A social and institutional framework analysis of desalination as a technical solution for agriculture in the San Quintin Valley, Baja California, Mexico

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Abstract: Hi-tech responses, specifically construction of desalination facilities, have been the solution to saline intrusion due to aquifer overexploitation from agricultural usage in San Quintin Valley, northern state, Baja California, Mexico. Water produced by desalination, combined with greenhouses, has allowed for continuous production of the most valuable crops despite deterioration of groundwater quality. Over exploitation of the aquifer can be traced back to a system of allocation of volumes in a top down institutional framework sans local government management or participation of local residents in decision making. Desalination development was completely market driven with indirect government support through subsidies on electric power. Only medium to large producers were able to afford the costs associated with desalination. Desalination has created new economic and social relationships, modified demographic patterns, and resulted in social unrest.

Keywords

Groundwater, demographic, migrant workers, socioeconomic, institutional, energy

Introduction

The San Quintin Valley is a highly productive agricultural valley in the northern peninsula of Baja California, Mexico. Most of this agricultural production is exported to the California, USA market. However, San Quintin Valley receives one of the smaller volumes of rain in all of Mexico. Water has always been *the* limiting factor for local agriculture. With little intervention by the government, efforts to manage this resource have been mostly in the hands of farmers harnessing technological innovation to improve water use efficiency. As a consequence of changes in farm technology there have been social and economic changes which continue to affect population dynamics in the region.

The rainfall recorded for the state of Baja California has been on the order of 203.7 mm per year for the period between 1941-2005, the second lowest in the country after the state of Baja California Sur with 176.2 mm. The Regional Water Program 2002 - 2006 for Region I, Baja California, published in the Official Journal of the Federation of January 16, 2003, identifies 48 aquifers located in the state of Baja California with a total of 1,277.6 hms3 extracted per year and a recharge 1097.17 hms3 representing statewide, a degree of overexploitation on the order of 11%.

1.1. Agriculture, water use and population dynamics in San Quintin Valley

The Agricultural region of the San Quintin Valley is one of the most productive areas of the State of Baja California, Mexico. Since the 1970s large producers, some of them financed by foreign capital, have settled in the region to produce high value crops mostly to export to the California, USA market. From the early stages irrigation was based on ground water.

Water in the San Quintin Valley comes almost entirely from its aquifer. Presently it has a total of 428 wells with an allocated volume of 29,512,319 m3 per year. The aquifer has been showing signs of overexploitation for some time now; a 2009 study of 65 wells show that many have salinities outside acceptable limits for agricultural use, with the added problem that in some cases an increase in salinity has been observed since the study was performed. The response of farmers to salinity increases of the aquifer has been to shift crops towards species with higher salinity resistance (e.g., onions). This strategy was and is still used by small scale farmers. But middle to large scale farmers have followed a different path, switching to high value crops sensitive to salinity (e.g., tomatoes, strawberries, raspberries, and blackberries) but irrigated with desalted water from the aquifer. The technological switch in crop management was completed by the use of shadow

