing agencies, farmers had fewer options for selling their small harvests. They were being pressured to “modernize” through the adoption of more capital-intensive techniques, yet it was not clear whether the investments would pay off in the new environment of liberalized prices. Maize was no longer a remunerative crop, but farm households were receiving little direction on what might be viable alternatives that would assure their subsistence requirements. Those households who were primarily subsistence oriented, faced rising consumer costs and a loss in purchasing power of their agricultural resources. In short, households were facing a new, highly competitive market without the institutional and economic support to help them find their place in it.

Study Sites
The two case study communities were located in the state of Tlaxcala, a tiny state in the Altiplano of Central Mexico. Tlaxcala is situated in the Transversal Neo-volcanic Axis, where elevations range from 2000 to over 4000 meters above sea level. After centuries of agricultural exploitation, the volcanic soils in Tlaxcala are thin and heavily eroded. Tepetate, an unpenetrable calciferous material underlying Tlaxcala’s soils, has been exposed to the surface in many areas making crop production impossible. Less than 13% of the cultivated land is irrigated, and water resources for agricultural use are generally scarce. According to the latest census (INEGI 2000b), Tlaxcala’s population was 21% rural, and 84% of the state’s land area was used for agricultural activities. Tlaxcala’s households are also predominantly small-scale. The average landholding size in 1990 was just under 2 hectares and 85% of the state’s rural production units were less than 5 hectares (INEGI 1993). Today, with 238 people/km², Tlaxcala has one of the highest population densities in Mexico.

Maize dominates crop production in Tlaxcala, as it has for centuries. In 1998/99, maize occupied 51.7% of the total area planted and 26.2% of the total agricultural value (INEGI 2000a)(Table 1). Despite the importance of maize in these terms, the crop’s yields are quite low. In the 1990s, yields averaged between 1.2ton/ha and 2.4ton/ha (SAGAR-Tlaxcala 2000). Over half (65.5%) of Tlaxcala’s households are thought to be subsistence households, selling only small quantities of their harvests as particular needs arise.
Aside from beans, Tlaxcala’s other principal crops – barley, wheat, and potatoes -- are considered commercial crops. Barley potentially can be sold to one of the several malt processing plants in the state as an input into the beer industry, and wheat can be marketed to one of the flour mills in Tlaxcala or the neighboring state of Puebla. Both crops can also be sold as grain for feed or hay for forage. Potatoes are planted on just a little more than 1% of Tlaxcala’s cultivated land, yet play an important role in agricultural revenues (representing 16.6% of total agricultural value in 1998/99).

<table>
<thead>
<tr>
<th>Table 1: Principal Crops, Tlaxcala 1998/99</th>
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<tbody>
<tr>
<td>Crop</td>
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<tr>
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</tr>
<tr>
<td>Maize</td>
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<td>Barley</td>
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<td>Maize-forrage</td>
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<td>Beans</td>
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The farm households in the communities of Plan de Ayala and Los Torres were generally representative of the rural households in Tlaxcala: they had limited land, were reliant on traditional technology (draft power, manual labor, and minimal purchased inputs) and focused on the production of basic grains. They differed, however in their involvement in agricultural markets and proximity to centers of urban services and off-farm employment. Plan de Ayala’s ejidatarios had often, over the years, produced a surplus of grain, which they had traditionally sold directly to grain merchants or through intermediaries to larger distributors. Many of the younger adults in the ejido also had access to factory employment and other non-farm economic activities without having to leave the ejido. Los Torres households, in contrast, rarely sold more than a few kilos of grain at a time, and this was typically only to meet immediate household expenses. They focused on maize and beans production for subsistence purposes (Table 2). Los Torres was also far more isolated geographically, limiting the interaction of households with other sectors of the economy. Importantly, Los Torres households had, on average, a third as much land as those in Plan de Ayala. This differentiation facilitated a comparison in this study of how market uncertainties and agricultural policy changes interacted with climatic risks in household decisions, and how climatic risk affected households with different agricultural income potentials.
### Table 2: Study Sites

