URBAN WATER SUPPLY IN MEXICO

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Index

ABSTRACT 9
RESUMEN 10
INTRODUCTION 11
1. METHODOLOGY 15
2. THE LITERATURE: A LOOK AT EACH OF THE 32 MEXICAN ENTITIES (THE 31 FEDERATED STATES, PLUS MEXICO CITY), WITH A FOCUS ON WHAT IS BEING DONE, AND WHAT CAN BE DONE 17
2.1 Aguascalientes 17
2.2 Baja California 19
2.3 Baja California Sur 21
2.4 Campeche 22
2.5 Chiapas 23
2.6 Chihuahua 24
2.7 Coahuila 26
2.8 Colima 26
2.9 Durango 27
2.10 Guanajuato 28
2.11 Guerrero 29
2.12 Hidalgo 30
2.13 Jalisco 31
2.14 Mexico 32
2.15 Michoacán 33
2.16 Morelos 33
2.17 Nayarit 34
2.18 Nuevo León 35
2.19 Oaxaca 36
2.20 Puebla 37
2.21 Querétaro 37
2.22 Quintana Roo 38
2.23 San Luis Potosí 39
2.24 Sinaloa 39
2.25 Sonora 40
2.26 Tabasco 41
2.27 Tamaulipas 42
2.28 Tlaxcala 42
2.29 Veracruz 43
2.30 Yucatán 44
2.31 Zacatecas 45
3. DISCUSSION 47

4. CONCLUSIONS 51
REFERENCES 53

ABSTRACT

The urban water supply in Mexico is a prevalent issue in Mexican affairs and calls attention to the failings of numerous Mexican states over time. This book will look at how Mexican states consistently fail to prepare for the future and seem confounded by interest group politics, by a lack of technical expertise, by a failure to conceive of best practices that might leverage more out of finite water resources, and by archaic water infrastructures that are – admittedly – quite difficult to replace or upgrade. It is suggested that a Made-in-Mexico solution can be found, but that it will most likely reside in doing the following: setting priorities; creating multidisciplinary and multi-pronged solutions to local water issues; and perhaps developing local technologies that can aid in water reclamation, protection and security.

Key words: conservation; desalination; extensions; infrastructure; reclamation; specialization; water diversion.

RESUMEN

El abastecimiento de agua urbana en México es un tema predominante en los asuntos mexicanos y llama la atención sobre los fallos de numerosos estados mexicanos a través del tiempo. En este libro veremos cómo los estados mexicanos fracasan consistentemente en prepararse para el futuro y parecen confundidos por la política de grupos de interés, por falta de experiencia técnica, por no concebir las mejores prácticas que podrían aprovechar más los recursos de agua finitos y por arcaicas que son - ciertamente - bastante difíciles de reemplazar o actualizar. Se sugiere que se puede encontrar una solución hecha en México, pero que probablemente residirá en hacer lo siguiente: establecer prioridades; la creación de soluciones multidisciplinarias y multifacéticas para las cuestiones locales relacionadas con el agua; y quizás el desarrollo de tecnologías locales que puedan ayudar en la recuperación del agua, la protección y la seguridad.

Palabras clave: arquitectura; biosferas; conservación; aplicación; ley del medio ambiente; propiedad ambiental; contaminación.

INTRODUCTION

The ensuing book is a systematic review of the contemporaneous situation vis-a-vis the urban water supply in Mexico. The purpose of this study is to ascertain policy failures, administrative and bureaucratic shortcomings, and persistent issues that hamper the optimal dispensation of water to residents and businesses within urban Mexico. There are 32 Mexican entities and, so far as possible, this book will briefly explore the state of affairs in each of them. What should become apparent is that the situation in Mexico does vary rather substantially from one region to another: while all Mexican states do have struggles ensuring that water supplies in urban regions are appropriate, some of the most impoverished regions/states are particularly hard-hit by a lack of infrastructure, a lack of oversight, and by a lack of bureaucratic and operational coverage. Because of this, Mexico is a country that is wracked by water insecurity, by the human development challenges this poses, and by a deepening crisis over how it will be able to adequately meet the water needs of its growing urban populations and bustling businesses. Urban water supply within the country might well be the single most profound issue facing the nation on a domestic level, organized crime and political corruption notwithstanding.

To commence, no introduction is sufficient without carefully assessing the background of the subject at hand. According to Miller (2017), reports from the New York Times in early 2017 pointed to acute water shortages in Mexico City. Other literature paints a similarly grim picture: according to the National Water Commission, as of 2017, at least 9 million Mexicans do not have access to potable water, while another 10.2 million lack basic sanitation infrastructure in their homes (Mexico News Daily, 2017a). Suffice it to say, not all of these people will be people residing in urban parts of the country. Nonetheless, the mere fact that millions lack the most basic water amenities speaks to the profound challenge confronting Mexico as it tries to dispense water to all of the businesses, residences, communities and families in its midst. The issue is simply not going away. And the matter is perhaps most acute when one looks closely at unfolding events in urban Mexico.

Specifically, some urban centers – such as Leon, Guanajuato – have, in recent years, exhibited efficient and thoroughly reliable water supply systems; in the matter of Leon, this continues to be the situation even though it exists in a dry zone of Mexico. Conversely, cities like Acapulco, Guerrero and Mexico City struggle mightily with burdensome water service and supply problems (Mexico News Daily, 2017a). When one considers that 29 million homes in

Mexico, as of March, 2017, rely on direct water delivery services that range in frequency from daily to occasional, when one considers that aging hydraulic infrastructure is the primary cause of leakages involving as much as 40% of the country's water supply, and when one considers that 80% of water that could be otherwise reused goes down the drain at the same time as municipal water suppliers have seen budget cuts reaching as high as 70%, then it is manifest that Mexico has a water supply issue that strikes at the very heart of whether or not the country can properly provide for all of its citizens – or even the great majority of them (Mexico News Daily, 2017a). The country is unambiguously grappling with an almost intractable problem that seems to afflict many developing or lower-income nations: the issues arising from the problem are clear enough, and easy enough to diagnose, but it is not at all clear that the resources – both technological and human – are available to make the situation better. That urban water supply in Mexico should be such a concern even in the heart of Mexico City clearly demonstrates that the country is shouldering a serious water shortage burden at a time when it is also growing in population and must find a way to nourish a dynamic industrial economy. And, as one might expect, the recent background to this grim water shortage issue has given rise to angry denunciations about who – or what – might be responsible for the present unhappiness.

Pedro Moctezuma, the Coordinator of the Water Sustainability Program at the Metropolitan Autonomous University, insists that the National Water Commission (CONAGUA), is most responsible for the ongoing mess: he maintains that CONAGUA has badly mismanaged water resources; he also maintains that Mexico's fledgling civil society should be involved in the debate surrounding how best to dispose of the nation's resources vis-a-vis domestic water supplies. Moctezuma also argues that a 2012 General Law on Water that guarantees access to water and sanitation as a basic human right of Mexican citizens should be belatedly debated after much delay. Moctezuma is particularly keen to emphasize that the law is comprehensive in scope and includes provisions for such matters as water accessibility for all, water quality, the restriction of the practice of mining aquifers, and over-exploitation of existing water supplies – which are all, in one way or another, items that need to be addressed comprehensively and thoroughly if Mexico is to reduce its vulnerability during times of drought and flooding (Mexico News Daily, 2017a). It is not at all clear, at least at first glance, why a law of such import has been so readily ignored for so long when its implementation and enforcement might well be precisely what Mexico needs to ease its current water deficit. But what is unmistakably clear is that the country cannot begin to curb its water supply issues until such time as urban

distribution systems are improved and wastewater is better treated and reused to add to the availability of potable water for urban residents and business concerns.

As a further note of concern pertaining to the contemporary urban water supply problem in Mexico, it should not be overlooked that there are, within Mexico City alone, roughly 200 neighborhoods that rely upon the delivery of water by tanker trucks. The absence of a comprehensive, universal water distribution system means that struggling families are often forced to come up with crude and unsanitary means of recycling precious water, while critics charge that poor water management practices by the more affluent within Mexico City result in the waste of vast sums of water that could be used to nourish and aid as many as 4 million families (Mexico News Daily, 2017a). The foundation for this article has grown out of a preoccupation with why so many Mexicans must grapple with lack of water, and why the government seems incapable of resolving the crisis and the human health and development issues it spawns. Canadian technology firms that have looked into the viability of offering their services to aid Mexico are quick to note that Mexico's per-capita availability of water will drop markedly from 2007 to 2030 as a consequence of apparent technological shortcomings and because of poor water use efficiency and an exploding national population (Element Four, 2017). The background of this article is thus well-established and clear: it is a natural outgrowth of a burgeoning awareness that Mexico has a crisis on its hands that could prove devastating if more care and attention is not taken to institute best water use practices, to institute better water distribution systems, and to create a political and bureaucratic culture that actually protects and serves the basic needs of urban-dwelling Mexicans. Something substantive is long overdue.

The purpose of this book has, in many respects, been delineated in the pages above. But the critical thing to bear in mind is that it differs from many other treatments of this subject by exploring the situation in all 32 Mexican entities. In some instances, not much information is available publicly – or at least not readily accessible. Nonetheless, a state-by-state exploration of the situation can shed valuable light on promising practices that already exist within the Mexican context, and can go a long way towards highlighting how Mexico can use its existing resources to largely resolve its own problems without the recourse of having to rely upon outside help. As Herrera (2017) boldly asserts in her work on water politics and clientelism in Mexico, bolstering the water situation in urban Mexico does not have to be an insuperable problem. It will, though, require some courage and a fresh approach.

