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Livelihood change, farming, and managing flood risk in the Lerma Valley, Mexico

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Abstract In face of rising flood losses globally, the approach of "living with floods," rather than relying on structural measures for flood control and prevention, is acquiring greater resonance in diverse socioeconomic contexts. In the Lerma Valley in the state of Mexico, rapid industrialization, population growth, and the declining value of agricultural products are driving livelihood and land use change, exposing increasing numbers of people to flooding. However, data collected in two case studies of farm communities affected by flooding in 2003 illustrate that the concept of flood as agricultural "hazard" has been relatively recently constructed through public intervention in river management and disaster compensation. While farming still represents subsistence value to rural households, increasingly rural communities are relying on non-farm income and alternative livelihood strategies. In this context, defining flooding in rural areas as a private hazard for which individuals are entitled to public protection may be counterproductive. A different approach, in which farmers' long acceptance of periodic flooding is combined with valuing agricultural land for ecoservices, may enable a more sustainable future for the region's population.

Keywords Vulnerability · Flood · Livelihoods · Agriculture · Mexico

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Introduction

The frequency of flood disasters around the world is rising (Douben 2006). Hypotheses for this phenomenon are numerous: increased climatic variability, the expansion of human settlement in flood plains, and land cover and land use changes together are believed to be increasing human exposure and sensitivity to flood impacts (Kundzewicz and Kaczmarek 2000). The persistence of loss in face of increased knowledge about the dynamics, drivers, and outcomes of hazards may well signal a significant lack of sustainability in social-environmental relations, as well as a need to reconsider the underlying principles of flood management.

In Mexico's Lerma River valley—one of the most densely populated regions in Mexico—rural land and urban settlement patterns are rapidly evolving, institutions are in flux, and consequently perceptions of flood loss are also changing. To date, Mexico's approach to flooding on the Lerma has been almost exclusively structural, relying on a series of dams, river straightening, and dredging and dike construction. Now that the valley's population of 2.3 million is rapidly encroaching on what remains of the valley's undeveloped floodplain, the incidence of flood damages is rising.

This article will illustrate how these processes are not only altering the impacts of flooding but also are changing the way farmers value the use of their land, thus transforming their perceptions of risk and the subjective meaning of flooding in rural areas. We draw from the rich history of hazards research to explore how evolving livelihood strategies and the consequent shift in the role of agriculture in the Upper Lerma Valley may provide insights into the meaning of flood losses to rural populations, and thus new opportunities for flood management. Hazards—or events with the potential to create harm—are very real phenomenon of the natural and built environment. Nevertheless, the meaning of harm and

loss has a significant subjective component and thus varies among individuals and from place to place (Hewitt 1997). Understanding this subjective experience is not only necessary to ensure that policy effectively addresses the needs of vulnerable populations, but also, as we argue here, is necessary to enable more effective and flexible policy solutions to evolving risk.[1]

Building on the tradition of political ecology in hazard research, we illustrate the implications of livelihood change, agricultural policy reforms, and urbanization for the experience of flooding in two rural communities in central Mexico. The current policy framework in the region presents an un-nuanced view of flooding as a rural hazard producing losses in need of compensation. This relatively narrow perspective misses the policy opportunities that might emerge from a more subtle understanding of the changing relationship of farmers to flood risk. Acting on such opportunities is not only critical in the context of the current high frequency of flooding in the Lerma River valley, but also important in light of the possibility of increased rainfall intensity with global warming (Magaña et al. 2005).

In the next section, we describe insights into flood vulnerability and management that have emerged from political ecology and hazards literatures. We follow this discussion with an introduction to the concept of "living with floods"—a relatively new approach to flooding that is beginning to be adopted in Europe and other regions characterized by chronic flood problems. We then move on to discuss flood-risk policy and farmers' responses in the Lerma Valley in the state of Mexico, illustrating how the public policy effectively creates a flood *hazard* from flooding that was previously a well-known and accepted dimension of the hydrology of the Lerma Valley. In doing so, current efforts by the public sector to control flooding paradoxically may both increase the probability that material losses will occur and also raise expectations for protection in the public. By neglecting to consider how farmers perceive flood events and how they have lived with flood risk for decades, the government neglects a potentially more sustainable development pathway that would build on farmers' long experience with flood risk.

Understanding vulnerability to flooding

The preference for structural measures for flood control in both industrialized contexts and emerging economies reflects in part a deeply engrained technocratic epistemology that continues to characterize water management globally yet that has been contested in hazard theory and water management since the mid-twentieth century (Hewitt 1983; White 1986; Parker 2000). River valleys offer distinct advantages for economic development: fertile soils, flat plains, and water for transportation and development. Nevertheless, as population density and the value of economic activities increases in these high-risk areas, policy-makers are often confronted with a relatively narrow range of choices in addressing the problem of flooding (Douben 2006).

On the one hand, water managers often face the immediate politics of the so-called "levee effect" (Smith 2004, p. 198), in which specific economic interests demand flood protection from the government, which in turn leads to wider-scale flood plain development and a consequent increase in political pressure for continued public investment in levee construction—often at considerable expense. On the other hand, in light of the continued high cost of flooding internationally, the non-structural approaches designed to combat the levee effect (such as mandatory flood insurance and land use zoning) does not seem to have had greater success in promoting social resilience or sustainable development.