<table>
<thead>
<tr>
<th>Crops planted</th>
<th>Avg. land/household</th>
<th>Technology</th>
<th>Market orientation</th>
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<tbody>
<tr>
<td>Los Torres</td>
<td>Maize, beans</td>
<td>4 ha*</td>
<td>Manual, rainfed</td>
</tr>
<tr>
<td>Plan de Ayala</td>
<td>Barley, oats, wheat, maize, beans</td>
<td>9 ha</td>
<td>Manual and mechanized; rainfed</td>
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</tbody>
</table>

*This average excludes two “outliers” – a household with 50 ha, and a household with 20 ha. The remaining 20 households surveyed each had less than 12 ha.

**Climatic Risk**

Although Tlaxcala has a total area of only 4,062 km², the state’s complex topography is the source of considerable climatic variability within the state’s boundaries. Most of the state is classified as having a sub-humid climate with summer rains, rainfall totals range from 400 mm in the arid far-eastern corner of the state, to over 1200 mm on the slopes of state’s towering volcano, La Malinche. The communities participating in this study received on average between 600 mm to 700 mm of rainfall annually (INEGI 2000a).

Tlaxcala’s elevation ranges from 2200 m above sea level to over 4400 m at the peak of La Malinche. As in many parts of the state, the land in both of the studied communities is subject to frequent frosts, which in recent years have occurred in the middle of the growing season. The risk of frost rises steeply in the end of September, abruptly ending the growing season. Drought is also common, particularly in the north and eastern parts of Tlaxcala where the community of Los Torres is located. Tlaxcala is also on the border of the large region in Mexico affected by the canícula, or the mid-summer drought. The canícula is characterized by a decline in the number of rainy days during the months of July and August, and, when particularly marked, can have a significant impact on yields of rainfed crops (Magaña et al. 1999).

The variability in Tlaxcala’s climate is now thought to be partially explained by the El Niño / Southern Oscillation, although the topography of the region complicates the relationship (Conde et al. 1999). U.N.A.M.’s analyses of rainfall anomalies have shown a tendency for reduced precipitation (mm/day) during the summer rainy season during the first El Niño year of a two-year ENSO event, and a delay in the start of the rainy season during second year (Conde et al. ND). El Niño events can also accentuate the dryness of the canícula, depressing yields even further. La Niña events typically have less impact on the regional climate, however particularly intense events such as the 1998/1999 La Niña can result in excessive autumn rainfall in the area (Magaña 1999).

Given the intensity of the 1997-98 El Niño and the 1998-1999 La Niña events, it is not surprising that the last three years of the 1990s were particularly difficult for households (Figure
3). Although the 1997 season began auspiciously, by June the rains had become erratic and by July the state was suffering from drought. At the start of the 1998 rainy season, drought and the land clearing activities of households were causing forest fires in the state. The onset of the 1998 summer rains was late, causing many households to delay planting until June, and in some cases, July. There were reports of damages from both late and early frosts in May, September, and October, and anomalous rainfall in September. The 1999 season reportedly began in drought for households, with the rains again arriving late. Households’ complaints, however, were of the frost damage, which again occurred mid-season, and the excessive rainfall that hit the region in October. Only a few households lost entire harvests to mud slides and flooding, but many others suffered crop losses to rot and mold.

According to data from the agricultural secretary, SAGAR, maize yields in 1997, 1998 and 1999 averaged just over 1 ton/ha, making those two years the worst years for maize production in the last decade (INEGI 2000a). From the household surveys completed in communities, the impact of climate events was severe in not only 1999 but also in 1998. In Los Torres, a total of 59% of the area planted by the surveyed households in 1998, and 89% of the area in 1999, was affected to some extent by hazards. In 1998 the damage was largely attributed to drought, and in 1999, to frost. In Plan de Ayala, respondents claimed that 54% of the planted area was affected in 1998, and 73% in 1999. Frost was the main culprit in 1999, and frost and drought together destroyed harvests in 1998 (Figure 4).

