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Water, Cities and Peri-urban Communities: Geographies of Power in the Context of Drought in Northwest Mexico

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ABSTRACT: The urban-peri-urban interaction is frequently studied with a focus on the necessities of urban expansion, chronicling the concerns of land annexation, housing construction and infrastructure. However, in arid regions such as Mexico's drought-prone northwest, the research on peri-urban issues must increasingly focus on the under-examined issue of the power geometries that are reshaping the contours of access to water in fast-growing areas.

This paper examines geographies of power of the urban-rural interface in Sonora, Mexico. Focused in the political ecology framework, we compare the success of Hermosillo's water supply projects while analysing some cases of peri-urban water users and grouping them into three general types: negotiation, passiveness and resistance, with large powerful water users, referred to in this paper as 'counterpoint cases'.

We argue that urban water augmentation strategies reveal a distinct set of urban-peri-urban relations of unequal social power where peri-urban water resources are transferred to urban areas; reflecting, over the last three decades (1981-2010), the demands of powerful, politically connected urban populations and large irrigation districts. While during the same period, peri-urban small-scale communal farmers or *ejidatarios* lost access to their water as it was moved or used to supply the needs of Hermosillo's expansion.

KEYWORDS: Water, geography, power, peri-urban, ejidos, Mexico

INTRODUCTION

While the urban-peri-urban nexus has been examined in the context of land (Lavadenz and Deininger, 2001; McGregor et al., 2006; Tacoli, 2006), limited studies analyse the implications of growing urban water demand on peri-urban areas. Undoubtedly, the change in land use, i.e. from agricultural to urban use, is one of the most important impacts of urban expansion; however, water transfers from the peri-urban fringe are critical as well, especially in arid and semiarid regions, because many peri-urban income activities depend on the availability of water (Wilder and Romero, 2006; Allen et al., 2006).

Although the analysis of how peri-urban livelihoods are affected by water transfers is quite important (Díaz-Caravantes, 2012), it is also critical to examine how access for urban water resources has been carried out in fast-growing and semi-arid regions in northwest Mexico. To answer this question, this paper examines the period 1981-2010 and draws on research conducted in 16 communal farms or *ejidos* in a peri-urban region outside the city of Hermosillo, the state capital of Sonora, Mexico.

Ejidos are communal farms created during the land reform programme resulting from the Mexican Revolution (1910-20) in which landless peasants demanded land from the government. Through the past three decades, ejidos in Mexico have faced a barrage of neoliberal transformations to land tenure,

water policy, agricultural supports, and trade arrangements (De Janvry et al., 1997; Banister, 2007; Wilder et al., 2010).

As shown in this paper, most of the projects to provide water to the city of Hermosillo during the 1981-2010 period were implemented in the peri-urban area. This disproportionate emphasis on the peri-urban area is not based only on technical or physical conditions, but also on power relations. In order to demonstrate this point, we contrast the urban water augmentation proposals in the peri-urban ejidos and in large powerful water users, referred to in this paper as 'counterpoint cases'. This examination reveals a distinct set of urban-peri-urban relations of unequal social power where peri-urban water resources are transferred to an urban area, reflecting the demands of politically connected urban populations and large-scale irrigation districts[1] over marginalized rural producers.

In the first section of this paper we examine the relevant literature to this study; we state that political ecology is an adequate framework to address this topic. Then, we describe the study area: first the city of Hermosillo and secondly the peri-urban ejidos as the main focus of this paper. In the section titled *Empirical case study findings*, we present the key turning points of the recent history of Hermosillo's water scarcity; in this part we also show the peri-urban ejido cases (Reshape and negotiate, Passiveness, and Resistance) and the 'counterpoint cases'. We finalise this paper with the *Discussion* and *Conclusion* sections in which we present our main arguments.

LITERATURE REVIEW

Peri-urban regions resist an easy definition (Brook and Davila, 2000; McGregor et al., 2006; Tacoli, 2006), but following the sense of the prefix *peri*, it can be first defined as the immediate zone that surrounds a city's existing boundaries. However, this territorial definition does not satisfy many scholars because according to them, the peri-urban is best understood as a series of flows or processes or an interface of goods and services between the rural and urban areas (Allen, 2003; Brook et al., 2003; Narain and Nischal, 2007). Each peri-urban area has properties unique to its context, and may manifest urban, rural characteristics or a mix of both. The peri-urban area can be seen as a kind of transition zone with more urban characteristics in the area closest to the city's boundary and a more rural character at its farthest edge. Alternatively, peri-urban areas may have patches of both urban and rural spots throughout the peri-urban zone's landscape, or in some cases, there may be a sharp edge to the urban boundary that marks a clear demarcation with an essentially rural area beyond the boundary. The peri-urban transition zone between urban and rural areas defies a universal definition and is context-specific. A peri-urban region can be best understood as an area of transition along an "urban-rural gradient" (McGregor et al., 2006).

From an environmental perspective, the peri-urban interface can be characterised as a natural ecosystem affected by the material and energy flows demanded by both the urban and rural (Brook and Dávila, 2000; Allen, 2003; McGregor et al., 2006). Allen (2003) identifies three processes of environmental change in the peri-urban interface. The first is the change of land use, such as the one from agricultural uses to residential or industrial uses. Another is the change in the use of natural resources, such as forests and water. Finally, there is a change in waste generation, with an increasing amount of solid and liquid waste in peri-urban areas.

Most existing research has chronicled the peri-urban to urban transfer of natural resources in terms of land annexation (Brook and Davila, 2000; Lavadenz and Deininger, 2001; McGregor et al., 2006;

[1] In Mexico, the irrigation district consists of one or more previously defined surfaces and within the perimeter of the irrigation area, which has hydraulic infrastructure such as storage vessels, direct referrals, pumping stations, wells, canals and roads, and others. Basically, the irrigation district is managed by the water users. These districts may include ejidos, private owners or indigenous communities.

Tacoli, 2006). Lavandez and Deininger (2001: 18) found that urban expansion of Mexico's 110 major cities "represents one of the greatest challenges for the agrarian sector during the coming decades". It is forecast that these major urban centres will require 700,000 new housing units each year, and that over two-thirds of the land required for this expansion will come from the ejido sector – specifically, from peri-urban ejidos located at the edges of cities (Lavadenz and Deininger, 2001).

Allen et al. (2006) analysed the link between peri-urban livelihoods and the water supply and sanitation services in the peri-urban areas around Mexico City. They argued that water use for economic livelihoods in peri-urban areas is quite important because many income activities depend on the availability of water. Specifically about in Hermosillo's case, Scott and Pineda (2011) state that Hermosillo is the biggest city of Mexico without wastewater treatment. These authors established that given the negative connotations of wastewater and the direct implications of having poor water quality for agriculture, private farmers avoid cultivating with wastewater and only the peri-urban ejidatarios of La Manga, La Yesca and Villa de Seris use this type of water; however, they are limited in their choice of crops due to the possible implications on human health and land degradation by using wastewater (Scott and Pineda, 2011).