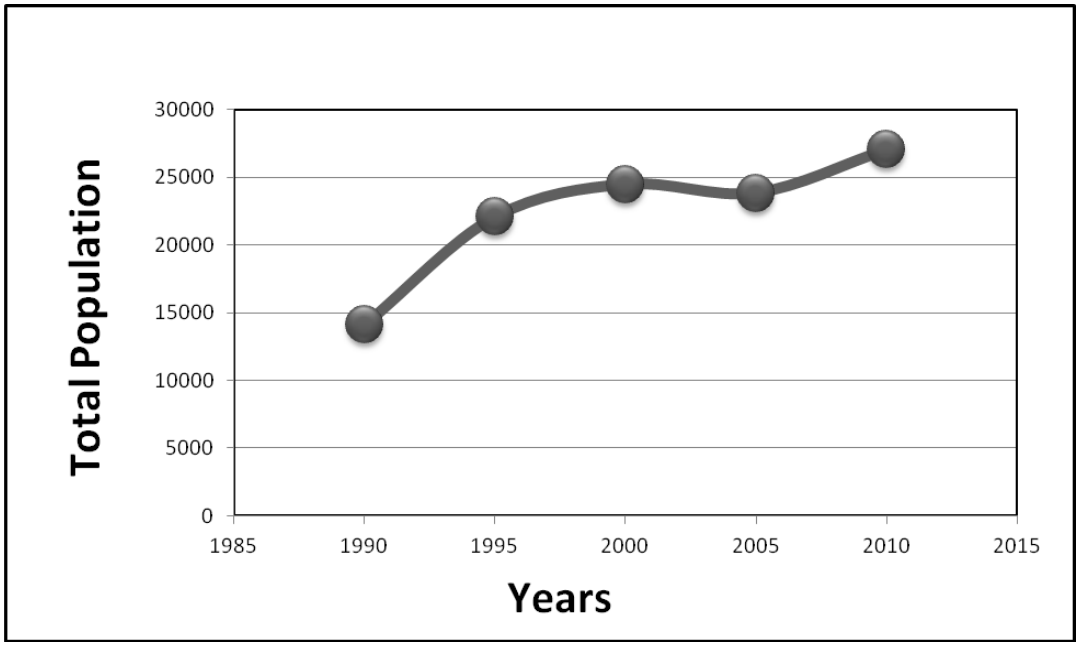
mesh and mostly greenhouses to improve the efficiency of water use, controlling both temperature and evaporation and allowing for a continuous cycle of production.

1.2. Social and Economic Implications of Technological Changes in water management:

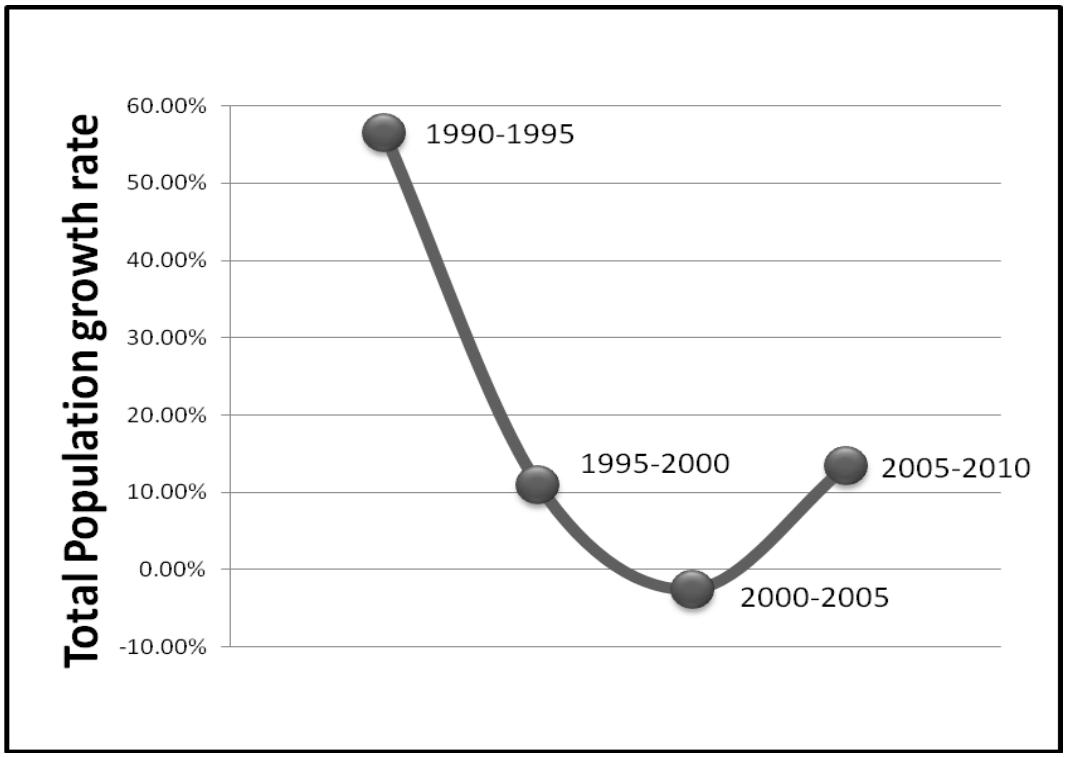
Technological changes in water management have serious economic and social implications. Farm productivity has increased because crops are no longer seasonal, and farm labor is consequently now needed all year round but in smaller numbers than when the seasonal system was utilized. These changes in "productive cycle" have had a profound change in labor migratory patterns observed in the region (Gallardo, 2010). The rapid population growth that characterized the region in the 70's 80's and 90's came to a halt by the turn of the 21st century. As demand for migrant workers rapidly declined and permanent positions began to surface, many laborers abandoned their migratory patterns and settled in the region creating housing, public health and education challenges. Technology changes resulted in reduction of cultivated areas, better water management and an increase in production and productivity (Gallardo, 2010) but also created new labor relationships. For example, temporary migrant workers who struggled in years past to improve their labor and living conditions (Velazco, 2000) now confront new forms of agriculture and transformation into permanent worker status. An insidious change which needs to be immediately measured, exposed and addressed is pesticide exposure, which is now year round for farm workers (Ojinaga, 2012). Farm worker compensation has also shifted, from a timed labor day of 8 hours to payment based on volume of berries collected.

