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Monica Wehbe, Hallie Eakin, Roberto Seiler, Marta
Vinocur, Cristian Ávila,
and Cecilia Marutto

AIACC Working Paper No. 39
September 2006

Direct correspondence to:
Monica Wehbe, mwehbe@eco.unrc.edu.ar

An electronic publication of the AIACC project available at www.aiaccproject.org.

AIACC Working Papers

Distributed by:
The AIACC Project Office
International START Secretariat
2000 Florida Avenue, NW
Washington, DC 20009 USA
www.aiaccproject.org

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The AIACC project is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency. The project is co-executed on behalf of the United Nations Environment Programme by the global change SysTEM for Analysis Research and Training (START) and The Academy of Sciences for the Developing World (TWAS).

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1. Introduction

The *municipio* of González, Tamaulipas, in northern Mexico, and the South of Córdoba Province in the Argentinean *Pampas* are both regions strongly dependent on agriculture. To different extents, adverse climatic events (e.g., floods, droughts, and frosts) can have negative repercussions for the economy of each region, through impacts on the service and industrial sectors, as well as socially, in terms of migrations from rural to urban areas.

Without conscious efforts to adapt potential increases in the frequency or in magnitude of adverse climate events or changes in climate averages (IPCC TS WG1, 2001) may make it more difficult for some producers to participate in the agricultural economy. This may be particularly true for those small- and medium-sized commercial farmers with limited capital who are not always able to recover from recurrent crop failures.

In this chapter, we present two case studies of grain and cattle producers in two regions in Argentina and Mexico. The cases are distinguished by important differences in their respective socio-productive structures, and these differences point to the importance of local context and circumstance in understanding the challenge of adaptation. Yet in

¹ The research reported in this paper was supported by grant number LA29 from Assessments of Impacts and Adaptations to Climate Change (AIACC), a project that is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency and co-executed on behalf of the United Nations Environment Programme and by the Global Change System for Analysis, Research and Training and The Academy of Sciences for the Developing World. Correspondence regarding this paper should be directed to Monica Wehbe, mwehbe@eco.unrc.edu.ar.

presenting the cases together here, we illustrate that the farmers in both locations have experienced similar processes of institutional and policy reforms that have had important implications for adaptive capacity. For this reason, we argue that any interventions intended to enhance adaptation to climate risk need to be considered in the context of the opportunities and constraints posed by the broader institutional environment and, conversely, there is a need to examine closely how institutions and policy explain differential adaptive capacities at the farm level.

In countries such as Mexico and Argentina, where resource access is far from uniform, the constraints on production choices and strategies can be considerable for some farmer groups (Liverman, 1994). The centralization of sector policy also implies that adaptation strategies may be assessed and planned without taking into consideration the need for particular strategies and technologies suitable to local conditions. At the local level, the availability of technology, information, and other resources are what determines the socio-economic characteristics of production and the performance of farmers and communities in both productive and social terms.

Understanding the existing coping and adaptive strategies of farmers in specific geographic contexts is thus a first step toward the identification of appropriate options to increase the potential for adaptation of particular farmer groups. Local-level analyses also can help highlight the primary constraints to adaptation and the differential nature of vulnerability of particular groups. Local-level analyses can help prioritize adaptation interventions and thus facilitate the creation of a more sustainable and equitable production environment (IUCN / IISD / IISDnet, 2004; Wehbe et al., 2005a). In this chapter, we illustrate how the adaptive capacities of farmers operating in quite distinct

social and geographic contexts are structured by similar institutional processes, as well as the importance of considering the interaction of these processes with local context and existing practices of farmers in any effort to enhance adaptive capacity through public policy.

The material presented here is part of a broader study addressing the social vulnerability of farmers in both countries to climatic variability and extreme events in the context of trade liberalization and domestic agricultural policy reforms. This broader study considered farmers' adaptive capacity and their livelihood sensitivity to climate events as two key attributes of vulnerability¹. In this chapter, we focus on both qualitative and quantitative data collected in the study pertaining to farmers' specific actions in response to climate stress and their perceptions of the constraints associated with these coping and adaptation strategies.

In the next section, we briefly introduce both case studies and the methods that were used in our analysis of adaptation. In section 3, we present the principle climatic and nonclimatic threats to which farmers are exposed in each case study. We then discuss and compare the farmers' current strategies for managing these risks in relation to the constraints on adaptation and their adaptation needs. In section 4, we outline what we found were the main opportunities for intervention at both the level of the farm household and community, taking into account principal climatic threats and the broader socio-economic environment in each case. The final section summarizes our findings and discusses the implications for future adaptation.

2. Geographic Background and Methods

2.1. González, Tamaulipas (Mexico)

The *municipio* of González encompasses 3,491 km² in southern Tamaulipas, in the watershed of the River Panuco (or Guyalejo). The city of González, the seat of the *municipio*, is less than 80 km from the Gulf of Mexico. Much of the territory is relatively flat and, with the exception of one prominent outcropping, does not exceed 200 m above sea level. Rainfall is concentrated in the months of June to September, with a midsummer period of diminished rainfall (*la canícula*) in July and August. Annual rainfall totals are in the range of 850 mm. Drought is the most common hazard in this area, although occasional flooding has occurred as a result of cyclonic activity and even hurricane landfalls from the Gulf of Mexico.

Together, crops and pasture cover 50% of the *municipio*'s land, and nearly 60% of the economically active population is involved in primary sector activities (INEGI, 2000). In the southwest of the *municipio*, surface water irrigation from the Las Animas dam is available for irrigated production, and here, vegetables are planted in addition to irrigated grain crops. In the rain-fed area, sorghum is the principle crop, followed by safflower, maize, and soybeans (according to the Secretary for Agriculture, Livestock, Rural Development, Fisheries and Food, SAGARPA, these crops represented 47%, 17%, 13%, and 12% of the planted area in 2002, respectively). As in the Argentinean case, many farmers manage two harvests annually: sorghum during the summer rainy season and safflower or additional sorghum in winter with the residual soil moisture.