Although it can be argued that its impact on the more pragmatic aspects of flood management has not been substantial, an alternative perspective on hazards and social vulnerability has been advocated for several decades. In his classic volume *Interpretations of Calamity* (1983), Hewitt identified the dominant technocratic and reductionist approach to hazard management as a socio-cultural construction, resulting in the mischaracterization of disasters as "Acts of God" rather than the result of historical, political-economic, and cultural processes interacting with the dynamics of nature. In their contributions to Hewitt's volume, authors such as Watts, Waddel, and Copans emphasized the neglect of the state, power struggles over land, historical patterns of development, and inequities in resource allocation in the creation of vulnerability to hazards such as drought, frosts, and floods.

Blaikie et al. (1994) furthered this work to theorize a political ecology approach to disaster and vulnerability, in which both environmental processes and political-economic conditions interact to generate unsafe conditions and, ultimately, the social context of disasters. Research in this vein has illustrated how vulnerability to floods is associated with historical processes of land use change, the politics of resource allocation and political disenfranchisement, and socioeconomic marginalization (e.g., Mustafa 1998; Pelling 1999; Few 2003).

While such analyses illustrate the importance of history, policy, and power in flood causes and outcomes, Mustafa argues that political ecology interpretations of hazard causes and outcomes could benefit by a renewed emphasis

[1] We use a common definition of risk as the probability of a hazard occurring and creating loss. Risk is thus a function of both the biophysical hazard (e.g., probability of a flood event) and the expected consequences of the event (e.g., its material, social, ecological and economic impacts). See discussion in Smith (2004) and Tobin and Montz (1997).

on risk *perception,* as a means to "understand local-level subjectivities regarding resource management and vulnerability" (Mustafa 2002, p. 103). Risk perception and the motivations of individual behavior in face of risk was a central theme of hazards research by Gilbert White and others as early as the 1950s (see White 1986 for a review), but has not been a feature of political ecology research. Others have also drawn from behavioral perspectives on hazards to argue that it is necessary to understand the social and cultural nature of individuals' perceptions and experience of their environment in order to determine what fundamentally *matters* to them, and thus what is truly "dangerous" (Dessai et al. 2004). If such perceptions are not accounted for in vulnerability assessments, there is a risk that all externally measured losses (e.g., damages to crops, property, health or livelihood) will be interpreted as manifestations of social inequity and marginality, and the individuals who experience such loss as "victims" lacking agency (Ellemore 2005).

Pragmatically, understanding how populations interact with a landscape and what their expectations are from their environment can provide greater flexibility for policy makers aiming to achieve broader social and ecological objectives (e.g., see Brouwer et al. 2006; Rashed Chowdhury 2003). Here the concepts of *accepted* and *acceptable* risk are particularly useful in linking perspectives on the motivations of individual behavior and the political, economic, and cultural structural processes that shape vulnerability (Tobin and Montz 1997: 295–97). Hazard policy is designed to manage and reduce risks posed by hazards to society on the basis of an assumption of what forms of risks are acceptable and what are not. For example, the observation that populations settle on floodplains even when cognizant of a high probability of property loss from flooding is sometimes viewed as a reflection of the degree of risk that is tolerable or "acceptable" to them. The basis for such a conclusion is that their behavior is a manifestation of their conscious evaluation of the tradeoffs between flood risk and the benefits of accessible housing or land (e.g., a "revealed preference"). Yet political ecology would suggest an alternative hypothesis: their behavior may well be simply a reflection of a lack of choice and a history of disempowerment rather than conscious acceptance of their risk exposure. In other words, the population accepts the risks that they live with, but the risk would not be *acceptable* if they really had a choice in the matter.

Given the impossibility of reducing risks completely, policy makers design their interventions to address risks that exceed a threshold of tolerance. In balancing the need for efficient investments and social equity in hazard policy (see discussion in Johnson et al. 2007), policy-makers must distinguish between risks that are potentially acceptable for different social groups, and risks that are accepted because the populations' lack of entitlements leaves no other choice. In essence, the threshold of risk tolerance defines the boundaries of public intervention and responsibility toward individual citizens and the public good.

In this article we argue that what is "an acceptable flood" needs to be evaluated in the context of the changing social and economic conditions of the region exposed and, more specifically, in relation to local attitudes and perceptions of the threat of flooding. Although there is ample evidence in Mexico that hazard vulnerability is tied to the country's history of land distribution and inequality in resource access (e.g., Liverman 1990), a closer look at households' changing livelihoods and engagement with their resource base in the Lerma Valley provides grounds for a different interpretation. We present an analysis of flooding in two rural communities to illustrate that perception of risk can change as the threat of flooding to livelihood stability diminishes, thus opening new avenues for policy. In the next section we describe a new approach to flood-risk management that builds on opportunities afforded by land use and existing ecosystems. This approach—often called "living with floods" or "making space for water"—could become a viable option in central Mexico.

Agriculture and "living with floods"

Internationally, the growing acknowledgement that flood management must change has led to the exploration of a new approach: "living with floods" (Brouwer et al. 2006; Johnson et al. 2007; Klijn et al. 2004). Living with floods posits the idea that flooding may well be inevitable and that both structural and non-structural measures aiming to control the physical hazards often result in *increasing* losses by inhibiting the function of ecological buffers and altering the dynamics of hydrological regimes. Infrastructure designed to reduce hydrological variability in the short-term often tends to increase disturbances of greater magnitude in the long-term (Brouwer et al. 2006; Huang 2005). The intention of "living with floods" is to achieve a more resilient relationship between society and flood risk by valuing equally the ecological, social, and economic components of a system exposed to flooding (Johnson et al. 2007). Implementing this approach can involve reconstituting wetlands and marshes, engineering for flexible embankments and flood barriers to allow seasonal flooding, and creating reservoirs to absorb excess water.

