

Drought policy in Mexico: a long, slow march toward an integrated and preventive management model

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Abstract

Mexico is exposed to droughts and vulnerable to their impacts. Despite a history of serious economic and social consequences from drought, until recently national water policy did not acknowledge this type of natural disaster as a priority issue. This paper analyses how drought policy in Mexico has evolved since the creation of the National Water Commission in 1989 up to 2013, when the most specific initiative in that regard was introduced: the National Drought Program (Programa Nacional Contra la Sequía, PRONACOSE). Over that period of time drought has slowly but steadily gained importance in national water planning and management. Significant initiatives have been implemented, including a national drought early warning and monitoring system. Nevertheless, efforts still focus on compensating economic losses after the fact and little has been achieved in terms of reducing the country's vulnerability to drought. There is a great need to increase public awareness and boost the scientific knowledge necessary for the design of appropriate preventive measures. A long way remains to establish an effective, forward-looking, integrated and preventive drought management model.

Keywords: Drought policy; Mexico; National and regional water programs; National Drought Program (PRONACOSE)

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1. Introduction

1.1. Background

Mexico is the world's 11th most populated country (125.4 million inhabitants), 15th largest national economy in terms of gross domestic product (GDP) and with over 1.96 million km² of territory, ranks 14th in size (World Bank, 2016). Mexico's climate is relatively dry, with a mean annual precipitation (760 mm) well below the world's average (1,127 mm). Large tracts of the country normally receive much less precipitation than the national average, below 500 mm in most of the north and central regions (Figure 1). Consequently, about 54% of Mexico's territory falls under the Very Dry (BW), Dry (BS₀) or Semiarid (BS₁) categories of the Koppen-García climate classification system (García, 2004). In five northern and central states (Aguascalientes, Baja California, Baja California Sur, Coahuila, Sonora), that figure exceeds 90%.

Mexico is prone to droughts, i.e. episodes of significantly lower-than-average precipitation – see Mishra & Singh (2010) for a detailed exposition of drought concepts and categories. Exceptionally intense and prolonged droughts affecting large swathes of the country occur about every 50 years (Méndez & Magaña, 2010) but significant drought events strike almost every decade – for a historical chronicle of droughts since the fifteenth century, see Florescano Mayet et al. (1980). The most recent 50-year drought to affect the country occurred from late 2010 to mid-2013. At the drought's peak, up to

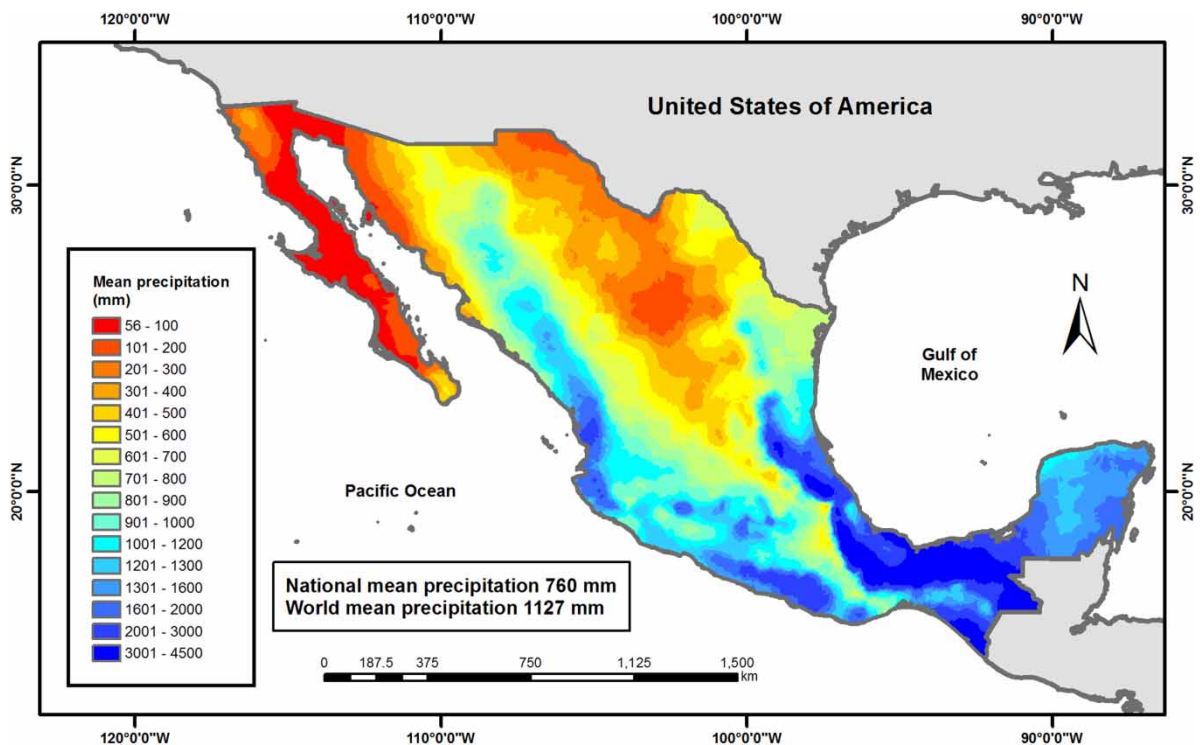


Fig. 1. Mean annual precipitation in millimetres (mm), Mexico. Source: CONAGUA (National Water Commission) (2015).