The majority of the farmers in the *municipio* are *ejidatarios*, or farmers who received land as part of the land distribution program after the 1910 Agrarian Revolution.

Approximately 20–30% of the farmers have a form of private tenure that generally permits larger landholdings (*pequeños propietarios*)². Although sorghum is one of

Tamaulipas' most important commercial crops, the local economy is not particularly prosperous, and it has not improved much over the last decade. Approximately 71% of the economically active population reported receiving less than two minimum salaries in 2000, only 10% less than in 1990 (one minimum salary in 2000 in González was approximately US\$100/month) (INEGI, 2000). Over one-half of the adult population in the latest population census reported having had none or incomplete primary school education, and 13% was illiterate (INEGI, 2000).

2.2. South of Córdoba Province (Argentina)

The South of Córdoba Province is a region defined by nine departmental units of the twenty-six that constitute the province. It is located in the center of Argentina and occupies an area of approximately 9 million hectares (75% dedicated to agriculture activities) in the western portion of the Argentinean Pampas, a transitional area between the humid and arid regions. Average precipitation during the year ranges from 900 mm in the northeast of the prairies to 700 mm in the southwest (SMN, 1992). The seasonal distribution of the precipitation for the whole area is typical of monsoon climate regimes, mostly concentrated in the months of September to March (Ravelo and Seiler, 1979). The region has a population of more than 800,000 inhabitants and an established trend of rural to urban migration.

In the period between the last two National Agricultural Censuses (1988 and 2002), the number of farm units declined from 21,645 to 14,299. An accelerated process of land concentration, particularly during the 1990s, has left 50% of the agricultural land in the province in the hands of 9% of landowners (each with more than 1,100 hectares). The other 50% of land is distributed among 90% of the remaining highly heterogeneous

farmers with wide ranges of landholding sizes (INDEC, 2002) and levels of capitalization. The majority of these farmers are family farmers that depend heavily on agricultural activities for their livelihoods.

Much of the commercial grain and cattle production of the area is rain-fed, although a few farmers have incorporated groundwater irrigation systems. Because the soils rarely freeze, most farmers manage two harvests annually: wheat and other fodder crops in winter, and soybean, maize, peanuts, sorghum, and to a lesser extent sunflower (among other less important cash crops) in summer. The area is historically characterized by a mixed cash crop and livestock production; however, declining relative prices for beef have resulted in a reduction in the size of herds in the last decades. Similar declines have been noted in the pork, lamb, and poultry industry, which prior to the MERCOSUR (the Southern Common Market) trade agreement were complementary activities within the farm. In the last four to five years agriculture has been benefited from an increase in the exchange rate and high international prices of soybeans and maize.

2.3. Methods

This project involved a farm survey, interviews, and workshops with farmers and other actors in the agricultural sector (public officials, leaders of farmer unions, rural infrastructure specialists, and academics) in both regions. The survey was designed to collect data on farm characteristics (e.g., type of production system, landholding size, agricultural practices, income sources), farm-level resources hypothesized to be associated with adaptive capacity (e.g., education, age, technology use, climate information use, risk perception, finances), and indicators of the farm households' sensitivity to climate impacts (e.g., frequency and extent of crop losses) (Table 1:

Summary Statistics; see also Wehbe and Eakin, 2005). Although some of the specific variables measured in each case differed, an effort was made to use a similar survey instrument in both Argentina and Mexico in order to have comparable indicators of vulnerability and adaptive capacity. A total of 234 farm households, stratified to include *ejidatarios* clustered in seven *ejidos* (farm communities) and *pequeños propietarios* scattered throughout the *municipio*, were surveyed in González of an estimated population of 3,985 in June and July of 2003. In Córdoba, during 2003/2004, 240 farmers were surveyed within four selected communities (the latter represent four different agroecological zones) and were distributed in terms of the total number of farmers in each community. The survey sample was stratified as to capture only more representative agricultural systems in the studied area, namely cash crop producers, mixed cash crop and cattle producers, and only cattle producers.

Data from the survey, as well as from interviews, are used in this chapter as evidence of the types of adjustments farmers have reported making to current climate risk and the obstacles they face in incorporating such adjustments. In González, interviews were conducted with individual farmers, as well as with representatives of agricultural services (credit, extension and research), federal and state agricultural offices, and with leaders of local farmers' associations. In Argentina, an interview protocol was designed to explore farmers' risk perceptions and their attitudes regarding coping with environmental stress (Maurutto, 2004). Nineteen farmers were interviewed in four localities, between July 2003 and March 2004. The interviews were analyzed using a matrix, enabling the research team to evaluate how frequent and characteristic were farmers' replies. The quotes presented in the following sections have thus been selected from this matrix as

representative of farmers' perceptions, irrespective of age, activities performed, and the place of origin of the respondent. Workshops were also held in both regions to capture the perspective of farmers and public officials on the principle constraints and opportunities for adaptation.

Together, these data were integrated in a vulnerability assessment in which the adaptive capacities and sensitivities of farmers were evaluated (Eakin et al., 2005). This assessment permitted the identification of the primary resources and characteristics of farms in each region that were considered necessary for adaptation (adaptive capacities) and the degree to which those characteristics were either present or absent in the population. In the process, the resources associated with adaptive capacity were assigned weights through consultation with farmers, according to the importance of each resource for facilitating adaptation (Eakin et al., 2005). This method allowed adaptive capacity to be evaluated as a product of resources and attributes, in which no one resource or attribute is a substitute for another but rather different combinations of resources can provide households with similar degrees of flexibility in the face of risk. While it is not the subject of this paper to describe in detail the evaluation of adaptive capacity for different farm groups, this evaluation provided an essential framework for the exploration of potential obstacles to adaptation options in each case study.