The approach implies a profound transformation of land use. The Netherlands, for example, is experimenting with using new social, ecological, and economic criteria to help identify land that would be flooded more frequently than other areas in order to achieve greater overall hydro-ecological stability in flood-prone regions. Nevertheless, the Dutch government faces a significant challenge in

balancing economic and ecological costs and benefits, and in orienting economic activities and land uses to a new regime of higher exposure to flood waters (Klijn et al. 2004). In the UK, similar efforts have also run into problems in equitably balancing economic, social, and environmental interests and costs (Johnson et al. 2007). Economic goals tend to be prioritized over ecological and social objectives, undermining the transformative intention of "living with floods." There is increasing recognition that new forms of water governance are needed that privilege the participation of diverse stakeholder groups in the implementation of policy (Pahl-Wostl 2006).

In regions where investments in flood control are not yet significant, and where policies for environmental protection are under development, there may be more opportunities to implement a "living with floods" approach. Van Ogtrop et al. (2005), for example, argue that in rural Mozambique, the population's prior experience with flood hazards might make such an approach viable under specific conditions: the public's active engagement with the process of risk management, the availability of a reliable and accessible early warning service, the implementation of innovations in residential architecture, and the creation of safe havens from floodwaters to minimize losses associated with increased exposure to flooding. In most cases, such an approach implies a need for a deeper understanding of what flood losses mean to particular populations through participatory planning (Johnson et al. 2007). It also requires greater attention to how disaster policy can build on the wealth of experience and capacity for learning within local communities (Pahl-Wostl 2006).

In Mexico rural communities have historically manipulated flood events in a variety of settings to improve agricultural potential, provide habitat for useful flora and fauna, and expand cultivable land. These benefits are what have made river valleys such as the Lerma in central western Mexico one of the more agriculturally productive regions in the country. The meaning of flooding to farmers has changed over time as the material value of agriculture and infrastructure in the Lerma Valley has also changed. During the colonial period, draining wetlands was a priority for ranchers and *hacienda* owners eager to participate in the growing colonial economy. As the value of agriculture has declined in central Mexico, protecting harvests from flooding may not necessarily be a priority for rural landowners.

Today one of the more important drivers of the observed increases in flood losses worldwide is the conversion of agricultural land into urban use and the encroachment of dense human settlement onto drained marshes, floodplains, and coastal lowlands (Montz 2000). The threshold that distinguishes a flood as resource from a hazard maybe somewhat flexible in an agricultural context, dependent not only on the value of land use but also individual experience, risk tolerance, and preferences for environmental amenities such as wetlands (Rashed Chowdhury 2003). This threshold is likely to be significantly less flexible once land use is predominantly urban and flood losses threaten the built environment and infrastructure. In the Lerma Valley, the current process of urbanization of both agricultural land and rural livelihoods will have significant implications for flood management in the future.

In the sections that follow, we describe how floods as *hazards* have been, in essence, created through recent public interventions in the rural sector that assume a low level of tolerance for flooding and that have not accounted for the changing values and meanings of agricultural production to farm households. We use two case studies of the agricultural communities (*ejidos*)[2] of Emilio Portes Gil (EPG) and San Bartolo de Llano (SBL) in the state of Mexico to illustrate the disconnect between local experiences and perception of risk and the public interventions in flood management (see Table 1 for summary statistics). A flood occurred in these communities in September of 2003, affecting 373 ha and 506 ha of maize in each community, respectively. Drawing from interviews and survey data collected in between 2003 and 2005, we present farmers' perceptions of flood risk in the context of rapidly changing socioeconomic conditions in which the value of maize, the primary crop in the area, has declined, rural land is undergoing fragmented urbanization, and increasingly the livelihood activities of farm households take place outside the space of rural residence. Simultaneously and paradoxically, after years of inattention, rural flood events are now being defined by the public sector as "agricultural hazards."

Mustafa coins the term "hazardscape" to reflect the idea that the experience of hazard is a hybrid concept, incorporating both the very real experience of material losses and deprivation as well as the context in which those losses are experienced, interpreted, and reproduced through risk management (Mustafa 2005). In a similar vein, we argue that whether the public sector intervenes to compensate farmers for losses where compensation is not expected, or moves to protect land from flooding that was previously farmed with the expectation of flooding, the outcome is similar: The state collaborates in both the material and imaginary creation of

[2] The Agrarian Reform constituted a period of land distribution following the Mexican Revolution of 1910–1917. It had its peak in the 1930s but continued until 1992. Over this period 51.4% of the national territory was distributed to smallholder farmers in agrarian communities called ejidos and *comunidades agrarias.* Most of the land now farmed in ejidos is done on an individual basis. A reform to the constitution in 1992 was followed by a land regulation program "PROCEDE" that registered both individual ejido titles as well as land that had been fragmented and informally assigned to others in the decades following the original land distribution program. This titling process led to the formalization of plot fragmentation and also the official recognition of landholders in the ejidos.

