Chapter 1
Contemporary Model for Water Management and Alternative Approaches

Roberto M. Constantino-Toto

Abstract Water is a natural good with the characteristic of being interpreted in different forms due to its transversality (Some examples of the importance of water based on the multiple ways in which it can be interpreted are, among others: an ecological way, establishing it as an essential factor for the sustaining of life; an economic one, through the exegesis of considering it an essential input in the provision of material goods which constitute the basis of social welfare; an institutional one, interpreted as an element essential to the formation of collective prosperity; a social one, as a vehicle for stability which allows the cohesion and reproduction of the system; a sanitary one, regarding it as a determining factor in the quality of life of the population). Of course, they are all equally important and occur simultaneously, which in turn highlights how significant and essential its availability is. Water availability is at the center of public welfare formation and prosperity evolution in all society. Nevertheless, it is a topic of growing public and institutional interest in the case of arid and semiarid societies, and those with heterogeneity in its distribution, such as the Mexican one. This is because the allocation processes to be encouraged should yield the maximum effect of public welfare from its exploitation process. This chapter puts forth the need to supplement water management capacities in Mexico through the incorporation of alternative analytical efforts such as those of water footprint and virtual water, which may strengthen the processes to identify the best practices in the exploitation of this resource, according to the potential supply sources and may foster the configuration of new arrangements for the required public infrastructure and investments development that aims at reducing vulnerability in water availability, derived from the institutional strategy that consolidated over the long term.

Keywords Water management · Alternative approaches

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1.1 An Institutional Perspective on Water Availability and Its Scarcity

The process of water supply for a society is related, at a first stage, to the natural physical availability of hydric resources. However, not all the water quantified form natural availability is susceptible of being used in the supply. Evapotranspiration, underground filtration, accumulation in superficial bodies, as well as the capacity of the infrastructure actually in place to extract, condition, distribute, and eventually collect water must be deducted from the estimated resource flow from the hydrologic cycle; that is to say, effective water availability in a society is remarkably affected by the technical choices made for its provision.

From an institutional perspective, the water supply process has a first limit in the capacity of the infrastructure for its provision, and therefore, of the underlying costs structure for the system operation, the maintenance of infrastructure, the increase of capacity, and the eventual creation of new facilities and equipment. In that regard, in a scenario of gradual increase of the natural demand of flows resulting from the demographic and productive dynamics, water availability may face an institutional situation of scarcity if the capacity growth rate or the required investment to that end, does not evolve at the same pace as exploitation.

An additional condition that determines supply sufficiency is one related to exploitation practices. Water availability is affected by the utilization pattern among the different types of uses. This condition is the result of the setting of incentives, whether they are explicit or not, that encourage extensive technological patterns of exploitation in the case of water as an input for production activity; or the result of careless consumption practices in the case of domestic uses. Two of the evident results of completion for the use of water resources in the face of a water offer with a steady technological trajectory and without the presence of corrective resources on exploitation are, on the one hand, overexploitation of water reserves: On the other hand, the presence of critical conflicts among users and between them and the authority responsible for the supply systems (Sainz and Becerra 2003).

The availability scenario is completed by the incorporation of the exploitation of waste or utilized water. To practical ends, all water volumes used that are not reconditioned to give them immediate exploitation properties back constitute a reduction of the accessible water reserve that is usually compensated for with a substitution of new flows, which tend to put pressure on ground or underground availability of supply reserves.

Institutionally speaking, the social demand for water availability is usually met, under conditions of political comfort and technological stability, by gradually increasing the extraction of hydric resources with a small capacity to promote a transition in the way supply is run. This usually generates concentration of budget resources and efforts on extraction, transfer, and distribution activities. Thus, reducing the management capacity for maintenance activities in the carrying lines, which in turn causes a deterioration process and an eventual reduction of the transmitted flows due to fractures in the distribution lines.

This puts into perspective the fact that in the face of scenarios of relative institutional stability regarding incentives and rewards related to moderation in the consumption, with significant fiscal restrictions versus the operation costs, which would subsequently have to incorporate those related to the reestablishment of supply sources, and under conditions of persistent technological stability to meet the public problems of water supply, an inevitable result is the water shortage as a product of the imbalance in managerial and institutional architecture.