3. Adaptation Strategies

3.1 Climate threats

The farmers surveyed in both regions face variable climate conditions with frequent climate extremes—namely drought and floods—which continue to exert a toll on production, suggesting that farmers have not yet managed to ameliorate their sensitivity

to climate risk. The vulnerability assessment identified how farmers viewed the primary climate extremes in both regions and how they perceived their sensitivity to them.

In González, not only is rainfall highly variable but also climate extremes have tended to follow a pattern of decadal oscillation (Conde, 2005), and there may be associations of winter rainfall with the Pacific North American Oscillation and the El Niño-Southern Oscillation (ENSO) (Cavazos, 1999). Extremely wet seasons are associated with increased convective activity in the Gulf of Mexico, including cyclonic activity bringing surges of moisture inland. Such patterns were more typical in the decade of the 1970s when farmers faced repeated floods and events of excessive rainfall, contributing to the abandonment of cotton production in the area. In the late 1980s and 1990s, agricultural drought and high temperatures have been the norm, contributing to agricultural loss. In general, since the 1970s, greater overall variability in climatic patterns have been observed, and a decrease in precipitation (Sanchez Torres et al., 2005). The year 2000 was particularly poor for sorghum and safflower farmers in the *municipio*, and it was this year that was reported as the worst in memory by 64% of the farmers surveyed. Pest outbreaks are particularly problematic and associated by farmers with the magnitude of the midsummer drought (July-August).

In interviews, farmers reported experiencing recent climate change in terms of increasing temperatures, and some associated an increase in precipitation in September with greater moisture available for winter planting. Although models of climate change for the region are inconclusive in terms of changes in future rainfall, they are consistent in indicating that the area will likely experience higher temperatures and, possibly, a consequent decrease in soil moisture availability (Sánchez Torres and Vargas Castilleja, 2005;

Conde, 2005). The city of González already experiences deficits in water availability, and this deficit is likely to increase even without climate change, according to recent modeling efforts (Sánchez Torres and Vargas Castilleja, 2005).

In the South of Córdoba, thermal and water conditions are important variables affecting the variability of crop yields, the soil moisture content being the most limiting factor.

Winters are mild and short and are characterized by frost events coupled with soil moisture deficits. The interannual variability of temperatures and the risk of frost are a source of production uncertainty. Although there is a surplus in the average water balance of the region, the interannual variability of precipitation can generate occasional droughts (from survey data, the most worrisome event) of different frequency and severity.

According to the farmers, hail storms, ranked after drought in terms of the overall impact on production, are also frequent hazards that occur from September to March. (Rivarola et al., 2004a; Vinocur et al., 2004).

The impact of climate events in the region becomes more complex due to the soil properties and topography of specific areas (depressed areas and flood-prone basins, salty soils, drainage difficulties, soil water capacity, etc), causing different levels of risk to drought or flood and differences in environmental responses. For example, drought risks increase from the east of the region to the west and south (Rivarola et al, 2004b) whereas floods are more common in the south of the region, where three major flood episodes occurred during the past 25 years, affecting agricultural production and the economy of the areas for several years after each episode (Seiler et al., 2002).

Climate variability in the region may be associated with the El Niño-Southern Oscillation, providing the possibility that ENSO-based forecasts might be developed to

guide production strategies. An analysis based on four locations of the South of Córdoba (Seiler and Vinocur, 2004) showed evidence of strong La Niña signal, causing significant diminutions of rainfall associated with most of the analyzed rainfall periods in the west of the region, and with Nov–Dec rainfall period in the east of the region. However, not enough evidence was found of a clear El Niño signal associated to positive rainfall enhancement during El Niño years, as compared to neutral years. Podestá et al. (2002) also found an ENSO signal on precipitation during the period Oct–Dec and on yields of some summer crops throughout the Pampas region, but they also found large precipitation variability within ENSO phases, which decreases the potential usefulness of an ENSO phase forecast.

Climate change scenarios projected increases in mean temperature for all seasons with higher values for summer and spring. Increments of precipitation of different magnitude are also expected for summer, spring, and fall, while small decreases are projected for the winter season. The projected increments in precipitation during the summer and fall may increase flood risk in the flood-prone basin of the south of the region (Seiler and Vinocur, Final Report, 2005).

3.2 Additional threats

It is important to recognize that climate is only one of several factors to which farmers are making intraseasonal, interannual, and longer-term adjustments in their production strategies (Risbey et al., 1999; Smit et al., 1996). In México, the price of grains—principally maize, but also wheat and sorghum—have declined during the 1990s, and further declines are projected (Claridades Agropecuarias 2004). Mexico’s liberalization of grain import markets during this period has meant increased competition for González

farmers and has required the government to provide financial support to help farmers commercialize their sorghum harvests. A restructuring of public agricultural institutions paralleled market liberalization, reducing the availability of publicly subsidized credit, insurance, and technical assistance for smallholders (Appendini, 2001; de Janvry et al, 1995). Nevertheless, current agricultural plans for the region focus on facilitating farmers' risk management through the promotion of contract farming (to provide greater price stability) and private insurance schemes (to address climatic risk).