Barley as an “Alternative” Crop

If one looks at Tlaxcala’s agricultural data, there is some evidence that barley might be the alternative crop that the agricultural officials hope will both mitigate farmers’ vulnerability while involving them in more commercial production (INIFAP 1998). Not only does barley have a shorter growing season than maize, unlike maize (which in Tlaxcala is primarily a subsistence crop) barley is considered a commercial crop whether sold as grain or as forrage. There is at least one malt plant in Tlaxcala, theoretically serving as a market for the barley in the state. To promote the crop, hybrid barley seed and fertilizers are being marketed at subsidized rates through the state’s Kilo por Kilo program, in the hope of encouraging farmers to invest in higher quality inputs and improve their yields. Through this “crop conversion” program, the government hopes to reduce the area planted in maize by 91,200 hectares, and increase the area planted in barley, oats and pasture grasses by 73,600 hectares between 1998 and 2010 (INIFAP 1998: 18).

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3 The state’s directory of industries lists only one malt plant, “Cebadas y Maltas, S.A.de C.V.” that was established in 1984. There are also several malt plants in Puebla.
Although oats are not considered as commercially viable in Tlaxcala, oats have been offered as a drought-recovery crop, given that its growing cycle is only 80 days and thus can conceivably be planted until the end of July. The government distributed subsidized bags of oats seed after households lost maize crops to unusual mid-summer frosts in 1999 and 2000 with the idea that households would be able to replant their fields and recover some of their losses.

Agricultural statistics for the state show that between 1995 and 1999, the area under barley expanded by 78% (Figure 5). The area planted in oats also increased since 1995, yet remained proportionally small in comparison to the state’s other crops (Figure 6). Forage maize (maize harvested green as silage) also showed a remarkable increase in area planted. Although the average area of this crop was only 600 hectares between 1992 - 1997, in 1998 and 1999 its area expanded 7405 hectares, over 12 times its previous average. Like barley, maize planted purely for forage has a shorter growing season than maize planted for grain.

These trends were mirrored by a simultaneous contraction in the area planted in maize grain and wheat during the same period. In 1997, the area planted in wheat fell by 10,212 hectares as barley expanded by 10,905 hectares. In 1998, the displacement was primarily in maize. The area planted in maize fell by an astonishing 25,566 hectares, while the hectares in barley increased by 11,146 hectares, and wheat and maize forage together expanded a total of 12,422 hectares.

These apparent trends are in contrast to the findings of surveys of farmer household behavior in the 1990s that have found that despite the declining profitability in maize, households have actually expanded the planted area in the crop (de Janvry et al. 1997; Nadal 1999). This has been explained by the increased marginalization of smallholder households, who, unable to participate in the market, have “retreated” into subsistence production, and even expanded into more marginal land in an effort to meet household needs (Nadal 1999). Maize in the 1990s was also the only crop that still enjoyed price controls and thus represented some relative stability for households. Thus there is some evidence that one adaptation of households to the increasingly competitive economic environment has been to plant more maize, not less.

**Household Decision-Making and Crop Choice**

Although the aggregated data of the agricultural census offers some optimism for the potential role of crop choice in adaptation, it says little about which of Tlaxcala’s farmers are participating in this apparent crop switch and what the crop choice means for different types of agricultural households. From the data collected in the focus groups and interviews in the two farming communities in Tlaxcala, it would seem that actually relatively few farmers are
participating in the shift in crop from maize to barley and oats as a response to climate conditions, and even fewer are doing so because of participation in the government’s promotion of these crops as commercial alternatives. By the government’s own estimation, only 6% of Tlaxcala’s “rural production units” were participating in the hybrid seed promotion program, Kilo por Kilo between 1996 and 1998. In the two communities surveyed in Tlaxcala, only one household in Plan de Ayala participated in the Kilo por Kilo seed program, despite the fact that barley, wheat and oats were commonly planted along with maize in the community. This low participation rate was in part because acquiring the seed entailed transport costs, time, and a considerable outlay of money for the purchase of the seed despite the discounted prices offered to households. Most households were accustomed to selecting their own seed from each year’s harvest, and thus spent nothing on seed purchases.