three quarters of the country registered abnormally dry conditions according to the standardized precipitation index (SPI) – a standard drought index first proposed by McKee *et al.* (1993). Figure 2 reports that index for 2011 and 2012; note that the relatively arid northern and central regions were the most affected. Ortega-Gaucín & Velasco (2013) estimate that this drought caused in 2011 alone, over USD1,300 million in agricultural losses (mostly in the northern and central states), reduced national GDP by 10% and affected 48 million people.

Mexico's northern, arid and drought-prone region harbors a significant share of its population and economic activities. Table 1 illustrates this with the four border states of Tamaulipas, Nuevo León, Coahuila and Chihuahua (Northeastern Mexico, NEM) that together comprise most of the Río Bravo Basin (RBB). This region encompasses more than a quarter of the nation's territory and 42% of its arid lands. Its 14 million inhabitants produce over 16% of the country's GDP, almost a quarter of its

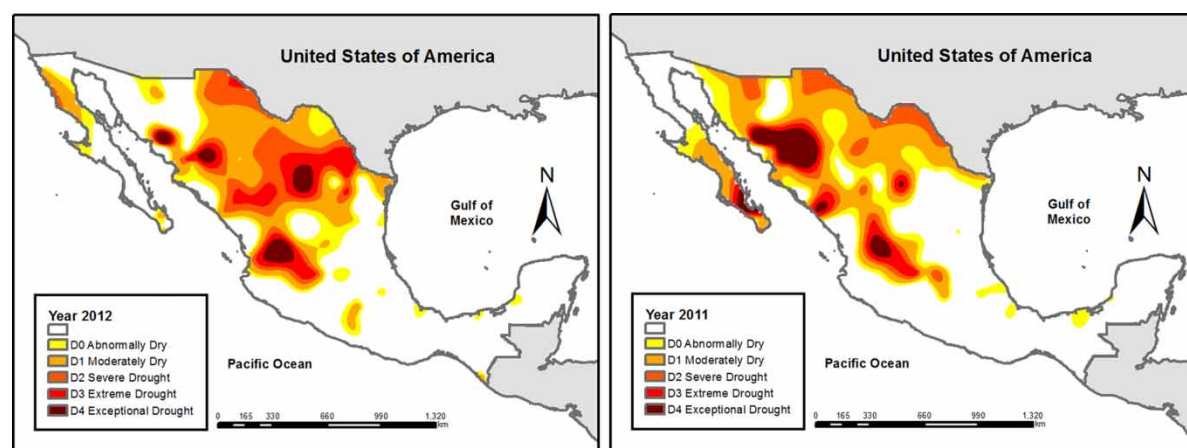


Fig. 2. SPI, Mexico, 2011 and 2012. *Source:* Authors.

Table 1. Territory, population and economy, Mexico and NEM, 2010.

| | Territory (10^3 km ²) | | Population (10^6 inhab.) | GDP (10^6 \$MXP) | | | GPD p.c. (\$MXP) |
|--------------|--------------------------------------|-------------------|-----------------------------|---------------------|--------|--------|------------------|
| | Total | Arid ^a | Total | Total | Manuf. | Agric. | |
| México | 1,964 | 1,077 | 112.3 | 11,966 | 2,017 | 390.9 | 106,519 |
| Tamaulipas | 77.2 | 55.5 | 3.3 | 381.2 | 63.8 | 14.1 | 116,640 |
| Nuevo León | 64.2 | 54.7 | 4.7 | 855.0 | 205.9 | 6.1 | 183,740 |
| Coahuila | 151.7 | 151.7 | 2.7 | 380.9 | 137.0 | 9.8 | 138,584 |
| Chihuahua | 250.3 | 195.5 | 3.4 | 326.7 | 67.7 | 21.8 | 95,894 |
| NEM | 543.4 | 457.5 | 14.1 | 1,943.8 | 474.5 | 51.8 | 138,086 |
| (national %) | (27.7) | (42.5) | (12.5) | (16.2) | (23.5) | (13.3) | |

^aSurface classified as BW, BS₀ or BS₁ (Koppen-García climate classification system).

Source: Authors, with data from the Mexican federal statistical agency (INEGI).

manufacturing output and thanks to an extensive system of irrigation infrastructure, 13% of its agricultural production. The region's GDP per capita is 23% above the national figure.