1. METHODOLOGY

Stated in brief, the methodology for this book is a systematic and thorough review of the existing literature for exposition into the prevailing water supply situation in all 32 Mexican entities. The predominant focus shall be upon the political and bureaucratic and technological reasons for any persistent shortcomings, as well as an inquiry into any progress that has been made in the various jurisdictions in recent years. As one might anticipate, not all of the Mexican states have a great deal of scholarly material devoted to them; to the fullest extent possible, their situation will be illustrated through resort to public documents and government materials, as well as to media stories depicting the state of affairs in each area. In any case, the methodology will cohere around finding the most recent scholarly materials (preferably peer-reviewed) and using them as a foundation for evaluating what Mexico is doing both right and wrong to alleviate its water concerns. This review of the literature, which will be informed by the theoretical models of Herrera (2017) and other academics concerned about Mexico's ongoing urban water shortage crisis, should successfully highlight some of the blind spots and shortcomings of the literature, while also calling attention to some possible resolutions and alternatives. Of particular note, brief case studies will be introduced where possible to show what can be done differently – or what is being presently done that offers promise for the future. In the final analysis, the literature does suggest that a Made-in-Mexico solution is very much possible.

2. THE LITERATURE: A LOOK AT EACH OF THE 32 MEXICAN ENTITIES (THE 31 FEDERATED STATES, PLUS MEXICO CITY), WITH A FOCUS ON WHAT IS BEING DONE, AND WHAT CAN BE DONE

2.1 Aguascalientes

Avelar González et al. (2011) write that the state of Aguascalientes has at least five aquifers: Aguascalientes Valley; Chicalote Valley; Calvillo Valley; Venadero Valley; and El Llano. The same group of scholars note that groundwater in the state is drawn from at least 2846 identified wells. Perhaps most significantly, the aforementioned Aguascalientes Valley aquifer appears to be the main aquifer for providing water to the state: it provides nearly 100 percent of the water for all sectors, and satisfies 100 percent of all urban and industrial water demand (Avelar González et al., 2011). This is a deeply problematic situation insofar the aquifer has, at least according to studies dating back to the early 2000s, shown manifest signs of being over-exploited: the average abatement of static levels is more than two meters overall per annum, while the annual average in the City of Aguascalientes being around four meters. As one might expect, the substantial over-exploitation of the aquifer has caused persistent fissures and subsidence, while also increasing the risk of infiltration of pollutants into the extant aquifer (Avelar González et al., 2011). A cursory review of the available evidence plainly shows that urban water supply in the state is frightfully precarious and could very easily descend into almost no water – or water that has been deeply compromised by pollution. The tapping of further aquifers or, more practically, better water management and reuse practices can ostensibly lead to the preservation of the Aguascalientes Valley aquifer.

At the same time, one cannot overlook the grim reality that even water reclamation and reuse projects will scarcely serve to improve things in Aguascalientes if the overall quality of tap water and aquifer water is not substantially bolstered. The available evidence suggests that policy initiatives in the state (especially in urban locations) have fall well short of desirable levels of competence and comprehensiveness. For example, the state of Aguascalientes has a grim history of very high chronic kidney disease rates amongst infants – especially in the municipality of Calvillo – that appears to be proximately linked to the high concentrations of xenobiotics, arsenic,

fluorides and metals in the drinking water (Arreola Mendoza et al., 2011). This is another contributing factor to relatively low levels of potable water access insofar as toxic and polluted water cannot, at least not at great personal risk, be consumed by humans. Once more, a more thorough and competent processing of water reservoirs needs to be formulated so that water resources can be utilized fully and to the salutary benefit of the urban populace of Aguascalientes.

Pressing forward, Aguascalientes appears very much to be a state that is blessed with adequate water reservoirs – at this time – but which seems to rely very heavily upon one main aquifer while falling short of purifying and treating water in a fashion that mitigates the threat of waterborne pathogens and disease. Still, the penetration of water service in the state, especially in urban locations, should be applauded: in the early 2000s, the OECD conducted a study of Mexico's prevailing water situation, and noted that more than 99 percent of all residents of Aguascalientes had access to public water, whereas the states of Veracruz and Guerrero had only 70 percent of their residents sufficiently blessed to have access to public water supplies (OECD, 2003). The infrastructure for public water delivery appears to be in place, but the state must do a better job of diminishing its reliance upon the Aguascalientes Valley aquifer, and it must accompany this with a better focus on purifying the water it does have. There is a foundation here, but one that must be nurtured and developed further.

Interestingly, before proceeding onward from our discussion of Aguascalientes, at least passing attention must be paid to the intermix of public and private water provisioning within the state of Aguascalientes. Pérard (2013) writes that the city of Aguascalientes does presently have a 30-year concession contract with private concerns whereby these concerns are charged with providing water to local residents. The privatization of water provisioning may well lead to greater efficiencies in terms of conveyance, but it may be asked if such privatization of the water supply has not also put in place the conditions for water supply safety and cleanliness taking a backseat to simply ensuring that the water infrastructure is profitable and delivers water in the amounts needed by businesses and residences. Whatever the subtleties and intrigues of Aguascalientes' approach to the dispensation of water, the alarming cases of CKD among children, coupled with the aforementioned high levels of metals and fluorides (Arreola Mendoza et al., 2011; Armienta, Rodriguez, Segovia, & Monteil, 2010), are a strong indication that the integrity of the water supply is of lesser import than economic and business objectives. At some point, local officials will need to confront this

state of affairs if they are to avoid a troubling human development crisis that will only exacerbate existing socio-economic problems within the state.

2.2 Baja California

The urban water supply situation in Baja California, is reflective of the broader difficulties that continue to bedevil water management and provisioning in Mexico. For one thing, urban population density in Mexico is quite pronounced; one study from several years ago noted that nearly half of Baja's entire state population was housed in the city of Tijuana, while all of the cities within the state – excepting Mexicali – have posted annual population growth averages in excess of three percent (Castro Ruíz, 2006). Increasingly, Baja California's total population is being clustered in the state's 39 border municipalities, a phenomenon which has been unfolding for many years (Castro Ruíz, 2006). Baja California, is thus a state that has no choice but to confront the nettlesome issue of how best to supply potable water to urban populations that are growing at an explosive rate.

The scholarly evidence, to the extent it exists, paints an unfortunate and sobering image of unfolding events in Baja. The urban water supply in the state is considered poor and this seems to be uniform with water across the state, wherever it may be found. Because compromised water is not easily made potable, a need arises for water to be imported from out of state – which drives up water costs. Despite this, the degradation of groundwater supplies in the state of Baja California, historically continued without stint (Michel & Graizbord, 2002). The water stress that this created is hard to exaggerate: between 1944 and the turn of the twenty-first century, the urban water allotment from the Colorado River for the state of Baja California, rose a remarkable 56 times (Calleros & Ramírez Hernández, 2003). It should come as no great revelation that, by the early 2000s, various urban communities in Baja were grappling with significant potable water shortages (Michel & Graizbord, 2002). If a state such as Aguascalientes largely has the architecture but not the capacity or will to keep its water supplies clean, then Baja seems to be a state that simply is not keeping pace with the dynamic growth of its urban centers.

One of the striking features of the urban water supply situation in Baja California, is that water importation is a staple of local water management and provisioning. The problem with this practice, sadly, is that constant water importation does more than just drive up the cost of water: it also contributes to the perpetuation of water despoilment and contamination locally. To this is added the additional stressor that constant water

importation makes it possible for more people to flock to burgeoning urban areas; in other words, the importation of water makes further residential and industrial expansion possible. But this expansion is unnaturally sparked by importing water from outside the state instead of safeguarding it within the state; the end consequence is that poor water management practices continue and they do at the same time as the population – and associated settlements – are exploding in areas that may well lack the auxiliary water architecture needed to properly sustain them (Michel, 2002). The long-standing practice of water importation seems indicative of a fundamental unwillingness to invest in the kind of sweeping water reclamation and reuse technologies and practices that might cut down on the very use of comparatively expensive imported water. Certainly, anything that can be done to recycle and conserve existing water supplies in Baja California, should be done as a means of nudging the state away from long-time behaviour that has proved both debilitating and despoiling over many years.

Examining the situation in brief, it seems as though Baja California, has failed to consider a number of viable alternatives for strengthening its water supply reservoirs and water management practices. For instance, scholars have argued for the plausible implementation of a number of alternatives that might well foster more resilient and reliable water supplies to the state's crowded urban areas. These include the following: idealized water markets; wastewater reuse (as touched upon above); seawater desalination; and infrastructural expansions. According to at least one study, enhanced wastewater reuse, coupled with targeted infrastructure expansions, makes the most sense and is the most economically and temporally viable. In particular, those in favor of such measures stress the value of creating a larger aqueduct that can better convey Colorado River water to the west. Desalination, at least at the time when these scholars were presenting their findings, is perceived as uneconomical because of water prices and the hefty associated operating costs (Medellín-Azuara, Mendoza-Espinosa, Lund, & Howitt, 2008). If history is any indicator, it is unlikely that the proper targeted infrastructural investments will be made, or that better conservation will occur: using the plight of the city of Tijuana as an example, water resource management here continues to persist in a linear, narrow process that does not take into account the social elements of water management. Furthermore, there remains marked inequality in the spatial distribution of water services, and little reuse of treated wastewater. All in all, a desperate need for long-term planning continues to be the status quo even though a need for precisely this is required to secure the city's water supply and water sustainability after 2020 (Navarro-Chaparo, Rivera, & Sánchez Benítez, 2015).

Baja California seems to be following the unhappy tradition of Mexican states that recognize a problem, but seem politically incapable of addressing it.