In Argentina, trade liberalization and retrenchment of the state roles aimed at the agriculture sector to drive again national economic growth. As a result, farmers' resources and their production decisions now have greater weight in determining their economic feasibility. In the 1990s, a fixed exchange rate translated into declining relative prices of traded to nontraded goods and high real interest rates, producing a 60% decline in farmer's purchasing power. Despite devaluation of the Argentinean peso in 2001 and the consequent economic recovery of farmers, rising costs of production and finance, and newly incorporated export taxes have prevented smaller agricultural enterprises from maintaining agricultural equipment and acquiring sufficient capital to finance their production. This situation, in a sector characterized by greater competition and economic consolidation, has increased the economic vulnerability of lower-scale producers (Lattuada, 2000) and has reduced the demand for locally sourced agricultural inputs and services and thus a drop in local economic activity.

3.3 Current adaptations at farm level and public sector support

In both case studies, farmers are practicing a variety of production strategies that represent their different capacities to manage risk and to take advantage of new

opportunities in their respective agricultural sectors. From the farmers' perspective, production, income, and investment decisions are made rarely in response to a single stressor such as drought risk, but rather the outcome of a process of considering simultaneously a wide variety of stressors—including, but not limited to climatic factors. The degree to which households are able to and do respond to a specific climatic threat is, in part, determined by their perception of the threat, as well as the relative importance they place on climatic risk compared to other sources of stress and the range of choice and opportunity they have been given by the particular socio-economic conditions in which they live.

In the households surveys conducted in both case studies, some of the changes that farmers reported having had made in the past five years could be classified as strategies for “coping” with recent economic and climatic stress, while other responses may be better interpreted as “adjustments” or even “adaptations” in that they represent actions designed to address and mitigate future risk and vulnerability. The responses of farmers to the survey and interviews are described in detail in the following sections.

3.3.1 González, Mexico. To assess farmers' adaptation options, we thus evaluated the factors that farmers consider in their production decisions and the specific role of climate and climate information in those decisions. We also recorded their current climate risk management strategies, such as crop diversification and seasonal crop switching, the potential of cattle-raising and pasture as a more sustainable alternative under drier conditions, the use of irrigation, and financial mechanisms such as insurance.

The survey revealed that climate factors—particularly, the onset of the rainy season—were determinant in the crop choice decisions for nearly one-third of the farmers.

However, an additional one-third cited the availability of government support for particular crops as determinant in their crop choices, illustrating the continued importance of government intervention in farm strategies. Surprisingly, despite the liberalization of markets, crop prices appeared to have relatively little influence on farmers' seasonal crop choices.

Although climate factors did not determine decisions for all farmers, 68% of the surveyed households reported using climate information (consisting of primarily daily forecasts and 3- to 5-day forecasts) in their production decisions.

Farmers reported a range of adjustments to the drought conditions of the 1990s, including changing their crop-planting date, switching crops, changing crop varieties or livestock breeds, modifying infrastructure or inputs, or a combination of these strategies. On an interannual basis, over one-third of the farmers surveyed reported adjusting their crop choice, according to their observations of the timing and quantity of the initial rains of the season. The total range of crops planted in González, however, is relatively small (averaging between 1 and 2 crops per household per year in the survey) and because of the homogeneity of production, local markets are often saturated. As one agricultural official commented, "If everyone is planting sorghum as a response to the lack of rain, there are problems with commercialization because of so much of the same harvest."

The government is now promoting diversification into nontraditional crops and livestock, as a possible strategy for addressing both environmental challenges to production (e.g., soil degradation as a result of sorghum monocropping), as well as the lack of commercial opportunities in grain farming (Secretaría de Desarrollo Económico y del Empleo, 2001). Some of the alternatives being promoted—tequila *agave* (*Agave tequiliana* Weber azul)

and aloe (*Aloe barbadensis* Miller) for example—are particularly well suited to drier and warmer climates. The planting of buffle grass is also being encouraged through a national program of crop conversion (PIASRE, or Programa Integral de Agricultura Sostenible y Reconversión Productiva en Zonas de Sinestralidad Recurrente) (Yarrington Ruvalcaba, 2004).

In the Rural Development District of González (a territory that includes González's neighboring *municipios* of Altamirano and Mante), the area under planted pasture increased by 63% between 1999 and 2002, although only a handful of farmers reported receiving support through the crop conversion program in the survey administered in the *municipio* of González in 2003.

Some of the smaller-scale farmers interviewed argued that the government's support for these alternatives was insufficient and that the investment necessary was prohibitive. Much of the land planted with *ágave* and aloe, for example, was rented from *ejidatarios* by investors from outside of the region. The *ejidatarios* perceived that the small scale of their production and the variable quality of their products were important obstacles to getting credit and commercializing their harvests.

However, an increasing number of farmers were investing in livestock both as a response to repeated crop losses and problems in commercializing their harvests, in part supported by a government program called Program of Incentives for Livestock Productivity, or PROGAN. The survey data illustrated that livestock was an activity most associated with smallholder *ejidatarios*, who dedicated proportionally more land to livestock activities and reported, on average, proportionally greater income from livestock than was reported by *pequeños propietarios* (14% vs. 5%). Not all experts interviewed agreed that a

livestock-pasture strategy was the most appropriate response to a perceived increased frequency of drought. One agricultural official commented, “Those [who] have livestock have been the most affected by drought in recent years. Because of a lack of pasture, they have had to cull animals and sell them at very low prices. Some have had to buy sorghum from neighbors to feed their cattle. The problem is made worse because live cattle are entering from the United States with the liberalization of the cattle market. This is driving local prices down.” Some farmers interviewed concurred that having cattle could be a liability should drought affect the productivity of pasture and thus require purchasing hay or grain. In fact, the survey revealed that farmers who had planted pasture reported some of the highest losses to drought in 2002, and many sold cattle as a result.

