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Desalination and Water Security: The Promise and Perils of a Technological Fix to the Water Crisis in Baja California Sur, Mexico

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ABSTRACT: Across the globe, desalination is increasingly being considered as a new water supply source. This article examines how the introduction of desalinated water into the municipal water supply portfolio has affected water security in the coastal tourist city of Cabo San Lucas in Baja California Sur (BCS), Mexico. It also analyses the competing discourses surrounding desalination in the region and discusses alternative water management options for achieving water security. This article challenges the notion that desalination is an appropriate and sufficient technological solution for arid regions. The findings provide evidence of increased yet delimited water security at a neighbourhood scale while identifying new vulnerabilities related to desalination, particularly in the context of the global South. This article concludes that implementing a technological fix on top of a water management system that is plagued with more systemic and structural problems does little to improve long-term water management and is likely to foreclose or forestall other water management options. This multi-scalar analysis contributes to the emerging literature on water security by considering both a narrow and broad framing of water security and identifying a range of factors that influence water security.

KEYWORDS: Water security, desalination, adaptive water management, Los Cabos, Baja California Sur, Mexico

INTRODUCTION

Ensuring adequate quantities of clean, safe water for the needs of humans and ecosystems is one of the greatest challenges worldwide. Satisfying demands for freshwater is expected to become increasingly difficult in the context of a changing climate, with many regions facing more variable precipitation patterns and decreased water availability (Milly et al., 2008). Water managers and planners are increasingly looking towards desalination – the conversion of seawater or brackish groundwater to freshwater – as a technical, supply-side solution that can meet current water demands and buffer against the negative impacts of climate change on water resources. Despite its high energy demands, the Intergovernmental Panel on Climate Change (IPCC) lists desalination as an 'adaptation option' which may be particularly important in arid and semiarid regions (Bates et al., 2008: 49). The bilateral International Boundary and Water Commission (IBWC), which is responsible for settling issues related to boundary and water treaties between the US and Mexico, has established a core working group dedicated to finding new water resources, including proposed binational desalination projects in Ensenada, Baja California, Rosarito, Baja California, and Puerto Peñasco, Sonora (López Pérez, 2009; McEvoy and Wilder, 2012). As part of Mexico's 2007-2012 National Infrastructure Programme, the federal government identified eight priority desalination projects in north-western Mexico (Conagua, 2012a) (Figure 1). In Baja California Sur, the state's long-term water plan identifies desalination as the principal means by which the major cities and growing tourist destinations of Los Cabos and La Paz will overcome future water deficits, which are projected to be 34 million cubic metres (Mm^3) and 14 Mm^3, respectively, by 2030 (Conagua, 2012b).

Figure 1. Priority desalination projects (Conagua, 2012a).

A National Research Council analysis of desalination technology found that desalination is a realistic option for future water supply (NRC, 2008). In the last 15 years, the cost of producing desalinated water has dropped by 50% due to continued improvements in reverse osmosis membrane technology, implementation of energy recovery devices, increased efficiencies of pumps, increased competition among suppliers, and benefits of economies of scale associated with larger projects (Elimelech and Philip, 2011; Tal, 2011). Desalination is also appealing in arid regions where it may be less politically divisive than other water management options, such as interbasin and inter-sectoral transfers (Downward and Taylor, 2007; Kohlhoff and Roberts, 2007; Swyngedouw, 2013).

However, as the NRC (2008) report concludes, there is a lack of long-term research and considerable uncertainty about the environmental impacts of desalination. The limited research conducted on the impacts of seawater desalination has mainly focused on the direct environmental impact of the saltwater concentrate, or brine, discharge on marine ecosystems (NRC, 2008). Findings from existing studies are inconclusive, with some studies indicating minor to major impacts on marine ecosystems, while others found no significant impacts (NRC, 2008: 130). A few analyses have considered a broader range of potential impacts and risks of desalination technology, including compounding water-energy demands, increasing greenhouse gas emissions, inducing urban and regional growth, shifting geopolitical relations, greater privatisation of water supplies and increasing water prices, among others (Feitelson and Rosenthal, 2012; McEvoy and Wilder, 2012; March et al., 2014). But there remains a lacuna of empirical research that looks at the impact of the technology on water security.

To this end, I draw on a theoretical framing that considers water security in both a narrow and broad sense (Cook and Bakker, 2012). I use empirical evidence from household surveys, semi-structured interviews, and planning documents to examine how the introduction of desalinated water into the public water supply portfolio has affected water security, in a narrow sense, in the coastal tourist city of Cabo San Lucas in Baja California Sur (BCS), Mexico. This is followed by an analysis of the competing discourses surrounding desalination and a discussion of alternative water management options for achieving regional water security, in a broad sense. The results from this case study provide empirical evidence regarding the potential benefits and problems of desalination as a solution to water management in Mexico and other arid regions, particularly in the global South. I now turn to a review of three dominant water management paradigms, with a more focused discussion of the emerging concept of water security, and then discuss the research results.

WATER MANAGEMENT PARADIGMS: FROM THE HYDRAULIC PARADIGM, TO INTEGRATED WATER RESOURCES MANAGEMENT, TO WATER SECURITY… AND BACK AGAIN?

Over 70 years ago, Gilbert White, the iconic early hazards and water management expert, embarked on a study of United States national floodplain management practices (White, 1945). His study came to the counterintuitive conclusion that structural flood controls (i.e. dams and levees) did not necessarily reduce people's vulnerability to flood damage. Given the limitations of structural works, a large flood event was likely to overcome the design protections. In such cases, the additional development induced by the perceived protective works would increase the magnitude of flood losses beyond what they would have been without the structural protective works. White argued that instead of building more single-purpose infrastructure, management agencies needed to consider "multiple adjustments" to floods, most notably better land-use planning (Platt et al., 1997).

This debate is mirrored in two competing contemporary water management paradigms. Early 20th century water projects, under what is often referred to as the 'hydraulic paradigm', focused on hard path solutions to provide subsidised water for irrigation and urban development (i.e. the construction of dams and aqueducts) (Gleick, 2000; Saurí and del Moral, 2001; Kallis and Coccossis, 2003). But this supply-oriented paradigm largely ignored issues of equity and environmental degradation, resulting in an uneven distribution of costs and benefits, with marginalised social groups and the environment typically incurring the greatest costs of water projects through displacement, loss of livelihoods, and environmental degradation (Ingram et al., 2008).

In the last 20 years, with growing concerns about the social and environmental costs associated with large infrastructural projects, a new water management paradigm, known as Integrated Water Resource Management (IWRM) has emerged. This market-led approach to water management has the twin goals of achieving neoliberal efficiency and environmental sustainability (World Bank, 1993, 2003; Conca, 2006). It moves away from centralised, state-led water management to decentralised, market-led water governance (Bakker, 2002; Kaika, 2003; Wilder, 2010). It is characterised by the application of neoliberal economic principles to encourage rational water use and foster the reallocation of water among competing interests (Glennon and Pearce, 2007). It also promotes the use of efficient technologies (e.g. drip irrigation, lined canals, leak detection, and modernisation of infrastructure) (Gleick, 2000), gives consideration to environmental water needs (Postel and Richter, 2003), and supports increased stakeholder participation (Kaika, 2003). In sum, this paradigm marks a shift from supply-side management to demand-side management and emphasises soft path solutions (e.g. water conservation) over hard path solutions (e.g. dams) (Gleick, 2003; Brooks et al., 2009). Despite this recent push to move away from expensive, large-scale, supply-driven water infrastructural projects, desalination is becoming a preferred water augmentation strategy throughout the Gulf of California region in northwestern Mexico (Conagua, 2012a, b).