Not only was acquiring the seed problematic, but few households perceived any commercial advantage in the crop. Barley was not a new crop for households in Plan de Ayala. They had always planted some of their land in the crop, along with wheat, maize and beans. When Plan de Ayala first started production as an ejido, some of the ejidatarios reported selling their barley harvest to Impulsora, a malt processing company, via intermediaries that came to their fields with trucks. By 1996 they had lost access to Impulsora as a result of poor yields and repeated years of poor quality grain from frost damage. They also were selling their harvests to CONASUPO until its closure in 1998.

The state’s malt plants offered the best prices for barley, but only for grain that met stringent quality requirements. According to an rural development expert in Tlaxcala, in years of high yields the malt plants may buy as much as 26% of their barley from regional households. However, the perpetual problem of frost damage in the barley harvests means that typically only 2-3% of the plants’ demand is met by local harvests. The risk of frost losses thus inhibits farmers’ investment in higher quality inputs, particularly when no insurance is available to cover their investment. A one frustrated farmer complained:

‘There is a ranch across the highway, where the fields are all yellow now with flowering barley – they get high yields, use lots of chemicals and tractors and fill whole trucks with the grain. And so they get a better price. It is hard to sell in small quantities at the quality they want. It isn’t worth it for me to invest in lots of chemicals when I can’t be sure I will even have a harvest in the end.’ (Don Camilo S. L., Sept. 13, 2000).

Instead of selling to the malt processors, farmers in Plan de Ayala first use their barley, wheat and oats harvests for feed for their own livestock. What little they did sell, was sold in
small quantities (kilos) to small merchants in Apizaco at relatively low prices, or was traded for seed or grain with their neighbors in Plan de Ayala or in the near by ejido, José Maria y Pavón. In fact, in the latter half of the 1990s, maize prices (although low) were almost always consistently higher than for alternative grains (Figure 7). As one farmer complained:

‘Before NAFTA there was a guaranteed price for barley, but not now. The government thinks we will do better with NAFTA but we haven’t. Now we are completely at the mercy of the intermediaries and the buyers. They always pay very little.’ (Don Emetario, May 23, 2000).

With such an uncertain market outcome, few households in Plan de Ayala were willing to invest in improved seeds and fertilizers, particularly if no insurance was available. As one farmer said, “Si no soy seguro que voy a cosechar, no me endrogo con la compra de semillas y fertilizantes.” (If I am not sure I am going to get a harvest, I am not going to fall into debt with the purchase of seeds and fertilizers).

In comparison to the ejidatarios of Plan de Ayala who had an average of 9 ha per household, Los Torres households’ landholdings averaged 4 ha. The priority of these households was the production of maize largely for subsistence needs. Planting a crop such as barley or oats would be, in their words, “purely for sale” and (ironically) thus not very useful. Maize is used as grain for household consumption, as well as a feed for small livestock. The maize stalks are used as fodder for larger livestock. In most cases, even maize damaged by frost or drought can be used as animal feed. Maize is also used as an informal savings account. While it is not grown for sale, households count on being able to “cash in” a few kilos of maize at a local market to obtain immediate cash for necessary purchases.

Barley and oats are not consumed by the households as food, and only to a limited extent as feed. Few households had large numbers of livestock, so most of the barley or oats planted would have to be sold. Thus for these households, the producer prices offered for barley oats or any alternative grain would need to be sufficiently high to enable a family to satisfy their maize needs commercially. With maize yields in good years only about 1 ton/ha, and annual maize consumption needs of at least 2.5 tons for a family of 5, a household with only 3 hectares could not spare area for other crops unless it could be assured that the harvest would be sufficiently remunerative to purchase the maize for consumption. For the yields a Los Torres household could expect, the prices for barley, oats and wheat were too low to risk planting these crops (see

4 After two years of heavy crop losses, a new insurance program was being offered to households, but only to those who were participating in the government’s fertilizer program. The insurance was limited to those suffering complete losses from hazards, and in those cases would cover not the value of the crop but the value of the fertilizer purchase ($1500/ha).
Figure 7). Investing in the necessary inputs to boost yields was, as in Plan de Ayala, too risky given the frequency of climatic hazards.