Table 1 Characteristics of Emilio Portes Gil and San Bartolo del Llano

Household characteristics	Emilio Portes Gil	San Bartolo del Llano
Average age of household head[a]	48 years	52 years
Illiteracy, percent of adult population (2005)	14	15
Average household size (2005)	4.7	5.1
Households with television, percent (2005)	92	83
Average education level, years (2005)	7.5	6.1
Female headed households, percent (2005)	24	19

[a] Interviews by the authors, 2003. All other data is from the national survey, *Conteo de Población y Vivienda 2005*, INEGI (2006), Aguascalientes

"hazard" and in doing so encourages new expectations of state intervention and patronage. Perhaps more worrying is the precedent that such a policy sets: unless there are counter measures in place, the riparian land now protected from flooding will easily convert into urban land use, driven by declining investment in land for agricultural production. With lives, material property, and infrastructure at stake, flooding then becomes an urgent political and social concern. In this context, "living with floods" is rarely an option.

Methods

The two case studies presented below involved the collection of qualitative data from semi-structured interviews conducted in July and August of 2004 with rural residents affected by floods, as well as from in-depth interviews with public officials at the municipal, state, and federal level associated with civil protection, agricultural policy, and water management. The household-level interviews were the result of a random sample of 20 households in Emilio Portes Gil and 28 households in San Bartolo de Llano drawn from a list of 104 and 426 households, respectively, who reported flood effects to the state Secretary of Agriculture and Rural Development (SEDAGRO) in 2003.[3] The goal of these semi-structured interviews was to explore the range of households' perceptions of loss in relation to changing livelihood strategies and the influence of public policy in the communities. Farmers were asked to describe what they perceived as a flood, to discuss the frequency of flooding in the community, and to describe the impact of the 2003 flood on their property, crops, consumption, livestock, and livelihoods. They were also requested to explain their own response to their losses as well as their observation of the response of the local, municipal, and state governments. The additional key-informant interviews with local leadership and public officials captured policy and sectoral perspectives on the cause and solution to the problem of flooding.

The Lerma River Valley

In the state of Mexico, the Upper Lerma watershed incorporates 5,548,540 km^2 (Fig. 1). Prior to the expansion of colonial settlement in the region in the early 1500s, the Lerma River consisted of a series of connected lagoons and wetlands that covered much of what is now the river's valley. At the start of its trajectory the river crosses one of Mexico's most densely populated regions, the metropolitan area of Toluca, with negative implications for the quality and quantity of water downstream (del Mazo González et al. 2001). Within the state of Mexico, the Lerma is fed by ten primary tributaries, including the Jaltepec River in the *municipio*[4] of San Felipe del Progreso, and the Sila River in the municipio of Ixtlahuaca, the two municipios selected for case study analysis.

Agrarian change in the Lerma Valley

Agriculture has long been a feature of the Lerma Valley's economy. The wetlands that constituted much of the upper Lerma watershed were largely drained in the late nineteenth century to promote large-scale grain production on commercial *haciendas* and to minimize flooding in the rapidly expanding urban areas of Mexico City and Toluca (Aguilar Santelises et al. 1997). Following the Agrarian

[3] As case studies, the household interviews were not intended to produce findings generalizable to the broader population of flood affected households in the Lerma Valley. Nevertheless, the similarity of characteristics of the interviewed households to the available statistics on households flooded in 2003 in the region suggests that at least in terms of age, landholding, and livelihood, the households interviewed for this study are not unrepresentative. The average age of the 48 households interviewed in the two communities was consistent with the average age of all beneficiaries of FAPRACC in the two villages (49–52 years) and representative in terms of landholding size (averaging 2 ha in EPG and 1 ha in San Bartolo). Although beneficiaries to the program FAPRACC are recorded only in terms of beneficiary age and total land area, an independent evaluation of FAPRACC in 2003 conducted by the National Autonomous University of Mexico (UNAM) found that only 34% heads of households affected by flooding in the state of Mexico claimed that agricultural activities were their only economic activity; for the majority agricultural activities represented one of two or three income sources. For all FAPRACC recipients that year in the country, agriculture constituted only 16% of household income. These statistics largely support the qualitative livelihood data reported by the farmers interviewed in the case studies.

[4] An administrative unit similar to a US county.