According to Wilder (2009), in keeping with neoliberal reforms, dramatic revisions to the nation's water policy in a new National Water Law were introduced in 1992. She argues that the 1992 water policy shift in Mexico was marked by a free market agenda and driven by the government's inability to fix a broken water system during the late 1980s (Wilder, 2009). The new policies derived from a context of global water reform prescribed by the World Bank and other international financial institutions for developing countries around the world, with the World Bank and the Inter-American Development Bank providing close to 50% of the total projected costs of the water reform programme in irrigation districts (Wilder and Whiteford, 2006). From the outset the water policy reform has been aligned with free market and privatization agendas and also linked to decentralisation and sustainability. In this context the National Water Law (NWL) was enacted in 1992, directed by the National Water Commission (Comisión Nacional del Agua, CONAGUA).

Some issues and modifications of the NWL of 1992 address water markets. One of these is that users are now free to trade their rights within irrigation districts or aquifers with no intervention from the CONAGUA (Garduño, 2005: 104). Regarding water governance in cities, the NWL of 1992 and 2004 allows the privatisation and decentralised management of urban water systems (Pineda, 1999; Wilder and Romero, 2006). According to Wilder and Romero (2006), cities increasingly acquire water rights as a way to expand urban supply. As an example, they indicate that Mexico City already relies on imported water to meet 30% of its local demand. Examining the case of several Baja California cities, although water management was decentralised, they still experience water scarcity due to overexploitation of local aquifers affected by competition from commercial agriculture (Wilder and Romero, 2006); although the state's innovative management scheme led to real efficiency gains and expansion of water services, it did not deal with broader issues such as rural-urban competition for the resource. In addition, they argued that although water markets could, from a social development and equity perspective, be a brilliant solution for some people, they present problems because market prices for land rentals and water transfers fail to compensate for the long-term loss of livelihoods (Wilder and Romero, 2006: 1990).

In places where water is fully appropriated, transfers between users or sectors are a typical mechanism used to redistribute the resources; according to Komakech et al. (2012) the process of water transfers from agricultural areas to cities takes many forms such as temporary transfers; permanent but gradual transfers; and permanent and absolute transfers.

In order to understand the peri-urban-urban water transfers, in our study case, the power relations of water users are critical. This topic can be addressed under the framework of political ecology, which has become firmly established as a dominant field of human-environmental research in geography. One

of the most significant contributions to human-environment research is that political ecology provides, in contrast to the more positivist human-environment approaches, theoretical tools to address the larger political and economic factors that contribute to environmental change (Robbins, 2004; Walker, 2005). Specifically, Blaikie and Brookfield's (1987) work gave to the human-environment approaches a 'chain of explanation' from the perspective of a broadly defined political economy. Two key notions especially have a great influence on the development of political ecology: (1) that social and cultural systems are based on historical material conditions and relations, and (2) that capitalist production requires the extraction of surpluses from labour to nature (Robbins, 2004: 46).

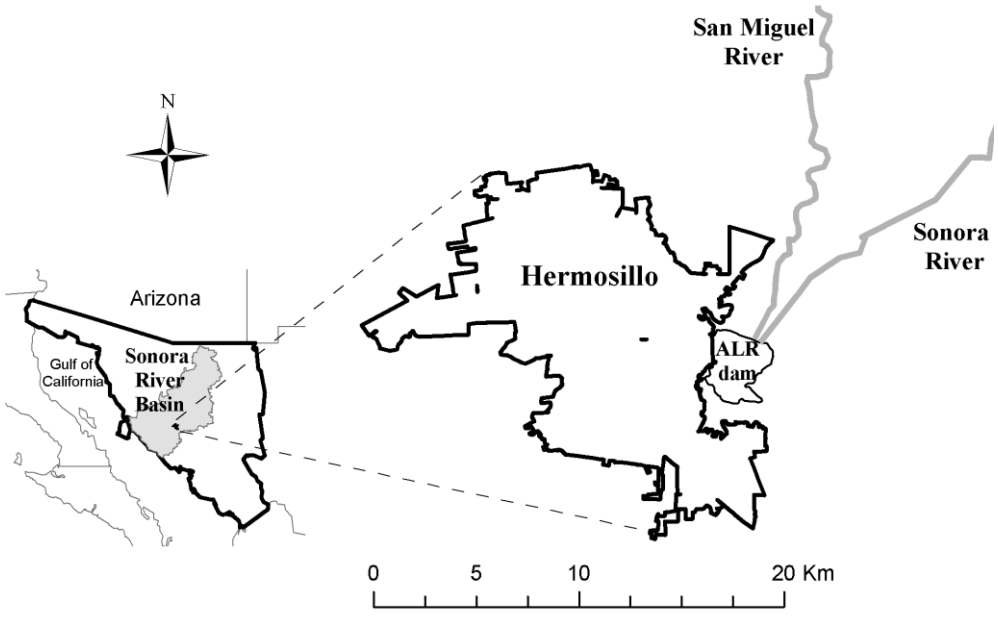
In recent years, political ecology has increasingly focused on water issues. Political ecologists utilise water as an analytical lens through which to examine relations of power, shifting access to resources through processes of economic restructuring and political transformation, and the complex interplay of multi-scaled forces (such as markets and government/civil society institutions) in different contexts. In particular, some scholars have highlighted how water should not be abstracted from the social ends and power relations that give it meaning (Bakker, 2003; Budds, 2008). For these scholars, the flows and circulation patterns of water through cities are at the same time reflective of the flows of power and the circulation of capital. The physical water networks, in turn, reflect policy choices that result from the governance of water.

STUDY AREA AND RESEARCH METHODS

Hermosillo

With a total population of about 715,000 inhabitants in 2010, the city of Hermosillo is the vibrant centre of the north-western state of Sonora, Mexico, which shares its northern border with the United States (see Figure 1). In Mexico, there were 36 cities with more than 500,000 inhabitants in 2010, similar to Hermosillo (INEGI, 2010); 20 are located in states with a strong pressure on water resources (CONAGUA, 2007). Hermosillo's case illustrates a broader phenomenon occurring in developing countries where rapid population growth is taking place in arid regions.

Figure 1. Study area.



Northwest Mexico is a highly vulnerable region that has grappled with water scarcity, due to rapid population growth, industrial development, and agricultural intensification over the last 30 years, and particularly due to climate-related factors (Liverman and Merideth, 2002; Ray et al., 2007). A semiarid region with low annual precipitation levels averaging only 450 mm, according to CONAGUA, the northwest is the country's most drought-prone region (CONAGUA, 2007). The most recent 15-year drought caused huge economic losses in the ranching and agriculture sectors, and caused some cities to ration water for the first time. Sonora is the most highly irrigated state in Mexico, with seven major irrigation districts located primarily along its western coast. Its coastal aquifers are among the most severely overdrafted in the country and saline intrusion is a significant problem (CONAGUA, 2007). Due to its location on the Gulf of California Coast, Sonora is highly vulnerable to intraseasonal, interannual and interdecadal climate variability that contributes to extreme climate events, including both floods and drought (Magaña and Conde, 2000; Hallack-Alegria and Watkins, 2007). In addition to climate variability, climate change is projected to increase temperatures and create drier conditions over the next 25 to 50 years, leading to reduced water supply and severe and prolonged droughts (Seager et al., 2007). Climate change will exacerbate existing problems of increased water demand from growing cities and intensified agriculture, competition amongst water using sectors, and the decline of water quality (Magaña and Conde, 2000).