The body of published literature on the social and economic impacts of droughts in Mexico, as well as the country's policy responses to the phenomenon, is limited in extent – this, perhaps surprising, state of affairs motivates this paper. A small number of contributions address impacts on agricultural output and employment (Ortega Gaucín *et al.*, 2008), spill-over effects through forward and backward economic linkages (Sisto *et al.*, 2011) and threats to urban water supply (Sisto *et al.*, 2016). Feng *et al.* (2010) corroborate quantitatively the long-held perception of a link between migration and drought, mentioned for example in Velasco *et al.* (2005); Neri & Magaña (2016) argue that the severity of drought impacts depends on the vulnerability of the region affected, including the type of water sources exploited – in Mexico aquifers provide about two thirds of water supplied to urban areas. The narrow literature on national drought policy suggests responses have been patchy and mostly reactive (Ortega Gaucín *et al.*, 2014; Arreguín Cortés *et al.*, 2015).

1.2. Objectives

This paper evaluates Mexico's institutional and policy responses to drought over the past quarter of a century. Specifically, it presents a detailed and critical analysis of how drought policy has evolved, focusing on national and regional water programs produced during that period of time. The paper is organized as follows. Section 1 offers background information on drought risks and impacts in Mexico. Section 2 shows how and to what extent the five national water programs presented since 1989 have addressed the issue of drought. This section also deals with two relevant initiatives introduced during that period: the National Fund for Natural Disasters (FONDEN) and the National Prevention Fund (FOPREDEN). Section 3 focuses on the National Program against Drought (PRONACOSE), a recent and key program intended to deal explicitly with droughts. Section 4 concludes.

2. Drought policy in Mexico's national water programs, 1989–2014

2.1. Mexico's national water management framework: a brief overview

Mexico's national water management framework is highly fragmented. The water sector's main actor, the national water commission (CONAGUA, created in 1989 by presidential decree) forms part of the federal ministry of the environment and natural resources (SEMARNAT). The federal ministry of agriculture (SAGARPA) also possesses wide authority in terms of water management. In total, 12 federal-level ministries exert influence on the matter. Moreover, 13 River Basin Organizations and 26 River Basin Councils, with a wide array of technical, administrative, legal and other functions, report directly to CONAGUA. The interior ministry (SEGOB) administers both the FONDEN and FOPREDEN programs. The former, established in 1996, provides funds to state and municipal governments facing emergencies following natural disasters (including hurricanes and droughts), while the latter, created in 2003, finances disaster prevention programs. Multiple actors, diffuse responsibilities and a lack of coordination have introduced a degree of dysfunctionality into Mexico's water management institutional structure (Organisation for Economic Co-operation and Development (OECD), 2013a).

2.2. Drought and its impacts: perceptions and knowledge

Policies should be grounded on sound information. We thus begin our analysis of Mexico's water programs with a review of what these documents reveal about how drought is perceived in relation to other water challenges, and how much is known about the impacts caused by drought events.

2.2.1. Drought as an object of concern. National water programs have systematically recognized the overall aridity that characterizes the country, especially in the north. Another recurring theme is the insufficiency of hydrological monitoring, especially in the case of groundwater. The 2001–2006 Program expressed concern over the growing pressure on groundwater, to the point of overexploitation in many areas of high population and economic growth (CNA (National Water Commission), 2001). It also emphasized that aquifers represent an essential resource for national development, as 75 million people, 1.6 million hectares of irrigated agricultural and half of the country's industrial water requirements depend on this source. The program furthermore suggested that climate change could occasion more severe, frequent and prolonged droughts, and thus reduce the availability of both surface and groundwater.

A series of regional, long-term water programs (Programas Hidráulicos Regionales de Gran Visión 2001–2025) made a substantial contribution to regional water planning as well as the understanding of river-basin scale water and policy issues. The RBB Program exemplifies this. It presented a clear assessment of that basin's main challenges: a limited natural availability of water in the face of increasing demands for both domestic and industrial uses, fueled by population and economic growth. Moreover, that program recognized the basin's vulnerability to drought as well as the relief provided by occasional hurricanes. It also argued that the existing institutional framework was too fragmented and uncoordinated to meet the basin's challenges effectively, and made the case for a more proactive governance model (CNA, 2003, pp. 22–23).

The 2007–2012 Program stressed the strategic value of water and noted the unfortunate fact that most of the country's growth occurs where water is least available. It also pointed out that per capita water availability was declining (CONAGUA, 2008). The 2014–2018 Program (CONAGUA, 2014) spoke briefly of the country's high vulnerability to drought (especially in the northern states) and emphasized the importance of adaptation to climate change, in particular with respect to a possible decline in surface flows by 2030 (using 2013 as baseline year). The program also expressed the need to deal with drought explicitly through a dedicated institutional program – this need would eventually be addressed by PRONACOSE.

