Effects, Perceptions, and Adaptations to Climate Change

Small Farmers in Argentina and Chile

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INTRODUCTION

Though climate change will have varied and dispersed effects, certain populations are far more vulnerable to these effects than are others. Those living in poorer countries and those largely dependent upon agriculture are among these populations, making small farmers in developing countries one of the most climactically vulnerable populations in the world. Furthermore, the vulnerability of small farmers is closely tied to issues of food security and poverty in developing countries. Understanding how small farmers experience, perceive, and respond to the effects of climate change is essential in ensuring the survival and resilience of this vulnerable population though the process of global development.

Vulnerability and Resilience

Climate change vulnerability is the "degree to which geophysical, biological, and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change" (Fussel and Klein 2006). Thus, vulnerability refers not only to the negative impacts experienced by certain systems and populations, but also their inability to respond or adapt to these effects. In contrast, resiliency is the ability to absorb effects of climate change and maintain or return to normal function (Folke 2006). Often, the term also encompasses the ability of the system to adapt and become more prepared for future effects of climate change (Nelson et al 2007).

Those living in developing countries are among the most vulnerable and least resilient populations to the impacts of climate change (Adger 2003, Mirza 2003, IPCC 2001). Developing countries are generally located near the equator, making the effects of even a slight temperature rise particularly severe (Posner and Weisbach 2010). Furthermore, these countries have fewer resources (capital, infrastructure, governing bodies) needed to adapt and respond to severe effects (Smith 2003, Posner and Weisbach 2003).

Farmers in both developed and developing counties are a vulnerable population because agriculture is strongly affected by seasonal rainfall and temperature patterns (Nelson 2009, Adger 2003, Darwin 1995). Furthermore, climate change is likely to exacerbate some of the biggest environmental challenges already faced by farmer such as pests, disease, and crop and livestock mortality (Morton 2007). Small farmers in particular possess high vulnerability and low resilience because their livelihoods are directly dependent on agriculture and they often don't have the resources needed to adapt to environmental changes (Hertel 2010, Harvey 2014). Due to this extreme vulnerability of small farmers in developing countries, it is critical that researchers examine how small farmers experience, perceive, and respond to climate change.

Effects of Climate Change

The effects of climate change for small farmers in developing countries are extremely varied, even within individual countries, but the most widely cited effects include altered precipitation regimes, temperature variability, and extreme weather events (Vermeulen 2014, Fernandes 2012). In addition to direct impacts on crop viability and yields, these changes can induce secondary effects including spread of disease and pests. Furthermore, these effects are extremely general, and often culminate into much more specific witnessed effects based on regional and environmental differences. The specific effects of climate change for small farmers are difficult to measure and describe due to the intrinsic complexity and regional specificity of small-scale agricultural systems and the vulnerability of these systems to many different global changes, climate change only one of many (Morton 2007).

Perceptions of Climate Change

There has been extensive research on how small farmers in developing countries perceive forecasting and other climate change information (Hansen et al 2004). The 2004 Hansen Study found that 38.4% of farmers interviewed perceived no trend or pattern in climactic changes, and 46.1% perceived changes as a part of a natural 8-10 year cycle. These perceptions, however, were based almost entirely upon individual experience, with 29% of climate change beliefs based on personal memory, 18% on conversation with other farmers, and only 11% based on the media. Generally, small farmers' perceptions about climate change are based primarily upon what they see and hear in their

personal lives, not on patterns identified in scientific forecasting, in part due to lack of access to information technologies, but also due to lack of temporal and location specificity in these forecasts (Madden and Hayes 2000, Nelson and Finan 2000). Consequently, some studies have found mistrust of scientific climate information in small farmer communities as a result of these forecast limitations (Letson et al 2001).

There has also been debate in the literature regarding to what extent small farmers understand information about climate change. Some studies indicate many farmers have difficulty in interpreting and understanding climate information, and in incorporating that information into farm practices (Austen et al 2001, Ridge and Wylie 1996). Contrarily, other research indicates small farmers do understand and appreciate the significance of climate forecasting but have a culturally different understanding of climactic changes, or deny the occurrence in their individual situations because they do not have the resources to respond (Luseno et al 2003,Ingram et al 2002, Bostrom 1994). Thus, this debate is likely a result of cultural differences and misinterpretation rather than actual lack of knowledge and understanding among farmers.

Adaptations to Climate Change

There is been far less research on if, how, and to what extent small farmers are adapting to changes in the climate. Main factors determining extent of adaptation include differences in farm characteristics, personality, climate perceptions, and decision goals of farmers (Hansen et al. 2004). Potential methods of adaptation have been explored primarily in Africa and include new crop varieties, tree planting, soil conservation, altered planting schedules, and irrigation, though methods are diverse and regionally variable (Deressa 2009, Thomas 2007, Mendolsohn 1999). This relative lack of information regarding small farmers' adaptations to climate change, though, could be contributed to (1) culturally different interpretations of "adaptations to climate change", in that, small farmers may see their adaptations simply as responses and interactions with weather, not climate change, and (2) interview-based research methods that rely upon small farmers reporting adaptations, rather than researchers observing adaptations that may not be perceived as such by small farmers.

The Need for Ethnographic Research

Much of the research done on small farmers' adaptations to climate change in the developing world has been survey and interview based. Though these methods enable researchers to encompass a wider study group, they often fail to capture the social and cultural complexities of small farmers' relationship with the changing climate. Furthermore, participants' social, religious, economic, and cultural background can play in an important role not only in how they perceive and respond to climate change, but also how they convey those responses in surveys and interviews (Roncoli 2006). Small farmers may also have difficulty in articulating their decision-making processes, as many adaptations to climate change are in response to years of subtle observation, interaction with the environment, and word of mouth (Luseno 2003, Hansen et a 2004).