2.3 Baja California Sur

The urban water supply situation in Baja California Sur is often overshadowed by unfolding events elsewhere, but it is definitely a serious matter. The problem of water supply shortages – a problem not confined to the crowded urban centers of the state – is increasingly acute: according to Luber (2012), population growth in the state has outgrown the ability of state desalination plants and subterranean aquifers to furnish adequate supplies of water. Although comparatively well-off relative to many other Mexican states, Baja California Sur is heavily dependent upon the capricious tourism industry, and local inflation seems poised to also hamper how much the state can do to address its urban water shortages and numerous other domestic concerns (Luber, 2012). A local economy that is almost a monoculture in terms of its lack of diversity, outdated facilities, massive population growth, and a dearth of subterranean aquifers – these all tend to suggest that Baja California Sur is in the infelicitous position of having a waxing population, but not waxing resources with which to furnish its growing populace with the water it needs.

Other research in the past decade seems to reaffirm that Baja California Sur has significant and pressing issues. For one thing, the urban area of La Paz, Baja California Sur, has persistently been wracked by the hydrological service of the water supply being insufficient for the formidable demand of the human population (Balibrea & Davis, 2011). Research focused on coastal urban centers in the state reveals that Cabo San Lucas is one center wherein it is easy enough to find evidence that far too many have limited access to water and must rely upon relatively costly water trucks to meet their needs. More desalination facilities will not, in and of themselves, resolve the problem of limited water supply: the existing distribution system remains weak and underdeveloped, and problems such as systemic leakage continues to confound the locality (McEvoy, 2014). If nothing else, it seems rather obvious that addressing urban water supply shortcomings in this community – as in so many others in Mexico – requires a multi-pronged approach that encompasses infrastructural modifications and expansions, improved oversight and administration, more sustainable water management practices (chiefly entailing better water conservation efforts), and upgraded desalination facilities. There is water available, but it needs to be optimally treated and it needs to be conserved and recycled in a fashion that enhances accessibility.

Staying momentarily with the situation as it exists in Baja California Sur, it is worthwhile to acknowledge that there appears to be only one public desalination concession in the state – and that one is in Los Cabos. There have been proposals for an additional desalination concession in Los Cabos, and there has been a proposal for an initial concession in La Paz. However, it seems as though these initiatives have been stalled as of late (Aranda Martínez, Muir, & Leinweber, 2014). Ironically enough, while a greater desalination network has been advanced as one way of enhancing water accessibility in arid Baja California Sur, there is something jarring about the expressed need for such a system when many marinas, private golf courses, and upscale hotels in La Paz (and evidently elsewhere in the state), do have desalination and wastewater treatment facilities (Aranda et al., 2014). There is something incongruous about the fact that private entities can have the very facilities that the wider public needs, but the state cannot provide comparable facilities to the general public. The answer lies in either making possible more private concessions, or creating an architecture whereby private concerns make available their desalination and treatment facilities in exchange for state gratuities, tax breaks, or special contracts. Once more, the technology that could be pressed into service to make the urban water supply in Baja California Sur more available and sustainable does exist; what does not exist, it seems, is the political will – or amity and shared enthusiasm – to make it all work out in a productive fashion.

2.4 Campeche

In this particular state, water tariffs for supply and sanitation do appear to be quite modest: a study penned by the OECD at the start of this decade underscored that the city of Campeche had the second-lowest water tariffs among all major Mexican cities as of 2010. The felicitous situation in Campeche also highlights that regulatory oversight of water tariffs varies considerably from city to city in Mexico, and the end result is that water operation and recovery costs are considerably higher in some regions and urban centers than in others (OECD, 2013b). While the city of Campeche should be lauded for making water relatively more cost-accessible, its predominant place in this domain also calls to mind the extraordinary lack of comity that exists within Mexico vis-a-vis water administration and regulation.

The OECD, while singling out Campeche for its success at keeping costs down, is not unafraid to note when the state is faltering or not meeting international standards. For instance, a 2013 study carried out by the OECD (a different one from the one described in the preceding paragraph), went to

lengths to emphasize that, over the ensuing 20 years, Mexico will have to provide a further 36 million inhabitants with drinking water and 40 million with sanitation services. The states that are most vulnerable to explosive population growth overwhelming urban (and rural) water supplies and sanitation infrastructures include among their ranks the state of Campeche (OECD, 2013a). While Campeche is doing a good job of keeping accessibility costs down, it seems to be less successful at crafting a forward-looking infrastructure plan that will accommodate the millions of new inhabitants that will swell its largest urban centers over the next generation. This ties in, of course, with the broader theme of Mexican policy makers not looking ahead sufficiently to what needs to be done to ensure that the water supply is not compromised by over-demand.

If available sources are correct, Campeche state has long received most of its water from the Santa Rosa aquifer and from urban wells; in fact, these sources comprise nearly 70 percent of the total water supply in Campeche. However, what has changed in the past decade is the serious and steady degradation of the groundwater supply within the state. The marked decline has led to calls for new and diverse water resources, and this has sparked a proposal for the creation of a costly Hobomó-Campeche aqueduct that would supply water to Campeche municipalities along the length of its 26 kilometers (Alonso, 2015). None of the extant media sources indicate that this proposed aqueduct has ever been completed, even though the national water authority (CONAGUA) broached the topic more than 2 years ago (Alonso, 2015). Overall, it may be said that the urban water supply situation in Campeche is marked by relatively good cost accessibility, but relatively limited infrastructure desperately in need of new extensions, and groundwater reserves that are increasingly degraded and problematic.

2.5 Chiapas

Chiapas appears to be one of the worst Mexican states when it comes to water supply provisions and the coverage of its infrastructure. A study by Barraque (2011) points out that, whereas a state like Colima had 98.3 percent of the total population served as far as water is concerned by 2005, states like Chiapas, Guerrero, Oaxaca, Tabasco and Veracruz all lagged behind with “between one-quarter and one-third of the population unserved” (Barraque, 2011). This is a rather massive deficit, and calls to mind the debilitating human development problems that can arise when children and youngsters are deprived of the appropriate amenities and fundamental protections early in life. Chiapas seems to be among the worst of all Mexican states in granting water coverage, and this suggests either human resources (lack of expertise)

and a political (lack of will or foresight) problem, or a financial problem. In all likelihood, the matter has been caused by a mix of all three.

When seeking to explain how a state with considerable water resources – Chiapas produces 30 percent of Mexico's water and the Grijalva River, one of the largest of its kind in Chiapas, has the capacity to supply 40 percent of the country's hydrological power (Wilson, 2014) – can struggle to provide proper nourishment to so many people within its teeming municipalities, it is worthwhile to illustrate that the state is marred by extremes of wealth and poverty, just as Mexico is likewise marred by such extremes. Indeed, while Mexico has some of the most well-developed and affluent communities to be found anywhere in the world, it also has extraordinarily poor regions that compare unfavorably with Sub-Saharan Africa. As it stands, the ten lowest-ranked municipalities in a study of socio-economic prosperity and wealth in more than two thousand municipalities in Mexico were invariably found in the impoverished and substantially rural states of Oaxaca, Chiapas and Guerrero. It cannot be lightly passed over that all of these states are situated in southern Mexico, a region long viewed as being Mexico's poorest (Ai Camp, 2017). If the tax base is barren, if those inhabitants residing in Chiapas's urban communities cannot afford local or state water tariffs, then two things are sure to arise: 1) the wealth needed to bolster existing water supply infrastructures is not going to be present; and 2) an appreciably significant portion of the local population is not going to be able to afford the costs of accessing water or having it delivered directly to them. There does not appear to be an easy resolution to this crisis, but surely some kind of exchange can unfold between north and south, between Chiapas and wealthier states, so that infrastructural extensions and subsidized water use for residences can be realized. The fact that such disparities exist within Mexico is deeply troubling.

2.6 Chihuahua

About Chihuahua, it is vital to commence by highlighting that the state does experience high levels of arsenic in its water courtesy the interaction of the water with Cenozoic volcanic tuff and, ostensibly, from lacustrine sediments. The El Mimbre area seems especially vulnerable to the aforementioned interaction, and it happens to be one of the zones that supplies potable water to Chihuahua City (Armienta et al., 2010). Thus, we can immediately identify that the distribution and water treatment infrastructure or network of Chihuahua State does not have the capacity – or certainly did not have the capacity at the start of this century – to appropriately cleanse potable water

of arsenic admixtures. The human toll this can potentially exact is hard to ignore or minimize.

Additionally, Chihuahua appears to have extreme challenges that are amplified by the demands of local agricultural production and the proximity of the state to the United States of America and a covetous Texas. To elaborate, the city of Ciudad Juarez, Chihuahua, is nestled within the Paso del Norte region that includes the American city of El Paso, Texas. The two above-mentioned cities, and Texas and the state of Chihuahua in a larger sense, are battling over water reserves that are already scarce: the competition for water is intense, agricultural production is unceasing and intensive, upstream surface water irrigation cuts down on downstream flow and degrades downstream water quality, and the extant Mexican water infrastructure tools and networks – to say nothing of the resources available to Mexican states to harvest and exploit water optimally – pale alongside the resources and tools available to their American neighbors and rivals (Turner, Hamlyn, & Hernández, 2003). Against this backdrop, any groundwater that falls in contested land is much more likely to be diverted to the American side of the border. Moreover, the state of Chihuahua, if the preceding source is correct, is not well-positioned to take advantage of any overflow water or novel water resources because its infrastructure for providing water to inhabitants remains distressingly in arrears of where it should be. The state of Chihuahua finds itself in a position wherein it has a growing population (City Population, 2015), and growing needs, but it must battle for invaluable water resources with a powerful northern rival unlikely to be accommodating.