2.2.2. Impacts of droughts. National water programs mostly report generic observations on the impacts of droughts, such as: reduced crop and cattle production; decreased hydropower generation; damage to flora, fauna and ecosystems; risk to urban water supplies through declining water availability; and, over-exploitation of aquifers (CNA, 2000; CONAGUA, 2008). The 2002–2006 Regional Program for the RBB (CNA, 2003) went further toward describing impacts on the agricultural sector, mentioning increased activity in agricultural land markets (sales and leases) and large-scale movements of cattle herds away from drought-affected areas. It also delved into the usually ignored realm of social impacts, including: unemployment, migration (in particular, of agricultural workers), abandonment of crop lands, conflicts among water users, and even family breakups and suicides.

Relatively little hard data on specific drought events can be found in water programs. Beyond the chronology of the most severe and geographically extended droughts since the middle of the last century (1948–1954; 1960–1964; 1993–2002; and 2010–2013), few detailed economic estimates appear, with some notable exceptions. Economic impacts of drought between 1980 and 1998 are estimated to have cost up to USD500 million (CNA, 2000, p. 17); the latter year is deemed particularly difficult, with most of the country affected (23 of 32 states, particularly in the north and central regions) and damage estimated at USD310 million (CNA, 2000, p. 18). The RBB was exceptionally hard hit. Reduced surface flows in that region impeded Mexico's ability to honor its water commitments to the United States (as laid out in the 1944 Treaty), triggering a serious conflict between the two nations.

The focus of that debate centered on whether the on-going drought qualified as 'extraordinary drought' as contemplated in the Treaty – under that clause Mexico would have no obligation to deliver water to the USA from the Río Bravo tributaries considered in the Treaty. The conflict escalated to such a level that there were voices in the USA calling for restrictions on (or even suspension of) deliveries of Colorado River waters to Mexico. For many months in 2001, this issue was at the very top of the US–Mexico agenda. For more detail on these binational arrangements and their connection to droughts, see Mumme & Aguilar-Barajas (2003).

2.3. Policy responses to drought

2.3.1. The importance of drought in water programs' objectives and strategies. Objectives stated in water programs and the strategies and projects proposed to achieve those reveal a great deal about national priorities and their evolution through time. Table 2 reports the objectives presented in all national water programs since 1989; for objectives that deal with drought, Table 3 presents the proposed strategies and projects.

The 1989–1994 Program did not mention drought at all in its objectives, strategies or projects. The 1995–2000 Program did not either (at least explicitly), despite the fact that the serious aforementioned conflict with the United States over binational waters was already brewing. That program did however introduce a multi-sectoral and wide-ranging strategy relevant for drought policy: the formation of River Basin Councils. The justification behind this was to strengthen cooperation between authorities (federal, state and municipal) and water users, in order to improve water planning and management. In all subsequent programs, River Basin Councils were to form a fundamental part of national water planning and management. The 1995–2000 Program also suggested the necessity of 'controlling adverse impacts' (CNA, 1994, p. 34) from extreme weather events such as floods and droughts (a clearly reactive stance), and of addressing the problem of groundwater overexploitation.

The 2001–2006 Program for the first time introduced drought explicitly in its objectives, albeit jointly with floods and as the last of six objectives. Strategies, projects and financing however focused entirely on floods. The 2007–2012 Program's sixth objective (out of eight objectives in total) implicitly included drought as part of 'extreme weather events'. Strategies and projects mostly focused on floods, but one drought-specific strategy did appear: the development of prevention plans. The program recommended these plans include rules on water allocations between competing uses under drought conditions as well as mechanisms to verify compliance. It also proposed that River Basin Councils 'lend support' to this endeavor. The latter proposal illustrates a larger problem, common to all national water programs: the lack of definition of responsibilities among multiple actors. Programs customarily present ample lists of institutions and organizations to be involved in meeting objectives, with a brief and general description

Table 2. National water programs: objectives, Mexico, 1989–2014.