In order to understand the complexities involved in small farmers perceptions of and adaptations to climate change, researchers must move to more participatory, ethnographic approach. Ethnographic research is based on the "recognition that engaging in daily life and social relationships provides a contextual understanding of cultural realities that can not be captured by formal research methods" (Spradley 1980, DeWalt and Dewalt 2002). In the case of small farmers in climate change, it allows researchers to explore (1) the social, cultural, and cognitive backdrop that shapes farmers' understanding of climate change and (2) the process of decision-making that determines farmers' responses to it (Roncoli 2006). These subtleties and complexities can not be captured through standard research methods, making current research on the topic far from complete.

Why Argentina and Chile?

Though small farmers throughout the world will be affected by climate change, Argentina and Chile are ideal locations to observe a wide variety of climate effects and equally wide variety of capability to respond to such effects. Argentina and Chile both stretch north to south, tropics to pole, offering a huge diversity of ecosystems and potential climate-related changes (Lumerman 2011). The actual impacts and expected impacts across the varied ecosystem types of these countries range from flooding to

drought as a result of increased rainfall in some regions and decreased rainfall in others. Other impacts include increased temperatures, severe weather, and recession of rivers and lakes (Meza 2012, Lumerman 2011, SADS 2009).

In addition to diversity of ecosystem type and climate effects, Argentina and Chile offer a wide range of development. Though both countries are still considered "developing," on the world scale, they are among the three most developed countries in Latin America (HDI 2014). This stage of development is ideal for observing small farmer adaptations to climate change because small farmers are still a large part of the agricultural sector, but they may have more access to climate-related information technologies and resources for adaptation than small farmers in other, less-developed countries.

METHODS

This research was conducted on eight different small farms, seven in Argentina and one in Chile, over a four-month period from January to May. Farms were typically chosen based on diversity of location, each farm located in a different agricultural region with different climate patterns and effects, though accessibility and communication abilities also determined which farms were observed. Farms ranged from 5 to 190 acres and included both subsistence-scale farms (meaning produce was used exclusively for household consumption) and larger market farms. Many, though not all, farms were organic (though uncertified) and all were considered "small farms" by regional definitions and characteristics. Most were found through the WWOOF (World Wide Opportunities on Organic Farms) or through personal connections.

A primary method of data collection was through direct observation, living and working on each farm for 2-3 weeks, as well as informal interviews. Many of the below questions were explored in informal settings, while working on the farms or sharing meals with farm families, and all informal and formal interviews were conducted in Spanish. Because not all effects, perceptions, and adaptations to climate change may be evident to the farmers experiencing them, this immersion enabled me to observe as an outsider and recognize effects that farmers might not otherwise report or link to climate change.

This immersion based ethnography approach combined with in-depth case studies also enabled me to look beneath overall global and country trends to explore how individual farmers and families are experiencing and responding to climate –related changes. Though much of the case study was observational, I also used formal and informal interviews to highlight specific questions and clarify observations. These case studies certainly can not attest to how all small farmers in Argentina or even in individual regions are adapting to climate change, but can offer critical, detailed insight into more subtle outcomes of the changing climate for members of an extremely vulnerable and extremely important population, small farmers in the developing world.

How do small farmers in Argentina experience, perceive, and adapt to the effects of climate change?

Effects

Have small farmers:

- *Seen any changes in the climate?*
  - *Changes in temperatures?*
  - *Changes in precipitation?*
  - *Changes in weather patterns?*
  - *Changes in crop yields?*
  - *Changes in pests and disease?*

    - *Changes in bodies of water?*
- *Witnessed any pattern in these changes?*
    - *Cyclical? Length of cycle?*
    - *Upward trend?*
    - *Response to el niño, la niña?*
    - *Related to any other variable?*

- *Faced significant challenges or problems in relation to witnessed changes in the climate or in related factors?*
    - *Crop damage*
    - *Crop mortality*
    - *Changes in crop yields*
    - *Water shortages or excesses*
    - *Changes in pests or disease*
    - *Weather damage (floods, storms, etc)*
    - *Changes in water sources availability/stability?*

Perceptions

- *Obtained most climate change information from*
    - *Personal experience?*
    - *Memory?*
    - *Conversation with other farmers?*
    - *Media?*
    - *Climate forecasts?*
    - *…which is considered most accurate?*

Do small farmers

- *understand climate change as*
    - *random?*
    - *a natural cycle?*
    - *a natural long-term trend?*
    - *a man-made cycle?*
    - *a man made long-term trend?*
    - *A pattern related to god or other religious beliefs?*

- *Understand important climate change terms?*
    - *Climate vs. weather*
    - *Effects of el niño, la niña*
    - *Averages*
    - *Cycles vs. trends*

- *Link witnessed changes to climate change or other causes?*
    - *Changes in precipitation*
    - *Changes in pests/disease*
    - *Crop yields/varieties*
    - *Weather patterns*
    - *Seasonal changes*
    - *El niño, la niña*

Adaptations

Have small farmers

- *Based most farming decisions on*
    - *Personal experience?*
    - *Tradition/instruction from elders?*
    - *Instinct?*
    - *Advice/examples of other farmers?*
    - *Climate/weather forecasts?*
    - *Availability of resources?*
    - *Government extension/education programs?*

- *Made any physical changes in their operation in the past 10-20 years?*
    - *Size*
    - *Crop type/variety/timing*
    - *Irrigation methods*
    - *Use of petrochemicals*
    - *Protective infrastructure*
    - *Planting/harvesting times*

- *Made any changes related to source of farm income in past 10-20 years?*
    - *Sell in new or different markets?*
    - *Sell specific/different products than previously?*
    - *Supplement farm income with other sources of income?*
    -
- *Consider these changes responses to*
    - *Economic change*
    - *Availability of technology and inputs*
    - *Market competition*
    - *Increased prevalence of pests and disease (but not directly linked to c.c.)*
    - *Weather changes*
    - *Climate changes*
    - *Nothing-not a response to any other factor, just a way of life.*

- *Experienced other global trends that have influenced their ability to adapt?*
    - *Market access*
    - *Market price*
    - *Rural to urban migration*
    - *Completion*
    - *Agro-industrialization*
    - *Availability of technology*