These new labor relationships culminated in protest by field workers that paralyzed growing fields in the San Quintin region in March 2015 (Jornada, 2015). Worker demands primarily confronted this new form of agriculture. Laborers demanded to be recognized as permanent workers, and to enjoy the same benefits as all permanent workers in Mexico, including health and retirement benefits, an 8 hour labor day, and the right to join trade unions for collective bargaining and negotiation.

Technological changes are also reflected in the population dynamics of the valley. During the 70's 80's and 90's the San Quintin Valley was one of the areas with the highest population growth of the state of Baja California, but in recent years that population growth has been reduced and in some cases like in the urban area of San Quintin itself has shown negative values for the period 2000-2005. According to the 2010 census, the human population living in the San Quintin valley was about 27,000 people with a population growth of 13.3 %, but that growth came to a sudden halt and the population has remained virtually unchanged since the turn of the century. Those demographic changes may be attributed to changes in the agricultural practices that eliminated the need for migrant workers. Those migrants who decided to settle in the region suddenly faced the prospect that although jobs were year round, the number of job openings were limited and the pay although higher than in their original states was not enough to support the high cost of living of the region (Velazco 2014).



Source: Own elaboration based on INEGI data (several years)



Source: Own elaboration based on INEGI data (several years)

2.1. Water for human consumption in San Quintin

A large part of the San Quintin population receives "urban use" water in their homes via a state managed network called CESPE (State Commission of Public Services of Ensenada). As in most other regions of the state, piped water is used only for domestic purposes such as cleaning and personal hygiene, never for drinking or cooking. People who are not connected to the network buy water from tank trucks (locally known as "pipas") some are private and others owned by CESPE they charge $ 8 to $ 15 (Mexican pesos) per barrel of 200 liters (pers. obs.). Additionally, there is a parallel market

for purified drinking water by reverse osmosis sold in 5-gallon jugs whose use is universal (pers. obs.). This differential water market is common in the whole region, which means that the piped water may be of inferior quality yet still meet the expectations of users since it is never intended for drinking or cooking. UNESCO recommends 100 liters per capita per day or 3,000 liters per month per person with a minimum of 20 liters per day per person or 600 liters monthly estimated by WHO and UNICEF. The average water consumption for San Quintin was estimated by Vasquez (2015) at 3,800 liters per month per household, which translates to approximately 950 liters per capita per month. Although these estimates of water use in San Quintin do not take into account the separate consumption of purified drinking water, it shows the seriousness of the water shortage problem.

2.2. Aquifer management for human and agricultural purposes:

Over exploitation of the aquifer has been ongoing, according to official data in a report by the C.N.A. (Comision Nacional del Agua). In 2002 the volume allocated for extraction was 28 million cubic meters, and the average recharge was only 19 million cubic meters. All aquifers in Mexico are managed by the Federal Government through the C.N.A. with delegates in each state. Although all decisions are the sole responsibility of a local C.N.A. delegate, in the management of the San Quintin aquifer there is an auxiliary organization with an advisory role formed primarily by users, the C.O.T.A.S. (Technical Groundwater Committee). In an interview in September 2013 with Mr. Ruben Hidalgo Carranza, President of C.O.T.A.S. San Quintin, Mr. Hidalgo points out they are aware that differences between allocated extraction volumes by the C.N.A. and average aquifer recharge is the most important factor in the rise of salinity and negative changes in the aquifer water table. According to Mr. Hidalgo, solutions to reduce the volume of water extracted from the aquifer were proposed by C.O.T.A.S. to C.N.A., but to no avail.