| Period | Objectives |
|--------|--|
| 89–94 | <ol style="list-style-type: none"> 1. To develop the infrastructure necessary to improve access to water and sewer services. 2. To promote the efficiency of water use. 3. To improve water quality in river basins and aquifers most affected by pollution. |
| 95–00 | <ol style="list-style-type: none"> 1. To improve access to water and sewer services. 2. To increase wastewater treatment efforts. 3. To grant legal certainty to holders of water use rights. 4. To promote the transition toward sustainable development. 5. To extend public participation in water planning and management. 6. To increase the efficiency of water management. 7. To promote efficiency in the allocation of water among distinct types of uses. |
| 01–06 | <ol style="list-style-type: none"> 1. To promote efficiency in agricultural water use. 2. To improve access to and quality of water, sewer and sanitation services. 3. To achieve integrated and sustainable water management in river basins and aquifers. 4. To foster the technical, administrative and financial development of the water sector. 5. To strengthen public participation in water management and foment a culture of responsible use. 6. To manage the risks and impacts of floods and droughts. |
| 07–12 | <ol style="list-style-type: none"> 1. To improve efficiency in agricultural water use. 2. To improve access to and quality of water, sewer and sanitation services. 3. To foster integrated and sustainable water management in river basins and aquifers. 4. To improve the technical, administrative and financial development of the water sector. 5. To strengthen public participation in water management and foment a culture of responsible use. 6. To manage the risks and impacts of water related disasters. 7. To evaluate the effects of climate change on the hydrological cycle. 8. To create a culture of compliance with the administrative dispositions of the National Water Law. |
| 14–18 | <ol style="list-style-type: none"> 1. To strengthen integrated and sustainable water management. 2. To increase water security in the face of droughts and floods. 3. To bolster water supply and access to water, sewer and sanitation services. 4. To increase the technical, scientific and technological capacities of the water sector. 5. To ensure water for crop irrigation, energy, industry, tourism and other activities in a sustainable way. 6. To strengthen Mexico's participation in the international water scene. |

Source: Authors, with original national water programs. For 1989–1994: (CNA, 1993, 1994); for 1995–2000 (CNA, 1995); for 2001–2006 (CNA, 2001); for 2007–2012 (CONAGUA, 2008); for 2014–2018 (CONAGUA, 2014).

of their intended participation. Strategies however usually do not refer to these actors, and when they do, the language is too vague ('to lend support', 'to facilitate', etc....) to establish clear responsibilities, let alone assess *ex post* performance.

The 2014–2018 Program elevated drought as the second most important objective (out of six) but again in conjunction with floods. It did however present a specific and innovative strategy: a drought prevention program (PRONACOSE). Given the relevance of this program, this paper's third section focuses on it.

Regional water programs on occasion have offered more concrete drought policy proposals than national programs. For example, the 2002–2006 Regional Program for the RBB (CNA, 2003) suggested: investing in new hydraulic infrastructure (dams, wells and water conveyance works); emergency distribution by water tank trucks to domestic users and ranchers; revolving suspension of water services in cities; and, specifically for the agricultural sector, investments in more efficient water

Table 3. National water programs, objectives, strategies and projects to deal with drought, 1989–2014.

| Objective (period) | Strategies | Projects |
|---|--|--|
| N/A (95–00) & (89–94) | These programs did not present objectives, strategies or projects to deal with drought. | |
| 6. To manage the risks and impacts of floods and droughts. (01–06) | 6.2 To implement rational water use policies to better deal with periods of drought. | These programs did not present explicit projects to deal with drought. |
| 6. To manage the risks and impacts of water related disasters. (07–12) | 9. To formulate preventive plans to better deal with drought and to back their implementation. | 6.9.1 To formulate a contingency drought plan for each Basin Organization. |
| 2. To increase water security in the face of droughts and floods. (14–18) | 2.1 To safeguard and increase the resilience of communities and producers in areas exposed to flood and/or drought risk. 2.2 To reduce vulnerability to impacts from climate change or variability. | 2.1.2 To implement the National Drought Program (PRONACOSE). 2.2.1 To strengthen the participation and co-responsibility of states and municipalities in adaptation measures for climate change or variability. 2.2.2 To create or strengthen funds for climate change adaptation and for the maintenance and restoration of hydraulic infrastructure. |

Source: Authors, with original national water programs. For 1989–1994: (CNA, 1993, 1994); for 1995–2000 (CNA, 1995); for 2001–2006 (CNA, 2001); for 2007–2012 (CONAGUA, 2008); for 2014–2018 (CONAGUA, 2014).

application systems for irrigated crops as well as temporary work programs. The program however clearly recognized that these measures would only serve to mitigate the impacts of drought.

2.3.2. Linking objectives with strategies and projects. The links between objectives, strategies and projects in national water programs reveal the slow evolution of drought policy during the past 25 years. Table 3 summarizes that long journey, from an initial point (the 1989–1994 and 1995–2000 periods) where no objectives, strategies or projects dealing with drought were stated, to the current period (2014–2018) where all three concepts are made explicit. The 2014–2018 Program however shows weaknesses in terms of articulating and linking objectives with strategies and projects. The program's second objective is the only one to refer directly to drought but most (if not all) of the remaining five objectives are presumably connected to drought – these connections however are not made explicit or discussed. Moreover, amalgamating drought and floods arguably muddles matters, as both types of disasters differ in nature and require different types of interventions.

Two strategies derive from the Program's second objective. The first proposes to increase resilience to floods and droughts in areas exposed to those risks however the only project presented (PRONACOSE) deals exclusively with drought. The second strategy is about reducing vulnerability to climate change and climate variability. This should encompass drought, but the relationship is not made clear. The two projects proposed: increased participation and co-responsibility for state and municipal governments, and the creation and strengthening of funds for adaptation projects, do not spell out many specifics with respect to drought. Moreover, the Program is rather vague about where the money required to fund these projects would come from.