To support investment in new crops, as well as to improve the reliability of the harvests of traditional grain crops, some farmers with sufficient capital are now constructing small earthen dams to capture rainwater for additional irrigation. These dams fill with rainfall during the rainy season and are used for auxiliary irrigation during dry spells. According to the survey, the farmers who reported constructing such dams did so in the last decade and were farmers with larger landholdings and private tenure. Interviews with some *ejidatarios* who had constructed dams revealed that there was a lot of skepticism about the effectiveness of the dams. They believed that if there were insufficient rain for their crops, there would also be insufficient water in the dams and thus the investment would be futile.

Only 20% of farmers reported having received agricultural credit in 2002, reflecting what has become a national problem of agricultural credit and finance (Myhre, 1998). Nearly all farmers receive a direct payment per hectare planted through a program called

PROCAMPO; however this program was designed not as a rural finance program but rather as a means to facilitate the adjustment of farmers to the market liberalization entailed in the North American Free Trade agreement in 1994. It is now the only source of external funding that many farmers receive for their production. PROCAMPO is to cease in 2008, and thus is not a long-term solution to aiding agricultural adaptation.

In an effort to reduce the financial burden of crop loss compensation programs for the agricultural sector, both crop insurance and contract farming are being actively promoted by the state and federal government to help farmers address climatic contingencies and price volatility (Yarrington Ruvalcaba, 2004). Very few (9%) of the surveyed farmers, however, had crop insurance. The majority of these farmers were *pequeños propietarios*, although a handful of *ejidatarios* in the irrigation district also had insurance. Lack of affordability, lack of information and general distrust were cited as reasons for not having contracted insurance by those farmers who lacked insurance. In the 1980s, *ejidatarios* were obligated to purchase insurance from a government parastatal with the loans they received from the public agricultural bank, BANRURAL. Repeated difficulty in receiving insurance payments, however, left farmers distrustful of insurance initiatives, and the recent declining value of their harvests has provided little incentive for purchasing insurance.

Relatively low education levels coupled with the absence of extension services (either private or public) also inhibit farmers from experimenting with new tools such as crop insurance, or new commercial crops. Also less than one-quarter of farmers reported being members of agricultural organizations in which they could conceivably acquire

information on public and private agricultural services and opportunities, as well as lobby for program changes to meet their common goals.

3.3.2 South of Córdoba, Argentina. The farmers in South of Córdoba Province not only differed in their exposure to specific climate stressors but also in terms of their production activities, their soil conditions and use, their material assets, their perception of risk, and landholding size (and therefore income). These differences affect the specific climate responses that they are able or have the will to incorporate; however, direct relationships are difficult to quantify (Eakin et al., 2005).

From the survey data, the most common agronomic adaptations of farmers were adjusting their planting dates (36% of total surveyed farmers); spatially distributing risk through geographically separated plots (52%); changing crops (12%); accumulating commodities as an economic reserve (85%); and maintaining a livestock herd (70%). Many of these strategies were not always mentioned as responses to climate conditions but rather as economic responses to general changes in the agricultural sector.

Drought is perceived not only as an event in and of itself but also the result of a combination of climate events, namely increasing temperature, decreasing precipitation, and wind, with impacts that potentially alter farmers' livelihoods for more than one year. Irrigation is an obvious technical support for drought risk mitigation, but the benefits of an irrigation system are diminished by its cost (making irrigation a less viable alternative for smaller farmers) and the quality of available groundwater. As farmers reported, "we have analyzed the possibility of incorporating irrigation, but its cost is enormous" and "against drought, irrigation [is an option], but it is very expensive, a costly alternative". Only 1% of farmers in the region count on irrigation systems, and these are large landholders.

In general, farmers dedicated to cattle raising activities perceive themselves as less vulnerable than those dedicated to cash cropping, with the belief that cattle raising is less sensitive to climatic anomalies and because cattle also serve as an economic reserve. For example, as one farmer reported, “cows are not being killed by hail stones, they are a kind of insurance, when a hail storm comes, I have cows”. The provincial government is now promoting livestock through different programs, including credit support.

Commercial hail insurance is one of the most specific strategies adopted by farmers to address the impact of hail storms. However, the use of insurance is not uniform. In the survey, only 65% of farmers reported having contracted insurance, and, of these, 53% contracted insurance annually. Another type of insurance, “climate risk insurance” is still not used widely in the region. Farmers commented that “it is very expensive” and “not well implemented”. Public officials interviewed reported that the subsidization of climate risk insurance faced problems in implementation because of oligopolistic practices by insurance companies. Some farmers argue that having had negative experiences with the insurance companies, it is not worth their trouble. In response to this sense of distrust, the collective action of a group of farmers recently resulted in a new cooperative program called Seguro Solidario. The participating farmers commit to contributing a certain amount of money to a collective fund in order to cope with climatic events. This local insurance mechanism was not widespread over the studied area, and the extent to which all participants can benefit from it depends largely on the severity of climate impacts. However, it is now being promoted at the provincial level and as a pilot program.

The primary source of government support to farmers for climate impacts is from a highly controversial mechanism under the Agricultural Emergency Law (AEL) (1983) under

which farmers may publicly declare their losses. With the objective of diminishing impacts from climatic, telluric, biological, or physical and unforeseeable or inevitable events, the AEL allows farmers to access benefits like delaying fiscal obligations, acquiring tax extensions or exemptions, accessing credit, and obtaining special considerations regarding transportation, among other benefits. However, farmers have generally viewed this mechanism negatively: “If you can cope by yourself, it will be better. After a while everything comes together, and at the end you still have to pay and it was just another great amount of papers.”

In contrast, participating in farmers’ organizations or associations with other farmers is considered to be highly positive, necessary, useful, and powerful. “Every organization procures common interests; the more the people are involved the more powerful”.

