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# PROGRAM OF PREVENTIVE AND MITIGATION DROUGHT MEASURES OF THE RIO BALSAS BASIN COUNCIL (PPMDM-RBBC)

David Ortega-Gaucin
Israel Velasco Velasco
Mexican Institute of Water Technology (IMTA)
ortega_gaucin@hotmail.com; ivelasco@tlaloc.imta.mx

Mario López Pérez
Justo Cardoso García
National Water Commission (CONAGUA)
mario.lopezperez@conagua.gob.mx; justo.cardoso@conagua.gob.mx

## ABSTRACT

Drought is one of the most complex natural phenomena which affects a lot of people in the world. Droughts in recent years have affected various socioeconomic sectors in Mexico, but especially the agricultural and livestock sectors as well as rural populations, leading to severe imbalances in the regional and national economies. In the 2011-2012 period this happened when a drought that has been considered the most severe of the last seventy years occurred. Therefore, in 2013 the Mexican federal government launched the National Program to Face Drought (PRONACOSE, in Spanish), which consists in the attention, monitoring, prevention and mitigation of this recurrent phenomenon. As an integral part of PRONACOSE, Programs of Preventive and Mitigation Drought Measures (PPMDM) for each of the 26 Basin Councils in the country were made. Thus, this paper presents the main results derived from the formulation of PPMDM of the Rio Balsas Basin Council (RBBC), which aims to minimize the social, economic, and environmental impact of potential drought situations. It presents, firstly, a brief description of the Balsas river basin; then exposes the main impact of past droughts in the area of this hydrological basin; continues describing the analysis of current vulnerability to drought in the basin; and finally, presents the series of measures that were defined under the RBBC to deal with future events of drought in three ways: before the phenomenon happens (strategic measures), at the beginning (tactical measures), and when it is already present (emergency measures). It is expected that the implementation of some of the preventive measures and mitigation strategies will begin to be implemented starting soon, and it is expected that adequate coordination between different government levels and the active participation of society, will result in tangible benefits and lower economic losses next times drought occurs.

**Keywords:** drought, water shortage, hydrologic basin, water resources management.

## INTRODUCTION

In the past few decades, due to the importance that has been given to study global warming and climate change phenomena, have been analyzed with great attention the changes that can occur in global and local climates, especially in the critical points of the hydrological cycle. Studies by the Intergovernmental Panel on Climate Change (IPCC, 2013), indicate that water cycle will be affected in coming years: will change the distribution of rainfall and increase the frequency of extreme weather conditions in both wet and dry; in fact, a good example of these climatic variations in Mexico are the frequent severe droughts that occur since the end of the last century (Martínez-Austria, 2007; Velasco, 2012).

However, despite the frequency and recurrent droughts in Mexico, historically, attention to the effects of this phenomenon has been based on a reactive approach, where the primary importance has been the attention of crisis and not the risk management; in other words, in the last few decades have been implemented measures and response actions "emerging" only after is known each of the ravages caused by drought, without the time required to plan and properly assess the options and resources available to deal with the phenomenon (Ortega-Gaucin, 2012).

For this reason, given the severe drought that took place in Mexico during 2011 and 2102, the federal government decided to implement since 2013 the National Program to Face Drought (PRONACOSE, in Spanish), which aims to implement a series of preventive actions and mitigation measures in order to reduce the vulnerability of the population to this natural phenomenon. As an integral part of PRONACOSE, Programs of Preventive and Drought Mitigation Measures (PPMDM) for each of the 26 Basin Councils of the country were made.

In this context, the objective of this paper is to present a summary of what is properly the Program of Preventive and Mitigation Drought Measures of the Rio Balsas Basin Council (PPMDM-RBBC), which aims to contribute minimize social, economic, and environmental impacts of potential drought situations in the context of the Rio Balsas Basin Council by posing a series of preventive and mitigation measures and response strategies that conduce to an appropriate risk management, i.e. from the probability of being affected by this natural phenomenon.

## DEVELOPMENT

### Description of Rio Balsas Basin Council (RBBC)

The RBBC corresponds to what is properly the Hydrologic Region number 18 Balsas (HR 18), and it is located southwest of Mexico, between the parallels 17°13' and 20°04' north latitude and meridians 97°25' and 103°20' west longitude. It has a hydrological area of 117,305.9 $km^2$, equivalent to 6% of the country (Figure 1).