Parallel to the IWRM paradigm, the concept of water security[1] has received increased attention in recent years. The term was used by the Global Water Partnership at the Second World Water Forum in The Hague in 2000 to describe a similarly integrative approach to water management. The term has since become increasingly used by academics and practitioners (Cook and Bakker, 2012). The discursive root of the term 'security' has historically referred narrowly to national security in terms of military threats from other nation-states (Ullman, 1983). However, as Cook and Bakker's (2012) review concludes, there is actually very little emphasis on military security in the current use of the term 'water

[1] In this article, the term water security encompasses the possibility of water 'insecurity' at various scales. Water insecurity refers to a lack of access to, or unavailability of, sufficient, clean, affordable, and reliable potable water and sanitation (Gerlak and Wilder, 2012).

security'. Perhaps, as they note, the more problematic discursive association is with the term 'crisis', which may be used to leverage other goals (see also McEvoy and Wilder, 2012; Swyngedouw, 2013).

Recognising both the productive and destructive potential of water, Grey and Sadoff (2007) provide one of the more widely cited definitions of water security: "[t]he availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environment and economies" (p. 547-548). Scott et al. (2013) build off this definition to account for the dynamic nature of coupled human-natural systems and uncertainties in water management. Their definition states that "water security constitutes the sustainable availability of adequate quantities and qualities of water for resilient societies and ecosystems in the face of uncertain global change" (p. 281). In this definition, adaptive water management becomes an important corollary to water security. Adaptive water management relies on social learning, knowledge exchange, and flexible strategies to increase the capacity to respond to uncertainties and change (Pahl-Wostl, 2007; Wilder et al., 2010).

These definitions reflect what Cook and Bakker (2012) consider a "broad framing" of water security, which shares much in common with IWRM. This broad framing of water security considers both water quantity and quality, and recognises the importance of meeting human and ecosystems needs. This includes clean and safe sanitation (i.e. sewerage) (Gerlak and Wilder, 2012). Additionally, it underscores the important role of good governance and adaptive water management institutions in achieving water security. By contrast, approaches that focus only on the quantity of water available for human use, or that emphasise infrastructure (and not institutions) exemplify a narrow framing of water security. Grey and Sadoff (2007) observe that "While it is likely and understandable that countries will initially place a premium on physical capital investments, human capacity and institutions can take much longer to build and adapt" (p. 559). They conclude that the best path to water security is through balanced investments in water infrastructure and institutions (i.e. governance), while giving special attention to issues of equity in the distribution of the benefits of these investments.

In determining the factors that influence water security, it is helpful to draw on the insights from vulnerability research (Liverman, 1994; Adger, 2006; Ribot, 2010). Akin to vulnerability, water security, is determined by more than just biophysical availability of water (i.e. the natural hydrological regime). There are also social, political, economic, and technological factors that shape water security (Zeitoun, 2011). This paper considers how water availability (i.e. supply), water demand by sector, technology and infrastructure, managerial abilities, and institutional environments influence water security. Because water security, like vulnerability, is disproportionately experienced by poor and marginalised social groups (Ribot, 2010; Zeitoun, 2011), attention is given to issues of equity and the distribution of water security.

While Cook and Bakker (2012) argue for a broad, integrative use of the term water security, they note that narrower definitions are needed for operationalisation in empirical research. But in doing so, they call for narrow framings to be "usefully allied" with broader framings in order to account for the "multiple stressors that affect water security" (p. 99). In addition, they call for "multi-scalar" analyses that provide a more nuanced understanding of water security.

METHODOLOGY AND CASE STUDY SITES

This analysis is based on data collected during nine months of fieldwork in the *municipios* (equivalent to US counties) of Los Cabos and La Paz in southern BCS (Figure 2). To assess the impact of desalination on water security at the household level, this article presents the results of a systematic random sample survey of 154 households in the *colonia popular,* or working-class neighbourhood, of Los Cangrejos in Cabos San Lucas. Since the purpose of the survey was to assess the impact of the desalination plant on water security at the household level, surveys were conducted in Los Cangrejos, the neighbourhood that receives the most water from the desalination plant.[2] To assess how desalination affects water security at the city and state level, as well as how it relates to alternative water management options, I present my analysis of 79 semi-structured interviews with 71 different stakeholders (Table 1) and government planning documents.

Figure 2. Map of case study sites: Los Cabos and La Paz, BCS, Mexico.

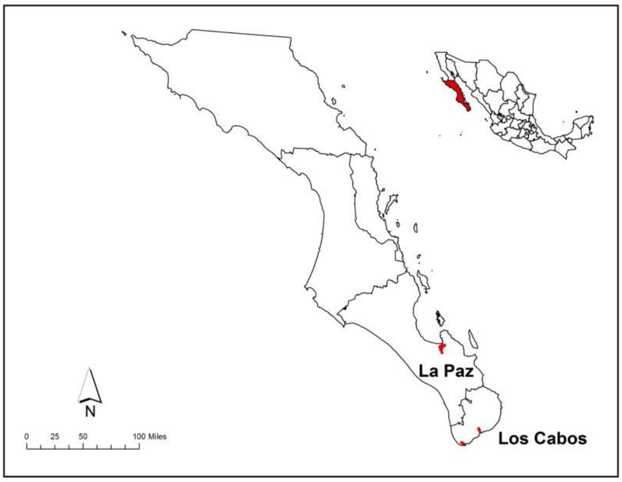


Table 1. List of interviewees by affiliation type.

Affiliation	No. of interviewees
Federal water commission (Conagua)	3
Federal government (other)	6
State water commission (CEA)	2
State government (other)	2
La Paz municipal water utility (SAPA)	3
La Paz municipal government (other)	3
Los Cabos municipal water utility (OOMSAPASLC)	2
Los Cabos municipal government (other)	3
Environmental Nongovernmental Organisations (NGOs)	5
Academic/Researcher	6
Private development, architecture, or real estate firm	9
Private desalination operator	1
Colonia residents	16
Colonia leaders	4
Expat residents	3
Other	3
Total no. of interviewees	71

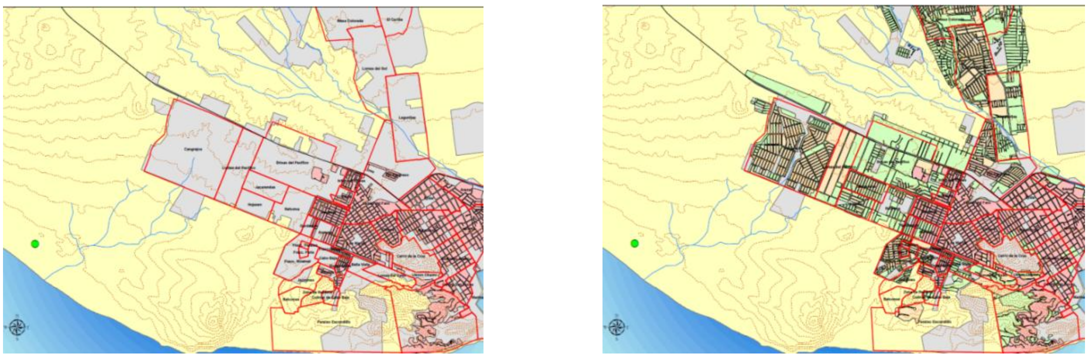
[2] Most respondents assumed that the *colonia* of Los Cangrejos received the most desalinated water because of its physical proximity to the desalination plant.