However, interviews revealed that the advantages and benefits of organization depend on the personal experience and the attitude of its members. Other interviewees suggested that participation in agricultural organizations is often simply a temporary response to periods of difficulty: “People do not trust [organizations] anymore and because the economic situation has improved since the devaluation of the peso, they believe institutions are not necessary anymore”. The perspectives of farmers articulated through the interviews concurred with the results of the more objective dimension assessed through the survey: only 50% of farmers participate in some organizations, the rest allude to them as not useful (13%); associated with bad experiences (12%); of little interest (27%); or lacking capacity (39%).

Aside from formal mechanisms such as insurance to reduce climate risk, adaptation is also facilitated through the use of climate information whether from the media, farmers’

empirical observations of natural indicators used as forms of climate forecasts, or their personal experiences with climate as transmitted through their family or collective histories. But, climate information, especially seasonal forecasts, is generally only accessed through private seed or chemical providers, internet, and special workshops/seminars organized by farmers' organizations. Despite the apparent importance of climate information in farmers' strategies, when asked directly about their decision-making process, farmers declared that their production decisions are based primarily on market signals, soil conditions, and the availability of working capital, while climate information is used to inform short-term decisions such as deciding planting and harvesting dates. Moreover, the farmers appeared to have no confidence in technical or scientific forecasts, based on their experience with this information: "We manage climate information; it is interesting, but you cannot base your decisions on them".

As a result of recent changes in macroeconomic and sector policy, farmers were increasingly aware that any action necessary to resolve local problems such as repeated negative climate impacts would require local action rather than interventions from the national government. Expressions like "the hand of the state is present, but against us"; "there is no agriculture policy"; "the provincial government still has some compassion for us, but the national government is killing us" show the perception of a lack of support or protection from the national government, and fundamentally, concern over the burden of export taxes. More recently, the farmers' dissatisfaction with the lack of government interventions has been ameliorated by the devaluation of the peso and the high prices of soybeans. Nevertheless, should conditions change, the climate threat would rise in importance: "We are being favored by a high exchange rate and high prices of soybeans,

but we also have very high export taxes, which is a not very noticeable situation because of good harvests, but this year, because of hail storms and droughts the real situation will begin to be felt”. Both factors, state interventions and climate, are considered unpredictable by farmers; “if government does what it likes, the climate will be even more fickle” and “it is easiest to know what is going to happen with climate than to know what the state is going to do for us”.

4. Opportunities for Intervention

In González, financial resources, such as credit and insurance; material resources, such as land, irrigation, and equipment; the degree of economic and agricultural diversification of the farm, as well as access to resources, such as technical assistance are all critical components of adaptive capacity (Eakin et al., 2005). In Córdoba, adaptive capacity is also a function of material and financial resources (such as farmers’ soil quality, landholding size, type of activity), and, to a lesser extent human/social resources (e.g., personal experience, the availability of technical assistance, and participation in organizations). Indicators of management capacity, for example, crop diversity, and farmer’s access to alternative nonfarm income sources, were also important for adaptation, together with specific climate adaptations, such as the use of insurance and climate information.

The identification of the resources and attributes of adaptive capacity *specific to each region* allowed for the identification of possible priorities for public sector interventions that would possibly enhance these farm-level capacities (a systematization of these priorities can be visualized in Table 2). These priorities are discussed below, together with potential obstacles for their implementation.

4.1. México

Consultation with farmers in the region and an analysis of the survey data revealed that improving access to agricultural finance should be a priority for facilitating adaptation in González. Credit is often taken for granted as part of the adaptation process in industrialized contexts, but in Mexico, the lack of long-term credit prohibits infrastructure improvements for many farmers. The majority of the adaptations described above (auxiliary irrigation, commercial crop diversification, conversion to a pasture/livestock production system) require finance. Although there are some limited credit windows for smallholders, the support is generally not extensive and most households increasingly depend on alternative income sources to finance their agricultural activities.

Agricultural infrastructure is also an important resource for adaptation. From the perspective of some of the larger-scale producers in the region, diversification into alternative commercial crops is only possible with appropriate tools and capital. For example, a larger-scale farmer who was experimenting with alternative crops (e.g., fruit trees, wood production, aloe, and vegetables) reported that the construction of greenhouses, “*mayas de sombra*” (artificial shade cover), and private auxiliary irrigation networks could be considered priority infrastructure for supporting new crops under warmer and drier conditions. Although public support exists for these infrastructure projects, farmers must seek out and register for the support and make substantial financial and labor contributions in the investment projects. While this expectation may seem reasonable, few small-scale farmers are risking the investment in infrastructure projects given the uncertain values of their harvests. Adaptation would thus be facilitated with targeted public support for specific infrastructure projects at the level of the farm,

combined with current efforts of the state government to guarantee farmers a living wage and greater security in marketing their harvests.

Although irrigation is another factor that many farmers have identified as a critical element for adaptation, the future availability of irrigation water is also questionable given the increasing demand on water resources from urban and industrial users (Sanchez Torres and Vargas Castilleja, 2005). Currently, *ejidatarios* with irrigation are generally part of the irrigation districts of the Rio Guayalejo, using infrastructure (often unlined canals) from the 1970s. For investment in auxiliary irrigation or for improved irrigation efficiency to be effective, the crop must be of sufficiently high value. Yet planting alternative cash crops with potentially higher value than sorghum (e.g., agave, onions, or other vegetables, fruit trees) entails new and often high economic risks (Eakin, 2003). Many farmers in these districts are thus increasingly renting their land to investors from outside the region and thus have little personal interest in improving the efficiency of their water works. González already has a seasonal deficit in water availability that is likely to increase in the future even under scenarios with current climate conditions (Sanchez Torres and Vargas Castilleja, 2005). Improved management of current irrigation networks and greater efficiency in new infrastructure are thus likely to be critical adaptations.