RESULTS

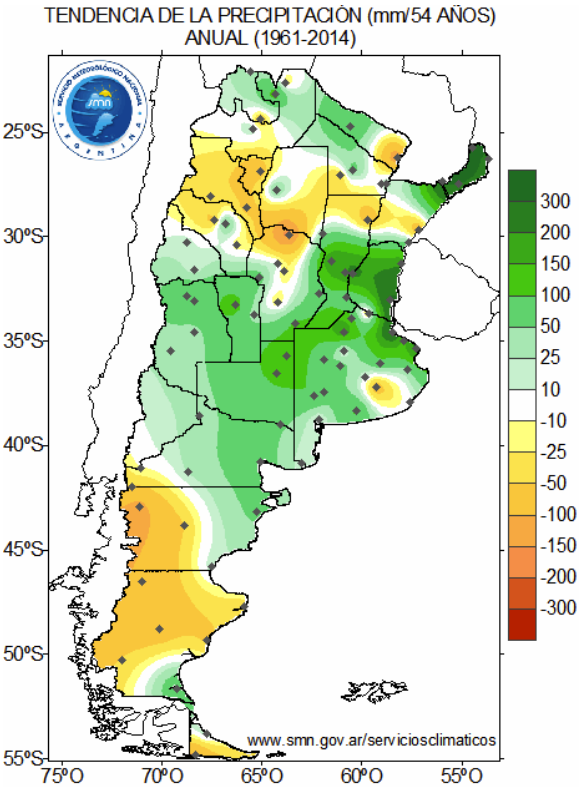
Farm A
Corrientes Province, Argentina

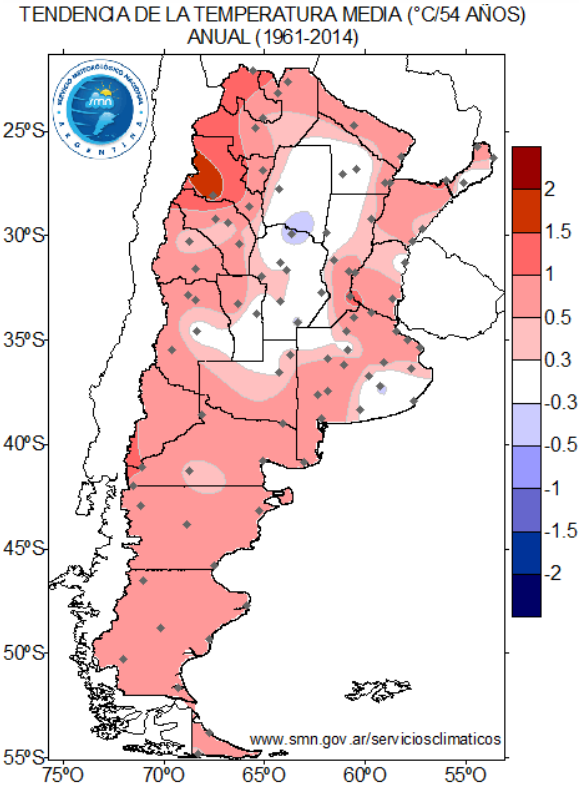
Farm A is a small-scale vegetable operation outside the provincial capital of Corrientes, and main crops include mandioca, lettuce, spinach, beans, and tomatoes. Most produce is sold at regional "ferias," the street markets of Argentina, and some pork and beef products are sold on a seasonal basis. The 32-acre plot has been under current ownership and operation for 12 years and the primary farmer does not have any sources of additional income.

Farm A is in the province of Corrientes, the Northeast of Argentina. This northern region is characterized by a subtropical climate with hot, humid summers and little seasonal variation. Notable climate trends in the province of Corrientes include overall increased rainfall and increase of severe storms, leading to flooding along the two principal rivers of the region. Overall, precipitation has increased an average of 8mm per year in the Northeast from 1960 to 2005, and the incidence of maximum level 1-2 day rainfall events has been on an upward trend since 1960. (Doyle 2012, Penalba 2010, Mariano 2009). The severity and timing of these events have contributed to flooding on individual properties as well as major flooding events along the Paraná and Uruguay rivers (Barros 2014).

As consistent with the overall climate data for Corrientes province, Farmer A witnessed unusually heavy fall rains over the past 3-5 years of cultivation and report that these rains killed several crops, but did not make a significant impact on overall crop yields or income for each year. They also reported that friends and acquaintances lost land and crops as a result of river flooding but that they are not close enough to large rivers to have witnessed these effects personally. Similarly, farm A owners indicated that they had observed increasing temperatures through their 12 years of farm ownership but that these changes had not yet significantly affected crop choice or survival and had little impact on their operation overall.

Although farmer A described little personal effects of climate change, he did indicate





his belief that climate change is on an upward trajectory, is at least partially human-caused, and will affect many small farmers in the future. He believes his operation has not been significantly affected because it is ideally located near an abundant water source and can therefore adapt to increases in temperature or other changes, but that other farmers further south may struggle. Farmer A bases most of his climate perceptions on conversation with other farmers at local ferias and also relies on personal observation and memory, though when discussing climate change, mentions more stories from friends than examples on his personal operation.

Because he indicates that climate change has not significantly affected his own farm, farmer A does not report he has made any adaptations to climate-related effects, however, several potential adaptations are evident. Farmer A describes putting roofs of plastic webbing over his fragile crops (lettuce, tomatoes, etc) over the past several years for protection from "too much sun." Though he views this simply as a way of improving his crop survival, one could infer that such webbing may similarly protect crops from extreme temperatures and severe weather events and may be serving as an unrecognized, perhaps unintentional, adaptation to changes in the climate. Furthermore, farmer A participates in an organization based in Corrientes that seeks to aid in the survival of small farmers through exchange of ecological and economic knowledge. He similarly did not report such activity as an adaptation or even as a significant help to his operation, though it is possible that this exchange has contributed to his awareness of and potential reactions to climate change.

Farm B

Buenos Aires Province, Argentina

Farm B is a 37-acre plot on the Northeastern edge of the province of Buenos Aires. It is an organic, primarily subsistence operation, although some products including honey and jams are sold on a small scale. The main crops grown are vegetables for household use, primarily lettuces, beans, tomatoes, cabbage, and squash. The farm has been under current ownership for the past 8 years and farm income is largely supplemented by the operation of an on-site yoga studio.