Figure 1. Geographical location of RBBC in Mexican Republic.

From an administrative point of view, the RBBC belongs to the Hydrological-Administrative Region IV Balsas (HAR IV), which consists of 420 full municipalities in eight states: includes all municipalities in the state of Morelos, and part of municipalities in the states of Tlaxcala, Puebla, Mexico, Oaxaca, Guerrero, Michoacán and Jalisco (Figure 2).


Figure 2. Delimitation of RBBC in the states of Mexican Republic.

In the Rio Balsas basin is used on average a total water volume of 47,332.70 cubic hectometers per year ($hm^3$/year), of which 96.1% corresponds to surface waters, and the remaining 3.9% is extracted from aquifers. The privileged geographical location of this basin, with respect to the main industrial and population centers in center of the country, enabling that has been regarded as very suitable for electric power generation, so the 81% of water used (approx. 36,831 $hm^3$/year) is intended to this non-consumptive use. However, within the consumptive uses (agricultural, domestic, industrial, livestock, farming, urban public services and aquaculture), the main use is agricultural, which consumes a total volume of 5,826.60 $hm^3$/year, of which the

81.8% corresponds to surface water and the remaining 18.2% is extracted from groundwater through deep wells (CONAGUA, 2010).

**Impacts of past droughts in RBBC**

States and municipalities that make up the RBBC, like many other areas in Mexican Republic, have historically been affected by recurrent droughts. One of sectors most vulnerable to scarcity and lack of water –as a result of drought–, has been and will remain the agricultural sector. The drought is, undoubtedly, one of the greatest scourges for agriculture, especially for agricultural production under rainfed conditions, where rain is essential for good crop yields.

According to information obtained from the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA, 2013), in the period from 2005 to 2011, drought caused total losses in 138 thousand hectares within the RBBC, being the main crops affected, in decreasing grade of severity impacts, the following: maize, sorghum, barley, wheat and beans. These losses meant a total outlay in compensation of 127.5 million pesos which were distributed in the same period by SAGARPA, as shown in Figure 3. This graph shows that in 2009 occurred the most severe drought in recent years in RBBC, with losses of crops higher than 80 thousand hectares and compensation payments for more than 70 million pesos.

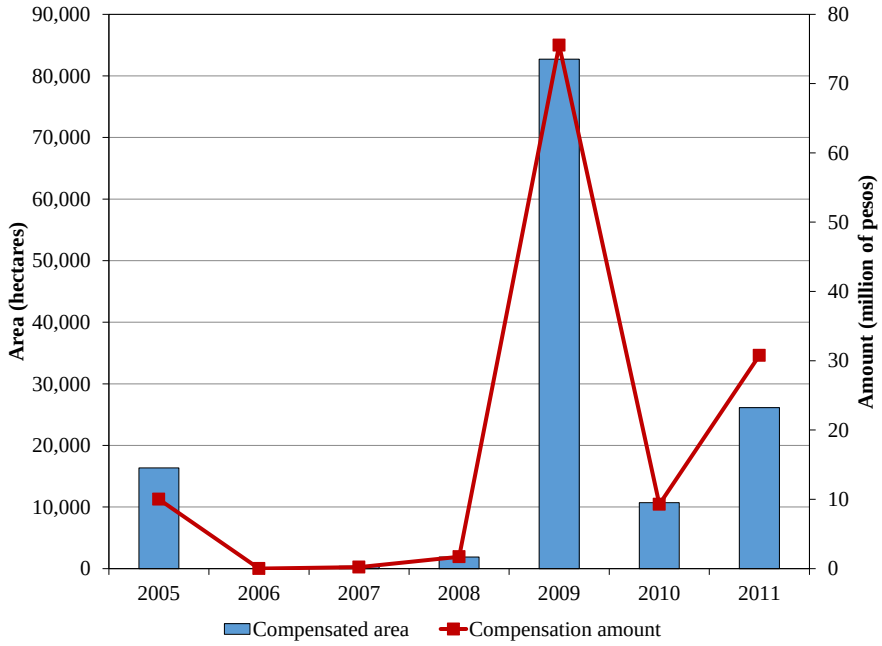


Figure 3. Crops surfaces affected by drought and compensation amounts per year in RBBC (2005-2011).