The 2014–2018 Program establishes for its objectives a set of performance indicators, with base values for 2012 and goals for 2018, clearly a good idea for evaluation purposes. Unfortunately, it is rather difficult to find the relationship between the six objectives and eight indicators, as no coding scheme is offered to establish that correspondence.

2.4. *The wider policy-making context*

Drought policy does not emerge in a vacuum; many factors influence what possibly can be achieved and what actually is achieved. Here we focus on four factors that have influenced the development of Mexico's drought policy: the process behind the formulation of programs; the emphasis on floods; financing; and, the predominance of a reactive approach.

2.4.1. The formulation process. National water programs should ideally be formulated in concordance with other national programs, especially those that deal with national development, the environment, natural resources and hydraulic infrastructure. In reality, this does not happen. Water programs do make passing references to other relevant national programs but clearly are not developed in close parallel collaboration. This lack of coordination is plainly revealed when considering the problem posed by drought in the northern states. This problem cannot be productively addressed without considering the multiple and complex set of rights and obligations specified in the 1944 Treaty between Mexico and the United States on sharing RBB and Colorado River Basin waters – an apparently obvious point that usually goes unnoticed in national water programs.

Another layer of complexity arises from stakeholders' involvement. National public forums and meetings with experts on an array of water management issues are typically carried out during the process of drawing up national water programs. This also happens at the regional level where forums attract politicians, public servants, academics and water users' representatives and other non-governmental organizations. Experience however shows that public consultations have little impact on the design and implementation of policies in general, including drought policy. For authorities, public consultations constitute an obligation that must be met in order to fulfill legal requirements on the matter – they do not reflect a deliberate effort to incorporate a bottom-up approach in policy making. As a result, public consultations appear to represent for authorities a goal, in and of itself.

The National Water Commission – the country's maximum authority in matters of water planning and management – typically bows to more powerful and well-funded federal ministries. More than 25 years after the commission's creation, the country still suffers from a fragmented institutional framework that lacks coordination. The push toward promoting public participation through River Basin Councils has had no measurable impact on water policy in general or drought policy in particular. The Councils lack the formal and legal structure, as well as the funding, to contribute effectively to river basin-level water planning and management.

2.4.2. The emphasis on floods. In terms of water-related natural disasters, national water programs have systematically put much more emphasis on floods than drought. There are obvious reasons for that. Floods (and the hurricanes or large tropical storms that cause them) are dramatic events that produce immediate and highly visible damage to life and property. As such, they attract more attention from the mass media, the public in general and policymakers than drought – a slowly evolving, diffuse phenomenon whose impacts are not nearly as spectacular and may even go unnoticed by large sectors

of the population, especially in urban centers. The National Water Commission to an extent has recognized this problem (CONAGUA, 2006, p. 235) but has stopped well short of offering any kind of a solution.

2.4.3. Financing. How much Mexico spends on drought-related activities, from policy design to actual projects, is hard to ascertain. National and regional water programs offer limited information on budgetary commitments and usually this information is too aggregated to separate out what is specific to drought, as programs and projects usually amalgamate floods, drought as well as other types of natural disasters and risks. Mexico's fragmented water sector institutional framework also poses difficulties in that respect. According to the OECD (2013b), the cost-effectiveness of the country's spending on natural disasters preventive and mitigation measures is difficult to determine as the multiplicity of actors and programs introduces a serious double-counting problem.

What information is available suggests a low order of priority for spending on drought-related activities. For example, the 2002–2006 Regional Program for the RBB (CNA, 2003) – one of the few programs to present budgetary commitments – spoke of a grand total of MXP7016 million to tackle all of its objectives. The amount dedicated to the sixth objective (on managing risks and impacts from floods and drought) amounted to MXP243 million – about 3.5% of the total. How much of this was spent specifically on drought-related activities was left unspecified, but certainly represented a small fraction.

2.4.4. Predominance of the reactive approach. Beginning with the 2001–2006 Program, national water programs have referred to risk management and prevention as key elements for water-related natural disasters policy. The 2007–2012 Program recognized the need to 'give more importance to preventive measures' in the specific case of droughts (CONAGUA, 2006, p. 235). In reality however the approach taken to deal with drought and other water-related disasters has been overwhelmingly reactive – in spite of the international consensus on the cost-effectiveness of prevention relative to disaster relief.

Monies allocated to the National Fund for Natural Disasters (FONDEN, the focus of which is to provide funds for reconstruction and disaster relief) and the National Prevention Fund (FOPREDEN, dedicated to funding preventive measures), yield some information about the federal government's actual priorities. According to the OECD (2013a), over the 2000–2010 period the former fund received on average about MXP4627 million per year and the latter, a mere 6.5% of this, i.e. MXP300 million. The same source also points out that FOPREDEN funds tend to be distributed to states with the capacity to present proposals and not necessarily on the basis of objective needs.