Farm B is located in the province of Buenos Aires, near the latitudinal center of the country. This region is considered part of the Argentina "pampa" and is characterized by a temperate climate with high heat and humidity. The most notable climate-related change in this province is growing incidence of off-season rainfall, with an increase of about 200mm from 1961 to 2014 (SMN 2015). This increase in rainfall has largely occurred through more common and more severe off-season storms in the Buenos Aires province, as the frequency of weather events containing more than 100mm of rainfall has tripled over the past 30 years (CITIES 2013, Leibmann 2004). Such events have led to many floods in the area, notably a record-setting flood in April 2013.

The primary witnessed effects on Farm B were consistent with the physical changes predicted for the province of Buenos Aires. Farm owners, based on the past 8 years of operation, discussed an increase in fall rains (March-June) and increased incidence of flooding. As irrigation creek runs through the property, these floods have heavily affected Farm B, with a fall flood in both April 2013 and 2014 destroying more than half the vegetable production for both years. Farmers described that, at times, up to 20cm of water covered their property, including the vegetable garden and chicken coop. Aside from these, farmers did not report any effects regarding increases in temperature, nor any secondary effects regarding pest and disease incidence.

Owners of farm B viewed the increased rainfall and consequent incidence of flooding as part of an upward trend, indicating that such events have consistently increased in frequency and severity over the past 8 years. When probed, however, they also indicate that they consider climate change overall as part of a natural cycle and do not see the effects they have experienced a consequence of anthropogenic climate change. They do link witnessed changes in precipitation to climate change, but do not link climate change to human influence. Nearly all climate-related information on farm B is based on personal experience and memory, the only outside climate information being a weekly newspaper summarizing monthly temperature and precipitation patterns.

Observed adaptations on farm B pertain primarily to sources of farm income as opposed to physical changes. Farmers discussed planting more trees near the creek and building more raised beds for vegetable production to help protect against potential floods. The biggest discussed and observed change, though, was the increased dependence on an outside source of

income, the yoga studio, and decreased dependence on the farm for subsistence. Farmers B now purchase about half of household vegetables, using this other source of income, and seem to be changing from a small subsistence farm to a yoga retreat with a supplemental vegetable garden. This adaptation, however, cannot be attributed solely to changes in the climate as the owners discussed many other economic and social factors that affected their transition of income source.

Farm C
Córdoba Province, Argentina

Farm C is a subsistence-scale farm in the Sierra mountain range, in the south central region of Córdoba province. Primary production on the five-acre plot includes vegetable production for household use, chickens for eggs and meat, and apiculture. Farm owners sell baked goods at regional ferias but use farm products exclusively for subsistence. The farm has been under current operation for five years and income is supplemented by sales at ferias, and by rental of an on-site guesthouse.

The province of Córdoba is in North central Argentina and has a varied, temperate climate with hot summers and dry winters. The southern region is primarily a plains area with high production of soybeans and maize, while the more mountainous regions host small horticultural producers. While many provinces in Argentina have experienced increased precipitation trends, overall precipitation in Córdoba has decreased by about 150mm since 1961 (SMN 2014). Additionally, temperatures have been highly variable, but an average temperature increase of 0.5 degrees Celsius has been recorded over the same time period.

Farmers C described both increased temperature and decreased rainfall over their time on the property, in line with climate data for the region. They also report, however, that such changes have not affected the success of production because a small creek runs though their property aids in production when rains are insufficient. They did mention that properties with such features are becoming increasingly coveted and expensive, as many people in the area are concerned about decreasing rainfall and water access in the future. They did not indicate any additional effects or problems in relation to climate change.

Farm C owners, though confident they have seen notable changes in temperature and precipitation over the past five years, believe that these changes are part of a natural cycle as opposed to a long-term trend. When asked about their particular views on climate change, the primary farmer responded that such changes are simply "el via del universario" or "way of the universe" and such matters are beyond human control. Consequently, they expressed little concern for climate change as a whole. Both farmers gain most climate-related information from discussion with neighboring farmers or other farmers at *ferias* and indicated their belief that the local concern over climate change is unnecessary, as the cycle will soon return to "normal."

Though they did not discuss watering systems in relation to observed changes in the climate, farmers on Farm C created a new system for watering during my period of observation. While they had before relied upon rains and occasional hand watering for their vegetable plot, I worked with farmers to construct a channel, drawing the nearby creek through the beds to eliminate the reliance on rainfall or need for manual watering. They did not report that the channel was constructed to combat the observed effects of climate change, but they did note that the channel would allow them to keep the vegetables growing when the "rains are bad," which has been a more common occurrence in recent times. Similarly to Farm B, they are also supplementing their income increasingly with rental of the guesthouse or with sales at *ferias*, relying less and less on farm production.

Farm D
Mendoza Province Argentina

Farm D is a five-acre organic operation located in the North of the Mendoza province. The farm focuses exclusively on organic horticultural products, one of the only in the region, growing carrots, onions, beans, squash, lettuce, potatoes, corn, peppers, and tomatoes. Products are sold at bi-weekly *ferias* as well as through a weekly CSA in cooperation with other local producers. The farm has been under current ownership and operation for 18 years and is not supported by any other income sources.

Mendoza is a heavily agricultural province on the western central edge of Argentina, along the base of the Andes range. Due to the proximity of the range, Mendoza has a continental,

dry climate with hot summers, cold winters, and somewhat infrequent precipitation. Several major rivers descending from the Andes snowmelt also run through the province.