1.2 Water Management in Mexico and the Predominant Contemporary Model

Addressing water management in Mexico is not an easy task. In a decentralized and federal government regime there are several possibilities for approaching the issue related to various characteristics, such as the different tiers of government responsibilities facing the problem, the pressure put on supply sources, the response capacity for the cleaning of used waters, the existence of more or less reserves, the magnitude of ecological costs induced by increasing extraction, characteristics of social inequality, and the existence of heterogeneous forms of exploitation. However, in spite of all existing differences in the country related to the above-mentioned elements, there are some shared aspects that determine the exploitation trajectories in the country as a whole. Among others, the preponderance of the federal government over the other tiers of the institutional structure, as well as the existence of a strategy that has privileged water offer and led to exceeding exploitation of the reserves, in the face of a lack of incentives moderating the demand and inducing cautious use of the resources, can be highlighted.

The contemporary model of water management is the sum of a series of processes, some of which have maintained a relative stability over time and have given shape to an exploitation pattern that responds to the institutional design (Tortolero 2000). Without incentives for agricultural producers, the main users of the largest part of eater volumes, tend to the promotion of technical change that makes water use more efficient and, at the same time, arousing the idea of a more responsible water culture among domestic users via a price reassignment (Jiménez et al. 2010). A phenomenon that presents relative inconsistency in the water demand correction strategy by omitting incentives aimed at the agricultural sector. The result of all this cannot be other than an increasing pressure on the surface of underground water reserves.

There is an important institutional tradition regarding water management in Mexico, which goes back to the colonial times. Ever since then, it is possible to identify the moments over time in which the scarcity of water has been invoked as a managerial resource to introduce modifications that have tended to accumulate and prevail, sometimes in an unnoticed way, up to these days: first, regarding the supply volumes of surface bodies,. then in relation to the supply coming from underground sources.

Some cases that adequately illustrate the remarks about scarcity caused by institutional and managerial conditions are found in the historic water archive. For instance, the case of the claims received by the Mexico City council regarding the reduction of water supply flows coming from the Santa Fe aqueduct in 1869. The shortage had different explanations; first of all, illegal canalizations (Ávila 1997) being made to detour water toward private potable water fountains because of the lack of public fountains (Suárez/Birrichaga 1997), as well as the corresponding derivations of the aqueducts to increase the potency of the power feeding the nascent factories in the Mexico Valley.

The above is completed with the authority's response to the identified problems and the technical decision that avoided flow reduction in the face of the detour of water coming from the aqueduct meant the design of underground piping to avoid flow loss through canalizations. This resulted in the gradual reduction of supply in public fountains such as the Salto del Agua or the Candelaria de los Patos in old Mexico City.

The notion of water shortage is not a sign that is exclusive of contemporary Mexican society. The competition for water use for the attention of different purposes has marked the evolution of the hydric sector in Mexico over time. Some examples of this are the many documented cases of dispute between different types of users trying to achieve larger exploitation volumes (Suárez/Birrichaga 1997; Iracheta 2001), among which the conflicts regarding the use of the Magdalena River as it passed through Coyoacan in 1789 (Ávila 1997), the conflicts between the use for irrigation related to population supply (Von Wobeser 1993) and the one related to water as a source of hydraulic energy for motor force in factories from the eighteenth century on (Suárez/Birrichaga 1997) and the deviations of water in towns and villages (Ruíz 1986).

All of the former puts into perspective that the model for water management has, over the long term, evolved through a process of increasing offer, based upon the highly spread belief of an abundant natural richness in the country (Salmerón 2003); given the exploitation patterns among the different types of uses, reaching the physical limits of the infrastructure capacity, tensions generate and they tend to be labeled as caused by scarcity.

The period between the end of the nineteenth century and the first half of the twentieth century constitutes a foundational moment in the structure of the water management policy and the accumulation of imbalances that would later be the basis of most of the contemporary diagnoses. On the one hand, the gradual process of water federalization that corresponds with the introduction to agriculture of great scale irrigation through the promulgation of the Law of Water Exploitation at the Federal Level in 1910 (Aboites/Tena 2004). On the other hand, the increasing federal exposition in the management of potable water services in local contexts that allowed the consolidation of a culture of apparent gratuity in the supply service, not because that was its purpose, but given the lack of updates in prices and tariffs