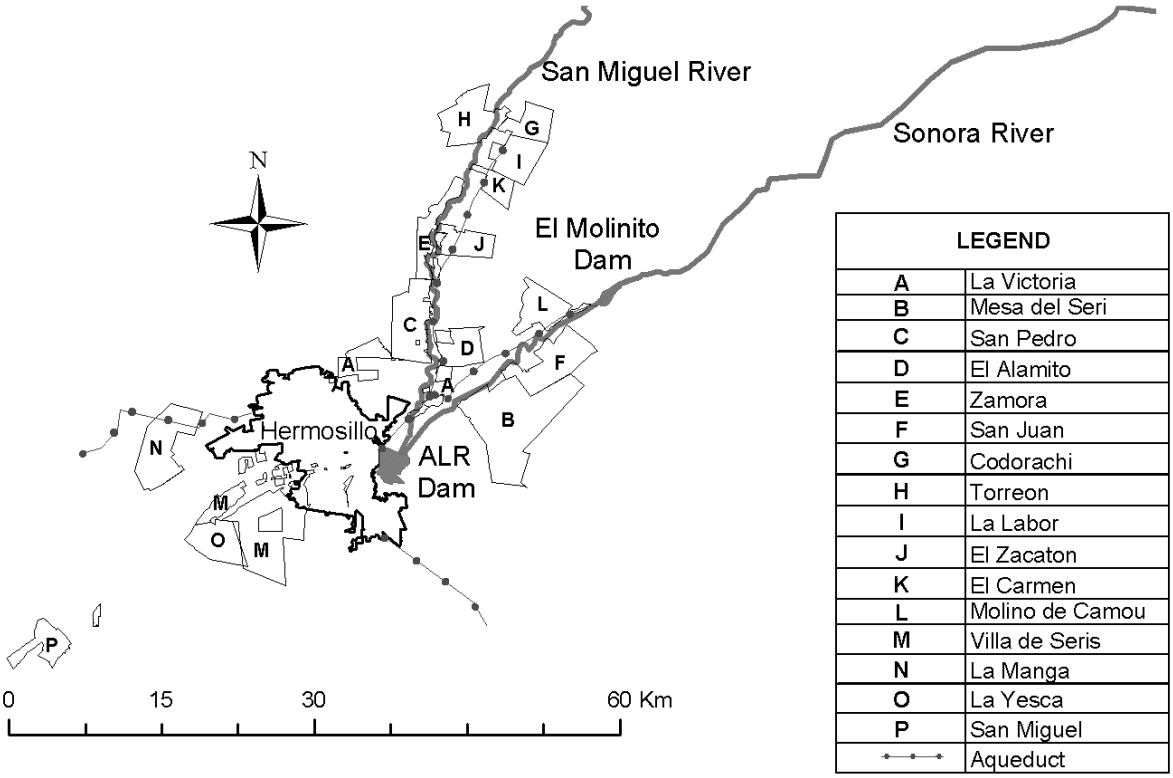
Peri-urban ejidos of Hermosillo

Ejido communities are the most marginalised and impoverished in Mexico; however, by 1980, half of Mexico's cultivated land was in ejidos. During the 71 years of one-party governance by the PRI (Institutional Revolutionary Party), ejidos and campesinos were an important part of the clientelistic structure and were able to negotiate resources in exchange for political support and loyalty. Since Mexico began its neoliberal economic reforms in the late 1980s, ejidos have experienced an economic squeeze based on trade liberalisation, loss of subsidies, and scaling back of state credit and support (De Janvry et al., 1997; Whiteford and Melville, 2002; Wilder and Romero, 2006).

Particularly, this research is focused on the 16 peri-urban ejidos (Figure 2) for several reasons: First of all, ejidos are the most prominent representative of the rural sector in Mexico because they represent half of the cultivable land in Mexico and are the most visible social sector of the rural population; in other words, one cannot talk about Mexican rural society without talking about ejidos. Secondly, ejidos are constituted by many producers and their families; by examining the effects on ejidos, the social impact of urban water supply strategies on the largest number of the most affected rural people is more readily understood. Third, Hermosillo's water supply augmentation strategies have had severe impacts on ejidos' access to water, more so than on any other of the study regions (Figure 3). Lastly, private landowners located inside the peri-urban area have individual land tenure and their landholdings, as a group, are more fragmented than the communal ejido lands. Thus, it would be a complicated research effort to collect information of each private landowner, while ejidos are groups of people.

The ejidos in our study can be divided by location: from A to L, in Figure 2, are the city's upstream peri-urban ejidos and from M to P the downstream ejidos. The downstream peri-urban ejidos belong to the Presa Abelardo L. Rodríguez (ALR) Irrigation District, which has a maximum of 13,000 irrigable ha and comprises private landowners and four ejidos: Villa de Seris, La Manga, La Yesca, and San Miguel. Currently, these users receive Hermosillo's wastewater. The upstream ejidos are not grouped in any water organisation; except for El Molino de Camou and Codorachi (L and G, respectively) that have surface water, all the ejidos use (or have used) groundwater.

Figure 2. Peri-urban Ejidos of Hermosillo.



Source*:* Registro Agrario Nacional.

The ejidos examined in this case study have around 32,000 ha with about 1,000 total ejido members, and were created in the 1930s (with the exception of San Miguel, created in 1987). The population inside the ejido´s land is about 13,000. This population include not only the ejidatarios, but also other people such as their relatives and friends, who have right for residential land use, but not for agricultural lands and grasslands. Table 1 provides the basic characteristics of these ejidos.

The principal productive activities in these ejidos are small-scale irrigated agriculture and small-scale cattle breeding. Ejidos that used to grow wheat in the fall-winter growing season and corn and beans in the spring-summer season have now turned primarily to growing grass to feed livestock. The principal destination of the calves is the US beef market. The ranching ejidos have an average of 11 head of cattle per ranching ejidatario. The farming ejidos have an average of 5 irrigable ha per ejidatario; due to urban water supply strategies that we analyse in this paper, many ejidos have lost their irrigation water and have had to abandon active production (Díaz-Caravantes, 2012). To supplement their incomes, some ejido families have off-farm sources of income from men working as day labourers on private farms in the vicinity or as skilled labourers in the city of Hermosillo (Díaz-Caravantes, 2012).

Because of its rapidly growing urban sprawl, its climate conditions, and the existence of peri-urban ejidos that depend on water resources, the city of Hermosillo and its surrounding countryside illustrate how the peri-urban zone is affected by urban water demand.

Table 1. Ejido basic information.