Last of all, time must be set aside to discuss the matter of pollution and water despoilment one further time. As discussed earlier, high arsenic levels are a serious concern in Chihuahua and greatly cut down on the amount of actually potable water available to citizens. But elevated fluoride levels are also problematic, and Chihuahua is one of those Mexican states that does seem to be wracked by this recurrent issue (Jiménez Cisneros, & Rose, 2009). Urban water supplies in Chihuahua may well be more plentiful than in an impoverished state such as Chiapas, but the extent of despoilment because of fluoride and arsenic infiltration means that health maladies and complications are still far too common and can still lead to various tragedies in the realm of human development and social well-being. Once again, something plainly needs to be done, and that something is likely connected to new filtration tools and reclamation tools that can cut down the presence of both of these toxic elements in the drinking water of Chihuahua's urban residents.

2.7 Coahuila

Coahuila struggles with the same water shortage issues that afflict other states in Mexico. For example, the town of Muquiz, in Coahuila, actually guards a cave spring that serves as a vital part of its potable water supply (Minckley & Deacon, 2017). This seems a rather impressive measure to take for just a cave spring, but it is indicative of the precious and finite nature of water resources within various parts of the state. Chiefly, online reports reveal that local aquifers are degraded as a consequence over-exploitation. This excess harvesting has produced significant saline intrusion while also sparking a disturbing infiltration of arsenic into water intended for human consumption. The latter problem is especially pronounced at Laguna, Coahuila (Explorando México, 2016). Inhabitants of Coahuila clearly face not only limited water options, discussed in greater depth below, but also dirty water that may well be toxic in numerous instances.

A study released in 2015, readily available online, reminds readers that more than half of allocated water use in Coahuila comes from groundwater – with by far the largest user of ground and service water being the agricultural sector. Fresh water is so scarce in Coahuila that the Mexican government has already made it manifestly clear that it will not issue new groundwater use permits for oil and gas development. Coahuila tends to be a very arid area that does not have a teeming number of aquifers. There is virtually no surface water in Chihuahua because of the spread of the Chihuahuan desert and the state receives only about 12 inches of rain annually – and this according to CONAGUA. And Chihuahua is the second-driest place in Mexico and ranks with the Arabian Gulf and Egypt as one of the driest places on earth. Yet, despite all of this, the aforementioned study stresses that Coahuila's cities consume 49.1 billion gallons of water annually (Schneider, 2015). An arid state with problems cohering around high arsenic content and stressed groundwater supplies is probably the best example extant of how difficult climactic conditions, limited resources, and growing demand collide in a fashion that is potentially devastating to human growth and development.

2.8 Colima

Amgonst Mexican federal states, Colima actually appears to rank highly when it comes to urban water supplies and services. According to Barraque (2011), Colima had the best water coverage of any state, with more than 98 percent served by 2005. Although a specific breakdown is not offered, it is believed

that Colima's urban populace essentially receives universal coverage (Barraque, 2011). However, in what seems like somewhat of a contradiction to Barraque's optimistic assessment Cecil (2007) argues that smaller urban communities – especially those located in relatively mountainous areas, such as the community of El Terero – do struggle with ensuring appropriate levels of potable water. Thus, strong inequalities exist within Colima when it comes to water access, as they do in the rest of the country. Overcoming such inequalities can start by making it possible for all members of local society to have access to suitable amounts of water.

2.9 Durango

All of the states in the Lagunera Region (Chihuahua, Coahuila, Durango, and Zacatecas), have elevated levels of arsenic in their surface waters (river waters). Indeed, water supplies containing levels of arsenic greater than 50 ug/l have been identified in Durango, as well as in the other above-mentioned Lagunera states (Murcott, 2012). Thus, even if water supplies were plentiful in the state, the fear of contamination and toxicity would be well-founded. At the same time, the state is considered to be low in population density (International Business Publications, 2010) and this certainly does help reduce the demand placed upon water resources – at least when it comes to residential water use. Although the available data is imprecise, and some of the scholarly material not especially well-written, it does seem as though there are more than 2500 tubewells in the Lagunera Region Irrigation District – which does include Durango (Hearne, 2007). This information is somewhat dated, however, but the implication appears to be that a great deal of water in Durango is set aside for agricultural pursuits and not for urban residential use.

On balance, surface water does appear to play a sizable role in providing water to the inhabitants of Durango. To give an example of this, consider the City of Durango, a large municipality which has historically drawn heavily for its water upon the Animas and Florida rivers (United States Environmental Protection Agency, 1981). In light of the unstable nature of surface water reservoirs and resources in areas marked by high aridity and harsh temperatures, and in light of the high levels of arsenic found in the region, one may conclude that Durango (both the city and the state) seem to face two serious issues: their water supply cannot be guaranteed to meet the needs of a burgeoning population; and the arsenic content in the available water – and the ostensible inability to screen out this arsenic – means that significant health complications and debilitating outbreaks of arsenic-related

illness or morbidity are an ever-constant threat. Durango seems to be in a very precarious position, indeed.

2.10 Guanajuato

An online article appearing at the end of 2013, penned by Molly Peterson, informs readers that more than 20 percent of Mexico's wells are situated in Guanajuato. This includes thousands of wells in the Silao-Romita aquifer. However, while the initial statement suggests a positive state of affairs when it comes to urban dwellers in the state, the reality is that much of the land housing these wells is actually sinking. Consequently, it appears as though this unusual occurrence is sparking deeper and deeper water drilling in the area. Unfortunately, the deeper that the drilling goes, the more water is uncovered that is despoiled by heavy metals found in the rocks nestled at such subterranean depths. Still, as the strain on shallower wells increases, the need for these deeper resources becomes more pressing. This inevitably means a local population that must rely upon water that is despoiled and even potentially toxic. Some have even gone so far as to argue out-migration from Guanajuato has been precipitated by an acute shortage of water, though much of the evidence for this does appear to be anecdotal (Peterson, 2013). What Guanajuato needs to do is to diversify its water supply – but, absent appropriate groundwater, that could mean costly importation from outside the state. Still, desalination and water reclamation technology could stretch the available potable water and allow the state to avoid relying upon subterranean water reserves that are simply not reliable or even especially safe.

Staying momentarily with the city of Guanajuato, it does seem that the water used by urban residents comes from more than deep water wells. At least in the City of Guanajuato, a regional watershed provides both surface water (found in two principal reservoirs found in the upper part of the watershed) and groundwater pumped from an aquifer situated in the central part of the watershed. It seems as though wastewater is discharged by the city into the downstream part of the watershed. Water levels appear to be fairly low most of the time in this vital water resource area, and this is most markedly exhibited by the Purisima Reservoir, which is commonly used (because it receives wastewater from the City of Guanajuato) to service agribusinesses desperately in need of water for their irrigation networks (Scott, Zarazúa, & Levine, 2000). Guanajuato is an agricultural state that has severe water needs; but it is also, sadly, a state with a water table that apparently drops by at least six feet a year (Brown, 2012). At some point, manifold alternative policies need to be explored. And those policies surely must include water

importation of some kind and desalination projects and facilities (along with water reclamation infrastructures) that allow for enhanced water use efficiency.

2.11 Guerrero

Among the many federated states of Mexico, Guerrero is perhaps the one that has seen the least scholarly attention devoted to its water supply problems – at least in the view of this observer. Be that as it may, Guerrero has a population of roughly 1.3 million people who lack access to a household water supply; the total above constitutes approximately 40 percent of the total population of the state. The limited and diminished water infrastructure has been further eroded by recent weather catastrophes – such as Hurricane Ingrid and the tropical storm, Manuel – which wracked the coastal state almost simultaneously in 2013. It seems as though state water infrastructures have still not recovered from the ravages of these two extreme weather events, and the situation has been so dire that even cash-strapped CONAGUA has found it imperative to assist in the construction of water and sewage networks in the state. In particular, the federal water agency has joined with local authorities to bolster the state's potable water infrastructure and its struggling sanitation infrastructure – and not merely in the crowded urban areas of the state. CONAGUA has also apparently agreed to provide much-needed maintenance for the compromised water treatment plants of Guerrero (Alonso, 2016b). While Guerrero has a modest population, and is rather marginal when compared to more teeming states with bustling metropolises and dynamic local industries, the problems the state has with water management and water supply is indicative of a larger issue that is confounding Mexico at present: the country simply does not have an infrastructure that can meet its commercial, manufacturing, agricultural and residential needs. And, worse than this, any such infrastructure appears cruelly vulnerable to natural disasters and to changing circumstances. CONAGUA may be able to help here, but it is an open question whether what it does in Guerrero will really prove lasting and substantive – and whether or not any positive progress can be transplanted to other states in the country.

Despite the understandable gloom that swirls about the current situation in Guerrero, there is a definable effort being made on the part of the federal government of Mexico to make the situation more palatable. Chiefly, President Enrique Pena Nieto has made it clear that his government is committed to, and has ostensibly already begun work upon, crafting public works that will improve the water infrastructure and water supply for the

state of Guerrero. Of especial interest, Pena Nieto's government has pledged to create a better water supply for Acapulco and for Chilpancingo – two major urban areas nestled in Guerrero – in the near future (Presidencia de la República, 2017). There is, therefore, some hope for the future. But it is not uncommon for governments to make promises and then retreat from them, and Guerrero's long journey towards a more sustainable water supply and a better future promises to be a long one, indeed.