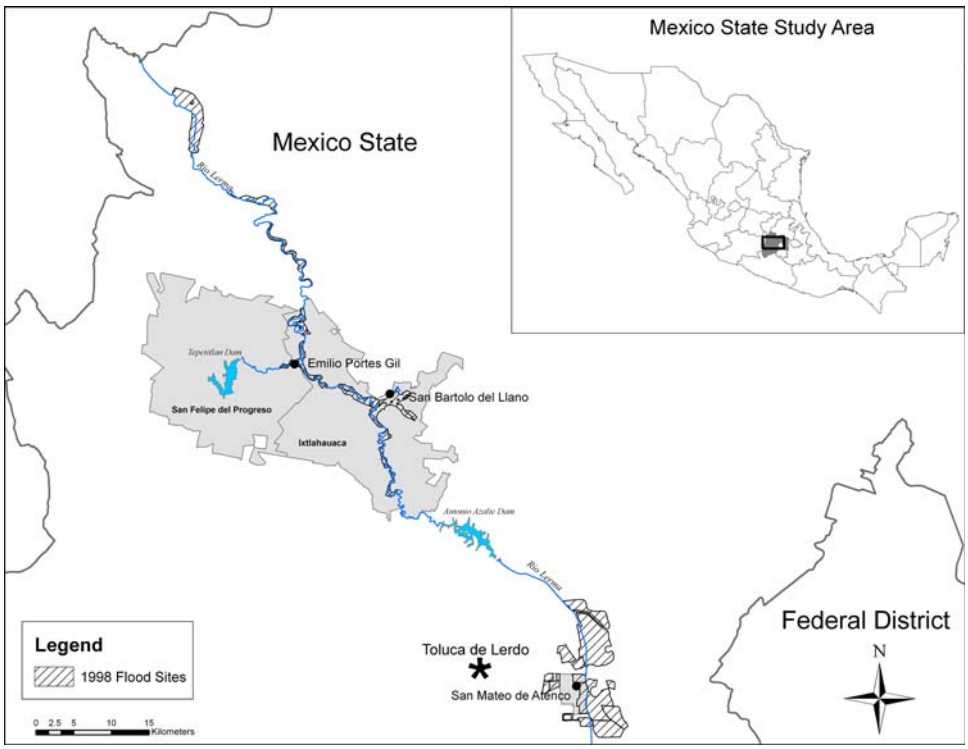

Fig. 1 Map of the Lerma Valley, State of Mexico

Reform of the 1930s (see footnote 2), the property of the large commercial haciendas in the valley was distributed to smallholder farm communities (ejidos).

In the late 1950s, an inter-basin water transfer agreement between Mexico City and the state of Mexico led to a proliferation of deep wells in the Lerma Valley and a new program of groundwater extraction and export, leading almost immediately to groundwater decline and subsidence (Esteller and Díaz-Delgado 2002). The municipio of Itxlahuaca has been one of the most negatively affected by the groundwater extraction. From the late sixties on, the Lerma Valley was targeted as a region to supply the burgeoning population of Mexico City with cheap corn. With the help of public investment in irrigation infrastructure, support for credit, and public subsidies for maize and purchased inputs, *ejidatarios* in the area became leading producers of maize as a cash crop. Both Ixtlahuaca and San Felipe del Progreso became centers of maize production.

Since the late 1980s, the situation has radically changed for farmers in the region. State price guarantees for agricultural products were withdrawn in the early 1990s, and with the growing volume of imports of maize under the North American Free Trade Agreement, the market for domestic maize produced by ejidatarios has all but disappeared. Without incentives to grow a marketable surplus, maize has again become a subsistence crop.[5] In many of the valley's rural municipios—including Ixtlahuaca and San Felipe—the population deriving its livelihood from agriculture is now half of what it was in the early 1990s (INEGI 2001).

As a result of these changes, land can no longer be claimed exclusively as an agricultural resource, but rather has been revalued as an asset for building residences. For this reason, housing is more likely to appear now in areas that were originally intended for agricultural production. Any land remaining in agriculture is now less likely to generate sufficient yields to feed a family, let alone produce an agricultural surplus for commercial sale. Nevertheless, even such fragmented land ownership translates into entitlements to new public transfer payments, such as the direct per-hectare payment from the PROCAMPO[6] program and, in the case studied here, support for recuperating production after flood losses.

Flood policy in the state of Mexico

The combination of high population density and the hydrology of the valley creates a circumstance in which flooding is a frequent, if not chronic, issue for the state of

[5] The national domestic maize supply, including Mexico City, has shifted towards high yielding regions such as Sinaloa and imports from the US.

[6] PROCAMPO is a program that was instituted in late 1993, prior to the implementation of the North American Free Trade Agreement. PROCAMPO was initially designed to provide farmers economic support while they transitioned out of a maize-based mode of production into more competitive crops. It has become the primary public source of economic support for rural households with land.

Mexico. Data on flood incidence collected by the state office of Civil Protection show a significant increase in the number of flood events reported since 1994 when reporting began, rising from around 20 in 1994 and 1995 to over 40 at the end of the 10-year period. While these figures mean little in hydrological timescales, they can be significant in the time-horizon of public policy and can be sufficient to inspire public action.

When a new state governor assumed office in 1999, flood protection was declared one of the state's primary goals in water management (del Mazo González et al. 2001). Nationally, the profile of hydrometerological hazards (drought, floods, and hurricanes) had been raised by the devastation wrecked by Hurricane Pauline in Oaxaca and Guerrero in 1997 and torrential rainfall and flooding in Chiapas in 1998, and in Puebla, Tabasco, and Veracruz in 1999. Although the flooding in 1998 in the state of Mexico was not as extensive as in other states that year, it was one of the more damaging events to have occurred in the state's recent history. Interviews with officials active in the government in 1999 revealed that the new attention to flood risk in development policy was in part a function of political pressure from the industrial sector that had experienced heavy property damage as a result of the unprecedented flooding in 1998 (see Fig. 1 for the flooded area in 1998). In essence, by 1999 flooding in the state of Mexico was being defined as an "unacceptable" risk, meriting greater action on the part of the public sector.

In May of 2003 the federal government approved the new support program for farmers affected by climatic contingencies (FAPRACC). In previous years, losses in agriculture were addressed through the Interior Secretary through the National Fund for Natural Disasters (FONDEN). FAPRACC created a separate fund for addressing agricultural-sector impacts, leaving infrastructure-related and urban disasters to FONDEN. By separating agricultural losses from more general infrastructural loss, FAPRACC aims to encourage individual farmers to adapt to climatic risk. In cases of unusual and anomalous events, farmers will be given support to re-establish their production. In cases of chronic or repeated loss, FAPRACC supports projects designed to change cropping patterns and land use to diminish the probability of future impacts (SAGARPA 2003).

In theory, by encouraging adaptation to risk, FAPRACC is promoting the idea that some climatic variability is not only *acceptable* but also should be *expected*. In other words, the concept of "living with floods" is potentially entirely compatible with FAPRACC's overt intentions. Paradoxically, as is illustrated in the cases described below, in the context of increased state and national attention to flooding as a *threat* to production and to the local economy, the emergence of FAPRACC in 2003 not only served to reinforce existing channels of political patronage but also reinforces demand for existing technocratic approaches to flood control.