Reference	Ejido	Creation date	Certification of land rights			No. of ejido commu-nities	2005 population in ejido's land
			Date	No. of ejidatarios	Total surface		
A	La Victoria	1934	2000	151	1414	2	3917
B	Mesa del Seri	1932	1995	63	5582	1	939
C	San Pedro	1937	1994	106	2449	1	3141
D	El Alamito	1937	1994	123	1181	1	726
E	Zamora	1933	1994	84	1374	1	1204
F	San Juan	1937	1996	40	2283	2	504
G	Codorachi	1937	1994	32	1083	1	319
H	Torreon	1938	1995	48	2038	1	68
I	La Labor	1937	1993	30	1466	1	58
J	El Zacaton	1936	1993	24	1198	1	296
K	El Carmen	1936	1997	21	713	1	68
L	Molino de Camou	1936	1994	61	1427	1	1222
M	Villa de Seris	1937	1996	192	4627	1	210
N	La Manga	1941	1997	79	2868	1	84
O	La Yesca	1937	1994	48	1517	1	99
P	San Miguel	1987	2002	30	1194	1	27
Total				*1132*	*32414*	*18*	*12882*

Source: Registro Agrario Nacional.

Research material and methods

The research for this study was carried out during a 10-month period from June 2008 to March 2009. The study of the ejido Molino de Camou was initiated in 2000-2001 and was updated in this recent fieldwork period. Snowballing is one of the ways to approach potential informants. The method consists of using one contact to recruit another contact, who, in turn, can put the researcher in touch with someone else (Flowerdew and Martin, 2005). Because trust in the interviewer is a critical issue and, by previous experiences, we knew that we would have more trust and a better response if some informant referred us to another, we selected the snowballing method. We conducted 58 open-ended and semi-structured interviews (in Spanish by native speakers) with ejidatarios and 17 semi-structured interviews with federal, state, and local water officials, as well as academics from the region, to determine how urban water infrastructure has affected peri-urban ejidos.

After that, we conducted 82 written surveys with ejido members.[2] The survey was basically divided into six topics: agricultural diversification, livestock production, land tenure and water rights, climate risk strategies, household information, labour, and the migration of ejidatario household members. The age of the respondents ranged between 30 and 83 years: 22% of respondents were between 30 and 50 years, 35% were between 51-60 years and 43% were older than 60 years. Of the interviewees 94% were men.

[2] For a broader description of the survey process see Díaz-Caravantes (2012: 45-46).

EMPIRICAL CASE STUDY FINDINGS

In the first part of this section, we present the key turning points of the recent history of Hermosillo's water scarcity. As shown in this section, most of the projects to provide water to Hermosillo were implemented in the peri-urban area, negatively affecting the peri-urban ejidos. As we show, this disproportionate emphasis on the peri-urban area is based not only on technical or physical conditions (such as the proximity of the surrounding zone), but on power relations.

Key turning points in Hermosillo from 1981 to 2010

The economy of Hermosillo is based on the automotive manufacturing service and tourism industry. The *maquila* (foreign-owned assembly plants) industry employs 28% of the economically active population and generates 47% of Hermosillo's income.

The principal key turning points in Hermosillo occurred in 1981 and 1996 as shown in Table 2.

Table 2. Key turning points in Hermosillo from 1981 to 2010.

Year(s)	Action	Location	Cause	Impact
1981	ALR Dam converted to urban use	Outskirts of Hermosillo	Need to increase city water supply	On downstream agricultural producers
1984	Ford Motor builds new plant	Hermosillo	Stimulate economic development	Creation of 1,200 direct jobs
1996	Hermosillo's water crisis	Hermosillo	Drought	Increased pressure to locate new sources of water for city supply
1998-2005	Onset of severe drought; reservoirs at record low levels	State-wide (including Hermosillo)	Periodic droughts; climate change	Severe economic impacts, especially in ranching; agriculture; water rationing in cities
2002	Transfer of water services management from state to municipalities	State-wide (including Hermosillo)	Conflict over desalination proposal; National Water Law allows the transfer	Agua de Hermosillo municipal agency created to manage urban water provision
2006	Alleviation of drought	Hermosillo	More normal precipitation years	Water is not rationed in Hermosillo

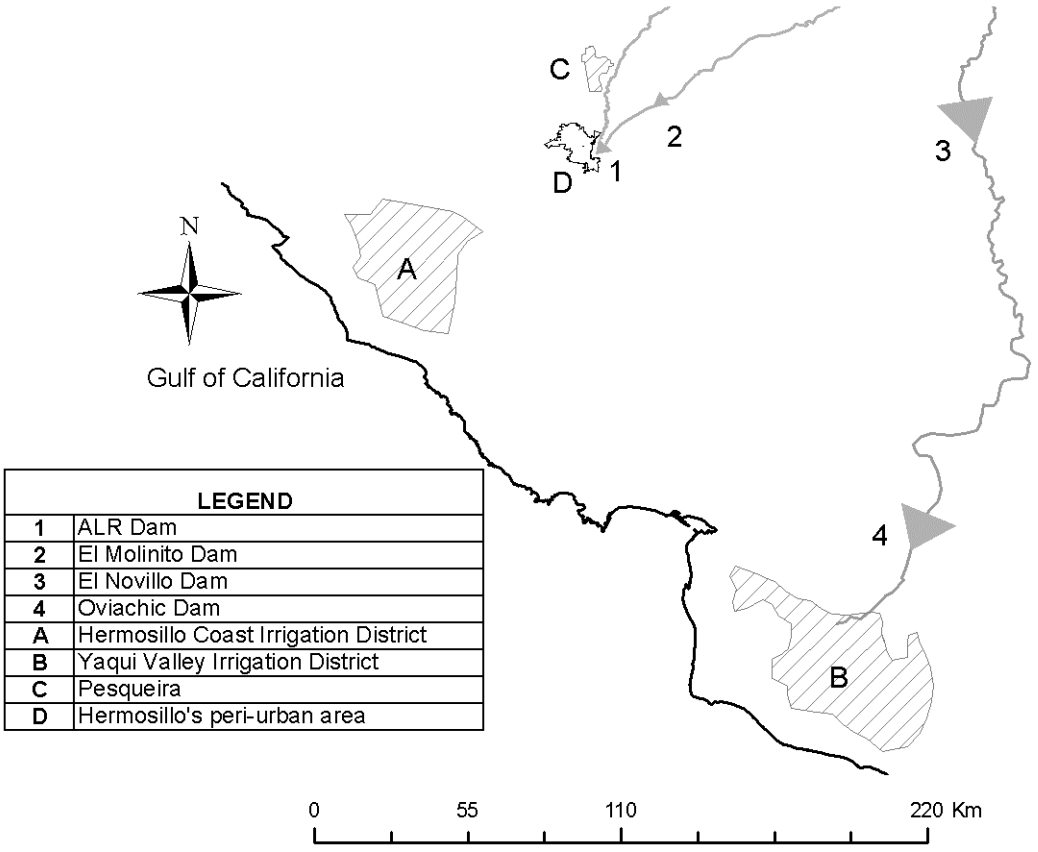
From the time the ALR Dam (see Figure 1) began operations in 1948 and until 1981, the city's water was supplied by wells located very close to the dam's outlet (del Castillo, 1994: 72) and the dam's water was used exclusively for agricultural purposes. However, in 1981 the state government reallocated the water impounded by the ALR Dam from agricultural to domestic use (del Castillo, 1994). The motivation for the change in water allocation was primarily population growth in concert with increasing industrialisation. From 1970 to 1990, Hermosillo's population increased by 130% (about 230,000 inhabitants). This demographic change is explained by Hermosillo's rapid industrialisation, especially the Ford plant which opened in 1984 with the capacity to produce 130,000 units per year and which generated 1200 direct jobs (Ramírez et al., 1997: 187). From the perspective of this study, 1981 is crucial because it began the era of water transfers from peri-urban agriculture for urban purposes.