2.12 Hidalgo

Historically, the state of Hidalgo has been wracked by water conflicts over the relatively modest water resources available, and the need to satisfy the imperatives of business, agribusiness, and residential lobbies and users. Barraque (2011) describes Hidalgo as being one of the jurisdictions in Mexico that faces both the legacy of historic conflicts over water use and reclamation/diversion, and the grim specter of further conflicts in the future. To give an idea of the long history of this unsettling tension, consider that, during the tumultuous late 1980s and early 1990s, there were at least 13 water conflict events in Hidalgo – though this number is surprisingly low when compared to other federated states in Mexico (Barraque, 2011). Nonetheless, the likely simmering tensions make it unlikely that there will be unified and concerted cross-sectoral and multidisciplinary efforts to resolve infrastructural issues that continue to plague the state.

Another issue, at least as far as urban water supply is concerned in Hidalgo, is that waterways and reservoirs that might be used for urban use are, instead, used as repositories for biological waste and despoiled water. For instance, much of what gets flushed down Mexico City's toilets ends up in the rivers and reservoirs of the rural Mezquital Valley, where it is subsequently used for irrigation purposes (In Mexico, fears a new plant will kill wastewater farming, 2017). Although the use of such water for irrigation is laudable and certainly a form of recycling, it is regrettable that a more comprehensive water reclamation and reuse infrastructure has not been in place historically to divert at least some of the aforementioned wastewater back to urban metropolises. Be that as it may, 2017 has borne witness to the first tangible efforts to erect a new $530 million water treatment facility, the Atotonilco plant, in Hidalgo. Although a major, and overdue, undertaking, many farmers in Mezquital Valley, Hidalgo, have expressed unhappiness at how the new treatment plant will take away their access to the raw sewage that has provided them with fertilizer-rich water for generations (In Mexico, fears a new plant will kill wastewater farming, 2017). Clearly, both sides need to come together and reconcile their frustrations and suspicions. Moreover,

it is manifest that wastewater farmers – and the state – must consider new diversion practices and farming practices (such as crops used) so that agribusiness in the state is not so dependent upon gravely compromised and potentially toxic wastewater. As a side note, a key reason why the wastewater from Mexico is so prized is because it does seem to offer an excellent source of nutrient-rich fertilizer, and it does seem to boost household incomes: the large Mezquital Valley, home to nearly half a million inhabitants, has a comparatively high standard of living, and those agriculturalists with direct access to the wastewater have a higher average income than those without (Romero-Alvarez, n.d.). There is money at stake in this battle, and that means that urban Hidalgo residents may prove the ultimate losers.

Additionally, it cannot be passed over lightly that 70 municipalities, from the states of Hidalgo, Mexico, and Tlaxcala, are included in the sprawling Metropolitan Zone of Mexico City (MZMC). The state of Hidalgo has even gone so far as to propose plans to incorporate 29 further municipalities within the state as part of the MZMC. Unfortunately, it seems as though having so many municipalities incorporated under the massive umbrella of the MZMC means that the resources of the extant Metropolitan Fund will be spread even thinner – which essentially means that water resources and basin levels could be even further mismanaged (Morales Novelo & Rodríguez Tapia, 2011). In the end, Hidalgo seems to be a state in which the urban water supply is bitterly contested, fought over by many parties, and endangered by the absence of twenty-first century infrastructure and political comity.

2.13 Jalisco

In Jalisco, the state of the urban water supply is most tellingly highlighted by problems in Guadalajara, the second-largest city in Mexico. The city has seen explosive demographic growth in recent years, with the existing infrastructure unable to keep up with demand. Further, the local Lerma-Chapala River Basin is a source of water for a substantial portion of Guadalajara's residents. Unfortunately, the water basin is massively over-committed, with total water depletion exceeding supply by an average of 10 percent by the early 2000s (Bertrab, 2003). Again, there is the over-mining of a finite water resource that is made worse because of a population that grows inexorably in Mexico's largest urban centers.

Others who have studied Guadalajara in more recent years, and who have been unafraid to link it to Mexico's poor water management practices, emphasize that Guadalajara has been seeking (not entirely with success) to

cut the volume of water used in its precincts. But the problem continues – a waxing population has a tendency to do as much – and it is made worse because poor water management has made proper pollution control impossible (United Nations Human Settlements Programme, 2013). Jalisco thus seems to a situation wherein whatever water that might otherwise be used for human consumption and residential use is fatally compromised because it has not been properly treated – or conservationist and eco-friendly policies and best practices have not been initiated that would otherwise prevent the pollution of surface waters and resources. In this regard, using Guadalajara as an example, Jalisco seems to be the author of its own demise.

2.14 Mexico

The state of Mexico is densely populated and the most populous federated state in Mexico – at least per 2010 Census data (Geo-Mexico, 2010) and it is perhaps here where the matter of water shortage is most conspicuous because of that substantial population and the insistent need to provide it with appropriate stores of potable water. To give an example of the problems bedeviling the state, consider that the Valley of Mexico and Panuco River Basins – which both spread across the state of Mexico, as well as a few other Mexican states – there are an estimated 200 or more wells that are contaminated by untreated wastewater originating from the industrial areas of Mexico City. This contaminated water has grossly impacted a number of Mexican urban communities, and the Mexican state cities of Chiautla, Ecatepec, Jatlenco and Coyotepec have been especially hit hard (OECD, 2013b). Right away, it seems evident that the state has not done a good job of establishing water treatment facilities that can cleanse this water and prepare it for use by the large urban populace of the jurisdiction.

Brackish water definitely appears to be a sizable issue in Mexico State. Water and drainage facilities are considered inaccurate, with complaints that the water for urban residential use is not only unavailable during large stretches of the day, but that the water is often undrinkable because of unclean piping systems. There is some evidence, though, that major extensions to the existing infrastructure are now underway (Pacione, 2013). The absence of potable water does seem to be a long-term concern that Mexico State has not satisfactorily addressed. That contaminated wells should continue to be an issue is a vexing indication of the failure of state and federal authorities to find the resources and tools to create a sufficient array of modern treatment and reclamation facilities.

2.15 Michoacán

To get started, there seems little controversy in stating that urban water supply issues in Michoacán are very much shaped by CONAGUA and its activities. For instance, it is reported by the OECD (2013b) that bulk water services in the state are provided by CONAGUA via the Lazaro Cardenas aqueduct. However, CONAGUA does charge tariffs on the above-cited service, and it appears as though the Lazaro Cardenas aqueduct is a major source of revenues for the federal budget (OECD, 2013b). Thus, any complaints on the part of urban water uses or property owners about tax levels are likely to be ignored: as long as the aqueduct offers financial nourishment to the Mexican government, any complaints about the cost of water use will most likely be conveniently ignored.

Treatment plants, clearly a vital necessity when water designated for urban use is being drawn from subterranean depths or from surface water (or being drawn from reservoirs containing water previously used for industrial or residential use), are an area of policy and implementation that has not always produced positive outcomes for the State of Michoacán. For instance, it is stated by observers that treatment plant initiatives have given only limited results. Part of this, it may be argued, is because many of the plants are clustered in the Lerma Basin, with treatment plants particularly situated in the municipalities of Brisenas, Jiquilpan, Sixto-Verduzco, La Piedad, Quiroga, Sahuayo, and Pastor Ortiz. As well, three of the plants first established more than a generation ago to combat brackish or contaminated water do not even work anymore (as of 2011): La Piedad, Sahuayo, and Pastor Ortiz (Peña, 2011). Once more, we see evidence that Michoacán is yet another Mexican federated state wherein water quality falls far short of what is needed to ensure a plentiful supply of potable water for urban residents. It is a grimly troubling matter that needs to be addressed, though it is not clear what changes in policies, funding and regulatory practices will be needed to arrive at a positive outcome.

2.16 Morelos

The OECD (2017) is quick to apprehend that the two most intractable problems facing Morelos are the following: 1) the inability to distribute clean water; and 2) the general lack of water in general. The state ruefully acknowledges that the two broad problems above can be broken down further into smaller issues that all contribute to the general lack of water for urban and residential users: 1) the lack of protection for supply sources; 2) water losses (seepage) within the distribution system; 3) and the lack of

coverage (including non-existent coverage) in areas that are relatively isolated (OECD, 2017). To its credit, however, Morelos has gone further than most Mexican states in doing what it can to improve the situation.

Notably, whereas there were once only 22 sewage treatment plants in Morelos in 2012, there are now 43. There has also been the construction and extension of sewer networks to better capture wastewater flows and direct them to the proper treatment sites. The urban water conveyance network has also been expanded in Morelos in the past few years, along with general conveyance of potable water, so that the percentage of Morelos's inhabitants who have access to drinking water has increased from 86 percent in 2010 to 94 percent by 2016. Finally, a further 133,000 additional people have been added to sanitary sewage services in Morelos, thus making it possible for 96 percent of the state's population to have sanitary sewage service coverage as of 2015 (OECD, 2017). If nothing else, this is one Mexican state that has shown that, when there is a willingness to move discretionary funds to projects aimed at mitigating water supply issues, some constructive steps can be taken. It is a model for the rest of the country.

2.17 Nayarit

About Nayarit, it is vital underline that some forward-looking efforts have been undertaken in recent years. For example, 2014 witnessed CONAGUA announce investments in a new wastewater treatment plant, an array of rainwater collection systems, and new storm sewers for the Riviera Nayarit. Ironically, while there is an acknowledged concern about the quality of water in Nayarit, it seems as though the movement towards more comprehensive water treatment was largely precipitated by a concern for upgrading and bolstering the tourism and hotel sector (Puerto Vallarta Angels, 2014).

Nayarit, as is true for so many Mexican states, has a serious water deficit problem (isciences, 2017). Thus, the water supply for urban dwellers is modest at best, and strained (or perhaps not even present) in the worst-case scenarios. The initiatives above are wonderful, but it is striking that so much attention has been directed towards the Nayarit Riviera and hotel and tourism sector: the 2014 CONAGUA water supply investments seem more preoccupied with ensuring that the hotel industry is not further inconvenienced than they were ever preoccupied with the nettlesome difficulties complicating life for urban residents in less-affluent areas. A change of focus towards the latter seems like the least that should happen in Nayarit at this point in time.