The RBBC states most affected by crops loss caused as a result of drought in recent years (2005-2011) have been, in order of severity, the following: Puebla, Tlaxcala and Guerrero, with affected areas higher than 30 thousand hectares in each one of them. And least affected states have been Michoacán, Jalisco, Morelos, Oaxaca and Mexico, with compensated surfaces less than 10 thousand hectares in each one of them.

On the other hand, coupled with losses in agricultural production, drought means a lack of water and food for livestock, which results in the appearance of malnutrition, disease and, in extreme conditions, death of animals. Finally, with respect to the effects of drought on the population, the historical record shows that fortunately in the Rio Balsas basin have not been registered very harmful effects on the inhabitants (such as famine, migration or death of persons) as a consequence of this phenomenon, because in reality the most drought periods occur are of short duration (from one to three months). The most notable effects are economic, resulting from crop losses and consequent increase in food prices as a result of the reduction in the supply of basic grains, mainly (Castorena, 1980; Florescano, 2000).

**Current vulnerability to drought in RBBC**

In general, vulnerability is the degree to which a system is susceptible to adverse effects, in this case, to drought. The concept is linked to the people (community) and therefore is specific to a territory and human group that inhabits it (IPCC, 2007). According to vulnerability analysis conducted by CONAGUA (2012) using the methodology of IPCC (2007), in RBBC there are no areas with very high drought vulnerability. The planning cells that present greater vulnerability are Tepalcatepec_Mich and Balsas_Pue, with a high vulnerability degree (Figure 4). These two planning cells, cover together 159 municipalities that correspond to the states of Michoacán (32) and Puebla (127), and occupy an area of 45,560 km$^2$, equivalent to 39.2% of the total area of basin.

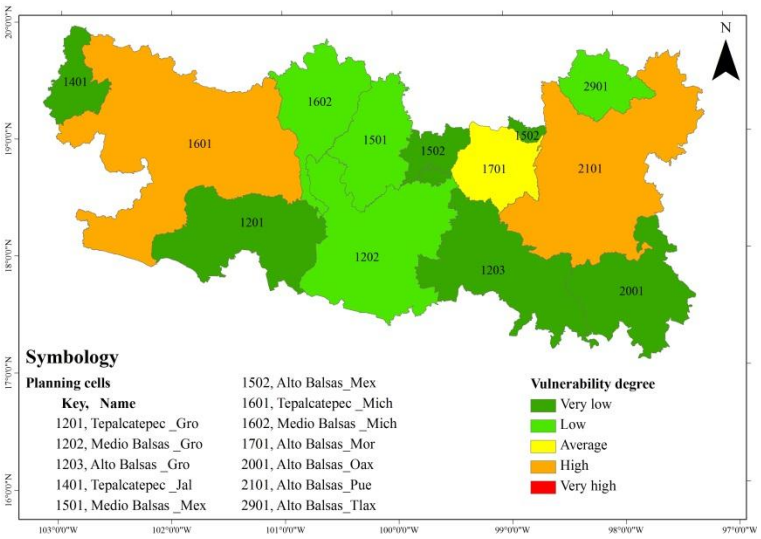


Figure 4. Vulnerability to drought in RBBC.

The Balsas_Mor planning cell is located in the third place of vulnerability degree, with an average vulnerability degree, which cover 33 municipalities in the state of Morelos comprising an area of 4,862 km$^2$ (4.2 % of total area). And finally found the rest of planning cells having a low vulnerability degree, which together occupy an area of 65,592 km$^2$, equivalent to 56.5% of the total area of basin.

However, to reduce the drought risk, it is necessary to strengthen and implement mitigation measures and response strategies that reduce the effects of the decreased availability of water resources in the short-, medium- and long-term, as described in the next section.

**Preventive and mitigation drought measures**

In the Program of Preventive and Mitigation Drought Measures of the Rio Balsas Basin Council (PPMDM-RBBC), are specified actions that can be implemented in the context of this Basin Council to deal with drought in three ways: before that happens the phenomenon (strategic measures), when just beginning (tactical measures), or when it is already present (emergency measures), as described below (CONAGUA, 2013):

- **Strategic actions.** They are long-term actions (lasting more than two years) and are generally of institutional and infrastructural character, which are part of the hydrological planning (storage structures and regulation, policy and management purposes).
- **Tactical measures.** They are short-term actions (lasting from several months to two years) planned ahead and validated under the drought program. They will be activated in pre-alert and alert phases.
- **Emergency measures.** They are very short-term actions (lasting weeks or months) and aim to face the water shortage caused by drought when it is present or when it is very advanced, and will vary depending on the severity, extension, and degree of damage.