The second turning point came in 1996. Prior to that year, the Sonora River basin (grey colour in Figure 1) had experienced more than a decade of about 45% above-average streamflows. Since the water crisis began, however, from 1996 to 2005 the Sonora River basin registered about 42% below-average streamflows and therefore the city's supplies drastically diminished.

The 1996 water crisis was the beginning of desperate efforts to provide water to Hermosillo. In some years, especially between 1998 and 2005, the city had to ration water to households by means of *tandeos* (staggered turns). According to the municipal water provider, *Agua de Hermosillo* (AguaH), with the tandeos water is provided by turns to different sectors of the city, resulting in a sector receiving water for certain hours of the day (AguaH, 2007). Although necessary, the strategy was not well accepted by the citizens, especially because some sectors of the city received water for fewer hours than the authorities had designated. AguaH attributed this to technical limitations in the water distribution network (Salazar, 2005a).

The water shortage of 1996 also triggered a competition between urban and agricultural water users. Figure 3 shows the four main agricultural regions that have been proposed as potential water suppliers: a) the Hermosillo Coast irrigation district, b) the Yaqui Valley irrigation district, c) Pesqueira, d) and the Hermosillo's peri-urban area. Figure 3 also shows the main dams on these regions: 1. ALR Dam (storage capacity = 219.5 Mm^3), 2) El Molinito Dam (storage capacity = 150 Mm^3), 3. El Novillo Dam (storage capacity = 2963 Mm^3) and 4. Oviachic Dam (storage capacity = 2989 Mm^3) (CEA, 2008).

Figure 3. Regions involved in Hermosillo water supply strategies (1981-2010).



LEGEND	
1	ALR Dam
2	El Molinito Dam
3	El Novillo Dam
4	Oviachic Dam
A	Hermosillo Coast Irrigation District
B	Yaqui Valley Irrigation District
C	Pesqueira
D	Hermosillo's peri-urban area

What has happened in and amongst these regions illustrates the power relations and differentiation embedded in urban water reallocation during the period from 1996 to 2010. This period was very remarkable in terms of the number of urban water projects. These projects were disproportionately

focused on ejidos in the peri-urban area. As shown below, the city's water transactions involving the peri-urban ejidos were either coercive or insensitive to the livelihood needs of the ejidos.

Peri-urban ejido cases

Although this research examined 16 peri-urban ejidos, for analytical purposes, we discuss in detail three categories of cases (not each individual case) which illuminate specific processes that frame the way *ejidal* water resources have been taken and with what responses from the ejidos: a) Reshape and negotiate; b) Passiveness; and c) Resistance.

Reshape and negotiate (downstream ejidos and ejido Molino de Camou)

In 1981, the state government decided to use the water of ALR Dam for domestic use (del Castillo, 1994). This water transfer affected the downstream ejidos (Figure 2: M, N, O and P), which, until that time, were the primary users of the water contained in the ALR Dam impoundment. After a couple of years of protests and negotiations, the state government agreed that, as compensation, these ejidos could use urban wastewater mixed with dam water. Yet, in 1996, all water contained by the ALR Dam was designated for Hermosillo's water supply, and since that moment these ejidos have solely used Hermosillo's untreated wastewater (Pallanez, 2002). Although using wastewater has evident health and environmental disadvantages, some ejidatarios believe the transfer helped them. Before these ejidos started to use wastewater, the availability of water depended completely on the availability of water in the ALR Dam, and the irrigated area varied drastically (Moreno, 2006). Since 1996, the availability of water has depended entirely on the city's wastewater. In this regard, some ejidatarios stated that this water transfer from freshwater to wastewater benefited them because now they have more certainty of water availability. The ejidatarios stated that now they experience water shortages only during vacation periods because most of the city's residents leave town and the wastewater significantly decreases. The untreated wastewater is also a limitation on what crops it can be used to irrigate. Ejidatarios stated in interviews that they cannot grow alfalfa and vegetables, for example, because the wastewater will 'burn' them. In sum, while wastewater has some supply advantages, it remains a variable water source and has more limited uses than freshwater.

The ejido Molino de Camou (Figure 2: L) is an additional case where a peri-urban user was able to negotiate with the city, but only after having many irreparable losses. In 1998, El Molinito Dam began to be used to supply water to Hermosillo. Since then, El Molinito Dam has been used to store water and release it through the Sonora River to recharge the aquifer Mesa del Seri-La Victoria, which is used to provide water for the city via the urban wells located in that area. The ejido most severely affected by this change was the ejido Molino de Camou because CONAGUA started to restrict the surface water for the ejido to a volume that was insufficient, even for one growing season of the 210 ha of its irrigable area (Díaz-Caravantes and Camou, 2005). This restriction caused serious economic problems, especially for the wheat producers who often lost their harvest because they had no water for the last of the six irrigations that they needed (Díaz-Caravantes and Camou, 2005); they did not receive any compensation for these losses. This restriction changed in 2008, when an aqueduct was constructed to provide 1,500 litres per second (lps) from the outlet of El Molinito Dam to the water treatment plants located close to Hermosillo (AguaH, 2007). This project was envisioned during the time of Hermosillo's water crisis in the mid-1990s. The project was completed in part because the mayor of Hermosillo in 2008 was of the same party as the governor (PRI). Ejido Molino de Camou benefited because the aqueduct, due to terrain characteristics, passes through the ejido's land, and AguaH had to negotiate with Molino de Camou. AguaH agreed that the ejido would receive water from the aqueduct. In 2007, the ejido also was able to negotiate with CONAGUA to increase its water right, from 1.4 to 2.1 Mm^3 per

year (about a 50% increase).[3] In part due to the Mexican agrarian reform of 1992, about half of the ejidatarios of Molino de Camou sold their lands to people from Hermosillo, some of them very influential in state policy, such as one new ejidatario who has been secretary of many state agencies.[4] These close political ties may also explain the ejido's success in negotiating water rights, and thus sheds light on the importance of power and social dynamics in negotiating water issues.