Case study site: Los Cabos

Los Cabos is one of Mexico's most well-known tourist destinations. With vast white beaches and over 300 days of sunshine per year, this arid coastal region attracts over a million visitors each year and is home to 251,871 residents, most of whom are employed in the service sector (INEGI, 2010; H. XI Ayuntamiento de Los Cabos, 2011: 179; IMPLAN, 2011). Los Cabos refers to the city of San José del Cabo, the city of Cabo San Lucas, and the 18-mile tourist corridor that stretches between the two urban centres. The *municipio* of Los Cabos is the local administrative unit, and consists primarily of these two urban centres, along with a few smaller outlying towns.

Growth in Los Cabos exploded in the 1990s, with the number of hotel rooms growing from 1524 in 1982 to 9663 in 1998, with 21,857 new jobs being added to the *municipio* from 1988 to 1998 (Borja Santibáñex et al., 2006). The population of the *municipio* of Los Cabos grew from 19,117 in 1980 to 71,031 in 1995, nearly quadrupling in just 15 years (ibid). With limited housing options for workers and their families, a politically led social movement began in 1994 to establish the *colonia popular,* or working-class neighbourhood, of Los Cangrejos on the outskirts of Cabo San Lucas (Personal communication,[3] 2012). Los Cangrejos was one of the first *colonias populares* to be established on the outskirts of the Cabo San Lucas city centre and it grew quickly from 3451 residents in 2005 to 10,948 in 2010 (INEGI, 2005; Valdez Aragón, 2006). Several other *colonias populares*, both formal and informal, have been established on the outskirts of Cabo San Lucas to accommodate the continued growth (Figure 3).

Figure 3. Map of growth around the centre of Cabo San Lucas, 2000 and 2010 (IMPLAN, 2011).



2000 2010

The *municipio* has struggled to provide infrastructure and services, including electricity, potable water, and sewerage, to the growing population of Los Cabos. In 2004, the *municipio's* potable water supply network reached only 74% of the households, leaving 26% of the residents to rely on water trucks for water provision (IMPLAN, 2011). The challenge of providing a clean, reliable supply of water to residents and businesses is due to both biophysical and socio-political factors. With an average annual rainfall of less than 285 mm, average annual temperatures between 22 °C (71.6 °F) and 24 °C (75.2 °F), and temperature extremes of over 40 °C (104 °F), the southern tip of Baja California Sur is one of Mexico's most arid regions (Conagua, 2009a, 2012b). Climate change is expected to negatively impact water resources and reduce water availability in the region. Downscaled models of climate change scenarios project that by 2070, precipitation in this region will decrease by 10-20% and annual temperatures will increase on the order of 4.5 °F (Martínez Austria and Patiño Gómez, 2010; Magaña et

[3] Personal communication with one of the interviewees indicated in Table 1. In accordance with the research protocol approved by the Institutional Review Board, all names have been withheld to maintain confidentiality.

al., 2012). Currently, groundwater is the primary source of water in the region. Of the five aquifers in Los Cabos, two are overdrawn (i.e. water extraction exceeds natural recharge) (Conagua, 2012b: 60). This includes the San José aquifer, which provides 64% of the water for Los Cabos (IMPLAN, 2011: 74).

Beyond the biophysical water scarcity, there are socio-political factors that limit water availability. As in many parts of Mexico, the water distribution system operates inefficiently due to deteriorating infrastructure and/or lack of reinvestment and repair. Conagua (2008) estimates that water systems in Mexico lose an average of 30-50% of their water due to leaks and system inefficiencies (p. 37). Although the water distribution networks in many of the recently established *colonias populares* in Los Cabos are new, there is still an estimated 19-30% of water loss due to system inefficiencies (Valdez Aragón, 2006; H. X Ayuntamiento de Los Cabos, 2008). However, the water system is not completely metered (including metering at the extraction wells, as well as meters for individual users), so it is not possible to calculate exactly how much water is lost in the system (Valdez Aragón, 2006).

In Los Cabos, the urban sector is the largest water user. The majority (69%) of water concessions in Los Cabos are for public-urban use (Valdez Aragón, 2006). The 1995 Los Cabos master plan recommended that new hotel developments include '*auto-abastecen*' or 'self-supply' (i.e. provide their own source of water) (ibid). Without an assured water supply from the *municipio,* new hotel developments had an impetus to build their own small-scale desalination facilities. Some older hotels also built their own desalination facility to ensure a reliable water supply. There are now 22 private, small-scale desalination plants in Los Cabos (Pombo et al., 2008).

The Los Cabos desalination plant is Mexico's first ever, municipal-scale desalination plant for public water supply. It is financed, constructed, and operated through a Public-Private Partnership (PPP) involving the *municipio's* water utility (OOMSAPASLC), state and federal water authorities, and INIMA, a Spanish-based company that won the bid to build and operate the Los Cabos desalination plant for a period of 20 years. The desalination plant is located in the *colonia* of Los Cangrejos and began operation in 2006. The plant was designed to produce 200 litres of water per second (lps) and meet the water demands of 40,000 residents in various *colonias populares* in Cabo San Lucas.[4] When the plant began operations, 100 lps of water were to be sent to Los Cangrejos (10,984 residents), 40 lps to 4 de Marzo (4673 residents), 20 lps to Las Palmas (8654 residents), and 20 lps to Mesa Colorado (13,823 residents) (Personal communication, 2010; INEGI, 2010).

Since the construction of the desalination plant, potable water supply coverage has increased from 74 to 96% (IMPLAN, 2011). Los Cangrejos, the *colonia* that is located closest to the desalination facility now has a nearly continuous supply of water. However, for 44% of the water users in the other *colonias populares* in Cabo San Lucas, this service is intermittent (ibid). The *municipio* has a scheduled *tandeo*, or water-sharing schedule, that directs water to different *colonias* during certain hours on set days every week. While *colonias populares* are supposed to receive water every three days, residents report going as long as 15 days without piped water service (Personal communication, 2012).

To adapt to, or cope with, the intermittent service, residents use a variety of water storage containers to maintain a water supply when the municipal piped water service goes out. These containers range from very basic *tambos*, or plastic jugs, to *tinacos*, or rooftop water storage containers, to more elaborate underground cement *cisternas*, or cisterns (Figures 4-6). The cisterns fill up automatically when the municipal water is on, and then use a pump to deliver water to the house when needed. A cistern with a 10,000 litre capacity costs around $50,000 (US$4167). *Tinacos* range in price, depending on size and brand, but cost around $1300 (US$108). A set of three *tambos* can cost

[4] While the Los Cabos desalination plant (200 lps) is a large-scale plant, it is considerably smaller than the largest plants in the world. For example, the Jebel Ali desalination plant in the United Arab Emirates produces 6134 lps (Simpson, 2013), the Ashkelon desalination plant in Israel produces 4572 lps (Cooley et al., 2006), and upon completion in 2016, the desalination plant in Carlsbad, California is slated to produce 2190 lps (Poseidon Water, 2013).

$1600 (US$133) (Personal communication, 2012). While a cistern provides the greatest degree of water security, the cost is prohibitive for many households.

Figure 4. Water storage containers known as *tambos*, or plastic barrels (author's photo).

Figure 5. Water storage containers known as *cisterna*, or underground cistern (author's photo).

Figure 6. Water storage containers known as *tinacos*, or rooftop water tanks (author's photo).

The *municipio* has a public water truck service, or *pipas*, which delivers water to neighbourhoods that are not connected to the public network or experience extended *tandeos.* However, the public service is insufficient and private entrepreneurs have filled the market, providing water at a high cost. A full water truck delivery of 10,000 litres of water (sufficient to fill a cistern) typically costs $500 (US$40) (Personal communication, 2012). But households that do not have the capacity to store that much water at once are charged for a portion of water, at the discretion of the private vendor (see results below).