It is important to mention that the distinction between strategic measures, tactical measures and emergency measures depends on the timing and way in which the RBBC intends to implement them. For example, the rehabilitation of wells (i.e., the restoration of water production from wells to its most efficient form through various treatments and methods), can be seen as a strategic measure if is done routinely to ensure that wells are in good operation conditions when a drought occurs; or, it can also be a tactical measure if is performed after the declaration of drought; ultimately, it can also be an emergency measure if is done when drought is well advanced and is necessary to extract groundwater urgently.

In addition to the above, the PPMDM specifies a basis for the implementation of actions, distinguishing between the supply side (offer of water), related to construction and distribution systems; and on the demand side that impact the use and consumption by users. This is known as the management or operation of supply and demand for water in drought conditions. As well, in the following tables are presented preventive and mitigation drought measures proposed for each of the major sectors of water users: municipal water systems (Table 1); the hydro-agricultural sector (Table 2); and the residential, industrial and commercial uses (Table 3).

Table 1. Preventive and mitigation drought measures for municipal water systems.

| Measures on the offer side of water | | | | | Measures on the demand side of water | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Objective | Measure | Type* | | | Objective | Measure | Type* | | |
| | | S | T | E | | | S | T | E |
| Improve the water distribution service in municipal systems | Increase of water rates depending on the consumption | | x | x | Raise public awareness about water care and preservation | Constant awareness campaigns | x | x | x |
| | Repair of leaks | x | x | | | Environmental education workshops | x | | |
| | Install or replace measurement systems | x | | | | Social programs and incentives | x | | |
| | Implement distribution water systems | | x | x | | Informational forums | | x | |
| | Replace obsolete pipelines | x | | | | Meetings and workshops | | x | |
| | Build wastewater treatement plants | x | | | Promote the participation of civil and organized society | Participation of non-governmental groups | x | | |
| | Distribute water in tank cars | | | x | | Timely resolution of conflicts | | x | x |
| | Make agreements with bottlers | | x | x | | Polls of public perception | x | x | x |
| | Make a resource inventory | x | x | | | Dissemination of information | | x | x |
| Create new water supplies, preserve or extend existing ones | Find new water sources | x | | | Lead to a reduction in consumption of water in different uses | Establishment of savings goals | x | | |
| | Drill deep wells | x | x | x | | Restriction of new water intakes | | x | x |
| | Enable deep wells | x | x | x | | Application of surcharges for waste discharges | | x | x |
| | Build rainwater harvest systems | x | | | | Devices savers in public and private buildings | x | | |
| | Recharge aquifers by storm sewers | x | | | | | | | |

*Types: S = Strategic measure; T = Tactic measure; E = Emergency measure.

Table 2. Preventive and mitigation drought measures for hydro-agricultural sector.

| Measures on the offer side of water | | | | | Measures on the demand side of water | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Objective | Measure | Type* | | | Objective | Measure | Type* | | |
| | | S | T | E | | | S | T | E |
| Improve the water use efficiency in irrigation | Coating of main channels | x | | | Make a more rational and efficient use of water in irrigated agriculture | Irrigation scheduling | x | | |
| | Coating of secondary channels | x | | | | Change from gravity irrigation to sprinkling irrigation | x | | |
| | Dam operation policies | x | x | | | Change from sprinkling irrigation to drip irrigation | x | | |
| | Curves of guarantee from users | x | x | | | Use of treated wastewater | x | x | x |

| Measures on the offer side of water | | | | |
|---|---|---|---|---|
| Objective | Measure | Type* | | |
| | | S | T | E |
| | Water volume measurement | x | | |
| Create new water supplies, preserve or extend existing ones | Drilling deep wells | x | x | x |
| | Deep wells rehabilitation | x | x | x |
| | Storage dams | x | | |
| | Water treatment | x | | |
| | Recharge aquifers through drainage | x | | |
| | Runoff management systems | x | x | |
| | Cleaning sewer lines, canals and dams | x | x | |

| Measures on the demand side of water | | | | |
|---|---|---|---|---|
| Objective | Measure | Type* | | |
| | | S | T | E |
| | Establishment of water banks | x | x | |
| | Voluntary break programs | x | x | |
| | Productive conversion | x | | |
| | Minimum-till and conservation tillage | x | | |
| | Rain-water catchment "in situ" (on the site) | x | x | |
| | Use of drought-resistant crops | x | | |
| | Crop rotation | x | | |