The flood of 2003

In September of 2003 the Lerma and its tributaries flooded after heavy rains, affecting 17 municipios and over 18,000 people (Secretaria de Agua and Comisión del Agua del Estado de México 2004). On September 25, the governor declared a state of emergency in order to request support from federal government through FONDEN and parallel support for damages to the agricultural sector through FAPRACC. The communities of Emilio Portes Gil and San Bartolo del Llano were among the affected communities. As the case studies below illustrate, the farmers' vulnerability to flooding is not necessarily a product of a long history of socioeconomic marginalization or failures in entitlements. Instead, the farmers are caught up in a policy process that has exogenously defined them as victims, and—in the case of San Bartolo—*creates* vulnerability through the public investment in flood control infrastructure.

Emilio Portes Gil

The ejido of Emilio Portes Gil (population of 3,076) is the one of the larger urban settlements in the municipio of San Felipe de Progreso. According to the municipal development plan for San Felipe, Emilio Portes Gil is one of the communities most exposed to flooding from the Lerma's tributary, the Jaltepec River, with some 170 households at risk (Presidencia Municipal de San Felipe del Progreso 2004). As illustrated in Table 2, the flooding that occurred in 2003 primarily affected the maize harvests and agricultural investments of farmers in Emilio Portes Gil and, in a few cases, family residences (Table 2). Most households resorted to extraordinary maize purchases at a price of $2.5 kilo/week for several months of 2003 (in a few cases for the whole year), unless the household had reserves from the prior year's harvest. For several households, contaminated flood waters were perceived to have affected the health of their families.

Nevertheless, flooding has always been a feature of the local landscape and the history of the community illustrates that flooding was an understood and expected process, managed through norms of communal land use. When the community was founded in the mid-1930s, two-thirds of the ejido's land (645 ha) were allocated for communal pasture (Colín López and Guadarrama Romero 2001). This land was primarily along the Jaltepec and Lerma Rivers where seasonal flooding was frequent.

The communal use of the riparian lands changed in the 1950s. As the population grew in the village, conflict erupted over land scarcity and the need to accommodate

Table 2 Impacts of the 2003 flood among interviewed households

Impact	Emilio Portes Gil $N = 20$	San Bartolo de Llano $N = 28$
	Percent of households (frequency)	
Average age of household head	48 years	52 years
Partial crop loss	55% (11)	60% (17)
Total crop loss	40% (8)	39% (11)
Property damage	15% (3)	11% (3)
Health impacts	25% (5)	18% (5)
Extraordinary maize purchases	40% (8)	77% (10)*
Average production cost/ha	$5662 pesos	$2800 pesos

* This number reflects only those households who reported purchasing maize in 2003 who normally do not purchase maize. Other households increased their normal maize purchases in 2003, beyond what their normal volumes. *Source*: interviews by the author with flood victims, 2003

the needs of the community's younger generation (Colín López and Guadarrama Romero 2001). In 1957 a presidential decree resolved the conflict, ordering the pasture land to be distributed to the landless households for cultivation. Despite the flood-prone nature of the distributed land, it became a new area for crop production in the 1960s.

With this new land distribution, flooding shifted from being part of the local hydrology, affecting communal lands, to a private concern—and an "accepted risk"—for those households whose need for land superseded their concern over periodic flooding. The families with land along the Jaltepec River matter-of-factly reported that their losses were "every year" and that "it is always going to flood." As one woman said, "we can't do anything about the floods. God sends the water, and anyway the river is always going to rise." Another farmer commented that "I have 15 years with my land here, always I am losing [to floods]… I've had a good harvest only once!"

With the new distribution of land, the importance of livestock in the community declined, and income was increasingly complemented by the growth of the cottage industry of household cleaning implements and through employment in the construction industry (Appendini and de Luca 2006). A survey conducted in 2003 by the Colegio de Mexico[7] found that 60% of the male household members and 69% of women were working outside the community (Appendini and de Luca 2006). As a result, the time women had to dedicate to making tortillas diminishes and, as one woman interviewed put it, "agriculture becomes a weekend activity." The flooded maize fields in 2003 were thus not necessarily a significant loss to the stability of the households' food supplies.

Perceptions of flooding have also changed with the growing presence of "*profesionistas*" in the village—salaried professionals who have chosen to reside in the rural community while working in nearby urban areas (Appendini and de Luca 2006). For these households, the flood losses in 2003 did not represent much of an economic impact because, as teacher who had lost his harvest to flood explained, "we have extra income." They said few profesionistas like them were interested in farming, given the low prices for maize and the frequent problems in yields: "No one wants to throw away their money in agriculture anymore." While many continued to plant in order to keep the land in production, their expectations of their harvests were relatively low.

Initially—in the early 1960s—the households most exposed to flooding might have been considered to be disadvantaged members of the community. They were the last to receive land, and the land they received was inherently risky. Initially, their "acceptance" of flood risk by settling along the river may well have been an indication of their lack of alternatives. Yet this interpretation of vulnerability may no longer hold. Today their income diversification means that flooding does not necessarily threaten their livelihood stability, although it may represent a rising health concern for those living near the rivers' waters.

Although the flood victims in Emilio Portes Gil had been registered to receive the benefits of the FAPRACC program, only a few of the interviewed households were clear about what benefits they had received and from what agency. The farmers expressed ambivalence about the government's interventions in flood compensation and control, declaring that the flooding was chronic phenomenon and there was little possibility that any intervention would successfully address it.