Case study description: La Paz

In 2001, La Paz was listed among the 100 cities in Mexico that is most likely to experience a "severe water crisis" (Cruz Falcón, 2007: 2). The scenario of growth and water availability in the *municipio* of La Paz, which includes the state's capital city of La Paz, along with a few smaller towns, is similar to that of Los Cabos. While the economy of La Paz is more diverse than that of Los Cabos, tourism is gaining importance (H. XIV Ayuntamiento de La Paz, 2011). The population has grown steadily from 111,310 in 1980 to 251,871 in 2010 (INEGI, 2010). Of the 15 aquifers in the *municipio*, six are overdrafted. This includes the La Paz aquifer, which is the primary source of water supply for the city of La Paz (Carrillo Guer, 2010). While Conagua estimates that the deficit of the La Paz aquifer (i.e. the difference between the amount of average annual extraction and recharge) is only 0.58 Mm^3, other studies have concluded that much greater deficits exist, ranging from a deficit of 8.98 Mm^3 annually to 20 Mm^3 annually (Cruz Falcón, 2007: 103).[5] The La Paz aquifer has experienced saline intrusion since the 1960s and in the 1980s, nearly all the groundwater wells within the city limits were closed and relocated, due to saline intrusion (Cruz Falcón, 2007).

Conagua has issued a *veda*, or moratorium on new water concessions (Conagua, 2009b). Existing water concessions for the La Paz aquifer are used primarily for public-urban water supply, which accounts for 62% of all water use. Agriculture accounts for 30% of water use (Carrillo Guer, 2010: 10). The distribution system for urban water supply is old and inefficient, with an estimated water loss rate of 44% (Carrillo Guer, 2010: 20). Despite these challenges, the water utility offers piped water service to 93.3% of all households (H. XIV Ayuntamiento de La Paz, 2011: 118). But this service is not continuous for many users who experience a *tandeo*, with water being directed to specific *colonias* every three to 15 days (Personal communication, 2012). Households in La Paz also rely on a variety of water storage containers and water trucks to make up for the lack of reliable, continuous water service. In La Paz, the public water truck service is more extensive than it is in Los Cabos. This public service is free, though residents say that truck drivers often ask for a *propina*, or tip, for service.

Despite limited water resources, the federally imposed moratorium on new concessions, and increasing water demand from the burgeoning tourist sector, La Paz has not adopted a recommendation in its master plan that new developments must provide their own water source. However, two of the newer developments in La Paz built their own desalination facilities to guarantee water supply to their residents. There is interest among some water managers and urban planners to build a large municipal-scale desalination plant, like the one in Los Cabos. A feasibility study for such a facility has already been conducted (IIUNAM, 2010). The state water plan identifies desalination as the principal means by which La Paz will overcome the increasing water deficit projected by 2030 (Conagua, 2012b). President Enrique Peña Nieto's administration has identified the La Paz desalination plant as one of the nation's top 38 water infrastructural projects (Cortés, 2012).

[5] In other regions in Sonora, scholars have noted an apparent intentional lack of scientific aquifer studies due to the political disinclination to create public awareness of the severity of water problems (see Moreno Vázquez, 2006; Wilder and Romero Lankao, 2006).

RESULTS: DESALINATION, WATER SERVICE, AND WATER SECURITY IN CABO SAN LUCAS

Following the theoretical framework outlined above (Cook and Bakker, 2012), I use both a narrow and broad framing of water security to assess the degree to which desalination technology has contributed to water security at various scales in Baja California Sur. I first discuss the results of the household surveys conducted in Los Cabos in order to understand how the adoption of desalination technology has affected water security, in a narrow sense (i.e.; accessible and affordable water of sufficient quality and quantity for household use). This is followed by an analysis of the competing discourses surrounding desalination and a discussion of alternative water management options to understand the drivers of regional water security more broadly defined.

Before the Los Cabos desalination plant was built in 2006, the *colonia popular* of Los Cangrejos was not connected to the city's water supply network. Residents depended on *pipas*, or water trucks, for their water supply. The public water truck service was insufficient to meet residents' needs, so private – and expensive – water trucks became the primary source of water for most households. Survey responses indicate that 83% of respondents who had lived in the *colonia* prior to the construction of the desalination plant had used private water trucks before 2006 (n = 54).[6] Like most respondents, one resident indicated that he had to hail a water truck twice a week, and paid $400 (US$33) a month for this service. As a side note to the survey question, he commented, "It was not fair, but that's all there was". Another respondent who had built a large cistern to store water spent $1000 (US$85) a month for water from private water trucks.

In addition to the financial strain of accessing household water from private *pipas*, survey respondents also made comments detailing the inconvenience of having to chase down a truck. For example, one respondent recalled how his neighbour would go out on his motorcycle at 5 a.m. to chase down the water trucks and try to get them to bring water to their block. Several respondents commented that private water trucks favoured the houses that have large *cisternas*, or holding tanks, because they could make more money in just one stop. In contrast, as one woman commented, she only had small *tambos*, or plastic barrels and she struggled to get the private water trucks to stop at her home. Several respondents commented that it was difficult to know when the trucks would come through the neighbourhood, and they often missed an opportunity to fill their water storage containers while they were at work. Respondents in certain neighbourhoods reported that water trucks were less frequent in their block because the street was badly rutted or because their neighbourhood was farther away.

In contrast, now that desalinated water is piped directly into homes via the municipal network to this *colonia*, 52% of respondents reported paying between 50 and $99 (US$4-8) per month, and 36% pay $100-199 (US$8-17) per month (n= 135) (Table 2). The new connections require a water meter, which accounts for the difference in billing. With desalinated water being delivered directly to the household water connection, most respondents are now paying less than half – and in many cases just a fraction – of what they previously paid for water from private water trucks.

When asked how satisfied residents were with their water service now (i.e. since the construction of the desalination plant), 76% of respondents reported being satisfied or very satisfied with their current water service (n = 140). Comments included satisfaction that "day and night we have water" or "now we don't have to wait for the water trucks and buy from them". Of respondents 23% were neutral because, "sometimes there is no water". One respondent reported being dissatisfied with his service because of a billing problem (Table 2).

[6] Of the 154 survey respondents, 81 (52%) moved there in 2007, after the desalination plant was operating, resulting in a smaller number of responses (n) to this question.

Table 2. Survey responses: Potable water service.

Question	Responses
How much do you pay each month for your public potable water service? (open-ended) (n=135)*	
$50-99 (US$4-8) per month	52%
$100-199 (US$8-17) per month	36%
$200-299 (US$17-$25) per month	9%
$300 or more (US$25 or more) per month	3%
How satisfied are you with your [public potable water] service? (n=140)	
Very satisfied	38%
Satisfied	38%
Neutral	23%
Dissatisfied	1%
Very dissatisfied	0%

*Note: Categories for all open-ended questions were created during data analysis.

When asked about the suitability of desalination as a water supply strategy for Los Cabos, respondents overwhelmingly (91%) agreed that it was a suitable strategy (n = 151) (Table 3). While 70% of respondents did not list any concerns or worries about the desalination plant in an open-ended response, 16% expressed concern about what would happen if the plant broke down, 6% expressed concern about water quality and 5% expressed concern about the chemicals used in the process (n= 140). Only two respondents expressed concern about the cost of the water in the future. When asked to list the benefits of the plant, the overwhelming response was the increase in water availability (n=152) (Table 3).