Passiveness (ejido La Victoria and ejido Mesa del Seri)

Due to the increase of urban water demand in the 1980s, 11 wells were established in 1986 around ejido La Victoria, located northeast of the city (Figure 2: A), very close to the ALR Dam (del Castillo, 1994). During the interviews, ejidatarios from La Victoria said that from 1986 to the mid-1990s, they had enough water from their wells. However, as we have noted, since 1996, the Sonora River basin registered below-average flows. To address the water shortage, in 1996 the state government constructed an infiltration gallery to collect subsurface flows from the river. The structure was located on the outside-edge of ejido La Victoria's agricultural land. The infiltration gallery provided around 500 litres per second (lps) for two years; yet, because of the lack of streamflows in the Sonora and San Miguel rivers, it did not operate after 1998. The infiltration gallery is now used as a part of the pumping system, but no longer for its original purpose (AguaH, 2007: 22). Ejidatarios from La Victoria state that this system was the beginning of a water shortage in their own wells. Before 1996, the ejidatarios had shallow wells that extended to about 40 feet below the surface. After the infiltration gallery was constructed, the ejido wells dried up. The ejidatarios argue that they cannot compete with the city's wells, which go to hundreds of feet below the surface and are located outside, yet adjacent to, the ejido boundaries. Evidently, the infiltration gallery in conjunction with the installation of urban wells (in 1986) and the water streamflow shortage in the rivers due to the drought concurred to adversely affect the ejido's wells.

Similarly, in order to fulfil Hermosillo's water demand, 14 wells were established in the summer of 1998 in the so-called Mesa del Seri area, located near ejido Mesa del Seri (Figure 2: B), very close to the ALR Dam. As was the case with ejido La Victoria, the ejidatarios of Mesa del Seri said that they had artesian wells and they could find the water at 40 feet below the surface. According to the farmers, the new urban wells significantly harmed their own water supply and now many agricultural parcels are dried up and abandoned.

These two ejidos exemplify a passive reaction to water transfer because they did not receive any compensation, and they did not protest against the transfer. The gradualness of the process, which is evident in the case of La Victoria, may help explain why there was no response. The location of urban wells outside ejido lands and therefore not under ejido control, also explains this passivity. The location of the urban wells and the uncertainty of groundwater dynamics complicate the empirical evidence of the water transfer. By contrast, surface water users in downstream ejidos and ejido Molino de Camou had an easier task in making their case.

Resistance (Las Malvinas case)

In 2006, for the first time, a project was implemented in which a private company supplied 250 lps of water to the city through a pipe of around 17 km from two wells located in the Las Malvinas zone in the San Miguel River watershed, situated to the north of Hermosillo (AguaH, 2007). This is the basic information that appears in a document of AguaH (2007); however, what is not reported is the conflict,

[3] The water right of 1.4 Mm^3 was verified in a document of the ejido (CONAGUA, 1991). The water right of 2.1 Mm^3 was verified through REPDA (the Mexican Public Register of Water Rights).

[4] The changes in ejido land rights were verified through the Registro Agrario Nacional (National Agrarian Registry).

resistance and protest to this project by many ejidatarios. The reason behind the protest was clear: these urban wells would take the water used by their agricultural wells. Although the principally affected ejidos were Codorachi, El Torreón, La Labor, and El Carmen (Figure 2), ejidatarios from El Zacatón and Zamora said they were adversely affected too, and for that reason, they also participated in the protest. Although they did not protest in their own case, some ejidatarios interviewed in La Victoria and Mesa del Seri said that they also participated in solidarity in this conflict because they did not want to see their own history repeated when, in the 1980s and 1990s, the city introduced wells in the aquifer of La Victoria-Mesa del Seri which dried up their agricultural wells.

The Malvinas project was announced in 2004 as the first transfer that initiated the age of "water marketing" in Hermosillo (Del Río Sánchez, 2005: 93). In 2004, the contract was signed with the water suppliers, who were owners of private land and water located very close to the aforementioned ejidos. According to the mayor, the Malvinas water would ensure Hermosillo´s water provision for the summer of 2005 and beyond. The contract between AguaH and the water suppliers established that the private company would be responsible for constructing and operating the pipe for 20 years, in which AguaH would pay to the company and, at the end of that period, the infrastructure would be transferred to AguaH. At the end of 2004 the pipe installation started, but a month later, around 200 ejidatarios stopped the work with a blockage (Montoya, 2010). The work remained stopped until in May 2005 (5 months after the taking) when state and municipal police officers displaced the ejidatarios from the works, and re-established the ejidatarios' new campground far from the construction zone (Salazar, 2005b). After this relocation, the resistance movement started to disperse. By the end of 2005, the resistance was completely dissolved (Figueroa, 2008). According to interviews in one of the affected ejidos, Codorachi (Figure 2: G), the agricultural ejido´s wells dried up when Las Malvinas infrastructure started to operate. This information was confirmed by CONAGUA officials in interviews. According to them, in an urban well which is part of the Malvinas project (La Tijera), the water table descends about 30 metres per year and because of its over-extraction the wells of the surrounding ejidos dried up. This is the case of the ejido Codorachi where the well completely dried up. The ejidatarios of Codorachi continue irrigating thanks to a source of surface water they have had since the 1930s, but their irrigated land of 120 ha was reduced to 40 ha because they no longer have groundwater.

In short, the resistance to the Las Malvinas project only slowed down the state's plan but it was not able to stop it. In this regard it was an ineffective resistance. The power differential between small ejido farmers and major urban interests was too great to be overcome.

In this section, we see that ejidos in the peri-urban area have largely been unable to resist the city's growing demand for water, and have lost access to their water resources in almost all cases. In this study, we demonstrate that the focus on the peri-urban regions as a source of water is not a hydrographical or physical coincidence, but is linked to social relations of power in the region. In an interview, a manager of AguaH stated that finding water for the city is a "big problem because wherever you look [for water] you find political opposition, particularly from large irrigation districts". To better demonstrate the importance of political power in water supply decisions in Hermosillo, we examine in the next section two counterpoint cases (regions A and B in Figure 3). These are large and influential irrigation districts that were successful in challenging and ultimately taking advantage of the water augmentation strategies advanced by the city of Hermosillo, unlike the peri-urban ejidos.

Counterpoint cases

Desalination proposal and the Hermosillo Coast Irrigation District

The Hermosillo Coast irrigation district, established in 1945, is located to the southwest of Hermosillo with its western edge near the Gulf of California. It is able to irrigate a district of 66,296 ha. This is the largest groundwater irrigation district in Sonora. It has a water concession granted by CONAGUA for around 430 Mm^3. The source of the district's water is the aquifer of the same name located in the same

area. According to CONAGUA (2007), this aquifer has been highly overexploited and is one of the many Mexican aquifers that have problems of saline intrusion. As an example of this overexploited trend, in 2008, the recharge to the aquifer per year was 250 Mm^3, but the extraction was of 430 Mm^3 (CONAGUA, 2009).