Contrary to the indications of the aggregate statistics for Tlaxcala, households in Plan de Ayala and Los Torres actually increased the area planted in maize from 1998 to 1999 (Table 3). In Plan de Ayala, households increased the area planted in maize from 28.7% to 36.1% of their total area, and decreased the area in barley from 39.5% to 34.8%. The area planted in oats increased from 16% to 22.2%, and the area in wheat declined from 13.9% to 3.3%. Households also planted more beans, from 1.2% of the land area to 3.6%.

In Plan de Ayala, when asked how they decided what crop to plant, 56.4% of the respondents said that their decision was based on the timing of the rain, the suitability of a crop for the land available, given particular climate conditions, or the crop’s resistance to hazards. This suggests that the change in land use observed in Plan de Ayala was primarily in relation to the onset of the rainy season, by which households can estimate the length of the growing season and thus the suitability of planting longer-cycle crops. In 1998, the rains arrived unusually late. Households planted maize, but restricted this planting to the most frost-protected area on the *ejido*, a hill called “El Mirador” on which each *ejidatario* had between 2 and 3 hectares. In 1999, the rains arrived earlier than usual (although tapered off mid-summer) and households expanded their maize area off of the hill into the fields that were more exposed to frost, replacing the barley fields of the previous year for maize. They also expanded their area in beans, a crop that is almost always used for subsistence. This again underscores the preferences of Plan de Ayala households for maize and beans, within the constraints of climate.

Table 3: Land Area by Crop (% of total area)

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<thead>
<tr>
<th></th>
<th>Plan de Ayala</th>
<th>Los Torres (with 2 largest landholders)</th>
<th>Los Torres (without 2 largest landholders)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>28.7</td>
<td>36.1</td>
<td>49.0</td>
</tr>
<tr>
<td>Beans</td>
<td>1.2</td>
<td>3.6</td>
<td>11.2</td>
</tr>
<tr>
<td>Barley</td>
<td>39.5</td>
<td>34.8</td>
<td>23.6</td>
</tr>
<tr>
<td>Oats</td>
<td>16.0</td>
<td>22.2</td>
<td>14.4</td>
</tr>
<tr>
<td>Maize/Bean</td>
<td>-</td>
<td>.2</td>
<td>.2</td>
</tr>
<tr>
<td>Wheat</td>
<td>13.9</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td>Fallow</td>
<td>-</td>
<td>1.6</td>
<td>0</td>
</tr>
</tbody>
</table>

In Los Torres, the change in the distribution of crops between 1998 and 1999 consisted primarily of the two largest landholders (20 ha and 50 ha) switching from barley and oats in 1998 to maize in 1999. The change in land use by the remaining households was primarily accounted for by households planting more maize and fewer beans in 1999, a switch that probably had less
to do with climate than with normal crop rotation practices. Over half (54.5%) of households surveyed in Los Torres claimed that they chose what crop to plant on the basis of either their family’s consumption needs or crop rotation schedules. Thirteen percent claimed that their decision was primarily limited by the amount of land they had available (which normally did not change from year to year). Only one household based their crop choice decision on climatic patterns. With a few exceptions, the land constraints in Los Torres limit households to planting subsistence crops: maize and beans. Only in cases where households had livestock, or where they had more land than necessary for meeting their subsistence requirements, did households plant alternative crops.

Thus even though the rains were particularly late in arriving in 1998, 21% of the maize fields planted were planted in June and July, far later than recommended if households were going to avoid the risk of frost losses in the fall. Households in Los Torres planted maize and beans in spite of the climate risk because there were no alternative fast-maturing crops that would meet their food requirements. Although they were fully aware of the risk in planting maize as late as July, they risked planting on the off chance that they would be able to harvest at least fodder for their livestock, if not a few hundred kilos of grain for their own consumption. Their investment in planting was minimal: the seed they had stored from a previous harvest and their own labor. They gained little by not planting, and saw no advantage in planting commercial crops that required investment in seed and herbicides, and whose value was so low in local markets. In other words, the risks posed to their livelihoods by not planting maize were greater than the risk of climatic losses.