San Bartolo del Llano

San Bartolo is the third largest community in the municipio of Ixtlahuaca, with a population of 9,827 in 1,811

[7] This article draws primarily from the household-level data collected in the two communities. To enhance the historical and contextual understanding of the relationship between flooding and livelihood change, supplementary data is also drawn from this prior work, including a survey of 114 households in Emilio Portes Gil carried out in 2003. The survey was applied to a sample of households in EPG as part of a larger project, *La transformación de la ruralidad mexicana: modos de vida y respuestas locales y regionales*, coordinated by Kirsten Appendini, El Colegio de México, with funding from Conacyt. (See Appendini and De Luca 2006).

households. One of the primary concerns of the municipio is the expansion of its urban area into former agricultural lands, resulting in "highly dispersed" urban settlements and "irregular occupation of agricultural land" (Gobierno Municipal de Ixtlahuaca 2003: 22, authors' translation). Although no official records were available to confirm the pace of land conversion, authorities in San Bartolo agreed that there was an active informal land market and most of the transactions were taking place at the village boundaries, in the lands closest to the urban area of Ixtlahuaca where flooding of both the Lerma River and its tributary, the Sila River, is frequent.

In September of 2003 the walls of the Santa Catarina reservoir upstream from San Bartolo were breached after several weeks of heavy rain. The fields of San Bartolo were flooded when the reservoir's discharge exceeded the capacity of the Sila River. According to the official records, 426 households reported agricultural damages averaging 1.19 ha per household. Interviews with flood-affected households revealed that most of them—60%—suffered partial crop loss (amounting to 48.8% of their normal expected production in the affected fields) (Table 2). As in EPG, the losses also represented a loss of investment and, for a few households, property damage. Nevertheless, the event of 2003 was significant not simply because of the unusually heavy rainfall and the failure of the Santa Catarina dam. Its impact was exacerbated by changes in land use that ironically were the result of the government's efforts in flood protection.

Historically, as in EPG, flooding was part of the community's annual production cycle and norms of land use. Flooding was, essentially, an accepted part of the farmers' interaction with the wetland ecosystem. The low banks of the Sila River tended to overflow towards the end of the rainy season, creating a seasonal wetland in the ejido. Interviews with elderly residents of the community revealed that farmers worked around this annual phenomenon, using the residual moisture the flooding left in the soils to plant winter wheat when the waters retreated. The local diet had even accommodated this production pattern: the women made their tortillas from an unusual combination of wheat and corn, taking advantage of the winter crop for subsistence.

Two interventions in the local hydrology changed the farmers' relationship with the Sila River, setting a new path of development that led to the recent creation of floods as agricultural "hazards." First, in 1966 the community agreed to the perforation of wells in its lands as part of the export of water to Mexico City. The farmers noted an immediate change in the humidity of their soils, and within three years they had abandoned the practice of planting winter wheat because of lack of moisture. The second significant intervention in the local hydrology was the decision of the state government in 1999 to straighten and dredge the segment of the Sila River as part of its new agenda for flood control, and in the process raised the height of the river's embankments. This public works project effectively ended the seasonal flooding of the farmers' fields.

With the security offered by the new embankments, farmers in San Bartolo expanded the area they planted in summer rainfed maize to the edge of the river. While annual floods were now more unlikely, any flooding that did occur would now directly affect something of value: maize. The embankments also increased the velocity of the river's flow, channeling water with greater force to the intersection with the Lerma River. As a result, households were now faced the possibility of more infrequent but more powerful events and, with the higher embankments and natural subsidence of the soils, less possibilities for natural drainage. This was exactly what occurred in 2003, when the flood waters from the Sila River stagnated in the surrounding fields for the better part of a month. Flooding had been transformed into an *unacceptable* risk.

Ironically, the changes to the river prevented farmers from easy access to the river's waters for irrigation, which they had come to depend on as the water table declined. Prior to the straightening of the river, some farmers had practiced diverting the Sila River onto their fields through temporary make-shift dams. Local leaders in the community revealed that the farmers were now planning to petition the agriculture ministry for funds to provide a sluice and pump in order to extract the Sila's waters during the dry season onto their fields as needed. In other words, the efforts of the state to protect Ixtlahuaca's industry and urban areas from flooding had translated into both into a new agricultural opportunity and also, ironically, exacerbated hazards—flooding and drought—for San Bartolo residents.

Opportunities for "living with floods" in the Lerma Valley

Farmers in both communities have a long history of living with the dynamic nature of the Lerma River and its tributaries. This history does not provide evidence of significant flood vulnerability but, on the contrary, evidence of adaptation to hydrological variability in a region characterized by wetlands and lagoons. When asked to explain the frequency of flooding in the area, many farmers responded that the river was seeking its natural path that had been denied through decades (if not centuries) of development. The older farmers in San Bartolo del Llano remembered watering their maize plants with clay pots from the Sila's waters, and the annual flooding of the lowlands near the

river was part of their understanding of the local ecology. In Emilio Portes Gil, archives from the original land allocation to the ejidatarios documented how the farmers planned to distribute their farming and livestock activities according to the most appropriate use of land, taking into account its topography and climate.