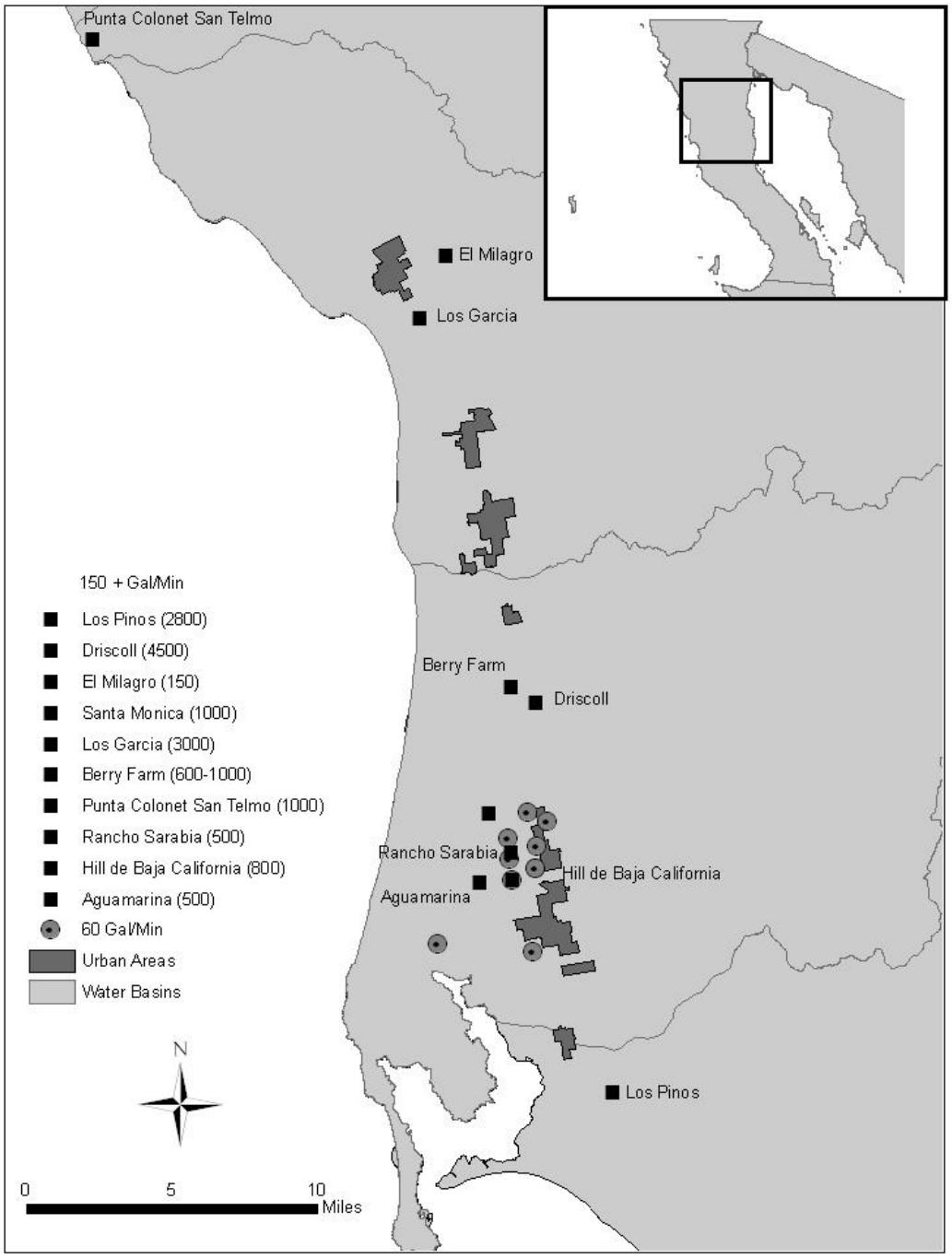
Some wells for human consumption are located in the lower part of the basin. Those wells have been affected by the increase in salinity observed in all the lower aquifer and sinking of the phreatic water level. New wells have been established in the upper part of the basin far from the saline intrusion, but their volume of extraction is inadequate to cover all domestic needs of the valley.