Table 1.1 Water supply and economic growth

Variable	Coefficient	Standard Dev.	t-statistic	Prob.
C	1.408683	0.874285	1.611241	0.1176
Ln supply	1.007327	0.097454	10.33639	0.0000
R-square	0.780767	Dep. Variable Mean		10.41433
R-square adjusted	0.773460	Dep. Variable S.D.		0.864068
Regresion S.G.	0.411264	Inf Akaike criterion		1.121300
Quadratic sum of errors	5.074150	Schwarz criterion		1.212909
Verisimilitude Log	−15.94080	F-statistic		106.8409
Durbin-Watson statistic	1.405449	Prob (F-statistic)		0.000000

Isoelastic model LnGDP = f (Ln Supply). *Source* Own elaboration with data from: INEGI, National Account System. Conagua, Water Statistics (2011)

resulting from the lack of controls by the federal authorities.[1] Decentralization of operations, modernization of user records, and a new institutional architecture in the face of fiscal deficit, are attempts to revert this, from the decade of the 1980s.[2]

The evolution of the institutional architecture on the subject of water along the twentieth century consolidated a model of stable exploitation, in which water as a productive input shows constant returns to scale. Thus, part of the country's economic prosperity depends on a growing water volume (Table 1.1).

The idea that water can become an obstacle for the prosperity and compromise the welfare conditions of a society is an acceptable argument. However, if the reference to limits possibly imposed by its scarcity are associated only to the containing capacity of the infrastructure of the predominant sources for exploitation, different approaches should be explored that do not lead exclusively to an institutional response that increases the offer.

1.3 The Potential of Water Footprint and Virtual Water Approaches for Institutional Strengthening on the Subject of Water in Mexico

Scientific and technological advances on the subject of water have led to a better understanding of the natural processes determining availability through the water cycle. Additionally, they have led to a better idea of the institutional implications regulating the interchanges between the ecologic and socioeconomic systems, and the precursors of the apparent water scarcity.

[1]The promulgation of the Law of Cooperation for the Supply of Potable Water to Municipalities of 1956 is the institutional piece that would consolidate the federal intervention model in local management of potable water supply and the begging of the management deceleration process.

[2]The process starts with the reform to Article 115 of the Constitution, in 1983.

This has translated into a process of gradual strengthening of the technological capacities regarding supply, distribution, and quality assurance. Nevertheless, facing the increasing demand of water derived from demographic evolution, population relocation, economic performance, and use patterns, one of the elements that has been diagnosed as a potential contender for apparent water scarcity is the increase in the efficacy of water supply systems.

In the search for options to improve the country's water standpoint, it must be considered that the notion of scarcity that prevails currently is that which is linked to the limits of institutional supply strategy and not to the lack of efficiency itself. This is, ultimately, the visible result and not the main cause of institutional malfunctions over time.

The idea that public water affairs can be considered a transversal topic in a formal government agenda is closely linked to the implicit acknowledgment that water is a multidimensional factor of society's well-being. Everything needs water, one way or another, in an abundant list, but what can be summarized as the set of goods and services associated to the prosperity of a given society and its capability to reproduce itself: food, energy, production inputs, population's health, and manufactures of different complexities. Likewise, it is essential to the stability of ecological processes that accompany social and economic evolution.

The rise of alternative approaches to the water analysis within society such as those of water footprint and virtual water tend to emphasize the complex net of interconnections developed over the exploitation of hydric resources, through the estimation of the technical water coefficients required by the type of product, activity sector, or territorial region; and their eventual transformation into productivity and economic impact indicators. Therefore, the objective to develop a model of transversal management of water that does not contain information regarding supply and consumption volumes by type of source directly exploited only is strengthened through the incorporation of information about the economic impacts of contemporary exploitation patterns, their corresponding chains, and the potential water exploitation sources not commonly accounted for.

The concept of virtual water in the specialized literature usually refers to the volume of freshwater commonly required for the production of economic goods and services. Just as this literature points out (Garrido et al. 2010), the concept may have two different acceptations. The first , refers to the offer side of goods, as water required for the production of goods in their manufacturing or production site. The second , regarding the demand for goods, as the water content needed for the production and disposal of merchandises in the consumption site.

Just as the pioneer study by Arreguín (2007) asserts for the Mexican economy, as well as the converging study of Aldaya (2008) for the international case, commerce of goods between regions within a country or at world level allows contending the negative effects of limited water availability which may affect, among other things, food production. Goods and services interchange is, in a way, a process of exchange and moving of water. But not an exchange or move of the water directly contained in them, but of that required for their production and disposal (Mekonnen/Hoekstra 2011).