*Types: S = Strategic measure; T = Tactic measure; E = Emergency measure.

Table 3. Preventive and mitigation drought measures for residential, industrial and commercial uses.

| Measures for the residential use | | | | |
|---|---|---|---|---|
| Objective | Measure | Type* | | |
| | | S | T | E |
| Reduce water consumption in household | Installation of water saver devices | x | | |
| | Replacement of traditional systems for efficient technologies | x | | |
| | Reuse of gray water for garden irrigation | | x | x |
| | Leak repair in hydraulic installations | | x | x |
| | Reduction in use of air-conditioning systems | | x | x |
| | Restriction of garden irrigation with drinking water | | | x |
| | Restriction of car washing with drinking water | | | x |
| | Restriction of sidewalk washing with drinking water | | | x |
| | Restriction of swimming pools filling | | | x |

| Measures for the industrial and commercial uses | | | | |
|---|---|---|---|---|
| Objective | Measure | Type* | | |
| | | S | T | E |
| Reduce water consumption in industry and commerce | Installation of water saver devices | x | | |
| | Replacement of traditional systems for efficient technologies | x | | |
| | Reuse of gray water in industrial processes | | x | x |
| | Leak repair in hydraulic installations | | x | x |
| | Reduction in use of air-conditioning systems | | x | x |
| | Restriction of garden irrigation and landscapes foreign | | | x |
| | Restriction of ornamental fountains operation | | | x |
| | Restriction of car and truck washing with drinking water | | | x |
| | Use of recycled water in car wash centers | | x | x |

| Measures for the residential use | | | | | Measures for the industrial and commercial uses | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Objective | Measure | Type* | | | Objective | Measure | Type* | | |
| | | S | T | E | | | S | T | E |
| | Restriction of new gardens planting | | | x | | | | | |

*Types: S = Strategic measure; T = Tactic measure; E = Emergency measure.

In addition to preventive and mitigation measures that are listed in Tables 1, 2 and 3, in the PPMDM-RBBC are proposed others of general nature, with long-term trend (strategic measures), which can be implemented at national level:

- In terms of governance, promote monitoring of strict observance of the National Water Law (NWL) and the application of sanctions for non-observance.
- Respect and enforce the agreements of the Technical Committee of Hydraulic Works Operation, in regard to the annual volumes assigned to draw from the dams for different water uses.
- Implement a payment program for hydrological services of CONAGUA (soil conservation to maintain its infiltration capacity) similar to the payment for environmental services of the National Forestry Commission (CONAFOR).
- Establish agreements of water distribution inside of each basin, and agreements for water transfers between neighboring basins, when drought conditions so require.
- Promote that CONAGUA assume operational and financial control of the operator agencies of drinking water and sanitation.
- Promote the modification of the Mexican Official Standard NOM-011-CNA-2000 in order to improve the estimation of water availability from aquifers be calculated with real data of extracted volumes, and not based on concession volumes.
- Implement mechanisms in the existing legislation to enable that CONAGUA could count with water volumes reserved for use in times of drought.

## CONCLUSIONS

In the Rio Balsas basin drought events have occurred since always, and its effects have been basically economic: crop losses in agriculture, livestock deaths and price increases in agricultural products as a result of decreasing supplies. The purpose of the PPMDM-RBBC is precisely to anticipate droughts, providing solutions to meet the demands, avoiding situations of water shortages and conflicts between users for the use of vital liquid. The risk can't be completely eliminated but this program is useful to mitigate its effects. The implementation of various preventive measures and mitigation strategies proposed in the PPMDM, and proper coordination between different government levels and the active participation of society, surely will result in tangible benefits and lower economic losses next time that a drought occurs.

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