Table 3. Survey responses: Desalination (suitability, problems, and benefits).

Question	Responses
Indicate your level of agreement with the following statement: Seawater desalination is a suitable strategy to supply water in Los Cabos (n=151)	
Agree	91.4%
Neutral	5.3%
Disagree	3.3%
What have been the problems or concerns about the Los Cabos desalination plant? (open-ended) (n=140)	
No problem stated, stated 'no problems' or 'no problems up until now'	70%
Stated concern about 'plant breakdown'	16%
Stated concern about 'water quality'	6%
Stated concern about 'chlorine' or 'chemicals' in the water	5%
Stated concern about 'cost of water'	2%
What have been the benefits of the Los Cabos desalination plant? (open-ended) (n=152)	
Stated 'there’s more water' or 'now we don’t lack water'	97%
Stated 'don’t know'	3%

Respondents in Los Cangrejos were also asked about their household water use activities (Table 4). Respondents reported using desalinated tap water for most activities, including bathing, cleaning the house, and washing dishes (n = 155). While 89% use desalinated tap water to clean fruits and vegetables, 11% preferred to use bottled water for this task (n = 153). Of the respondents 73% reported using desalinated water to wash their cars, three respondents mentioned using recycled water for this task and three respondents mentioned using a bucket to save water. While most houses had dirt yards with perhaps a couple of plants, 76% of respondents reported using desalinated tap water in the garden, primarily to keep the dust down (n=132). Five respondents reported using recycled water from the laundry for this activity as well.

Interestingly, only 13% of respondents reported drinking their desalinated tap water (n=151). Instead, the majority of households rely on purified drinking water purchased from a vendor. Despite the relatively new and modern distribution network and the water utility's assurance that the water delivered from the desalination plant is potable, respondents' primary reason for not drinking the desalinated tap water was concern that the water is not hygienic or could cause illness. The second most commonly cited set of reasons for not drinking the water was that it was too chlorinated and tasted or smelled bad. Many respondents also said they were simply 'accustomed' to drinking purified water, typically from a 5-gallon *garrafón*, or plastic jug sold in stores and by street vendors. Six respondents mentioned being concerned about the desalination process or not being fully aware of what this process involves.

Table 4. Survey responses: Use of tap water.

Question	Responses (%)
Do you use tap water for the following? If not, why?	
Yes, bathing (n=155)	100%
Yes, cleaning the house (n=155)	100%
Yes, washing the dishes (n=155)	100%
Yes, washing fruit and vegetables (n=153)	89%
No, use purified water to wash fruit and vegetables	11%
Yes, washing the car (n=146)	73%
No, I don't have a car	21%
No, I use recycled water	2%
No, no reason given or other	4%
Do you drink the tap water? (n=151)	
Yes	13%
No	87%
*If you don't drink the tap water, why not? (n=132) (open-ended**)*	
Stated 'too much chlorine', 'smells bad' or 'tastes bad'	39%
Stated 'it's not healthy' or 'I get sick'	48%
Stated 'I'm used to drinking purified water'	14%
Stated 'I don't have confidence in/am unsure about, the desalination process'	5%

**Note: Respondents could list more than one reason.

Survey respondents reported spending about the same amount of money each month on purified drinking water as they do on tap water. Forty-seven percent of respondents spent $40-120 (US$3-10) per month on purified water; 31% spent $212-200 (US$11-$17) a month. Another 12% paid $201-280 (US$18-23). Ten percent spent as much as $281-600 (US$24-50) a month on purified water (n = 144).

In sum, desalination has played an important role in providing continuous piped water service at reasonable cost to this particular *colonia*, which otherwise would not have piped water. When analysed at the scale of the *colonia*, desalination has been used to address pre-existing inequities in water provision and has increased water security in the narrow sense (i.e. increased water availability for human use). The results from the household survey also highlight the important role that water storage containers play in increasing water security at the household scale. An underground cistern is one of the most important water-security adaptations at the household level.

Despite resistance to drinking the desalinated tap water, residents of this *colonia* are generally satisfied with their water service and have a favourable opinion of desalination, seeing it as a suitable water supply strategy that has improved access and affordability of water for household activities. However, most respondents did not trust it as a drinking water source and continue to pay a considerable amount of money each month for drinking water. Although desalination is a cutting edge technology, in Los Cangrejos and across Mexico the cultural bias against drinking piped water is strong and the availability of desalinated water has not been able to overcome this bias. Given this finding, the degree to which desalination improves water security, even in the narrow sense, is questionable.

While the desalination plant has benefitted the 10,948 residents of Los Cangrejos, it has not solved the problem of water scarcity in Los Cabos. Despite an 87% increase in the *municipio's* total water supply from 1999 to 2009, the population grew by 126% during the same period (IMPLAN, 2011: 74). Other *colonias populares* continue to receive water on a *tandeo* system and may go as long as 15 days without piped water delivered to their house. The introduction of desalinated water has not been able to address the inadequacies of the existing distribution system. Residents fill their storage containers on the days when water is available, and many pay for water delivery from private (and expensive) water trucks when they run out. The degree to which desalination technology has increased water security, even in the narrow sense, is extremely uneven and depends on the scale of analysis used. When considering desalination as a water management strategy at the state level, other issues emerge.

RESULTS: DISCOURSES SURROUNDING DESALINATION AND WATER SECURITY AT THE STATE LEVEL

At the federal, state, and local levels throughout BCS, water managers and urban planners are looking towards desalination as the principal way to close the gap between water demand and supply in this arid, coastal state. A recently completed state water plan, which is part of the national *Agenda 2030* planning process, identifies desalination as the principal means by which the major cities and growing tourist destinations of Los Cabos and La Paz would meet the growing deficit between water demand and supply (Conagua, 2012b). In La Paz, desalination alone is expected to account for 44% of the projected water deficit of 15 Mm^3 by 2030 (Conagua, 2012b: 25-26). The state plan also emphasises the need for water efficiency, including agricultural modernisation, efficient appliances in both industrial and commercial settings, and repairing leaks and improving infrastructure, and an expanded role for treated wastewater reuse. Taken together, these actions are expected to contribute an additional 42% of the water needed to overcome the projected water deficit in La Paz. The state water plan provides a breakdown of the proposed water management measures and their contribution to the projected deficit in La Paz (Table 5). Similarly, in Los Cabos, expanded desalination is expected to make up 54% of the projected water deficit of 34 Mm^3, with other measures accounting for 37% (Conagua, 2012b: 28).

The state plan also provides a cost-benefit analysis of each water management measure and ranks each possible action according to its marginal cost (Figure 7). Measures that promote conservation and improve system efficiencies (e.g. repairing certain leaks, agricultural modernisation, and low-flow appliances) are listed as having a negative marginal cost, indicating that the revenue generated by the implementation of these measures would be greater than the cost of their investment. In contrast, desalination (shown as *desalación osmosis inversa)* is listed as having a positive marginal cost (Conagua, 2012b).

