Implementation of the Drought Monitoring System in Northwest Mexico

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In the last 13 years, the State of Chihuahua suffered a lingering drought that caused social, economical and environmental impacts hardly quantifiable; main reason of why in 1997, the State's Government together with CONACYT and INECOL created the Center of Investigation About the Drought (CEISS). Since 2002, a monitoring system was implemented to watch the evolution of the meteorological drought in Chihuahua, recently being broadened for the states in the North of Mexico. The evaluation of the meteorological drought, was based on the estimate of the Standardized Precipitation Index (SPI for the Spanish initials) used in an international scale and especially by the *Drought Monitor Center* (in Nebraska, USA). Another component that complements this surveillance system is the annual tracking of the deficit or excess of the glide volumes on three of the main dams in Chihuahua, the purpose of the evaluation of the hydrological drought on the level of the basin of the Conchos River.

Conceptual Frame of Drought

The drought is considered as one of the more complex natural phenomenon, less understood and that it affects more people, it doesn't present a defined trajectory, it tends to extend on an irregular basis through out time and space, its effects are accumulative and can remain even after the culmination of the event; such characteristics distinguish it from other natural phenomenon (Wilhite, 2000). Numerous definitions on the drought have been developed since several disciplinary perspectives; where each discipline, involves a wide variety of environmental, social and economical factors on its own definition. Nevertheless, the lack of a clear and universally accepted definition for drought, contributes to confusions in regard to the existence of this phenomenon (Glantz and Katz, 1977). A broad review of definitions for drought can be found on technical notes published by the Worldwide Meteorological Organization (WMO, 1967); other sources as Subrahmanyam (1967), Sandford (1979), Dracup, *et al* (1980), group the drought into three kinds: meteorological, hydrological and agricultural.

In figure 1, the relation between these kinds of drought it is shown in regard with the duration of the event.

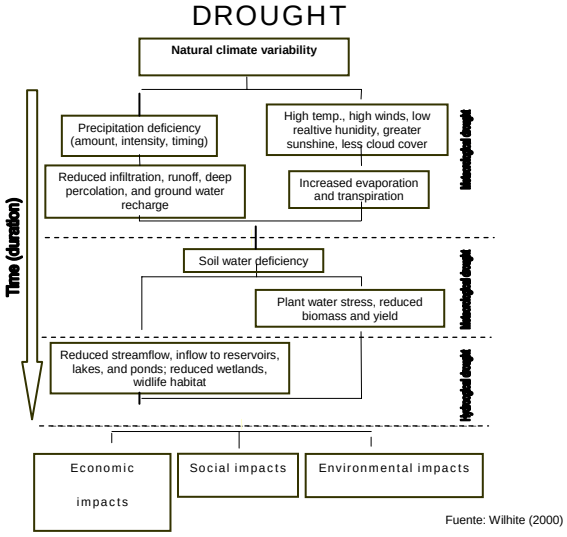

Figure 1. Relation and impacts of the different kinas of drought.

Evaluation of the Meteorological Drought in the CEISS

In figure 2, it is shown the diagram of procedures of the Monitoring System on the Drought in Chihuahua (SIGSECh). On a first phase, historical series of rain precipitation are collected coming from the 28 climatic stations located on the state's territory of Chihuahua. Missing data gaps were completed basing on the statistical procedures described by Young (1992) and Wanielista (1997). On a following phase, a modulated programming language was coded, the methodological procedure for the estimate of the SPI described by Edwards (1997) and Giddings *et al* (2005). The source code, was compiled to create a computer program, with which it can be derived a level of climatic station, historical series of values for the SPI in time scales of 1 to 48 months. The spatial distribution of the SPI was determined through spatial interpolation techniques using a reverse method of the distance between stations included in Arc/Info©. The interpolated values were

classified in accordance with the classification scheme proposed by Agnew (1999). Under this classification scheme, it is considered that a drought event begins when the values of the SPI are inferior to -0.7 (McKee *et al*. 1995; Edwards *et al.*, 1997a). On the other hand, Wilhite (2000) points out that the period that normally requires a drought event for its establishment fluctuates from two to three months. Taking into consideration the before said, on this drought monitoring system, it is determined the maximum duration and intensity of the event.