Mendoza is arguably considered the province of Argentina most affected by climate-related changes because it has experienced a variety of effects and is economically dependent upon the production of fragile fruits. Rising temperatures, severe storms, and drought all significant concerns. Temperature recordings show average temperatures in Mendoza have increased about 1 degree Celsius from 1961 to 2014 and average precipitation has increased about 25mm over the same time period (SMN 2014). This level of increased precipitation isn't significant in itself, but more concerning is the frequency and intensity of severe storms, particularly hail, that result from increased temperatures and humidity in the region (Universidad de Cuyo 2011). Hail alone is reported to reduce crop yields in Mendoza by more than 10% (Salas 2012). Furthermore, Mendoza faces problems related to melting of glaciers, as river flows for irrigation are reduced in the late summer when farmers most need them, resulting in drought conditions (SMN 2014, Salas 2012).

Owners of Farm D describe problems consistent with those reported for the province as a whole, though also demonstrate significantly more concern for economic and political struggles than those related to the climate. The largest climate-related concern at Farm D was potential lack of water; owners live in an agricultural community where irrigation rights are shared amongst many small farmers, and owners expressed concern that seasonal drops in river flow could affect these rights. They did not report that lack of water had yet affected their production, but rather expressed it as a future concern. They also described an increased incidence of heavy storms, notably hail storms, over the past 18 years of operation that had damaged some crops but did not significantly damage or jeopardize the operation.

Farm D owners did not describe significant damages to their operation as a result of climate-related changes, but did express strong concern for the future regarding irrigation rights and the occurrence of hailstorms. They do believe the changes they have seen are part of an upward trend and fear more severe effects to come in the future. Although expressing uncertainty about the cause of such changes, they do perceive changes in temperatures, river flows, and storms as part of a larger climate change trend. They based their beliefs on personal experience and observation, and also discussed climate events with other local farmers and neighbors.

Farm D owners made significant changes to their operation over the past 18 years. They reported these changes were economic and moral decisions, not necessarily reactions to climate change. For the first 12 years of operation, Farm D was a conventional, monoculture operation, selling cabbages to a large regional market. Four years ago, as a consequence of a loss in the family, owners decided to switch to a diverse, organic operation, one of few in the area.

Farm E

Mendoza Province, Argentina

Farm E is also located in the province of Mendoza, on the southwest edge, close to the Andes range. It is an 18-acre farm, main crops being apples, peaches, squashes, lettuce, and tomatoes. Primary sales are at weekly *ferias,* although owners also sell to some local restaurants and to individuals door-to-door. The farm has been under current ownership and operation for the past 54 years and is the family's only source of income.

Farm E owners reported, and I observed, significant problems as a result of severe hailstorms. Because the farm produces many fruits it is particularly vulnerable to hailstorms, as are many other farms in the fruit-heavy area of Mendoza. The owners reported that they experienced occasional storms when they first started the farm over 50 years ago but that these storms have been consistently more frequent and more severe recently, particularly through the past 20 years. They said that these storms were only nuisances in the past but are now seriously jeopardizing their apple and peach crops. Farm E owners also reported problems with certain vegetable crops as a result of rising temperatures, confirming they have also seen a rise in temperatures over the past half decade. They described that when the operation began, the maximum temperature they experienced during the summer was about 25 degrees Celsius and they now experience some days as high as 35 degrees Celsius. As a result of these temperatures, they report, they can no longer successfully grow certain crops, notably lettuces.

The owners do consider these changes part of a consistent upward trend and are certain

they are part of a larger global climate change. When probed about the cause of climate change, they reported they were uncertain, but that "mineral extraction and fossil fuels must have something to do with it." They base their belief that severe storms and temperature maximums are increasing on personal observation and conversation with other farmers, but base their views of the larger idea of climate change on television climate reports.

The owners did not report any adaptations in direct relation to changes in the climate but several were evident as an observer; they are simply growing more of the crops that can survive and fewer that can't. While in the past they relied more on fruit sales, the owners are growing more and more vegetables that can withstand potential hailstorms. Similarly, they are planting more high-temperature vegetables such as tomatoes and corn and fewer colder weather crops. The farm owners did not consider these changes "adaptations to climate change", but rather, thought of them as responses to the "hot weather" in order to continue making a living.

Farm F
La Pampa Province, Argentina

Farm F is a 190-acre plot, considered a "small" farm in La Pampa region, focused on cultivation of wheat and grasses for meat production. The farm is located near the center of La Pampa province and sells wheat at nearby markets. Cattle produced on site are sold at larger meat markets near the capital of Buenos Aires. The farm has been under current operation for 18 years and current ownership for 7 years and is not supplemented by any other sources of income.

La Pampa province is a large, sparsely populated, agricultural province near the center of Argentina. It is a flat region, with temperate weather and low humidity and an average of about 500mm of precipitation per year (SMN 2014). There are two major rivers on the edge of the province, but they do not lie close to main agricultural centers, and are being diminished as a result of irrigation diversion in the northern Mendoza province.

The most marked climate-related change observed in La Pampa is an increase in precipitation, with annual precipitation growing by about 30% between 1921 and 2009 (Peréz 2012, SMN 2014). Though most researchers agree that such rainfall is actually encouraging agricultural production in the area, there are also concerns regarding risks of extreme floods and seasonal droughts (Asseng 2013, Pérez 2015). While the trend overall has shown an increase in rainfall, La Pampa province has also experienced severe droughts in some recent years, notably 2008-2009, in which yields of soy and wheat decreased more than 30% (Veron 2015, Barros 2014). Through other periods of the past several decades, the same area has experienced severe flooding as a result of frequent severe storms, including major floods from 2000-2003 and 2012-2013 (Kuppel 2015, Pérz 2015). While increased precipitation may be benefiting agricultural production overall, the extremes of both drought and flooding may pose huge risks for farmers with less capability to adapt on a year-to-year basis.

Owners of farm F report observations similar to recorded climate-effects in La Pampa but also report significant losses from a recent drought event. They confirm that rains in the area have generally increased, allowing them to expand the area of planted cereals and size of their cattle herd, and agree that these rains are largely beneficial for agriculture in the area. They did discuss, however, the 2008-2009 droughts and substantial loss of cereal crops and cattle through the summers of both years. Overall, they report more frequent and substantial rains, but also more significant droughts during "bad years" than they had seen in years past. They also discussed decreased temperatures in spring and fall but did not report any consequent effects on their operation, nor did they report any effects of flooding that are common in other regions of La Pampa.