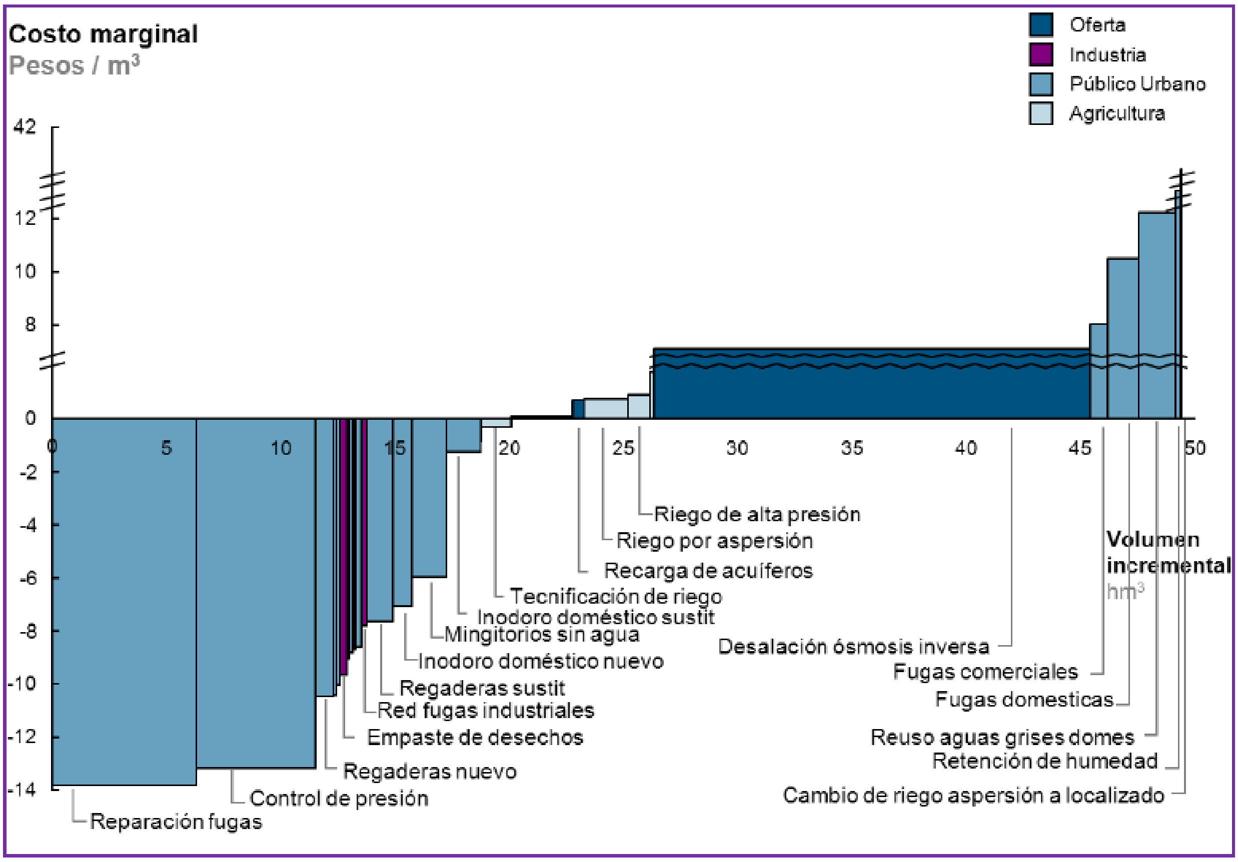
Table 5. Measures for covering the water deficit in La Paz, BCS (Conagua, 2012b: 26; author's translation of table originally published in Spanish).

Measure	Quantity	Unit	Contribution to deficit (Mm³)
Irrigation modernisation (parcel)	159	ha	1.10
High precision irrigation	189	ha	0.20
Sprinkler irrigation	347	ha	0.90
Replacing domestic toilets	100,759	person	0.80
Replacing commercial toilets	33,541	person	0.10
New domestic toilets	9,015	person	0.10
New commercial toilets	5,748	person	0.02
Replacing showerheads	78,368	person	0.60
New showerheads	13,431	person	0.10
New low-flow faucets	13,431	person	0.02
Dry urinals (commercial buildings)	2,623	urinal	0.50
Pressure control and sectorisation	31,374	connection	1.80
Repairing leaks in the distribution network	1,764	leak	2.10
Repairing domestic leaks	131,141	leak	0.50
Repairing commercial leaks	131,141	leak	0.30
Reusing domestic grey water	65,570	person	0.058
Using reclaimed water to irrigate parks	0.77	ha	0.03
Industrial leaks			0.10
Industry waste filling			0.10
Water used in industry			0.10
Aquifer recharge			0.20
Desalination plants	2	plants	7.80

*ha = hectare

Despite its cost, desalination has been adopted before the implementation of all conservation and efficiency options. This contradicts the recommendation in Conagua's national-level *2030 Water Agenda* that "the measures that should be implemented first of all are those with a negative marginal cost" (Conagua, 2011: 18). Clearly, there is a disconnect between the discourse and practice of policies regarding desalination. Given this contradiction, a logical set of questions to ask is: how and why was this capital-intensive technology implemented in Los Cabos; what is the current debate surrounding desalination in La Paz; what are the alternatives to desalination; and how might the trade-offs between investments in desalination versus alternative water management strategies affect water security? To answer these questions, I turn to an analysis of the political economy and competing discourses surrounding desalination in the region.

Figure 7. Technical solutions for bridging the water deficit in BCS by 2030 (Conagua, 2012b: 21).



Given that desalination requires a substantial financial investment, the PPP model has been important in facilitating its adoption. In Los Cabos, financing for the desalination project was split between federal (34%) and private (64%) sources. Of course the private sector is interested in participating in water projects that are profitable (Swyngedouw, 2005; Bakker, 2010). In a feasibility study for a binational desalination project in Puerto Peñasco, Sonora (near the Arizona border), the US Trade and Development Agency (USTDA) determined that a desalination project represents "a potentially significant commercial transaction in terms of capital investment and the long-term export potential needed for its expansion. Additionally, there is a recurrent revenue element due to membrane replacement and maintenance activities" (USTDA, 2008: 30). This represents an important business opportunity for engineering firms and manufacturers of desalination technology. Despite public concern about the privatisation of water resources (Barlow and Clarke, 2002; Swyngedouw, 2005; Goldman, 2007; Bakker, 2010), private-sector participation in various infrastructural projects in Mexico, including the Los Cabos desalination plant, has been promoted through federal-level programmes and policies (e.g.; PROMAGUA) (PPI, 2013).

In addition to financial support from the federal government, the regional Conagua office has been instrumental in promoting desalination through the *2030 Water Agenda* (Conagua, 2012b). The state water agency (CEA) also supports desalination and has a department dedicated to the development of this technology. The director of this department strongly supports further investment in desalination, stating, "[w]e believe that it is necessary to cover all of Baja California Sur with desalination plants… for us, the future of potable water is desalination" (Personal communication, 2012).

In the case of Los Cabos, it appears that there was a high level of local interest in building a desalination plant. A key informant who held a position within the local water utility (OOMSAPASLC) recounted how the decision to pursue desalination was made:

> In 1999, the Workers' Party (Partido del Trabajo, PT) gained political control here [in Los Cabos]. In the first few months they provided benefits for 10,000 families in the working-class communities. They started out by providing electricity for Cangrejos [the largest working-class neighbourhood in Cabo San Lucas]... After that, they solicited potable water. But Cabo San Lucas only received 80 lps for the *colonias populares* (working-class neighbourhoods) – and this had to be on a *tandeo* (water sharing) – one day with water and three days without. So we understood that there was not enough water for Cangrejos… so we proposed the creation of a desalination plan (Personal communication, 2012).