2.18 Nuevo León

In Nuevo León, there has been a recent effort to update and extend water and sewage services in Nuevo León. In particular, May of 2016 saw CONAGUA and the governor of Nuevo León, Jaime Rodriguez, sign an agreement that would see efforts to bolster water reclamation facilities and conveyance tools for potable water and for water earmarked for agricultural pursuits. At the same time, the drainage and sanitation network would be significantly upgraded, though CONAGUA's Director, Roberto Ramirez de la Parra, declined to outline the cost involved in modernizing the water infrastructure of the northern state (Alonso, 2016a). While welcome, Nuevo León is actually in the vanguard of Mexican states insofar as it actually suffers far less from water impoverishment in its urban centers than most of the rest of the country: according to a recent report, only about 4.2 percent of the state population lacks access to household water supplies, or about 200,000 people (Alonso, 2016a). This is fairly impressive water coverage by Mexican standards, and indicates that Nuevo León, perhaps because it is a northern state and therefore has access to manufacturing and export dollars not available elsewhere, is better at addressing its urban water supply needs than most other jurisdictions in Mexico.

Still, there are challenges. Research conducted over a period of years reveals that the state capital city of Monterey relies heavily upon three water basins within the Sierra Madre Oriental: The Santa Catarina River Basin; Basin of the San Juan River and La Boca Dam; and the Basin of the Ramos and Pilon Rivers. This sounds like a sufficient storehouse for a city such as Monterey, but the reality is that the region is quite arid and is increasingly populated and industrialized. As such, pressures upon water supplies have increased robustly in recent years. Moreover, many of the deep wells drilled in the 1970s (a decade which seems to have been marked by an aggressive pursuit of better resources for Monterey and the surrounding area), simply came to naught: 18 of the 41 deep wells struck in that decade never drew water, or only drew water for a brief period of time (Oesterreich, Medina Aleman, & Martinez de la Cerda, 2002). From this, we may divine that, while the area has shown itself to be progressive in some respects, it is blighted by failed wells, by compromised or impoverished groundwater reserves, and by the usual crush that accompanies the weight of a growing population and bustling business enterprises. Fortunately, Nuevo León does appear to be pointed in the right direction.

2.19 Oaxaca

Like Nuevo León, Oaxaca has shown an ability to look ahead and to prepare the state for the water challenges of the future. For instance, acknowledging its own vulnerable position, the Government of Oaxaca prepared a Strategic Plan for the Water Supply and Sanitation sector; this plan was part of a larger governmental blueprint for state development that was to cover new evolutions and developments within the state in the years 2011-2016. Essentially, the plan cohered around expanding assess to water and sanitation and sewage services in urban areas; improving water service quality and financial sustainability vis-a-vis water utilities; ensuring an increase in wastewater treatment coverage; and expanding water and sanitation/sewage coverage and services in the rural hinterland (The World Bank, 2014). As of 2012, challenges still remained in terms of guaranteeing a measure of water coverage to everyone, but Oaxaca has mitigated the issue by allowing ample space for NGOs to also offer their expertise to bolstering the water supply: Water for Humans, for instance, has devoted itself in recent years to such projects as a large rainwater catchment system for the Bravo Ahuja District of Oaxaca, while also overseeing and shepherding a wetland for sewage treatment in Santo Domingo Barrio Bajo Etla (Scaff, 2012). The incontrovertible message to other Mexican jurisidictions appears to be this: creating a plan for the future is quite advisable, but drawing upon the expertise and accumulated skills of foreign and domestic NGOs can also be of great import in making water more accessible to urban dwellers – and anyone else.

A last point to be raised is a somewhat more sobering one, alas. Chiefly, while Oaxaca has done a good job of planning for the future and for taking measures to bolster its reclamation capabilities, the lack of groundwater resources, combined with regional aridity, has definitely placed the state in a parlous condition vis-a-vis water supply. Most of all, Oaxaca's state water utility has spent recent months desperately seeking funds and assistance from CONAGUA to aid it in its difficult battle with a severe drought that has markedly reduced the water supply (Rodriguez, 2017a). As long as Oaxaca lacks effective deep wells and plentiful aquifers, it seems as though it will always be cruelly susceptible to the social harms occasioned by severe drought.

2.20 Puebla

In 2013, the OECD furnished a report on the status of the urban water supply in Puebla, Mexico. The study found that demand for a suitable and secure water supply has dramatically increased in Puebla in recent decades because of the growth of the population and because of the maturation of the industrial sector. The groundwater sources needed to fuel this growth, however, are increasingly coming under terrific stress because energy subsidies allocated to agribusiness operations have – in part – sparked an overuse of the water and worked against conservation policies and undertakings. The decline in water precipitated by such overuse has led to growing pumping costs, to diminished water quality, to debilitated wetlands, and soil quality that has been severely compromised (OECD, 2013c). Suffice it to say, Puebla is fast becoming what too many other Mexican states have become: a region in which water is not sufficient, general practices are poor, and the cost of extraction much too high.

The urban water supply in Puebla is most certainly not one that can be described as safe and secure. Puebla suffers significantly because a long legacy of clear cutting has removed (in large measure) the ability of cascading water to seep into the ground. Meltwater stores have also diminished, and the substantial Rio Atoyac has become one of the most contaminated and polluted waterways in Latin America. To this unhappy state must be added the disquieting fact that the city of Puebla has a population of two million – and growing. It also has a growing manufacturing base, most notably in the form of the large Volkswagen plant that is a major employer in the area, and manufacturing pressures are already building on groundwater reserves that are not considered plentiful or sufficient (The Global Compact, 2010). In the end, there is hardly any question that Puebla is in the infelicitous position of having compromised water resources that are further depleted because of errant and inappropriate water usage practices.

2.21 Querétaro

One of the best ways of examining the state of affairs in this somewhat underappreciated Mexican state is to briefly contemplate current events in the City of Querétaro, its most significant urban center. Manifestly, what is clear is that the city relies very heavily upon what seems an antiquated water conveyance apparatus: the water supply is provided by the Querétaro River and conveyed by a colonial overhead stone aqueduct; it enters Querétaro via the elevated east end of the city (Schlarman, 2013). Right away, the

inescapable fact is that Querétaro is a large urban cluster of residences and businesses that seems to draw far too much upon both the Querétaro River and an aqueduct conveyance that seems conspicuously behind the times.

As the most populous urban settlement in the state of Querétaro, the City of Querétaro is quite remarkable for the things it does not do, apart from whatever it may do. The most pertinent non-action, for the purposes of this book, is the city's inability to craft a workable and sustainable water reclamation system. For example, an OECD study of approximately three dozen major international cities around the globe found that Querétaro City ranks near the bottom in terms of the percentage of wastewater produced by the city that is subsequently collected and treated to at least a basic or primary level (OECD, 2016). Sadly, of the cities that rank below Querétaro, all five of them appear to be situated in Mexico (OECD, 2016). Although this state is easy enough to overlook when surveying events and trends within Mexico, it sadly appears as though the State of Querétaro is laggard in crafting an architecture that will safeguard its water supply and make the most out of the water that is available to it and its inhabitants.

2.22 Quintana Roo

Quintana Roo is notable as a tourist hotspot of some renown. However, the growth of the tourism sector has aggravated an underlying trend of agglomeration, or large numbers of people clustering in various urban locales which might be ill-prepared to handle their numbers. It is stated by close observers that the rapid growth of tourist activity, coupled with a concomitant explosion in the population around such areas, has resulted in uneven and even slovenly urban development. Quintana Roo is described as crafting enormous construction projects without consideration for the fragility of the indigenous ecosystems. There has been, courtesy rapid and overweening development, serious damage done to the underground water supplies, and both Playa de Carmen and Cancun are hobbled by serious water shortages and water impoverishment in some parts – to say nothing of a lack of sanitation and basic services in less-affluent parts of both urban communities (Morlet, 2014). Seen against this backdrop, it is plain that Quintana Roo is very much a state that seems in accord with other Mexican states insofar as it has urban populaces that seemingly are not furnished with the water, and accompanying services, they desperately need.

2.23 San Luis Potosí

San Luis Potosí is a good example of a state that has fought a frequently losing battle with poor water supplies because of its own haphazard management and lack of synchronous and concerted policy direction on the matter of water service and security. There is cause for optimism, however: the local water provider, Interapas, has undergone management changes and the state has worked hard to identify alternative water supplies from local catchments. Moreover, it seems as though San Luis Potosí has tapped into the El Realito Dam bordering the adjacent state of Guanajuanto. However, wastewater and stormwater reuse are still laggard, and the jurisdiction has also been laggard in pursuing the idea of using stormwater in a recycled format to meet less-quality functions such as toilet flushing or aquifer recharge. Finally, the state has been slow to map aquifers on the basis of pollution vulnerability, and has fallen unsatisfactorily short of rehabilitating and extending its urban sewer networks (Martinez, Escolero, & Kralisch, 2010). Until these measures are wholly embraced and fully implemented, San Luis Potosío – and, especially, the San Luis Potosí Metropolitan Zone – will continue to struggle with water security and gratification.