Though aware and in agreement that the phenomenon of climate change is occurring on a global level, the owners of Farm F do not perceive increased rainfall and more severe droughts in La Pampa as part of global climate change. They view the increased rainfall as part of an 8-10 year ENSO cycle and do not believe changes in this cycle are related to overall changes in the global climate. When asked about the future, they do believe rains will return to "normal" and they are therefore seeking to capitalize on abundant rains while available. When asked about the severe 2008-09 droughts, farm owners perceive the event as part of the climate cycle and similarly do not consider it a noteworthy event in relation to climate change. As a student in an agricultural college in La Pampa, the owner of Farm F obtains most climate information from a government agricultural extension, INTA. Based upon

conversation with representatives at agricultural fairs and professors at the agricultural college, as well as pamphlets, assigned readings, and website information, most climate related information is still portrayed exclusively as "global warming." Nearly all of these information sources discuss higher temperatures and the incidence of droughts, but none mention *increased* precipitation in relation to climate change. It is possible the lack of connection between witnessed changes and overall climate change are due to the owners' perceptions of climate change as exclusively a warming and drying trend, based on the climate information most prevalent in their education and surroundings.

Farm F also offers an interesting case in relation to adaptation, particularly to effects of precipitation changes. Because they have no source of above or below-ground irrigation, all crop survival is dependent upon rainfall exclusively in most of La Pampa province, including the area of Farm F. Consequently, in times of drought, very few adaptations are available. A salient adaptation on Farm F, as in much of the Pampas, is the adoption of agricultural technology. Farm F now relies heavily on more drought-resistant seed varieties for less favorable rain years and also uses chemicals to improve yields, regardless of climate stressors. It seems these technologies are much more widely available and common en La Pampa, likely as a result of American and European owned agro-business in the flat, fertile region (Murmis 2012).

Farm G
Rio Negro Province, Argentina

Farm G is a 20-acre biodynamic farm in an agricultural community of northern Patagonia. The farm produces exclusively biodynamic horticultural products and sells at local markets, as well as through a cooperative CSA model. The farm has been under current ownership for 8 years and current biodynamic operation for 4 years, farm products being the only source of income for family G.

The Rio Negro Province lies in the South of Argentina, on the northern edge of the Patagonia region. Rio Negro has a highly variable climate, with a temperate climate in the North and much colder, wetter climate in the South and over the Andean peaks. An important water source over the temperate plains is the Rio Negro River and glacial melt largely feeds the western and southern edges.

While most areas of Argentina have seen general trends of increased precipitation, the most evident effects of climate change in the northern Patagonia region are decreased precipitation combined with increased temperatures. The average precipitation has dropped between 50mm and 150mm in the past 50 years, and these drying trends are particularly strong on the western and southern edges of the province (SMN 2015, Caziana 2014). Some parts of Northern Patagonia have seen a 30-50% reduction in precipitation over the same time period (Barros 2014, Vera 2006). Increased temperatures are also characteristic of the region with an average 1 degree Celsius temperature rise from 1961-2014. These increased temperatures combined with decreased precipitation are resulting in generally dryer conditions through the province. Other, less prevalent concerns through the Rio Negro province include seasonal variability of glacial melt and coastal storms surges (Parry 2007, Barros 2014).

Though the family did describe evident drying and warming trends, they did not say such trends had significantly affected their operation. The farm lies close to, and is fed by a small river near Andes range and the family has been able to use this river as their primary water source, thereby not heavily affected by regional warming and drying. They also reported that neither trend has been significant enough to affect what types of crops they grow or the survival of such crops. Their only concern, they expressed, was the water level of the river, their only irrigation source, in relation to glacial melt and decreased precipitation in the region through late summer.

Family G was relatively nonchalant regarding their perspectives on climate change, likely because they have experienced little effects personally. They expressed that witnessed precipitation and temperature patterns seem to be part of an upward trend but they are "not sure" whether the trend will continue or whether it is part of a larger cycle. They expressed the same uncertainty when asked about the potential causes of climate change overall. Owners of farm G obtained all climate information from personal experience and conversation with other farmers, and made no reference to television, news, or other sources of climate information and forecasting.

As family G did not describe experiencing many, if any, significant effects from climate

change, they similarly did not report making any adaptation to such changes. They did make a significant economic adaptation, though, that could be equally relevant to climate change as economic change. The farm has been operating on a cooperative CSA model over the past 4 years, in which 35 families "subscribe" for a share in food produced every year. There is no guaranteed type or amount of food, simply an equal share of what is produced. Thus, given a potential effect of climate change, for example, a reduction of crop yields as a result of a dry spell or heat wave, the farm would not lose any money for that year; they would simply provide a smaller or different CSA share. This makes the family less reliant on specific yields, which are heavily affected by climate change, and more reliant on the seasonally stable cooperation of other families.

Farm H
Chiloé Island, Chile

Farm H is located on the northern edge of Chiloé island, a 42-acre property under current ownership and operation for the past 36 years. The farm produces a variety of products and encompasses a variety of income sources, but main crops include apples, strawberries, and various vegetables. They also produce milk, cheese, and butter, which they sell at local markets in addition to the horticultural products. On the same property, the family owns a restaurant in conjunction with an agro-tourism operation, providing additional income.

Chiloé is an isolated island in the South of Chile, also in the northern Patagonia region. The island has a cool, temperate climate with frequent rainfall and is characterized by humid rainforests. In addition to the high precipitation, there are also several rivers running through the island.

General climate trends in southern Chile closely resemble climate trends in southern Argentina, both in the northern Patagonia region. Unlike most of Argentina and Chile, the characteristically rainy island is experiencing decreased precipitation and increased temperatures. Average temperatures in this region have increased about 1 degree Celsius between 1961 and 2014 and precipitation has decreased about 150 mm over the same period (SMN 2014). These trends are resulting in warmer, dryer conditions through most of Southern Chile, an important change on the usually cool, rainy Chiloé island (Pesce 2014, Karmalker 2007). Another concern in Chiloé in particular is storm surges along the coast and potential wildfires through the interior forests. (De porras 2014, Iglesias 2014).