While local water managers in Los Cabos seem to have embraced desalination as a water augmentation strategy, the directors of the local water utility in La Paz have expressed concerns – particularly about the cost – of adopting desalination. The transcript from a local news report on *Desaladoras en Debate* (Desalination Plants in Debate) captures the differences in opinion between the regional Conagua director and the former director of the local water utility in La Paz (SAPA) under the 2007-2011 administration. The Conagua representative supports desalination stating, "We have not been able to satisfy this volume of growth, including additional immigration from other states, therefore, this volume must be complemented with desalination" (quoted in Cuevas, n.d.). This strong preference for desalination was met with reserve from the perspective of the former director of the La Paz SAPA who expressed concern about the high cost of the technology, stating "It's a process, which to date is very expensive – it's more than $1 dollar [presumably the unit of reference is US$1/m³]. It's not an appropriate water source to incorporate in the urban zone. Who will absorb this cost? This is what I would like to know. I don't think anyone is going to subsidise it" (quoted in Cuevas, n.d.).

While official information on the Los Cabos water utility's financial budget was not accessible, a local journalist reported that the utility buys desalinated water from INIMA at a rate of $12.50/m³ (US$1.04/m³) and resells the water at a rate of $3.3/m³ (US$0.28/m³) to the public (Gámez Vázquez, 2009). According to this calculation, the desalinated water in Los Cabos is subsidised at the rate of $9.2/m³ (US$0.77/m³) (Gámez Vázquez, 2009). While the exact mechanism of the subsidy was not explained by any interviewees within the local water utility, other government officials interviewed assumed that the subsidy for the desalination plant primarily comes from the higher water rate tariffs that are charged to the industrial sector (which includes the hotel and tourism industries) (Personal communication, 2012). A document obtained from the Municipal Institute of Planning or Instituto Municipal de Planeación de Los Cabos (IMPLAN) shows the different tariffs charged for lower income residential service ('domestic A'), other domestic service ('domestic B'), rural areas, commercial service, and industrial and tourist service. The Los Cabos *municipio* uses an increasing block rate structure based on the amount of water used. In 2011, the tariffs for 'domestic A' were $70.16 (US$5.95) for the first 18 m³ of water used, plus an additional $2.93 (US$0.25) for the next 15 m³. The price increases modestly for every additional 15 m³ used thereafter. In contrast, the 'industrial' and 'service' sectors were charged $1,488.58 (US$126) for the first 15 m³, plus an additional $299.31 (US$25.39) for the next 15 m³. Thereafter, as little as $14.39 (US$1.22) to as much as $35.08 (US$2.97) was charged for every additional 15 m³ used. The utility also charges the industrial and tourist sectors significantly more to establish a water connection ($988,052 or US$83,733) than is charged to lower-income domestic users ($3,930 or US$333). While Los Cabos is able to charge higher water tariffs on the hotel industry, it is not clear if this cross-subsidy is enough to pay for the full-cost of adopting desalination.

It is questionable whether other cities, like La Paz, will be able to cross-subsidise the expense of providing desalinated water. As stated by a key administrator in the La Paz SAPA under the current (2011-2015) administration:

> It's no secret. We all know that what you are charged for water does not reflect the real cost. Water is subsidised by the government – and even so, there are people that complain that it's too expensive. So imagine if you have to provide them with desalinated water. Well, there's no money to cover that! (Personal communication, 2012).

Given a lack of transparency, inaccessibility of information, and a history of financial mismanagement within the local water utility in La Paz (see Rubio, 2012), critics are concerned about the equity aspects of this solution (Gámez Vázquez, 2009; IIUNAM, 2010). The adoption of desalination technology may introduce new vulnerabilities in terms of water pricing and distribution of new water sources. For example, one of the proposals for a desalination facility in La Paz would provide water to new tourist developments, rather than marginalised neighbourhoods. The justification is that new users in the tourist sector would be able to pay more for desalinated water (Personal communication, 2012).

While not opposed to desalination, the La Paz SAPA administrator emphasised the need to implement other water management actions:

> We have so much seawater here, so desalination plants are a valid resource for solving the water supply problem. But I think that we have not done everything that we could do before we reach this point. There are many things we have not done due to lack of resources, or perhaps because of a lack of vision – and we can still do it. We still have time to turn to these alternatives before running to desalination in a massive way (Personal communication, 2012).

In La Paz, there is strong public support and preference for pursing alternatives to desalination. La Paz is home to the state university (UABCS), several research institutes, and various environmental non-governmental organisations (E-NGOs), which have provided studies and reports to promote the adoption of conservation and efficiency measures, better land use planning, and improved governance within the local water management and planning agencies (Valdez Aragón, 2006; Cruz Falcón, 2007; Carrillo Guer, 2010; Pineda Pablos and Briseño Ramírez, 2012). Many stakeholders in La Paz are concerned about the social, environmental, and financial impacts of desalination and insist that it should be the "last resort" (Valdez Aragón, 2006; IIUNAM, 2010; Personal communication, 2011, 2012). However, these opinions have not been given adequate attention. As recounted by one water expert who was invited to participate in the state water planning workshops, his perspective and that of others, were not reflected in the final documents for the *2030 Water Agenda*:

> They invite you to participate, to talk, to give your opinion and to sign an attendance list, so they can justify their actions. They can say, 'We held a workshop, we had the participation of academics, civil society, some functionaries, but in the end, they make the decision. And that's what makes me so upset… it was clear that there were some projects that were given priority… What happens is, it's a *cadenita*, a chain. If the federal government says, 'This year we're going to build desalination plants', then everyone is in agreement. But it shouldn't be like that (Personal communication, 2011).

In sum, despite Conagua's rhetorical commitment to a soft-path water future (Conagua, 2011), in practice there is continued support for the hydraulic paradigm characterised by centralised water management, supply-side infrastructure, a lack of transparency, and little stakeholder involvement. Given limited resources, a priority focus on desalination is likely to forestall or foreclose alternative water management strategies that are preferred by many stakeholders. Furthermore, implementing desalination as a technological fix on top of a water management system that is plagued with more systemic and structural problems does little to improve water security in a broader sense.

RESULTS: WATER MANAGEMENT ALTERNATIVES

The water management alternatives preferred by many stakeholders in La Paz fall into three categories: 1) efficiency and conservation measures, 2) better land-use planning and 3) improved governance within local institutions. The first set of alternatives focus on the implementation of conservation and efficiency measures. One NGO's assessment of water management in La Paz argues that the first step should be the installation of water meters on all groundwater wells in order to have an accurate measure of how much water is being extracted (Carrillo Guer, 2010). In addition, micro-meters on all households, and commercial and industrial buildings should be installed. This would allow the utility to better detect leaks, improve system efficiencies, and encourage conservation through education and the implementation of progressive tariffs that charge consumers more as they use more water. This assessment identifies other priority conservation actions, including repairing and replacing broken infrastructure, incentivising the installation of water-efficient appliances, promoting xeriscaping and rainwater harvesting, expanding wastewater reuse, and increasing agricultural efficiency. It also highlights the importance of providing every family with sufficient water storage containers, so that they can maintain water security during the *tandeo*. Similar recommendations have also been made for Los Cabos, including the need to improve water metering, restructure the tariffs to incentivise water conservation, and improve billing collection for service (Valdez Aragón, 2006). In Los Cabos, there is also a need for meters at the well pumps in order to know more precisely how much water is being extracted (ibid).

The second set of alternatives focus on integrated land use and water planning. There are two important regional projects that take into account the management of the broader watershed. First, is a project aimed at re-vegetating and conserving soil in the upper watershed, where poor land-use practices have caused degradation leading to increased run-off. A group of NGOs, along with students and teachers from a local technical high school are building small-scale retention basins, planting native vegetation, and installing fences to keep cattle out of eroded areas. There is also a federally funded programme through the state forestry office that provides payment for environmental services, including water recharge projects and reforestation in parts of the upper watershed (Personal communication, 2011). The second watershed-scale project is located seven miles south of the city centre of La Paz, in an area that has undergone rapid urbanisation in recent years. This area is one of the principal recharge zones for the aquifer (IIUNAM, 2010). A private urban development firm, in collaboration with the federal government and an international development organisation, is seeking certification and funding from the Sustainable Integrated Urban Development Programme for an urban development plan that would incorporate a large water catchment system and green space to increase infiltration and reduce run-off (Personal communication, 2011).