Although the state and federal government are interested in creating a “culture of insurance” among Mexican farmers, the cost of insurance and the lack of confidence in insurance mechanisms inhibit farmers from entering insurance mechanisms. Without insurance, investing in new crops such as aloe represents a high risk, despite the fact that the crop may be better adapted to warmer or drier conditions.

In terms of scale efficiency, both in access to markets, as well as in the provision of services and information, farm organizations and producer associations may become increasingly important mechanisms in adaptation. Public support for the development of administrative and technical capacity in civil agricultural organizations is needed. The historical (and continued) use of such associations for political purposes, however, is an obstacle to farmers' participation in associations to achieve their technical and productive goals (Eakin, 2004).

4.2 Argentina

Although most farmers argue that “all” their problems can be resolved through increasing credit availability and diminishing export taxes, it is clear that under the current policy environment, these types of measures will not find support, at least at the national level. Sources of agricultural finance are now restricted to the private banking system and input suppliers.

According to the indicators of climate sensitivity created for the region (Eakin and Wehbe, 2005; Wehbe and Eakin, 2005), the climate event with the most negative impact is drought. Supplementary irrigation technologies imply an important fixed capital investment that can affect financial capacity of the agricultural firm and therefore the availability of working capital. Support for this option thus will require public interventions (tax incentives or interest rates subsidy) to overcome the cost of private banking credit. Moreover, despite the existing knowledge regarding supplementary irrigation within the National Institute of Agricultural Technology, farmers still lack experience with irrigation and will need extra support to enhance its use, and there is also a need for an accurate analysis on the potential capacity of regional surface and

groundwater as sources of irrigation supplies. Although climatic trends in the region show an increased pattern of precipitation, climate variability is also expected to increase together with drought impacts.

Because a lack of guarantees and the high insurance premiums are the principle problems for smallholder farmers, the government could further facilitate insurance use by supervising the completion of contract obligations, as well as by providing information and subsidizing insurance for lower-scale farmers. Public sector interventions in support of insurance are constrained by a lack of political will and the absence of required political infrastructure for establishing control over the industry. To date, the primary interventions of the government in insurance have been restricted to limited subsidies of insurance premiums and the declaration of an Agriculture Emergency only when an event affects an important geographic area.

Although farmers' concerns over flood risk are concentrated geographically, the farmers affected by flood illustrated the highest indices of sensitivity in the whole studied region, and floods are a principal source of conflict among neighboring farmers and between rural and urban areas. Interventions to support flood risk management in this region could entail infrastructure works, such as additional drainage or containment structures, the diversion of excess water, and road construction as well as improved rezoning of crops and improvements in land use practices. The magnitude of the required investments necessarily entails support from either the national or provincial government such that local policy can concentrate on smaller works or maintenance, which will have an important impact on the cost of flooding for farmers given the expected increase in precipitation locally.

Farmers agree that the fact that most technology is only accessible through commercial channels explains in part the wide gap in productivity levels, as well as observed trends in agricultural practices and thus the potential for climate adaptation among producers in the region. Public sector support for technology, research, and development is thus one way to increase the likelihood of adaptation for those farmers who have difficulty accessing commercial technology. Public intervention in research and development, however, is limited by the high cost of investment, the need for institutional coordination, and the lack of participation of farmers in producer associations to help articulate their technology demand.

4.3 Comparison of case studies

Despite the significant differences in the scale of production and agricultural histories in the two case studies, the research illustrates important similarities in the opportunities and constraints for adaptation. In both cases, one could argue for improved access to climate, market, and technological information as an important means for enabling the farmers to respond rapidly to economic and environmental change. Enhancing the accessibility of information entails supporting farmers' social and professional networks, as well as investment from public sector institutions in the synthesis and systematization of available information. Conflict and lack of coordination between the relevant sources of information and agencies responsible for dissemination are primary obstacles. However, it is the less endowed farmers who benefit most from any increase in the availability of free information.

In both case studies, it appears that without targeted interventions from the public sector and from farm associations, adaptation to climate change will likely to be uneven.

Currently, in the absence of appropriate resources, smaller-scale farmers are adjusting to both difficult economic conditions and climatic losses by diversifying into livestock, by renting their land (and thus guaranteeing a minimum return on their property without the risk of crop investment) and by diversifying economically through nonfarm activities. For these farmers to be able to sustain their agricultural livelihoods under a potentially more variable climate in the future, specific technical support will be required to facilitate their access to appropriate technological packages, markets for alternative cash crops, formal insurance mechanisms, and to support improvements in irrigation, drainage, and other productive infrastructure.

Should current policy trends continue, it is more likely that the farmers who will be best able to adapt to future climatic and economic changes will be larger-scale farmers or external agribusinesses with the capital to acquire credit, technology, and insurance.

Many of these producers will be outside investors renting or purchasing land. Small-scale farmers struggling with crop losses and commercialization problems today may chose adaptations outside the agricultural sector entirely, a movement which would stimulate not only a social transformation of the sector but also may entail important landscape and ecological changes in both regions.

Thus, despite the general decline in public sector investment and support for agriculture over the 1990s in both regions, it was clear that there still may be an important role for the public sector in taking the lead in responding to climate change. In both cases, farmers are feeling the absence of government support for finance, technical assistance,

and research. Many respondents argued that what was needed were targeted support programs to facilitate adaptation, reflecting the expectation that for substantial change to occur in the agricultural sector, it would need to be at least partially subsidized by the public sector.