In Emilio Portes Gil, a declining market for maize accompanied by livelihood diversification had changed the relationship of farmers to their land and their perceptions of flood risk. The experience of farmers in the 2003 flood illustrates that the material impacts of the flood were not necessarily significant to the overall livelihood security of the affected residents. In San Bartolo, floods as *hazards* had only emerged following the government's implementation of flood control measures in 1999. Prior to that year, farmers had little expectation of achieving viable summer harvests in the flood plain of the Sila River and instead had adapted their production cycle to the river's seasonal variability.

Rather than encouraging engagement with flooding as an inherent property of the social and ecological geography of the Lerma Valley, current public policy presents floods as private hazards to be partially compensated individually through FAPRACC and also as an "unacceptable risk" and thus a public responsibility. The policy does not recognize farmers' historic and continued engagement with and acceptance of flood risk, or the ecological value of wetlands and periodic flooding. In essence, the intervention of the state government in flood control and its program to compensate farmers for their losses has *created* floods as hazards in these communities.

It is undeniable that there is a need for the state to devote resources and attention to flood risk. The Lerma Valley is literally sinking as the water table declines—in some places by more than 1 m/yr (Esteller and Díaz-Delgado 2002). The rate of subsidence in a region once characterized by extended wetlands and lagoons implies serious problems for water management and flood control, particularly in relation to rapid and largely unregulated urbanization. The encroachment of urban settlement in former lagoons and river causeways has reduced the flexibility of water management in the valley, leaving engineers with little alternative but to follow flooding with dredging, embankments, bridges and sluices. Yet the valley is also in a period of transition, and outside the major urban areas land use is still largely agricultural. Interviews with local authorities as well as field observation suggests that the trend of conversion of agricultural land into rural housing plots is quite real, fueled by declining agricultural prices and rising remittances.

Compared to urban land use, agriculture is relatively flexible in face of flooding. The threshold that differentiates accepted from acceptable risk to farm communities is likely to be far more negotiable than in relation to residential and industrial uses. This is not to say that flooding does not represent a material loss to households. Domestically produced maize is still preferred for consumption purposes despite dramatic livelihood changes in villages, and rural Mexicans continue to invest important financial resources in farming. It appears, however, that agriculture is increasingly not central to livelihood security.

In this context, riparian agricultural land has value not so much in a protected, non-flooded state but rather as part of a flexible social and ecological system in which water occasionally leaves the rivers' banks and converts fields into temporary or seasonal wetlands. In an area where farmers now more frequently suffer from a lack of soil moisture, salinization, and erosion, enhancing the organic matter and humidity of soils through periodic flooding may well provide a local ecological service. Creating "space for flooding" thus can also represent an opportunity for continued agricultural productivity to the benefit of local food security—although farmers would have to accept the occasional crop loss or, as San Bartolo's farmers had done in the past, work around the seasonality of river flows. Perhaps more important, periodic flooding could prevent the conversion of farmland into dispersed residential properties, for which flood risk becomes a serious threat to material goods, livelihoods, and welfare.

It is apparent from the cases presented here that until relatively recently, these ecological and social values were intrinsic to the relationship farmers had with the seasonal variability of the Sila and Jaltepec Rivers. The challenge for policy is to design a risk-management strategy that builds on this relationship rather than recasts it in terms of threat, loss, and compensation. The state of Mexico is now in a position to incorporate such values into a policy that frames flooding as part of the social ecology of the Lerma Valley region. It is the accumulation of impacts across the valley and the political and economic pressures associated with impacts in urban zones (but now potentially in rural areas as well) that pose a significant social problem. Rather than defining hazards as individual crises, the state has an opportunity to work with farmers to select areas in which flooding will provide an ecological service, managed by landowners. Risk maps and land use zoning now exist as part of municipal planning documents, and with the development of the state *Flood Atlas*, the frequency and location of flooding can be monitored and better predicted. With the active participation of local residents, areas susceptible to flooding can be reclassified into more flexible categories reflecting appropriate land use and the livelihood and ecological value of the land to local residents. Farmers would not be compensated for any agricultural losses from flooding, but would be able to claim support for

their annual contribution to sustainable water and land management.

The concept of ecological services is not without challenges, as other geographers have recognized (Liverman 2004). Experimental programs providing payments to rural households for maintaining land cover in forest and for watershed conservation have already been initiated in some regions of Mexico (Contreras Marmolejo 2008). While the lessons from those programs should be fully investigated, particularly in relation to participation, equity, and fairness in the distribution of benefits (Liverman 2004), there may well be opportunities for extending these programs to floodplain management.

In the Lerma Valley for such a program to work, not only would there be a need for far greater participation in flood management and land use planning, but the state and federal authorities would need to commit to improving quality of the Lerma River water—now one of the most contaminated rivers in Mexico—to control for the health impacts of occasional flooding. Explicitly valuing riparian areas for ecological services also runs the risk of further embedding the patronizing relationship between farmers and the government in Mexico, if farmers perceive the support as a welfare or production subsidy rather than a payment for a valued service.

These caveats aside, it is evident that more explicit attention to the subjective dimensions of risk and the different meanings of loss may provide new opportunities for improved flood management. Perceptions and meaning associated with floods—ultimately, the "acceptability" of flooding—are intimately tied to the livelihood activities of the exposed population. The combination of agricultural policy and market change, livelihood diversification, and public interventions in the region's hydrology substantially altered the relationship of farmers to their land. Nevertheless, the two case studies illustrate that the households have substantially adapted to these political-economic stressors in their livelihood strategies. By ignoring these changes, the government's infrastructural interventions in the area assume a low tolerance for loss in rural areas, and thus set a new precedent of floods as rural disasters, rather than opportunities for improved social-ecological sustainability.

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