The district is principally a producer of table and industrial grapes, oranges, nuts and vegetables for exporting to the US market. The Hermosillo Coast produces about 31% of the total revenues from agriculture in irrigation districts of Sonora (CEA, 2008). In this district there are 1957 water users, including people who are very influential in the internal politics of the city of Hermosillo (Martínez, 2002; Moreno, 2006). Over 70% of the total volume of water granted in the Hermosillo Coast District is used by large private producers and just 4.2% of the volume is used by ejidatarios (Martínez, 2002).

After the 1996 Hermosillo water crisis, the state government proposed the construction of a desalination plant to supply water to the city. The project would have established a battery of wells located close to the coast. This battery of wells would have extracted water at a rate of 3400 lps, desalted the water using reverse osmosis, and transported it to the city through an aqueduct 110 km long (Moreno, 2006). The Hermosillo Coast irrigators were totally opposed to this proposal, arguing that this project would cause irreversible damage to the aquifer because it would create problems of saline intrusion. In reaction to this protest, the governor changed the project so it would pump groundwater nearer to the coastline, thereby avoiding the aquifer. The mayor of Hermosillo also opposed the desalination plant, mainly arguing that the cost of the water would be too high and the city had other options to obtain water such as an aqueduct from El Molinito Dam. Finally, in 2001, the mayor requested the transfer of the urban water administration from the state to the municipality of Hermosillo. Once urban water management was transferred to the municipality in 2002, the mayor dropped the desalination project (Pineda, 2006). The defeat of the desalination proposal demonstrates the political power of large private producers of the Hermosillo Coast irrigation district, many of whom are, or had been, elected officials in the city of Hermosillo (Moreno, 2006).

The Hermosillo Coast growers even found a way to benefit from the city's water crisis. Among the options Hermosillo's mayor proposed in 2001 was to buy water rights from the Hermosillo Coast irrigation district. This plan was implemented by the subsequent mayor. At the end of March 2006, AguaH acquired from the district 17.4 Mm^3 of water per year, at an average rate of Mex $3.26 per cubic meter to be used by the city of Hermosillo (Scott and Pineda, 2011). With these new water rights, AguaH was able to operate 15 new urban wells located inside the Costa de Hermosillo aquifer, specifically in Los Bagotes zone, which supply an average of 750 lps to the city of Hermosillo (AguaH, 2007: 23). While producers in the Hermosillo Coast district received monetary compensation for the loss of their water, the peri-urban ejidos in our study received no similar benefit.

Aqueduct from El Novillo

During the studied period, 1981-2010, a second long-term project was to supply water to Hermosillo through an aqueduct of around 150 km from El Novillo Dam (Figure 3). The El Novillo is a hydropower dam constructed in 1964 by the Mexican Power Commission (CFE). This dam, in conjunction with Oviachic Dam, is part of the Yaqui River dam system. The proposed aqueduct would have diverted water from El Novillo Dam, away from the Yaqui River irrigation district. This district is the largest surface water district in Sonora and has an irrigable surface of around 220,000 ha with nearly 20,000 producers (Wilder and Romero, 2006). The Yaqui River produces about 35.5% of the total revenues from agriculture in irrigation districts of Sonora (CEA, 2008). It was officially created in 1951, and it is the birthplace of the Green Revolution in wheat production as well as one of Mexico's most productive breadbaskets, producing about 30% of the domestic wheat supply (Wilder and Whiteford, 2006). This is a very well-organised and influential district in Sonora's politics. For example, the past state governor (2003-2009) is a prominent water user from this district. The Yaqui River, similar to the Sonora River,

has experienced below-average streamflows due to a prolonged drought from 1995 to about 2006. The reduction in water supply forced an 8-year hiatus (1999 to 2007) in cultivating most of the district's land in the spring-summer growing season. This may explain why, at the end of the 1990s, the irrigation district users rejected the aqueduct project arguing that any volume of water extracted from the Yaqui River would result in considerable damage to the development and economy of the Yaqui Valley region (Pablos, 1998: 106).

Recently, the water supply claims of large-scale irrigation districts in southern Sonora, particularly the Rio Yaqui Irrigation District, are being challenged again. In 2010, the current governor of Sonora rolled out a major water programme, Sonora Integrated System (Sonora SI), involving a transference of 75 Mm^3 of water per year via the aqueduct *Independencia* (Independence) from El Novillo Dam to Hermosillo. However, water users in the Rio Yaqui District have staged public protests and lawsuits against Sonora SI and the operation of the aqueduct is still in dispute between the government of Sonora and irrigation district users.

In addition to these major proposals, Hermosillo has also explored other augmentation strategies. In 1998, the zone called Pesqueira was proposed as another source of water for Hermosillo (Lagarda, 1998). This is located 30 km north of Hermosillo (Figure 3). Pesqueira is located in the aquifer of the Rio Zanjón, with a volume granted by CONAGUA of 90 Mm^3. This aquifer is overexploited at about 41.5% of the aquifer's capacity; as an illustration of this, in 2002 the recharge of the aquifer was around 77 Mm^3 per year, while the estimated actual use was about 109 Mm^3 (Moreno, 2006). This area primarily produces table grape by private landowners oriented to the US market. In 2006, around 2300 ha of table grape were produced. Although this project has not been carried out, it is still considered by the government as a water supply alternative.

Two additional projects have been implemented inside the city limits of Hermosillo. The first project, in 1987, consisted of about a dozen wells situated in the zone named La Sauceda, very close to the ALR dam outlet. Currently there are 18 wells in this zone that provide 500 lps (AguaH, 2007). In 2002, 27 deep wells were installed in three zones that provide 1600 lps. These are El Realito and Sur located within the dam impoundment, and Pueblitos located in northern Hermosillo (AguaH, 2007).

Table 3 summarises in chronological order the water supply strategies in Hermosillo during three decades: 1981-2010. Whereas between 1981 and 1995 just a few initiatives were proposed and implemented to augment the water supply for the city, from the onset of major drought in 1996 to 2010, 12 projects were proposed (and nine of them were implemented).

DISCUSSION

This analysis of Hermosillo's water supply augmentation strategies demonstrates how water is accessed by a politically dominant major urban area from marginalised peri-urban farming and ranching communities. In cases carefully documented in 16 peri-urban ejidos, this paper provides evidence for how the flows of water from the marginalised ejidos to the thirsty cities represent flows of power as well. In this analysis, we make the following arguments.

We provide evidence that in the aftermath of the 1996 water crisis and with the advent of a prolonged drought, AguaH increasingly sought to augment water supply from peri-urban sources; most of those efforts resulted in extremely adverse consequences for ejidos such as major reduction or even total loss of irrigation water. Subsequently, the analysis of the counterpoint cases of the desalination plant and the aqueduct from El Novillo provided evidence that powerful, politically connected irrigation districts (Hermosillo Coast and Yaqui Valley), during the studied period, were able to successfully resist attempts by the city to usurp their irrigation water for urban consumption. From 16 initiatives to increase water supply, ten were directed at, and implemented in, the peri-urban region and all of them,

except for the wells in the Willard zone, affected peri-urban ejidos. On the other hand, of the 16 initiatives, two were implemented inside the city and four were proposed in the counterpoint cases, of

Table 3. Water supply strategies in Hermosillo from 1981 to 2010.