3. The National Drought Program

3.1. *The origin of the program: circumstance*

In July 2011, amid clear and ample evidence that many parts of the country were in the grip of a severe drought, the federal government produced a document ('Strategies to Deal with Drought in Impacted States') that purported to ease the difficult conditions generated by the event. On the whole the solutions presented seemed like a knee-jerk reaction. Worse, some of the solutions were at odds

with well-grounded and long-standing policies – for example, the proposal to allow extraction from aquifers previously banned from exploitation because of severe overexploitation.

A few months later, the federal Congress approved a 2012 budget that did not earmark any funds to deal with the crisis (Arreguín Cortés *et al.*, 2015). This triggered a heated political conflict, with some legislators pressuring the executive branch to come up with funds to deal with the emergency. Of all potential sources of funding spread out over the spectrum of government agencies, the FONDEN was the most likely candidate. This fund however is regulated by rigid rules that prevent the quick disbursement of monies.

On January 25 2012, the federal government published another document which laid down how various existing federal programs were to be re-focused on protecting productive activities in the face of the on-going emergency, as well as providing humanitarian aid to affected communities (Arreguín Cortés *et al.*, 2015). Later in the same year, on November 22, the federal government emitted yet another document, this time providing guidelines on how to formulate mitigation and preventive measures to deal with droughts. None of the aforementioned initiatives were foreseen in the then current 2007–2012 National Water Program. Over the 2011–2012 period, authorities did react to circumstances and managed to provide a measure of relief (albeit insufficient) through temporary work programs, water and food distribution to the worst affected rural communities and help with crop insurance for farmers (Arreguín Cortés *et al.*, 2015). Nonetheless authorities' responses proved piecemeal, case by case, and revealed the absence of a coherent national policy.

In January 2013 the still on-going drought made headlines in the national press. Recognizing the ineffectiveness of the approach adopted so far, CONAGUA proposed a radical shift in strategy, from a reactive approach to a preventive one that hinged on a National Drought Program (PRONACOSE). The federal executive designated CONAGUA as general coordinator and administrator of the program and on April 5 2013 an Inter-Secretarial Commission (IC) was formally established. The IC gathered representatives from 12 federal ministries, the national electricity utility (CFE) and CONAGUA – the latter was put in charge of the technical sub-committee. A group of experts from various universities and research institutions were invited to form a special sub-committee tasked with contributing to the program's design and evaluation.

3.2. The program's design

3.2.1. Goals and features. The program's core goal is to reduce the country's vulnerability to drought through preventive and mitigation actions. For this the program contemplates three main sets of actions. The first set consists of planning; this includes a national system to detect nascent drought events, emit early warnings and monitor their evolution, as well as detailed river basin-level preventive and mitigation programs. The second set deals with providing relief to affected communities and safeguarding water supply for domestic uses. The third set is about coordination, including protocols to simplify and accelerate access to FONDEN monies.

The main implementation tool at the program's disposal comes in the form of 26 specific river basin plans (Programas de Medidas Preventivas y de Mitigación a la Sequía, PMPMS). These were adopted by the River Basin Councils between November 2013 and May 2014. The program also contemplates public information and education campaigns to raise awareness and understanding of drought and its impacts.

3.2.2. Achievements. The program has successfully implemented a national drought monitoring and early warning system. Since 2013 Mexico's National Weather Service (SMN) has provided monthly information in that respect for all river basins, state and municipalities and this information is freely available on the monitoring system's website. However, in order to become an effective management tool, the system will need to evolve and produce more information on on-going drought events, for example water consumption by type of use as well as the current state of underground and surface water sources.

Another significant achievement of the program is the formation of the IC. The ample participation of diverse federal ministries as well as national and regional water authorities makes explicit that water management problems are multi-sectoral by nature and cannot be solved by water authorities alone. This type of integration should ease the coordination problems observed so many times in the past – as the IC found out there are 114 federal programs that in some ways are relevant for drought policy (Arreguín Cortés et al., 2015). Although the sub-committee of experts at the time of writing had not yet produced a first evaluation of the program, it has put together a document outlining research priorities on drought from the point of view of several disciplines.

3.2.3. Shortcomings and challenges. Since the program's inception, no significant drought event has occurred. This precludes evaluating the effectiveness of the program's operational core – the aforementioned 26 river basin plans. Nonetheless, their basic design raises doubts. These plans establish lists of actions to be carried out in case of drought, contingent on the degree of the event's severity. Proposed actions however focus on adaption to a temporary reduction in water availability and do not address the underlying factors that make a region or water use sector vulnerable to drought. This arguably represents a fundamental flaw that will limit the program's ability to fulfill its core goal of reducing vulnerability.