2.3. Desalination of brackish groundwater as technological solution to continue high yield agriculture in the region:

Due to scarcity and rising salinity of some wells, desalination of brackish water has become an attractive option for many farmers. The desalination process adds new costs to production, but because the salinity of most wells is below 10,000 ppm the cost of desalination is 2.69 Mexican pesos per m3. In our field trips we found that a common practice was the use of small volume desalination plants (60 gallons/min) to treat water from wells with salinities of less than 5000 TDS (ppm). The reject water with salinities of about 15,000 TDS was then treated with larger, more powerful equipment. The reject water from these larger plants was about 40,000 TDS, salinity similar to seawater. This reject water was disposed of at sea.

This system of desalination includes large producers who have both types of desalination plants, and small farmers who have only small plants to treat water with low salinities. The reject water from these low salinity plants is collected through pipes and sent to large producers, who to use this water to feed their larger, more powerful desalination plants. In total in the San Quintin agricultural region we found 8 plants with desalination treatment rates of 60 gal/min, one plant at 150 gal/min, two plants at 500 gal/min, one plant at 800 gal/min, 3 plants at 1,000 gal/min , one plant at 2,800 gal/min one at 3,000 gal/min and one at 4,500 gal/min, for a total installed capacity of 15,730 gal/min. Once converted into metric units, this region has a total installed desalination capacity of 30,898,210.19 cubic meters per year (Comision Nacional del Agua).

The map shows the location of the desalination plants. Most desalination plants are in the lower part of the basin, near the ocean where the saline intrusion is more pronounced.



The total installed capacity of desalination plants (30, 898,221.19 m3 / year) is larger than all concessions of the C.N.A. for the whole aquifer that makes up the agricultural region of San Quintin (24 681.806 m3 / year).

This apparent excess of desalination capacity can be explained because all plants operate mainly during hours of reduced electricity rates (i.e., at night). While it is difficult to have the exact details of the hours of operation of the various plants, based on interviews with farmers and technology providers it can be estimated that desalination plants operate approximately 8 hours per day, resulting in approximately 10,299,407 cubic

meters per year or approximately 41.73% of the water allocated by the all the concession of the area being desalinated.

2.4 Water and Electricity:

From an economic point of view, rural water management in the Valley depends on electricity subsidies granted by the Federal Electricity Commission (CFE). The Law on Energy for the Countryside published in the Official Gazette on December 30, 2002 established a preferential electricity tariff, known as “Tarifa 09”. This tariff subsidizes the electric power used for water pumping for irrigation of land dedicated to the cultivation of agricultural products and lighting where pumping equipment is installed. With this special rate farmers pay a price well below the cost of producing energy. According to the National Institute of Ecology of Mexico (INE) Tarifa 09 is one of the most important factors in the overexploitation of Mexican aquifers (Avila et al., 2005). This review done by the National Institute of Ecology and Climate Change states that "…by nature, the current subsidy Tarifa 09 is regressive: [it] benefits more those who have more... [Changes in the subsidy] may be an opportunity to convert the subsidy or support progressive policies to promote technological improvement, increased productivity or simply to avoid the perverse incentive to use more water and electricity than necessary."

3. Mexican institutional framework of water management in the region

In Mexico, policies and strategies to sustainably manage water resources fail due to a lack of stakeholder equity, inadequate administrative procedures, and uncoordinated efforts among different levels of government. For too long, economic growth has been the main goal of water policies, with environmental and social objectives being swept aside. With its growth focus the federal government, in conjunction with the National Water Commission, has granted concessions and assignations to registered users so they can exploit surface and underground water. These users are paying little or no attention to actual conditions of the aquifers, even though they know they are being allocated more water than what really exists. Furthermore, the State has subsidised the cost of power needed by the users to obtain water. Therefore, it is not only that water resources are heterogeneously located throughout the country; rather, it is that their management is poor, and their apportionment among the different sectors is uneven.