Owners of farm H describe local climate trends similar to overall climate trends for northern Patagonia. They report a consistent trend of less frequent and less abundant rainfall over the past 36 years of operation, particularly in the past 8-10 years. Similarly, they have witnessed consistent increased temperatures, particularly an increase of warm, sunny days in the spring and fall. These changes have significantly affected the farm, as no exterior irrigation is used and production is entirely dependent on weather conditions. Owners report that, as a result of these trends, they are now unable to cultivate certain crops, notably crops with demand for cooler, moisture weather such as lettuces and other greens. They also report that some heartier crops are less successful, they believe, as a result of lack of moisture and high temperatures.

Beyond direct physical effects on the farm, the family reported that the cool, rainy climate in Chiloé is an important aspect of Chilotan identity and culture. As a result, they perceive the effects of climate change on their island as highly important, and they were visibly concerned about the observed changes. They described the changes they have seen as an upward trend and "fear" the trend will continue. More so, they consider climate change to be at least partially human-caused and see it as an intrusion on the otherwise isolated island. Owners of farm H obtained most climate information from personal observation and multi-generational memory, as well as conversation with other farmers. The family helps to organize local *ferias* as well as agro-tourism gatherings on their own farm, providing a large network of conversation with other farmers.

Owners of farm H reported several adaptations to climate change, while other adaptations were more evident as an observer. At a basic level, the family had stopped growing certain crops that cannot survive dryer, warmer conditions, such as lettuce, and were growing more of those that can. They also reported planting taller plants within their gardens to allow for greater shade and planting some crops beneath shadier fruit trees. Finally, the family reported producing fewer fruits and vegetables in general, and relying more on value-added products such as jams and cheeses, making them slightly less vulnerable to climatic shifts. It was also evident they rely now more on the income of

the restaurant than in the past. An unreported, yet important adaptation is the family's involvement agro-tourism. This involves farm visits about twice monthly, in which groups of 20-30 other regional farmers tour the operation.

DISCUSSION

Though the effects, perceptions, and adaptations to climate change of the eight farms in the study are as diverse as their locations and owners, I have synthesized four primary discussion points from my observations. These points are simply general trends observed on the eight farms and are not intended to represent all small farms in their respective regions or countries. These ideas do, however, provide detailed insight into how some small farmers are experiencing and understanding climate change, and how they are adapting in response. Such insight may help us to understand how we can ensure the survival of small farmers in many countries as we continue to face the reality of a changing climate.

1: Existing locations and water resources strongly influenced small farmers' perceived severity of climate-change effects and their abilities to adapt.

All farmers reported varied degrees of climate change effects, some significantly more affected than others. While much of this divergence can be attributed simply to regional differences and farm type, it seems existing locations and water resources were also important in how small farmers scaled the effects of climate change. The trend of changing precipitation patterns, though observed on nearly every farm, was considered a more severe effect on certain farms based on lack of access to other, more consistent water sources. Farms A, C, D, and G described changing precipitation patterns but reported that these changes did not significantly affect their operations, as they are ideally located near other water sources. These farms were able to adapt, and therefore did not consider the witnessed effects of climate change to be as severe. Farm C owners, for example, constructed a water channel to irrigate crops and were consequently less concerned about the decreasing precipitation patterns in the region. Using more of other water sources when precipitation patterns have changed can be considered a very basic adaptation to climate change, and those farms able to adapt in such a way reported fewer effects and seemed generally less concerned about climate change than others. Farms F and H, contrarily, described similar precipitation patterns but considered these changes significant to their operations. These two farms were not located near other water sources and were entirely reliant on consistent rainfall. Thus, farmers' access (or lack thereof) to certain resources, based on their locations, influenced the perceived severity of climate change effects, even if observed climate patterns were similar.

2: Almost all climate change perceptions were based upon personal experience and highly influenced by cultural inclinations.

Only one farm of the eight observed reported consistently using a source of climate information outside of personal observation and conversation. Thus, most farmers' perceptions of the phenomenon of climate change were based solely on what they were observing, which varied considerably with regards to existing social and cultural biases.

Social and cultural concepts were extremely important in how individuals perceived climate change, particularly because such perceptions were based almost exclusively on personal experience. The culture of Latin America, particularly of Argentina, is considered a "culture of optimism," which likely influenced participants' ideas regarding present and future effects of climate change. Most farmers agreed with the general premise that global climate change is occurring and many described witnessed effects as part of an upward trend; however, many farmers also believed that these witnessed effects were not a part of global climate change or were part of a natural cycle that would soon return to "normal." Many farmers also expressed uncertainty or lack of concern regarding the causes and future effects of climate change. It is likely that regarding climate change simply as the "way of the universe" poses important implications for consequent perceptions of and adaptations to climate change effects. This philosophical, religion-influenced view on climate change may have impacted these farmers inclination to actively implement measures of adaptation. Contrarily, some cultural views, such

as those of family H in Chiloé, influenced their attitudes towards climate change and potentially encouraged adaptation. The family's attitude towards climate change stemmed from cultural roots, from the pride and attachment to place of the Chilotans, as climate change is seen as one of the ways more-developed countries are intruding on the island. Thus, with climate change perceived as an intrusion upon their culture, this family seemed much more inclined to both recognize and adapt to witnessed changes.

3: Direct, physical adaptations to climate change were much less prevalent than social and economic adaptations.

While several farmers described direct, physical adaptations to climate change (though such changes were not considered *adaptations*), these were less common and less influential than more socially and economically-based adaptations. Farms, in compilation, reported general physical adaptations including more resilient primary crops, crop protection (trees, raised beds, etc.), crop diversification, and technology use. These adaptations were typically not considered adaptations by participating farmers, but rather as reactions to weather or as ways to continue making a living. Arguably, however, protecting crops against climate effects or growing crops that can withstand changes in the climate seemed to be synonymous with "making a living." Physical adaptations were most prevalent in the Argentine Pampa, in which adoption of technology is fairly widespread. It is likely that the relative lack of physical adaptations can be linked to a relative lack of physical resources, with the exception of La Pampa, thus necessitating less directly climate-related adaptations.