San Luis Potosí has no place to run from the water supply and integrity issues that seem to pervade the administrative and urban landscape of Mexico. A study presented by the Geosciences Center of the National Autonomous University of Mexico finds that concentrations of arsenic and fluoride in underground water resources in San Luis Potosí, as elsewhere in the country, have climbed substantially. Subterranean aquifers within the state of San Luis Potosí are also marred by very high levels of salinity (Mexico News Daily, 2015). Come what may, there is no doubt that San Luis Potosí is yet another Mexican state that cannot prevent the seepage of noxious elements into its table water and aquifers, and this seems consonant with the aforementioned complant of scholars such as Martinez et al. (2010), that the state has not taken the time to invest in new technologies that can advance water reclamation and designation efforts that might keep low-quality water away from urban residents while still allowing such water to be used for toilet functions and other such activities.

2.24 Sinaloa

Sinaloa is a state that is making progressive and meaningful advances in the realm of sewage and water infrastructure. For example, several short-term projects have come into view in the past few years, such as one that envisages the construction of the Miravalles aqueduct (Pichachos-Mazatlan

pipeline). Unfortunately, fiscal issues and political will are both in question, inasmuch as only 40 million pesos in state funds have been earmarked for the above-mentioned Picachos-Mazatlan pipeline and its initial stage. The total sum required is roughly 500 million pesos, so this effectively means that state and federal government negotiations have only resulted in about eight percent of the needed monies being released. Besides the fundamental human resources issues at play, the 26.7km pipeline is vitally needed because it transports water from Sinaloa's Siquieros Dam to the bustling beach resort of Mazatlan – a city which draws a lot of tourist dollars, but also grapples with acute water shortages (Rodriguez, 2017b). Because Mazatlan is one of those communities that is the face of Mexico to the world, it seems imperative that something be done in the near future to assuage fears that, once more, an important step forward in water management and conveyance in Mexico will not be taken.

If the under-servicing of critical urban centers in Sinaloa is a going concern, then further worry is surely precipitated by water management practices within the state. To elaborate, Sinaloa is one of those northern states that is using both groundwater and surface water, but it seems that (at least per recent studies), agribusinesses in the state use several times more water than the amount of water dedicated for residential use (Spring, 2015). If the state wants to allay fears that it will soon have an impossible water deficit vis-a-vis its urban centers, it will have to pursue water reclamation and diversion practices and infrastructures that set aside more of the state's vulnerable water supply for urban usage. Something must surely be done soon, for there is general evidence that urban Sinaloa does face a perceptible water deficit that will likely grow only worse as the state is projected to see less and less precipitation in the years ahead (Mario Molina Center, 2013).

2.25 Sonora

Sonora grimly joins the veritable legion of Mexican states that scramble to find water for their waxing populations and burgeoning businesses. Chiefly, research carried out at the start of this decade underlines that Sonora had the most area of any Mexican state under irrigation. Indeed, the state's irrigation systems (preeminently used for agribusiness enterprises) used (as of the close of the last decade) roughly 77 percent of all available water; water-starved cities within the state, by comparison, used only 14 percent of the available water. Sonora's focus on agribusiness seems understandable in light of the fact that the state is the agricultural breadbasket of Mexico in many respects. However, the disregard for the state's metropolitan areas is deeply problematic when one considers that Sonora's urbanization is being

driven by robust border industrialization occasioned by the existence of the North American Free Trade Agreement (Wilder, 2011). Sonora seems very much a state that is set up for crushing reversals and water shortages in the near future should it not reverse course and establish (perhaps by using some of those receipts or remittances from agribusiness and industrial enterprises) reclamation and diversion infrastructures that get more out of existing water – and that direct more water towards residential functions within the crowded cities of the state.

If one takes the city of Nogales in the state of Sonora, one uncovers that a critical source of water for the metropolis is the Santa Cruz River – which happens to be quite sensitive to drought. Furthermore, the Los Alisos aquifer which also nourishes the city has its own infelicities: it is hampered by the distinct possibility that it may not be receiving sufficient renewable recharge water from surface flows to satisfy the needs of Nogales (Diaz & Morehouse, 2003). At some point, Sonora will have no choice but to gravitate towards a more urban-friendly approach water management if it wants to avoid catastrophe.

2.26 Tabasco

By this point, the litany of water deficits, failures and future uncertainties is almost oppressive in its weight and pervasiveness. But, alas, Tabasco offers no respite from the grim state of affairs. In 2016, journalist Rodrigo Alonso informed his readers that the levels of the Grijalva and Carrizal Rivers in Tabasco were dropping alarmingly. Because of this unsettling trend, seven treatment plants in the city of Villahermosa were facing insufficient water supplies for the discharge of their functions. Additionally, Alonso (2016c) reported to his audience that the state water utility, Comisión Estatal de Agua potable y Saneamiento, had been compelled to put into service 11 water trucks to supply water to residents of 13 municipalities within Tabasco. What should be taken away from this situation is that Tabasco has not done a particularly good job of insulating itself from the ravages of major droughts and water shortages. Once again, finding a way to get more with existing water supplies, and finding a way to impress upon state inhabitants the value of conservationist policies, appear the only ways forward.

Other data highlights that Tabasco has potable water coverage that is distressingly poor and uneven: as of 2011, it was being reported that Tabasco was one of only four Mexican states with potable water coverage at or below 80 percent. Similarly, while the state of Sonora – certainly afflicted with issues of its own – had at least 106 treatment plants as of 2011, Tabasco had

only eight treatment processing facilities. And such a despondent and desultory situation is made even more unacceptable when one contemplates that Tabasco is located in the southern part of the country wherein subterranean and surface water resources are considered plentiful (Carranza & Vega, 2011). Maybe only the government of Tabasco really knows how much better it is capable of being, but the outward manifestations are not good.

2.27 Tamaulipas

Within the urban clusters of Tamaulipas, it is well-known (even to outsiders) that many homes do not have running water or access to electricity (Nations Encyclopedia, 2017). Still, the promise of progress does ring reassuringly in Tamaulipas inasmuch as the state is the focal point of a number of irrigation projects (The Tamaulipas Irrigation Projects) that, as per Presidential Commitment 185, will cost $175 million (USD) and will bring the irrigation districts of the state up to approved standards (Seneca Group, 2014). There is, of course, a certain disconnect between having so much expended on irrigation projects, while still so much needs to be done improve the state's urban water infrastructure.

Overall, if it remains the case that too many urban residences simply lack running water and ready access to water, then there is at least some tentative evidence that the state of Tamaulipas is going against the current and doing something to redress the matter. Of note, Guerra (2014) indicates that, since 2012, the state has been drilling deep wells to help expand the water supply in Bustamante, Tula, Palmillas, and Jaumave. The state has also taken it upon itself to extend the water infrastructure in the state highland areas to ensure that serviceable water networks can reach populated areas distinctly remote from the center of the state. In Tamaulipas, the major hurdle to be overcome is not so much water scarcity as it is a scarcity of infrastructure that can convey water to those who need it. The well drilling exercises described above are a worthy start.

2.28 Tlaxcala

The state of Tlaxcala saw its population grow at an accelerated rate of more than 2 percent in the 1990s. However, the first half of the first decade of the new millennium saw a significant decrease in this hitherto rapid increase (Morales Novelo & Rodríguez Tapia, 2011). This would most definitely seem to lessen the strain experienced by existing water sources for the state's urban populace. Likewise, the state has historically ranked near the bottom

of national studies that examines the volumes of water extracted for irrigation for each Mexican federated state (Vélez & Mejia Saez, 2011). Thus, at cursory glance, the state has reason for reassurance: its agribusiness sector is not enervating water supplies relative to unfolding events in other states, and its population growth has slowed at an advantageous time. And yet, all is clearly not well, as the state is evidently not grappling well with the ravages of severe droughts in recent years. For urban dwellers of Tlaxcala, it is of small comfort to remember that it seems agriculturalists are the ones especially suffering from these droughts and their aftermaths (Slade, 2013).

Overall, Tlaxcala appears headed towards a tidal wave of problems in the near future. Most of all, energy subsidies mean the over-harvesting of groundwater sources – still – by agriculturalists. The aquifers which nourish urban Tlaxcala are showing signs of overuse, and wetlands have been gravely compromised. Lastly, conservationist water policies have been roundly ignored, which puts even more pressure on underground and surface water reservoirs intended for the urban clusters of Tlaxcala (OECD, 2013c). It is an open question whether or not Tlaxcala will avoid the ignominious fate of other Mexican states that have found themselves mired in an ever-deepening water crisis partly of their own doing.

2.29 Veracruz

Within Veracruz, a key problem that rankles is the political intrigue and corruption that recently saw indigenous groups and indigenous landowners actually shut off the taps to the Yuribia water reservoir in a dispute about money – namely, that the former state government had reneged on pledges to pay indigenous landowners a considerable monthly sum to use the water housed by the Yuribia reservoir. The whole matter is a case study in what happens when a few reservoirs or surface water sources serve the vital needs of a significant population. To elaborate, the Yuribia water reservoir actually serves the municipalities of Minatitlan, Cosoleacaque and Coatzacoalcos in the southern part of Veracruz (Mexico News Daily, 2017b). To have so much riding upon a water reservoir that can be rather easily overrun by locals is probably a sign that the state must look at water diversification tactics and strategies to mitigate the prospect of something like this happening again.

Pressing forward, there is little doubt that Veracruz is a state that must do more to confront the troubling water quality issues that have perplexed and dogged the state for generations. Water in small villages is commonly unfiltered and has not been treated prior to being made available for general consumption. Water in larger cities is generally much safer, but it is still

advised that newcomers to the state refrain from imbibing the local water (Sanchez, 2014). The tragedy of having in place such a rudimentary and ill-equipped water filtration and treatment infrastructure is that the state has 35 percent of the state's water supply (History Channel, 2017). For the sake of its own posterity and the broader good of the country, Veracruz needs to identify what more money and resources are not being set aside to make the water supply – especially in marginal urban communities – more potable and secure.