**What does this mean for adaptation?**

Although the survey took place in only two of Tlaxcala’s 794 communities, the findings may shed light on what the real possibilities for adaptation to changing climatic conditions are in Tlaxcala. From the results of the surveys and interviews, the first priority of households in the two communities was to guarantee a supply of maize for their own domestic consumption. Maize was also a preferred crop because of its multiple uses – as forage and fodder, fresh as “elotes” and as grain for tortillas. As there was no advantage in market price for planting alternative crops, and the obstacles to commercialization were great, maize remained households’ first crop choice.

Thus households in Plan de Ayala, who had on average 9 hectares available to them, always planted their most protected land in maize (2-3 hectares) and expanded this area in years in which they felt the risk of frost was low, and the rains were timely. As long as they had livestock, they planted some area in barley, oats or wheat either for livestock feed or to sell to
seed stores in Apizaco. Households in Los Torrres, with severe land constraints, were not generally adjusting their planting according to variations in climate conditions. They alternated maize and beans to keep the soils relatively fertile, and because they required both crops for their consumption. Only households with livestock had an incentive to plant oats or barley, and then only when planting these crops would not compete with maize for their own consumption. By planting only maize, they risked impressive losses in yields to climatic hazards, but typically were able to salvage something that they could consume, postponing the need to leave in search of off-farm employment a month or so. If they planted alternative, “purely commercial” crops and lost these crops to drought or frost, they would have been far worse off. They would have invested in the production of a crop that would have no use to them domestically or commercially.

For this reason, if the cropping patterns observed in the state’s data is used as an indicator of apparent “adaptation” to climatic variability, it probably only reflects the 15% of Tlaxcala’s rural production units that have more than 5 hectares of land (and farm more than 100,000 hectares of Tlaxcala’s 199,227 hectares of cultivated land). This indicator ignores the full complexities of adaptation strategies that farm households are engaging in that are not directly related to crop choices. In both communities households were adjusting not only to climate risk, but also to the combination of risks and uncertainties posed by poor producer prices, rising input costs and consumer food prices (particularly in isolated rural areas such as Los Torres) and the limited opportunities for other sources of income.

Although the crop choices of Los Torres households do not appear to be direct responses to interannual climatic variability, their persistent preference for maize and beans reflects a sound adaptation to the rising consumer costs of these crops, and their lack of confidence that any other crop would yield sufficient revenue to satisfy the multiple uses maize plants serve in their domestic economy. In this case, rather than using crop choice as an indicator of adaptation, it makes more sense to explore the whole structure of household livelihoods in an attempt to understand its flexibility under stress. Few small-scale agricultural households depend solely on agriculture for their livelihoods. In addition to dedicating labor and time to crop production, non-farm activities and farm-related activities (equipment rental, honey and milk production, grain milling etc.) play important roles in household coping strategies.

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5 The only data available on farm size is from 1991 (1990 census). At that time, 88.5% of the total rural production units had access to agricultural land, and 15% of these had more than 5 ha of land. Thus: (76,816 RPU Total) – (65,474 RPU with <= 5 ha.) = (11,342 RPU x .885) = 10,037 RPU with land and greater than 5 ha. Similarly, the total area of all RPU was 241,211 ha. 82.6% of these ha were used for agricultural production. The RPU with greater than 5 ha had 143,724.92 ha. Multiplied by .826, there were 118,716.78 ha of land cultivated by these households in 1991.
Although households in Plan de Ayala generally have sufficient land to enable some flexibility in the range of crops they plant, their crop choices do not represent the full range of adaptations in which they are engaging. In addition to adjusting the amount of land planted in barley and oats, households were also adjusting their reliance on their livestock and on non-agricultural activities. Because the community is located very near a large industrial zone, there is a fairly flexible entry into the local labor market for the community’s young adults. This facilitated the stability of household income, even in years of heavy crop losses.