In the Northwest part of Mexico, attempts to accomplish the task of water management are more costly. In that region, freshwater is a limited resource, due to arid conditions (rain is very scarce, well below 300 mm yearly average). Increasing demand due to economic and social activities has almost depleted local sources (Semarnat, 2014: 6; cfr. Correa, 2008:108-109).

The Mexican government acknowledges that delivering water in sufficient quantity and good quality is more complicated in this region than in the rest of the country. To solve this increasingly critical problem, alternative strategies are quickly needed (policies, administrative tools, technology).

Mexico has institutional arrangements to address the water issue. Nevertheless, those arrangements need to reflect and adapt better to the heterogeneous geography and different socioeconomic dynamics of the country. Starting with the National Development Plan 2013-2018 (NDP) follows a discussion of three programs regarding water resources and agro-production: the Hydrological National Program 2014-2018 (HNP), the Sector Program on Environment and Natural Resources 2013-2018 (SPENR), and the Sector Program on Agriculture, Fisheries, and Food Development 2013-2018 (SPAFFD). The aim is to rescue useful orientations to reform policies and administrative trends which adapt better to the Northwest region, specifically to the San Quintin Valley.

3.1 National Development Plan 2013-2018

The NDP is a route map for programming and budgeting all of Mexico’s federal public administration. Statutorily, all programs (by sector, special, institutional and regional) that define the actions of the government are to be elaborated in line with the NDP. In such context, the Plan is a guiding document towards national development.

The NDP stresses that Mexico bears wide diversity of resources, enough to achieve economic growth. Nevertheless, the country faces huge challenge on the grounds of productivity: during the past 30 years, the total productivity of factors in the economy has decreased at a 0.7% yearly average rate. Indeed, negative growth of economy is one of

the main constraints for national development. (Gobierno de la República, 2013: 15).

Aiming to development, the NDP regards natural resources as essential factors of sustainable development; nevertheless, in practice little care is taken to protect and conserve them. Mexico must make use of her rich natural resources stock wisely. It needs, therefore, to reorient an erroneous productive rationale that favours degradation and overexploitation of waters, lands, and biodiversity. Understandably, the case of water is of prime importance, not because it is an essential economic asset only, but also because it is a public good and a human right (United Nations, 2003). As water is unevenly distributed in the territory, Mexico must undertake all necessary steps (political, legal, administrative, or technical) to reorient its use in an efficient, sustainable manner.

3.2 Hydrological National Program 2014-2018

The HNP aims at generating a significant reform to the water sector, paired with triggering the modernization of key aspects of hydrologic development. Three main objectives of the program have to do with water availability for economic and domestic purposes. One purports to fortify the apportionment of water and the access to basic services by means of caring for and increasing of the necessary infrastructure; another, pledges to increase the technical and scientific capabilities within the sector; and the third, guarantees water availability for agro-production and other economic activities (Semarnat, 2014: 37-39). Good purposes, however, have to be aware of reality. The HNP highlights, the uneven availability of water throughout the country, hence its catching and distribution is not an easy task. In fact, different from other parts of Mexico, rain precipitation is very scarce in the North and Northwest (Semarnat, 2014: 6); therefore, the HNP should propose other viable routes to succeed in its objectives.

In San Quintin, for instance, there is an old social demand of access to basic services (drinkable water and sanitation), which means an urgent need of building adequate infrastructure. Even though all levels of Mexican government have guaranteed water for agro-production and other economic activities, they pay less attention to the domestic demands, and that is particularly evident in peripheral settlements. The problem though, must be tackled in its entirety; water should be served in adequate quantity and quality to all residents and sectors, on an equitable basis. Agriculture, which is the most important economic activity in this region, not only succeeds with infrastructure and technology, it also needs a huge allotment of human labour; so, for the sake of a better social-economic environment, thus avoiding conflict, the social demand must also be satisfied. It is our view that, because San Quintin is located on the Pacific coast, and considering that freshwater sources are almost depleted there, a viable alternative is to look at seawater, and start discussing desalination infrastructure seriously.