5. Conclusions

The analysis above illustrates the importance of the local context, existing practices, and farmers' perceptions in the exploration of possible adaptation options to climate in agriculture. We have shown that although some sectors of the population are currently engaging in a variety of agricultural practices that may be helpful in mitigating climate risk, such as crop and economic diversification, insurance and irrigation development, widespread adoption of these practices and technologies are limited by access to finance, poor information networks, and market failures. Of particular concern is the differential access to specific coping strategies between large- and small-scale farmers and, in the case of Argentina, less capitalized family-run farms and agribusinesses. For there to be greater equity in access to adaptation opportunities, the public sector will have an important role in the development and dissemination of adaptation alternatives specific to the needs of local places. However, current policy trends in both countries indicate less government support for interventions in the solution of specific agricultural sector problems. Instead, the focus of public policy is on the development of an enabling environment for private investment and economic growth, with less attention to the distributive implications of such policy is given. Although improved economic conditions will undoubtedly facilitate the flexibility of some farmers in responding to environmental

change, problems in resource access and technology adoption in vulnerable subsectors demand more specific local action.

Thus for adaptation to occur in both case studies, there will be a need for increased collaboration between farmers, producer associations, the private sector, and local government. Given the significance of economic and political obstacles to the implementation of various adaptation options, the possible interventions identified above require rigorous evaluation within a participatory and collaborative local context where interventions have the greatest potential to foster the sustainability of the farm sector and thus positively impact economic, social, and environmental conditions of communities.

Acknowledgments

The research reported in this paper was supported by grant number LA29 from Assessments of Impacts and Adaptations to Climate Change (AIACC).

Footnotes

1. The approach used to establish those resources and households characteristics associated with adaptive capacity and sensitivity are described in Eakin et al. (2005a) and Eakin and Wehbe (2005) *Final Report, Social Component Project AIACC LA29*. Report available from the authors (mwehbe@co.unrc.du.ar).
2. The precise number of *ejidatarios* and farmers with private titles is not known. The last census of the sector was completed in 1990. Since then, *ejidatarios* have been encouraged to gain private title to their landholdings and a land market has been legalized. Data from 1997 from the state agricultural ministry indicate that 30% of the farmers have private land titles.

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Table 1. *Farmers' Socio-Economic Characteristics*

Capacity Attribute	Variable	Total South of Córdoba	Total González
Number of cases		227	234
Social/Human Resources	Potential experience (years)	36.5 (SD 14.1)	n/a
	Education (years)	10.1	3.4 (SD 1.77)
	Age (years)	52.6 (SD 12.0)	51.6 (SD 14.3)
Material Resources	Landholding size (has.)	649.5 (SD 716,6)	69.9 (SD 285.2)
	Machinery index	1.91 (SD 1.03)	1.62* (SD 1.86)
	Gross margin (Arg\$) (Income)	213,075 (SD 329,509)	n/a
Management Capacity	Rented land (as % of worked area)	38.2 (SD 34.5)	n/a
	Rented land (has/household)	n/a	13.9 (SD 54.9)
Financial Resources	Other sources of income (% of cases)	18.43	n/a
	Other source of income (nonfarm income as % of total income)	n/a	45.5 (28.3)
Information	Official technical assistance (% beneficiaries)	30.9	26.9
Diversity	Number of crops	2.4 (SD 0.79)	1.7 (1.0)
	% of hectares dedicated to cash crops	71.5 (SD 42.3)	n/a
	% livestock income	12.8 (SD 21.8)	12.7 (21.6)
	% of hectares dedicated to soybeans relative to cash crop area.	64.8 (SD 25.1)	n/a

Source: Survey Data. *Note:* In Mexico, the machinery index is the sum of six binary variables, representing the ownership of six different farm machines. n/a refers to the fact that the particular variable in question was not measured in the case study. SD means standard deviation.

Table 2. *Synthesis of Adaptation Options*

Measures	Irrigation	Insurance	Infrastructure	Technology	Information
Timing of measure (a priori or post hoc, and for what hazard)	A priori / drought	A posteriori / hail, drought, floods	A priori / flood	A priori / general	A priori / general
Type of measure	Individual or system development; groundwater or surface water	Commercial, publicly subsidized or cooperative	Drainage containment infrastructure, roads	Inputs (seeds, fertilizers, etc.) and management (conservation tillage etc)	Climate trends, variability, forecasts; markets, prices, new technologies
Who would implement?	Farmer	Farmer	Government (national or state)	Local government, public research institutions	All levels of government, farmer associations, extension services
Conditions	Hydrological studies, credit	Guarantees of contracts; Market transparency; information; high value crops	Public funds	Time for technology development; institutional coordination	Information networks and intermediaries; extension; human resources
Capacity to implement	Low to medium*	Medium (Arg.) Low (Mex.)	Medium (Arg.)	High (Arg.) Medium-low (for those technologies that require public investment)	Medium**
Potential obstacles	Cost of equipment Cost of maintenance Economies of scale (Mex & Arg) Skepticism (Mex)	Political will (Arg) Skepticism, distrust, Low value crops (Mex)	Competition for public funds, regional priorities (Mex & Arg)	Cost, Decline in public investment in research, Lack of explicit demand from social sector (Mex & Arg)	Lack of organizational capacity, lack of funding (Mex & Arg), lack of interest (Mex), lack of “culture of information” (Mex)
Benefits	Improved yields, reduced drought impacts (Mex & Arg), additional subsistence benefits (aquaculture, Mex), reduced risk in new crop investment (Mex)	Enables cost recovery after loss (Mex & Arg) Facilitates agricultural diversification (Mex)	Reduced uncertainty over production in flood-prone areas (Mex & Arg)	Reduces productivity gap between farmer groups; increases economic margins (Mex & Arg)	Better risk management and improved decision-making Improved dissemination of technology Greater access to public support programs (Mex & Arg)

* With financial and technical support

** Information is available but the network for distribution is not established