The program's own sub-committee of experts has expressed concerns about the paucity of impetus put into the development of the river basin plans. The original intention was to include in each of these plans, specific plans for two cities as well as for water utilities operating in the river basin – no progress to date has been registered on those fronts. The same can be said of a risk atlas, which was to be produced in coordination with the national civil defense authority.

This lack of progress can be directly ascribed to insufficient funding, but other external factors are also at play. In September 2013, Mexico suffered the consequences of two major hurricanes (Ingrid and Manuel). These put an end to the drought of 2010–2013 but also produced a radical shift in national attention towards the problem of floods, with drought as an object of concern quickly receding from memory. Later, the drop in international oil prices significantly affected the country's public finances and led to federal budget cuts in many sectors. In particular, the joint research fund administered by CONAGUA and the National Council for Science and Technology (CONACYT), which was to finance the PRONACOSE research program, was practically eliminated – despite a solid consensus on the need to expand and strengthen drought research and education (Ortega-Gaucín et al., 2014).

Looking forward, the drought program faces many challenges. For the IC to function effectively, it will have to overcome the coordination roadblocks to be expected within such a diverse workgroup. Also, there is a long way to go toward the program's integration with existing federal natural disaster programs such as FONDEN and FOPREDEN. Those programs, in light of their poor performance in dealing with drought, could be modified or even re-engineered. Finally, there is the broad issue of the program's responsibilities in terms of public information, education and participation. Up to now, the River Basin Councils (the program's key element for this task) have not proven effective in that

respect. As a series of personal interviews with high officials in CONAGUA reveal, there is a widely shared view that the councils have not operated successfully on the whole, save a few exceptions.

4. Conclusions

Given Mexico's high exposure and vulnerability to drought, the limited attention given to the issue in the national water programs of the last 25 years is striking. The country's drought policy has evolved and drought as a formal national priority has gained ground, although not as much as the matter deserves. It is worth noting that of the 38 initiatives presented in the National Water Agenda 2030 (CONAGUA, 2011), not a single one addressed drought, versus nine that dealt with floods.

The process behind the elaboration of national and regional water programs is problematic and needs radical improvements, if these documents are to serve as actual roadmaps for solving the problems the country faces. The programs do show awareness of, and concern for drought and its social, economic and environmental impacts. They also present conceptually valid initiatives to deal with the issue. The programs however exhibit serious limitations in terms of concrete proposals to solve identified problems and are plagued by vagueness and inconsistencies.

The need to refocus policy away from a reactive to a preventive approach has been recognized, but in reality little headway has been achieved. A risk management approach based on reducing vulnerability is still in the works. It is ironic that the national drought program, the most concrete policy accomplishment registered so far, came about in reaction to an exceptionally severe drought. Much remains to be done on several fronts, but awareness and knowledge gaps represent a significant challenge that needs to be overcome for progress to accelerate.

First and foremost, there is a general lack of public awareness about drought. This manifests itself clearly when proposals for large-scale projects to convey surface water over long distances (from where the resource is available to where it is needed) are presented. For important northern urban and industrial centers, such projects could help reduce risks to water supplies and increase robustness to drought. Experience however shows that proposals are met by apathy from the general public and fierce opposition from environmental and other civil organizations. Legitimate concerns can be raised over the negative impacts of large-scale hydraulic projects but the debate should then center on ways to minimize those. Wholesale rejection leaves no credible alternatives: if it is not acceptable to convey water, should populations and industry be relocated? River Basin Councils could play a fundamental role in improving society's understanding of the issues at hand, given their stated mission of linking water users and authorities. But for this to happen, the councils' foundations need to be firmed up in national water law and regulations and sufficient operating budgets must be provided.

Scientific and technical knowledge about drought is also insufficient. The quantification of drought risk requires an adequate characterization of both hazard and vulnerability, but such work in Mexico is only incipient (e.g. Neri & Magaña, 2016) – this presents a serious limitation for the design of preventive measures. Groundwater management is a good example of this. Aquifers form an essential part of urban and agricultural water supply, especially in the central and northern areas of the country exposed to drought risk. Currently most groundwater is obtained from overexploited aquifers; this exerts pressure on stored water resources and compromises their long-term value as a buttress against drought. Little is known however about drought-groundwater dynamics and this precludes the possibility of effective, forward-looking management based on sound operating rules (Mahlknecht et al., 2015).

In the Mexican context, drought policy has to be understood as a matter of water security, i.e. ensuring a steady, predictable and sufficient supply of water to cities, industry and agriculture. By extension, the matter speaks to national development and welfare. In this, every citizen, private firm, civil organization and public institution holds a stake and all should be fully aware of the necessity to proceed accordingly. In reality, the country is still far from reaching this state of affairs.

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