Similarly, while households in Los Torres may not adjust their crop choice from year to year in response to climatic variability, they are adjusting their dependence on other sources of subsistence. The lack of transport to the community has inhibited the community’s access to secondary education, restricting their non-farm employment opportunities in the immediate vicinity of Los Torres. However, in recent years, roughly coinciding with the sudden increase in climatic extremes in the late 1990s, young adults in Los Torres have begun to spend several months of the year living in the state of Puebla, where they work in cement block manufacturing before returning to Los Torres to invest with their family in the next agricultural season.

A policy that focuses uniquely on crop choice thus is not adequately attuned to the reality of household survival strategies and livelihood priorities. Evidence from the two communities studied in this project show that adaptive capacity is a function of a household’s land area, level of education, availability of labor, livestock resources, the diversity of “value added” agricultural products produced, and, importantly, a household’s access to non-agriculture employment and income. Rather than trying to convince households to abandon the very crop that offers them the most security, it may be far more productive to facilitate the full diversity of strategies in which households are already engaged.

Conclusion

This article has focused only on one small part of farmer’s decision-making and livelihood strategies, their crop choices. Again, crop and technology choice is relatively easily modeled and measured, and would seem to be a logical focus of any adaptation efforts. The evidence gathered in the two Tlaxcaltecan communities studied illustrates that the households’ strong subsistence preference for maize, combined with poor producer prices, inaccessible markets, and rising input costs complicate any assumptions about wide-spread adaptation to climatic risk through crop conversion. This does not mean, however, that households are not prepared to adjust to their changing environment, but rather that their adaptations will be far more complex than simple adjustments in crop type.
It should be remembered that it is extremely difficult to simulate the full complexity of a household’s decision-making environment and livelihood strategies. Climate parameters are not the only, or always the most important, factor in production decisions, and crop and technology choices aren’t the only choices households face. Households are simultaneously adjusting to new technologies, changes in sector and broader economic policy, new institutional arrangements, market opportunities and constraints, and their ever-dynamic personal economic circumstances. We cannot know what precise combination of factors will be relevant, or the particular weight and nature of any factor in a farmer’s decision at any given point in the future. We can, however, attempt to understand how today’s households are responding and adjusting to current uncertainty (environmental, socioeconomic and political), and through this analysis, gain insight on potential obstacles and challenges in the process of adaptation.

Furthermore, it is often forgotten in studies of vulnerability that few small-scale producers rely on agriculture as their only and primary source of livelihood. Other data collected in this study has illustrated the importance of education, the location and proximity of rural industries and social services, and the role of social networks in structuring the vulnerability of the farm households and the strategies they implement as they adjust simultaneously to changing political-economic and environmental conditions (Eakin 2001). We can assume that the development trends in related sectors and in rural living standards will continue to influence households’ decisions, livelihoods and vulnerability. If the frequency and intensity of hazards continues to destabilize production in Tlaxcala, households may increasingly rely on the rapidly growing urban and industrial sectors for support. Such decisions will shift the geography of vulnerability as the demands on resources change and the livelihood choices of rural and peri-urban households reflect different constraints and opportunities. The challenge remains for social science to develop methodologies in adaptation and vulnerability analysis that can accommodate these temporal and spatial dynamics.
Figure 1.

![Insured Agriculture Area 1995 - 1999](image1)

Source: CEASAGARPA and Statistical Yearbooks for the State of Tlaxcala, Various Years (INEGI).

Figure 2.

![Subsidies for Inputs as Percent of Production Value](image2)

Source: OECD 1997
Figure 3. Tlaxcala Climatology vs. 1997 and 1998 Monthly Rainfall Totals

Source: UNAM-CCA

Figure 4. Percent of Planted Area Affected by Climate Hazards


Figure 5. Area Planted in Rainfed Maize and Barley, Tlaxcala

Source: AGRIT database, SAGAR
Figure 6.

**Area Planted in Oats, Tlaxcala**

![Area Planted in Oats, Tlaxcala](image)

Source: AGRIT database, SAGAR

Figure 7.

**Producer Prices, Tlaxcala**

![Producer Prices, Tlaxcala](image)

Source: SAGAR-Tlaxcala
References