This same procedure was applied for the States of Sonora, Sinaloa, Durango and Zacatecas with the purpose of implementing this tool for the north of Mexico.

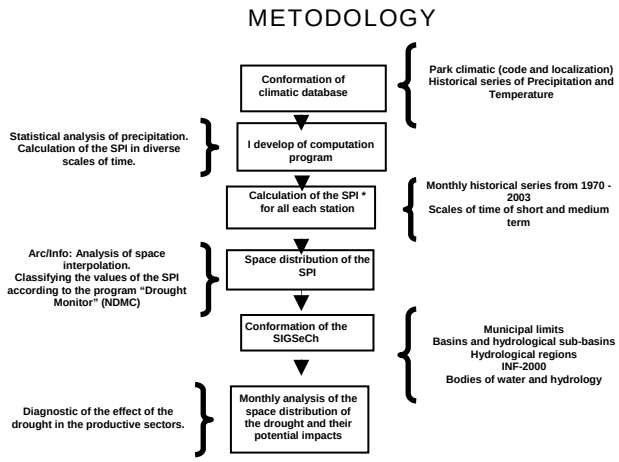

Figure 2. Flow diagram of the drought monitoring system in Chihuahua (SIGSECh).

Advances on the Monitoring System in Chihuahua and North of Mexico

1. Analysis of the SPI in climatic regions

The monitoring system developed in the CEISS, allows an analysis of the frequency, duration and intensity of the drought events that took place in several climatic regions.

2. Spatial distribution in the north of Mexico

On figure 3, it is illustrated a map of spatial distribution of the SPI for the northern region of Mexico, in the States of Sonora and Chihuahua. It can be appreciated that the SIGSE-northern Mexico allows evaluating the surface affected by the several drought intensities, on each evaluated month. The generated map will be published in a section on the CEISS web page (www.sequia.edu.mx), together with the monthly bulletin available to the public in general. There will be published the historical maps from the SPI-1 to SPI-48, since at least 2000.

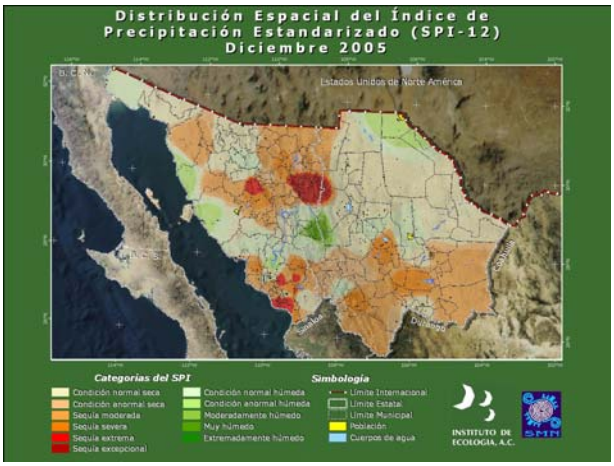

Figure 3. Distribution map of the SPI-12 for the northern region of Mexico.

3. Analysis of the distribution, frequency and intensity of the SPI in Chihuahua

As you can appreciate on figure 4, monthly the users have access to get to know the distribution of the drought intensity in the state of Chihuahua, on the legend that defines the types of drought and by its color the user knows the intensity that impacted each municipality. The CEISS's intention, on this sense is to coordinate with NMS (National Military Service) to develop this same system in all the country.