2.30 Yucatán

Yucatán's urban water supply is a source of troubling, even distressing, concern for a great many. Namely, it has historically been the case that Yucatán has been unable to craft water architectures and infrastructures that can keep pace with robust urbanization, with diversifying economic and industrial use, and with the strain occasioned by diversified residential usage – in other words, the use of water for things other than simple bathing and drinking or cooking (Kudlek & Schwarz, 1981). While the state maintains official statistics which insist that 97 percent of the state's population has access to water, and while water reservoirs and groundwater sources are plentiful, there is an open debate as to whether or not the water furnished by the state for drinking and grooming use is actually of sufficient quality to meet United Nations standards; a strong sentiment certainly exists in the scholarship that the needed quality is not present (Guardiola, González-Gómez, & Lendechy Grajales, 2011). Indeed, as a grim example of how serious water despoilment in the Yucatán is – and not merely in urban areas – it is underscored by Henry Vaux, Jr., of the University of California, Berkeley, that human and animal waste is frequently found in the water wells of the peninsula. Groundwater in Yucatán is generally compromised by waste from hog farms and human waste emanating from the city of Merida – a city which, as of 2007, had no central sanitation system and relied on at least 80,000 septic tanks for its waste water management (National Research Council of the National Academies, 2007). The Yucatán, it seems, is a cautionary tale of what can happen when a state with bountiful natural resources and an expansive endowment from nature chooses to degrade these gifts through poor planning, through short-sighted municipal sanitation practices and planning, and through a lack of concern for the viability of ground and surface water reservoirs.

2.31 Zacatecas

In Zacatecas, the urban water supply faces serious challenges because of concerns over arsenic despoilment (Montes-Rojas, Ospina-Noreña, Gay-García, Rueda-Abad, & Navarro-Gonzáles, 2015). International Business Publications (2009) affirms the severity of the water quality crisis afflicting various parts of Zacatecas by informing readers that the state lacks the internal water supply to rationally and equitably distribute the available water resources. It also must be understood that Zacatecas does not have in place modern recycling technology (in short, it lacks comprehensive water treatment tools) and this constitutes both a potential public health risk, and also imposes a significant burden upon the extant water supply (International Business Publications, 2009). Water diversion, water recycling, the capturing of used water so that it can be diverted to other functions or pursuits – these are in short supply in Zacatecas, and the state suffers as a consequence. Mercifully, some signs do suggest that the state is – albeit tentatively – moving towards a better treatment network that will meet the needs of its burgeoning twenty-first century populace: In September of 2005, the Zacatecas government and CONAGUA jointly announced that three wastewater facilities were slated to be built in Zacatecas. One of these would be erected in the Guadalupe-Zacatecas urban area, while the remaining two would be constructed in Fresnillo City. The announcement sparked some rejoicing, in part because, while potable water coverage in Zacatecas and Guadulupe was allegedly 85 percent at the time, and while sewage services ostensibly reached 90 percent of residents, wastewater treatment in the Guadalupe-Zacatecas urban area only stood at 17 percent in the middle-2000s (Brundell, 2005). It seems the state has historically been laggard at treating its water supply with the attention it requires – and part of this attention means ensuring universal water treatment.

3. DISCUSSION

The data and accrued scholarly material may not be perfect, and there does appear a dearth of empirical studies into the relationships and correlations between different factors and urban water shortages or privations in the Mexican context, but the one thing that comes across resoundingly is that urban water management in Mexico only intermittently (at best) addresses the issues of wastewater treatment, water diversion, water recycling, water conservation, and protections and securities that will keep promiscuous water use to a minimum. In states such as Aguascalientes, the presence of multiple aquifers does not change the fact that the urban water supply is considered precarious. And such states are marred by the absence of water reclamation practices and infrastructural heuristics that might make extant water supplies stretch further. Sadly, many states – such as Aguascalientes, Baja California (which must ship its water from outside the state), to name but two – have water that, in addition to not being appreciably reclaimed, is degraded and despoiled. If this trend continues, the end result will be both catastrophic water shortages, and water that could place the lives of untold numbers of citizens in grave danger. It seems that a great many Mexican states could use outside assistance in crafting reclamation and reuse best practices (and diversionary infrastructures) that will optimize water reservoirs and hard-pressed aquifers.

Constant water importation is described as a conspicuous problem in Baja California. Suggestions for curbing this problem have ranged from water desalination to expanding the existing infrastructure, to even idealized water markets. Another possible remedy is to involve a greater number of stakeholders so that diversified and wide-ranging resolutions can be formulated that meet the specific needs of various members of the community. A multi-pronged, multi-disciplinary approach to urban water supply and water treatment issues seems like the only way that states such as Baja California – or Baja California Sur – are going resolve their pressing water concerns. Other states, such as Campeche – which relies so heavily upon the Santa Rosa aquifer and a limited number of urban wells – should also explore comparable joint efforts that will focus on how water logistics can be invigorated, and water reclamation optimized, so that the state's urban populace is served adequately. Water desalination efforts unquestionably appear to be at the forefront of what these states, and many others, need to do for their own long-term stability and security.

Another thing the scholarship reveals is that socio-economic extremes can also cause urban water issues to become even more inflamed than they

might be otherwise. Chiapas is a good instance of a state that has pockets of substantial affluence enveloped by squalor and grinding poverty. Since those on the margins of society have no real power by which to make their voices heard, it may be said – even if it sounds cynical – that some of the urban water problems plaguing Mexico are allowed to persist (if only in part) because the people who suffer most do not count for a great deal in the eyes of those who form national and state-wide water policies and programs.

Continuing onward, pollution and water despoilment rear their heads in states such as Chihuahua – where fluoride and arsenic despoilment is a real and present danger – or even in states such as Coahuila, which relies heavily on aquifers that are vulnerable to arsenic and metal contamination. Finding a way to seal or protect these underground aquifers is of paramount importance, but it is not clear that the technology and resources are available to make this a reality. In some regards, Mexico may simply not be able to do what needs to be done to make things better, even if the country is plainly aware of the problems and the troubling extent to which those problems imperil the future vitality and health of the country's teeming municipalities. Another state that is threatened by high arsenic levels is Durango, even if here the issue is arsenic finding its way into surface waters that nourish such urban entrepots as the large City of Durango. Mineral and toxic contamination appear regularly in the scholarly treatment of urban water issues within the country of Mexico, and there must come a day when the country finally confronts this problem and develops the heuristics – or seeks out aid from outside its borders – to thwart the spread of such materials into the nation's waterways.

Another insight to be drawn from the scholarship is that there do exist examples of Mexican states assuming a leadership role in mitigating its water pressures. A look at the State of Guerrero reveals one instance in which political elites did take a resolute position aimed at bolstering the water infrastructure. This is at least a modest improvement upon what we see in Hidalgo, where the local water has been despoiled by animal and human waste and officials seem fixated on appeasing agribusiness interest groups (or massive urban incorporation undertakings) instead of devoting their energies to keeping the state's water clean and usable. Jalisco may be rightly described as another state that seems to take a negligent view towards wasteful water use practices. Better leadership is needed in these principalities.

Other instances of how vital local leadership can be in assuring competent water management are visible by looking closer to the capital of Mexico. To wit, even the State of Mexico has been accused of providing its urban inhabitants with brackish water that seems borne of the state's grimly under-maintained piping systems. Still other states, such as Michoacán and Morelos, have water quality issues, too, but Morelos has shown itself quite prepared to use discretionary funding resources to enhance sewage coverage and to bolster potable water conveyance. The State of Sinaloa is another state that is making some meaningful strides in this area, though it is not clear if tentative first steps will lead to bold and effective measures in the years ahead. Part of why early success may not translate into enduring success is because of the bitter political divisions that do wrack many Mexican states (Veracruz being one example) and the growing industrial and commercial economies that necessitate accommodating business leaders whose first objective is to safeguard their organizations and enterprises – not appease environmentalists. In any case, a state like Oaxaca does show what can happen when local political officials diversify and specialize their water management bureaucracies and recognize that water reclamation is a critical investment in the future that should not be disparaged. Municipal and urban leaders must decide what matters most to them: the water that nourishes and invigorates the populations under their care, or transient business interests that do not serve Mexico but another master (or masters).

4. CONCLUSIONS

Pointedly, the most elemental conclusions for the urban water supply situation in Mexico can be found by looking at the many challenges facing the urban communities of the country: the brackish water, the contamination issues, the shortages, the over-strained aquifers, and the lack of treatment and reclamation assets that can get more out of the water that has been bequeathed to Mexico by Mother Nature. The literature seems rather light on prescriptive measures, but there is no doubt that what the country needs is for a collaborative effort that leverages the resources of many different states, as well as the federal government and CONAGUA. Priorities need to be drawn, and those priorities need to cohere around the following: effective water treatment so that used water can be used repeatedly; water diversion infrastructures so that lower quality water can be directed towards industrial, commercial or non-essential functions and then recycled for subsequent use; water reclamation facilities and conveyance infrastructures that allow extant water resources to be used more efficiently and for a greater length of time; uniform best practices so that urban dwellers can make better use of their allotments of water; and a water treatment infrastructure that renders potable water that is currently compromised by mineral and toxic despoilment. Last of all, the various Mexican states need to establish a policy-making constellation that privileges environmentalists and water conservationists to a sufficient degree that neo-liberal business practices do not hold sway over how the states care for their water supplies. The urban water supply in Mexico is not quite hopelessly parlous or impoverished, but it is not roseate in 2017. More needs to be done, and more can be done, and Mexico can use such states as Oaxaca to see how a Made-in-Mexico solution is possible. The literature may only hint at the pathway to take, but a pathway there most certainly is.

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