Project	Affected water supply region	Date of implementation	Compensation to previous water users
ALR Dam used for urban water supply and urban untreated wastewater used for agricultural purposes	Peri-urban area	1981	Transfer to urban untreated wastewater
Wells in La Victoria	Peri-urban area	1986	None
Wells in La Sauceda	Inside the city	1987	No previous users affected
El Molinito Dam constructed	Peri-urban area	1991	Partial (just some agricultural users)
Infiltration gallery constructed	Peri-urban area	1996	None
All the water from the ALR Dam used for urban purpose	Peri-urban area	1996	Transfer to urban untreated wastewater
El Molinito Dam used for urban water supply and ALR Dam stopped storing water	Peri-urban area	1998	Partial (just some agricultural users)
Wells in the Mesa del Seri	Peri-urban area	1998	None
Desalting plant	Hermosillo coast	Not implemented	Not implemented
Aqueduct Pesqueira	Pesquiera	Not implemented	Not implemented
Wells in the Willard	Peri-urban area	2002	No previous users affected
Aqueduct from El Realito, Sur y Pueblitos	Inside the city	2002	No previous users affected
Buying water rights from an irrrigation district	Hermosillo coast	2006	Buying rights
Buying water rights from Las Malvinas	Peri-urban area	2006	Partial (not to third parties)
Aqueduct El Molinito	Peri-urban area	2008	Partial (just some agricultural users)
Aqueduct from El Novillo	Yaqui Valley	Implemented until 2010	The aqueduct is still in dispute

which just one was implemented, but unlike in the ejido cases, with monetary compensation. The water transfers with monetary compensation were only implemented between AguaH and producers from the Hermosillo Coast irrigation district and in the Malvinas project. Peri-urban ejidatarios were not compensated.

Second, all the studied ejidos suffered losses of access to their water resources due to the installation of deep urban wells, the construction of new dams or aqueducts to store and transport

water, or simple cutting off of access to traditional sources. In the case of ejido Molino de Camou, after many years of water problems, ejidatarios were able to negotiate a volumetric assignment of water rights when the municipality needed to gain access to ejido land in order to construct an aqueduct across it, thus giving the ejido Molino de Camou some powerful leverage in the negotiation. The downstream ejidos were also able to negotiate their water rights, although they use untreated wastewater. It is not a coincidence that the ejidos that were able to negotiate were users of surface water. We conclude that the fact of having surface water instead of groundwater gives to these ejidatarios an advantage in negotiating with authorities. Surface water is a more visible source; moreover, groundwater alteration is not as tangible as variation in surface water. Groundwater also varies interannually and seasonally in terms of its storage capacity, but the variability is difficult to measure. It is very well recognized that Mexican aquifers have been subject to few water balance studies (Carabias and Landa, 2005). The limited knowledge about groundwater allows the taking of the resource without compensation, as in the study cases.

Third, in keeping with these findings, we suggest that the notion of the peri-urban should be reconceptualised in the context of water. The *peri-urban waterscape* is a broader concept than that of the peri-urban landscape (Swyngedouw, 1999). It is defined by hydrological flows, topographic contours, and spheres of political influence and authority. The ability to capture water flows and channel them to cities across long distances creates an ample and more flexible 'peri-urban' phenomenon that is not as finitely bounded as in the case of land. For example, although ejido Codorachi is located nearly 30 km from Hermosillo, its water can be accessed by the city, making this rural farming area part of the peri-urban zone.

Bakker (2003) argued that the specific properties of water make it a uniquely uncooperative commodity and expensive to transport; yet as this case illustrates, if the demands of capital are sufficient – that is, the benefits of urban expansion exceed the costs of infrastructure and transportation – cities will invest in the necessary infrastructure. These flow properties of water and spheres of political influence enrol these more distant, rural areas as participants in a peri-urban waterscape. In this regard, water is not an uncooperative commodity, but actually too cooperative. Thus, even geographically distant, essentially rural communities may become involved within the urban-peri-urban transfer as thirsty cities go hunting for increased water supply under conditions of growth, drought, and intensified concerns about climate change.

Finally, when peri-urban land is targeted for urban expansion of housing or infrastructure, these land areas are brought into the urban area via annexation. They change in status from peri-urban to officially urban; jurisdiction of the area may move from one set of government arrangements to another, more local, government; residents of the peri-urban area become citizens of the urban area with the privileges and responsibilities associated with this status. In the case of peri-urban water resources, the equation is quite different. The city's professional staff of engineers and planners, appropriately make plans for increasing the growing city's water supply, and design the most cost-effective strategies that lead them to look as close as possible for new water sources closer to the urban boundaries. The politicians weigh the political ramifications of the proposed set of alternatives, and factor in where they are likely to meet greater acceptance or resistance. The city takes an action that turns off the spigot for the peri-urban water user, and diverts those water resources to new urban uses. The peri-urban water user stays in place, while his or her water resources are transported and used within the city boundaries, in many cases, kilometres away. The peri-urban water user's status does not change; he or she remains a resident of the same community under the same governmental authority, but the water that supported the livelihood of that water user is no longer available.

CONCLUSION

The needs of peri-urban ejidos for water that sustains their livelihoods have been systematically marginalised resulting in inequitable decisions reflecting governance failures. At one level, this represents a simple rural-to-urban water transfer to redistribute the resources to their highest and better use: urban 'public' consumption over crop consumption. However, as we have seen in Hermosillo's case, the peri-urban water transfers occurred under a very specific set of political processes that privileged large, politically connected commercial irrigation districts dominated by private growers who sell to export markets over small-scale, marginalised ejido communities who produce for personal consumption and sell to regional markets.

Focusing the city's expansion of the urban water frontier on capturing the water resources of peri-urban ejidos does not disturb the commodity chains produced by the large commercial irrigation districts, which will still have adequate water to produce wheat for Mexico City conglomerates and grapes for the US market. The commercial irrigation districts and large private corporate farms (such as the Hermosillo Coast Irrigation District and Pesqueira grape-producing zone) have had the political leverage to resist and turn back urban challenges for their water, while ejidos have had to give way. In this sense, it is important to recognise that the urbanisation of ejido water resources is part of nearly three decades of the neoliberal transformation of the ejido through water policy reforms, land tenure reforms, trade liberalisation, and agricultural policy changes.

Thus, the urbanisation of water for the city has contributed to the production of a new social landscape for the peri-urban area. Peri-urban ejidos in this study have lost or experienced reduced access to irrigation water that had allowed them to stay on and actively produce on their land. Both livelihoods and communities are made more vulnerable in the process as most households turn to migration as an alternative income strategy. As climate change promises to further diminish water supply in northwest Mexico, ejido farming communities are likely to lose out in future battles over scarce water resources, affecting the livelihood and viability of the community. In this regard, the case of northwest Mexico has significant implications for small-scale producers elsewhere in Latin America and the global South who face similar challenges to their claims of water resources.

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