Along with the concept of virtual water, the notion of water footprint or hydrologic footprint has risen with increasing importance. This is an indicator of the social appropriation of freshwater resources employed in the production of the flow of goods and services, apart from those contaminated by time unit. Water footprint has three components called blue water, green water, and gray water. Blue water is identified as the superficial or underground water reserves that are usually the object of traditional water policy through the construction of infrastructure that makes their exploitation immediate. On the other hand, green water is the component of the hydrologic cycle, also known as non-saturated zone water which allows the existence of vegetation based on soil humidity (Aldaya 2008; Garrido 2010; Mekonnen/Hoekstra 2011). Gray water represents the volume of water that is polluted during the production and consumption processes.

A region or a country's water footprint is estimated from the account of exploitation of local water resources and the incorporation of virtual water resulted from importing goods. In an evolution process of this approach, known as extended water footprint, the socioeconomic impacts of the water exploitation pattern are usually added by linking utilized volumes and the value of production or the induced effect in occupation growth, as well as the potential ecologic impacts.

From a perspective such as that of the water footprint and virtual water approaches, reflections on water scarcity, competition for the exploitation of hydric resources, and the impacts on public welfare of how those resources are utilized, take on a different dimension.

In Mexico, the idea of scarcity is usually associated to the limits of blue water exploitation, both in terms of the limits imposed by storage capacity of the infrastructure developed in the country for the direct exploitation of such resources, as well as in terms of the financial restrictions imposed by a structure of increasing costs derived from the exploitation pattern fostered over time, which has meant increasing exploitation of the supply sources, a frequent practice of transfers between basins, the increase of intangible costs ecology wise due to the prolonged deterioration of ecosystems, and an incentives structure limited to correct water consumption patterns (Jiménez et al. 2010).

There is a gradual institutional tendency in the country toward recognizing that water issues require a transformation in the way they are approached. Some indications of that can be found dispersed in the 2030 Water Agenda (Conagua 2012), the Special Program on Science and Technology on Water (FCCyT 2012) or the Special Concurring Program for the Sustainable Rural Development (CISDR 2007), just to mention a few of the contemporary government documents processing objectives aimed at reaching water sustainability. Nevertheless, the transversality of water issues demands harmonization processes for economic policy for the generation of incentives that correct the inefficient uses of water, the industrial and rural development policy that promotes exploitation processes with the highest possible economic impact, and the social policy tending to attenuate inequality among the population.

There is growing concern at the international level for the effects on development and welfare derived from the links between water and food production in a context of major climatic swaying (Waughray 2011). Mexico, just a like a great number of countries, devotes an important portion of its water extractions for the production of the agricultural sector. Arreguín (2007) has shown, based on his analysis of virtual water, that in the primary sector an involuntary result on water is that the Mexican economy is a net importer of virtual water based on the commerce of food. The best knowledge of water exploitation according to its colors and potential economic effects is a central factor for the construction of an institutional regime that promotes the best practice that increases resilience against meteorological changes in a territory in which drought tends to affect the population recurrently (Semarnat 2011).

Of course, and as Andre Santos states in Chap. 9 of this book, the fact that the country reduces its requirements of water coming from local sources for the production of food does not necessarily mean that an adequate food model is guaranteed.

The presentation above puts into perspective that there are a set of advantages in the utilization of the water footprint and virtual water approaches, but also limitations. The advantages are, the fact that they allow to make sense of the idea of required transversality in the implementation of the country's water policy must be highlighted. Second, they allow to identify a priority regime for the design of incentives based on the different colors of water for the development of the corresponding infrastructure. Third, they make it easier to articulate commercial strategies in the external sector that reduce pressure on local water resources.

Among the most significant restrictions identified in a transition process that strengthens water management policy upon the basis of the water footprint and virtual water approaches, are a lack of appropriate information systems for the estimation of technical coefficients according to water color and the adequate volumes consumed by product or region. Likewise, the presence of power groups that may be an obstacle for initiatives of change is important, due to the fact that these may mean they have to face significant costs derived from a turn in the conduction of water policy.

Of course improving the country's position upon the basis of the water footprint and virtual water analysis does not imply that the potential increase in welfare means a reduction of social inequality or that the food strategy is the fittest. Such demands cannot be met by water policy.

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