Such adaptations were overshadowed by larger social and economic adaptations, the most prevalent being an increased reliance on other sources of income. Four of the eight farms, all of which have historically relied on farm income exclusively, now report relying primarily on other income sources, such as on-farm tourism operations or off-farm jobs. Other common economic adaptations included new mechanisms of sale, including the increased sale of value-added products and increased use of new market types. Three farms reported selling less horticultural products and more value-added products including cheese, jams, and sweets. Two other farms reported selling in a new CSA or cooperative model that relied less on direct crop yields and more on participant cooperation.

Social networks, though still not considered adaptations by participating farmers, were also an important component of farmers' adaptations. Farm A and farm H in particular reported involvement in such networks, both networks of knowledge exchange between farmers, that likely are or will help these farmers to understand and adapt to climate change. Such changes are not the direct, physical adaptations I may have anticipated, they must also be considered as important tools in the discussion regarding small farmers adaptations.

4: Small farmers' socially and economically oriented adaptations may also serve as important adaptations to climate change.

Only two of the eight farms reported observed adaptations as being adaptations to climate change likely because 1) observed changes were considered simply a way of life, not "adaptations" and 2) such adaptations occurred for economic or social reasons, not as reactions to climate change. Such adaptations, however, may also serve to protect these farmers against effects of climate change.

The prevalent adaptation of changing income sources, though typically an economic decision, also decreased dependence on climatic conditions. Individuals more reliant upon a yoga studio or restaurant were less vulnerable to changes in temperature and precipitation and consequent crop yields. This idea, though, brings up an important distinction, the adaptation and survival of *individuals* versus the adaptation and survival of *small farmers*. Individual small farmers in this study adapted to economic and climate changes simply by not being exclusively small farmers. While this may have helped these individuals, it is not a sustainable solution for the existence of the small farmer; not being small farmers as individuals will not aid small farmers as a population.

Some of the economic adaptations observed, however, may also serve as adaptations to climate change for a greater population of small farmers. New market types, notably the cooperative CSA models, seemed to aid in the survival of small farmers against changes in the climate. Farmers participating in

these models received a guaranteed income from CSA subscribers and were therefore not heavily affected by a crop loss or crop damage resulting from changes in the climate. The model almost serves as a type of insurance against climate-related crop damage. This adaptation, however, would not function in conditions where crops are entirely or consistently ruined, as CSA participants would not subscribe sustainably if unsatisfied with CSA shares. Another notable adaptation was the transition to a more diverse operation on farm D. Though this adaptation has benefited the family economically, it may also be a form of resilience against the effects of climate change, as a diverse operation is less vulnerable to shocks such as severe storms, seasonal droughts, and pests.

Small farmers' socially-oriented adaptations, though also not intentionally targeted towards climate change, may also benefit them, particularly in the future. The discussed social exchanges including the farmer aid group and agro-tourism operation may serve as important settings for knowledge exchange, potentially benefiting farmers within these case studies and beyond. Those farmers who can learn from others what changes are occurring and what adaptations are most successful may be able to employ these adaptations in their own operations, whether as reactions to climate change or to other economic changes.

CONCLUSION

This ethnographic case study, though it did not encompass a wide study group, provided a more detailed, nuanced understanding of climate change effects, perceptions, and adaptations for small farmers in a rapidly developing region of the world. With the goal to help protect smallholder farming throughout the process of international development, it is important to recognize the diversity of both climate change and of small farmers. General information regarding climatic changes in given regions or overall effects of climate change for small farmers is important, but we must also explore more deeply to understand 1) the varied effects of climate change for small farmers based on location and existing resources, 2) how social and cultural concepts shape small farmers' perceptions of climate change and 3) how small farmers' adaptations to climate change correspond to other environmental, economic, and social stressors. Similarly, we must recognize the manners in which most small farmers obtain climate-related information, primarily through personal experience and conversation with others. Arguably, climate forecasting and climate education are not the most effective mechanisms for reaching small farmers, which we must be aware if we hope to aid in the survival of this vulnerable population.

It is also important that we continue to employ more observation-based methods, as small farmers' perceptions may create wide divergence between what is reported and what is observed. Most of the small farmers in this study did not report any adaptations to climate change, as they did not consider observed changes to be "adaptations" or were not reacting directly to climate change. I, however, observed many potential adaptations to climate change, most of which would have been lost in a more quantitative or standard interview-based approach. The social and cultural backdrop of every participating farmers was essential to understanding their perspectives on climate change, their adaptations, and why they did or did not consider them adaptations to climate change.

Furthermore, in the study of smallholder adaptations, it is critical that we distinguish between the survival of individuals and the survival of small farmers. If small farmers are adapting by finding other income sources or by growing and conventionalizing their operations, we must consider the implications of such adaptations for the existence and importance of smallholder farming. Many countries, Argentina included, are rapidly losing small farmers, as many "adapt" by finding other income sources or other occupations. Those that survive as small farmers are increasingly growing their operations or using more technology-based adaptations. Technology-based adaptations seem to benefiting individual farmers, but we must also consider the long- term risks of these adaptations and their implications for ideas regarding the ecological sustainability of smallholder agriculture.

Finally, we must remember climate change is just one of the many stressors facing small farmers in our rapidly changing world. If small farmers are to survive, we must recognize and understand 1) how stressors are connected 2) how small farmers are perceiving stressors and 3) how small farmers are adapting to multiple stressors simultaneously. We cannot assume that challenges such as social inequality, economic

instability, or climate change are acting independently nor can we necessarily separate small farmers' reactions to such challenges. Many of the stressors facing small farmers in the developing world may build on each other, but it is also possible that certain adaptations may aid small farmers against multiple stressors. These multi-purpose adaptations will be incredibly important tools for small farmers to discover, understand, and implement as they continue to face economic, social, and climatic changes throughout the developing world.

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