The third set of alternatives focus on issues of governance within water management and planning agencies. One of the greatest challenges to improved water management in Mexico is the frequent turnover of leadership positions within key administrative offices (Pineda Pablos and Briseño Ramírez, 2012). This turnover is typically associated with political elections every three years at the municipal level, and every six years at the state and federal levels. In a study of four different municipal water utilities in Sonora and Baja California, Pineda Pablos and Briseño Ramírez (2012) found that the average term for the director of a local water utility in each location was 2.6 and 3.5 years, respectively (p. 209). This study found a correlation between more frequent changes in political parties and lower levels of performance by the utility (Pineda Pablos and Briseño Ramírez, 2012). This continual rotation of leadership is associated with institutional instability and makes long-term planning difficult.

In Los Cabos, the Municipal Institute of Planning (IMPLAN), a public planning consultancy, was established in 2009 to provide advice and coordination between various agencies. It is composed of members from the public, private, and academic sectors. Because it is a consultancy with private-sector constituents (rather than a governmental office), the leadership positions within IMPLAN are expected to be more permanent, and thus provide a degree of continuity between political administrations (Personal communication, 2012). Furthermore, IMPLAN has the explicit goal of coordinating between various sectors. An IMPLAN report (2011) observes that there has been a lack of coordination between different sectors to resolve service problems and enforce regulations and laws. The report also notes that integrated planning for urban development has been limited, with a narrow focus on resolving short-term problems (IMPLAN, 2011). While it is too soon to assess the effectiveness of this nascent institution, some officials in La Paz think it is a potential solution for overcoming some of the problems associated with the constant turnover in government leadership positions (Personal communication, 2012).

An additional governance challenge, which is widely discussed but hard to document, is corruption and mismanagement. In La Paz, a watch-dog organisation believes that the water utility is used as a '*caja chica*' – or petty cash box for the city (Personal communication, 2011). In a study of urban water governance in a different regional context, Bakker (2010) observes that, "[a]s one of the largest revenue-generating agencies under the control of the municipalities, water utilities in some instances became 'cash cows', furnishing opportunities for cash injections into the municipal budget or for patronage through the allocation of desirable government jobs" (p. 62). Ortiz Rendón (2011), who worked in the water sector in Mexico for 20 years lists several examples of corruption, including giving jobs to unqualified individuals as political favours, approving permits for restricted uses or zones, manipulating the approval of environmental impact studies, allowing illegal uses or permits to continue without sanction, and so on. He notes that larger infrastructural projects provide more opportunities for corruption to occur. He also lists actions that are perhaps simply the result of poor management, rather than flagrant corruption, such as reliance on bad information, operating with a lack of information, or making bad investment decisions. Also, there's a culture of non-payment among water users, based on past high subsidies for water and a belief that water is a 'free' good (Pineda Pablos, 2006). Whether through corruption, insufficient resources, inadequate billing collection, or simply fiscal mismanagement, the local water utility in La Paz has accrued a debt of over $23 million (nearly US$2 million) to the federal water authority (Rubio, 2012). In this situation of financial turmoil, the utility is ineligible to receive federal funding to reinvest in the water infrastructural network, which inhibits its ability to improve water services.

DISCUSSION AND CONCLUSIONS

In conclusion, this multi-scalar analysis indicates that water security in Los Cabos and La Paz is influenced by biophysical, infrastructural, socioeconomic, and institutional factors. Certainly, the limited precipitation (averaging less than 285 mm annually) in this arid region contributes to the challenge of providing a clean, reliable water supply to a growing population. Future reductions in precipitation and increased temperatures due to climate change are projected to compound this challenge (Milly et al., 2008; Magaña et al., 2012). Desalination, a supply-side infrastructural investment, is an option for augmenting municipal water supplies. As shown in the case of the neighbourhood of Los Cangrejos, desalination has the potential to increase water security in the narrow sense (i.e. increased water availability for human use). In this particular case, desalination addresses pre-existing inequalities in water supply, to some extent, by delivering water to working-class neighbourhoods that would otherwise pay more for water delivery from private water trucks.

However, even in this neighbourhood, the increase in water security is limited. Survey results highlight the degree to which most water users continue to purchase purified water for drinking and washing fruits and vegetables. Despite assurance from the water utility that the desalinated water is potable, there is a sense of distrust by many users in the desalination process and/or the water distribution system. This is an important finding because it reveals that this high-tech, high-cost solution to water scarcity is not addressing the most basic water needs of residents (i.e. drinking water). If residents do not consider the water to be acceptable for human consumption, they remain at the mercy of private water vendors to meet this need. As such, the degree to which desalination improves water security, even in the narrow sense, is questionable.

Desalination, like other supply-side solutions, does not necessarily address inadequacies of the existing distribution system or governance issues. This means that other *colonias populares* in Cabo San Lucas continue to have limited water access and pay more for their water from informal sources (i.e. water trucks). Given that steady demographic and economic growth has continued and system inefficiencies (i.e. leaks) have remained largely unaddressed, demand has continued to outstrip supply at the city level.

Using a broader framing of the concept of water security highlights the need for institutional development and capacity building to promote good governance (Cook and Bakker, 2012). Desalination, as a technological fix to water scarcity, does little to address the more systemic and structural problems that are related to the socioeconomic and institutional factors that also determine water security. The sustainability of a socioeconomic development model based on constant economic growth and mass tourism remains unquestioned. Rather than challenging this business-as-usual development strategy, desalination enables it. As Smith (2009) observes, desalination can allow arid regions to "have limitless development 'cake' and eat it too" (p. 77). This solution, like other supply-side options, does little to improve the institutional capacity of the water and planning agencies.

Desalination is not the only infrastructural investment available to water managers. Indeed, many stakeholders insist that desalination should be considered as the 'last resort'. There are many other soft path infrastructural investments (Gleick, 2003; Brooks et al., 2009) that could be undertaken first. Furthermore, augmenting municipal water supplies through desalination does not require water managers to undertake more difficult institutional and political transformations within the water management agencies themselves. As Swyngedouw (2013) concludes in his study on Spain, "desalination is increasingly seen as a socionatural fix that permits a productivist water logic to remain the bedrock of Spain's global eco-modernization projects so that 'nothing really has to change' (di Lampedusa, 1960)" (p. 268). In BCS, as in much of Mexico and the global South, the lack of long-term, integrated water planning strategies, as well as lack of transparency in water and urban planning institutions result in poor water governance that ultimately reduces water security.

In sum, the nuanced and contextualised understanding of water security presented in this paper considers a range of factors that influence water security at multiple scales. This analysis highlights important, and often overlooked, dimensions of water security (Zeitoun, 2011) and shows the benefits of considering a broader framing of the concept of water security (Cook and Bakker, 2012). Additionally, it highlights the importance of investing in both infrastructure and institutions (i.e. governance) to improve water security (Grey and Sadoff, 2007; Cook and Bakker, 2012). This underscores the need to build adaptive capacity within water management and urban planning institutions in order to achieve water security, broadly defined (Pahl-Wostl, 2007; Wilder et al., 2010; Scott et al., 2013).

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