3.3 Sector Program on Environment and Natural Resources (SPENR) 2013-2018

The SPENR in a consequence of the National Development Plan, hence, its guidelines must be empathetic with the national objectives and goals. Among these objectives, three address the water issue. The first, seeks to fortify integral and sustainable management of water, assuring its access to the population and the ecosystem. The second aims at halting and reversing the loss of natural capital, as well as the pollution of water, air and soil. The third requires the State to develop, promote and apply policy instruments, and encourages all interested actors to fortify environmental governance.

Similar to the HNP, this program makes no particular reference to the water issue in the agro-productive and dry San Quintin region of Baja California. Nevertheless, it is plain for the SPENR that most of the allocated water is destined to agro-productive activity; furthermore, the program states that a large amount of water is lost due to mismanagement. On this latter issue, one reason is the lack of efficient technology; another is the cultivation of species that are highly demanding of water in regions where there is insufficient availability (Semarnat, 2013: 29).

The SPENR stresses that, to build a prosperous and inclusive Mexico, it is compulsory to adopt responsible and sustainable water management thus guaranteeing all the citizens the right of access to this vital liquid. In that sense, the program pursues assurances of adequate and accessible water services to all population, as well as availability of water for food security (Semarnat, 2013: 56). Without doubt it is imperative that the authorities urgently implement the necessary

means (in regards of laws, policies, and organisations) and adopt a responsible and sustainable management plan of water resources. Consuetudinary practices, either cultural or technological, should also be reformed.

In time, all these initiatives might result in the betterment of eco-systemic assets, and hopefully, reverses the pitifully degraded water sources and soils. Such a switch should happen soon, mainly in regions such as San Quintin where water availability is already a serious problem that is generating not only environmental but also economic and social problems. The recent social uprising that occurred in that region is not just due to dissatisfactory wages, the continued social conflict is grounded on improper governance that resulted in social inequity.

3.4 Sector Program on Agriculture, Fisheries, and Food Development 2013-2018

The SPAFFD agrees also with the NDP. Among its objectives, two have to do with the water issue. One is to support the productivity in this specific sector through investment in physical, humane and technological capital in order to guarantee food security; the other is to promote the sustainable use of natural resources in the country. The program makes it clear that the main problems of access to quality water are due overexploitation of aquifers, low efficiency in their use, contamination, increased demand, and diminishing of the replenishing sources. In the end, all those factors result in reduced availability of water for human consumption and production. On the grounds of food production, lack of irrigation infrastructure is an obstacle to productivity, because only 46% of the liquid destined to such purpose is used efficiently. The SPAFFD argues that the big challenge is to handle water rationally, through irrigation systems and advanced technologies, and enhance land surface under irrigation (Sagarpa, 2013: 59-60).

Again, it is worth noting that the SPAFFD makes little mention of water availability, the secretariat that is responsible for agriculture, rural development, and food production, still defends that water issues are the solely responsibility of C.N.A., an office inserted in the secretariat that deals with environment and natural resources aspects, despite the national directive of switching the sector rationale to one that is inter-sectorial. In fact, at the most, the SPAFFD stresses the importance of guaranteeing available water to attract private investors in the food and agribusiness sector. Therefore, it calls for coordinated efforts with C.N.A. via its irrigation division to set up incentives to increase investment in irrigation infrastructure to promote more efficient use of water, thus providing a decided impulse to agriculture (Sagarpa, 2013: 99).

It is evident from the previous paragraphs, that the Mexican government prioritizes policies of water management for agro-production and other economic activities, where social needs are only of marginal interest. The San Quintin region is exemplary of a circumstance in which such policies reach explosive levels and must be reversed or at least lowered. As stated, water should be available for all, thus the search for alternatives to accomplish this aim is frankly urgent. It is our view that technology is an immediate solution to make water available to the entire population, in adequate quantity and quality. Desalting is a technological route that it is already applied in the region in the agribusiness sector. It is the author's opinion that it is time to start thinking about making use of desalination processes for domestic purposes.

3.5 Hydrological Baja California State Program 2008-2013

Located in the Northwest part of Mexico, the Baja California state has clear understanding of the effects of water shortages. As noted above, it is one of the most arid regions in the country, and thus enough reason for the government to take steps to tackle the problem of water scarcity. Different to the centralist federal view, the hydrological state program (HBCSP) embraces technological fixes regarding water resources and desalination is a fundamental approach in the program; up to now, it has been seen as complementary to traditional ways to apportion water to the population for domestic and economic uses.

Even though desalination approaches in Baja California are known, concretely in the agri-business sector, desalination for domestic purposes is just starting as a public policy on water. In fact, the HBCSP stipulates, first, that new seawater desalination plants will serve as additional sources of supply in the distribution system of drinkable water; and secondly, that desalination would promote sustainable

development and preservation of the environment via rational use of water (Gobierno de Baja California, 2008: 93). The clear reference to desalination for domestic and drinkable purposes, not only means a turning point with regard to the traditional use of such types of plants in Baja California (agro-productive and economic activities); it also means the use of advanced water treatment technology to obtain better quality water. Another issue that will call attention in the coming years is the acceptance or reluctance that the population of Baja California is going to show for the "new culture" of the drinking water that "comes from the sea".

In any case, State Government is resolute in putting the desalination initiative ahead. Recently, the State Committee on Public Private Partnership Projects approved to subject a desalination project, the so-called San Quintin Integral Hydrological System (SQIHS), to a public bidding. With a calculated output of 250 litres/second, an investment of approximately 27 million US dollars, and under a 30-year public-private partnership scheme, the SQIHS is seen as essential to develop the San Quintin area (Vargas, 2015). Further projects to establish desalination plants in Baja California are those of Ensenada, La Misión-Ensenada, Camalú-Padre Kino, Leandro Valle-Los Pinos, Isla de Cedros, and Rosarito-Tijuana (Gobierno de Baja California, 2008: 90-93).

Conclusions

Due to the high economic value of San Quintin Valley crops, there have been important incentives to improve efficiency in water use by agriculture, the limiting factor of the economy of the region. The local aquifer that sustains all agriculture in the Valley is over exploited and a saline intrusion is evident in the coastal section, with an increase in salinity that makes the water unsuitable for the irrigation of the most valuable local crops. Some farmers' response at first was to switch to more saline resistant crops. At the same time other farmers were interested in continuing with their high value crops and started to adopt water saving techniques; first shadow mesh, then greenhouses, and finally desalination of brackish underground water. Desalination made it possible to irrigate high value crops in areas next to the coast. These have the best road and electric infrastructure of the Valley, but where the aquifer is more prone to marine intrusion. Presently, the most technologically advanced farms have increased their volume of production with the same amount of water used before the technological improvements. In the absence of a policy to guide and regulate technification, the technologies adopted were strictly market driven. The new technologies adopted (especially greenhouses and desalination plants) create a new pattern of production, from seasonal land extensive production to year-round land intensive crops. These new patterns of production generated major changes in the characteristics of the employment, from low skilled migrant seasonal workers to specialized year round local employees. The labor protests of March 2015 reflect these new economic relationships, stressing the need of adaptations in labor contracts to continue economic growth in the region. The legal framework of Mexico generally treats water as an economic development tool, but lacks specific management provisions at local levels. This is particularly evident in water scarce regions like the Mexican Northwest. A top down approach to water management in Mexico has resulted in depletion of aquifers and concentration of wealth and water rights in few hands. These policies appear to have the effect of encouraging investments in technology by subsidizing energy costs in the sector. In the absence of specific policies in favor of small agricultural producers, the adoption of market driven technologies tend to favor medium to large producers. Small producers are unable to afford the new technologies and are therefore being forced out of the market.

In the San Quintin Valley water for domestic use has always been scarce and locals are used to buying water from water trucks in many populated areas. Piped water is considered unfit for cooking and drinking, therefore all residents purchase drinking water from vendors that use reverse osmosis to remove all salts and impurities from the water of the aquifer. The quality of the piped water and of the truck vendors is the same since both extract the water from the same local sources; this water is only used for personal hygiene and various domestic uses like washing dishes or clothes that do not require human consumption. The planned government desalination plant for human supply of seawater may provide the needed complement to the present groundwater wells and improve the quality of the present piped water by mixing the low salinity water of the desalination plant with the high salinity water currently extracted from the wells.

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