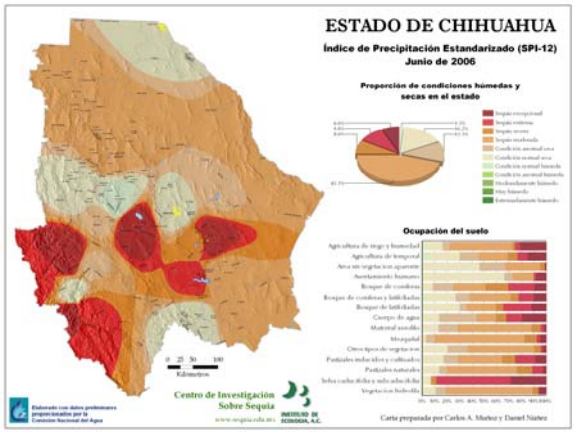

Figure 4. Distribution map of the SPI-12 for the month of June (2006) in Chihuahua

4. Monthly Drought Bulletin

On the CEISS page, it is Publisher on a monthly basis a map of the SPI 12 and of the SPI-3, with the purpose of informing the users the conditions of the drought, its intensity and kinds of soil uses that was impacted. The bulletin has a section to download the historical maps and the basic statistics of the monthly precipitation. You can also find a help menu on how to verify to the municipality scale the surface affected and the drought type that happened on the area of interest (Figure 5).

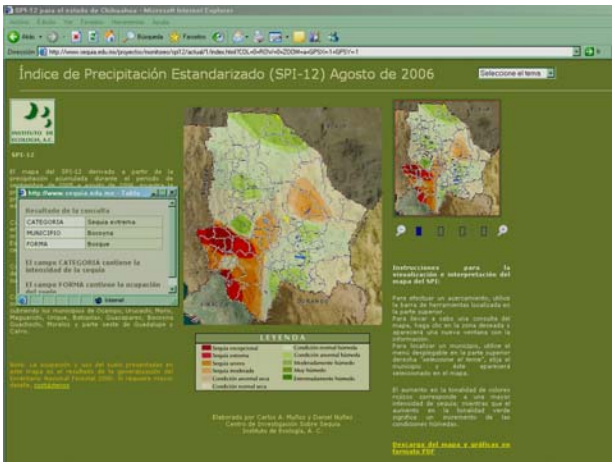

Figure 5. Monthly bulletin following the drought in Chihuahua.

5. Tendencies of Hydrological Drought

Through the Bergaoui and Alouini methodology (2001), adapted for the Chihuahua case, it is monitoring to an annual scale, the tendencies of the deficits or surplus of the glide volumes on three of the main dams in the State of Chihuahua, with the purpose of informing the public in general, on how the drought and or wetlands has impacted the agricultural regions in Chihuahua, above all those where most important watering districts operate (Figure 6).

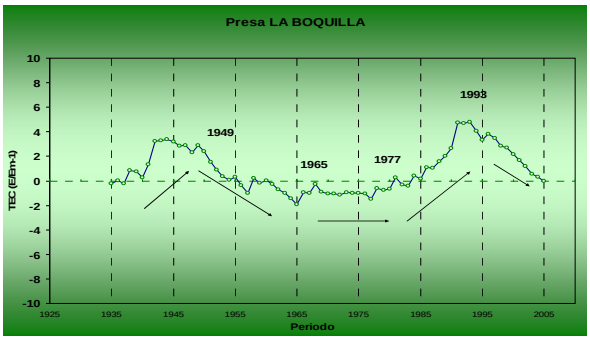

Figure 6. Index of the tendency of the hydrological drought in the Boquilla dam.

5 Conclusions

The Drought Monitoring System in Chihuahua complies with the following international rules for the estimation of the SPI:

1. It is estimated with the standardized index of precipitation used internationally, is special the Drought Monitor Center en Nebraska (E.U.A.)
2. It has as a normal media a historical series of at least 30 years of monthly precipitation.
3. The source code developed was compiled to create a computer program, with which you can derive to a climatic level, historical series of values of the SPI on time scales of 1 to 48 months.
4. The spatial distribution of the SPI was determined through spatial interpolation techniques employing the reverse method of the distance between stations included in Arc/Info©.
5. The interpolated values were classified in accordance to the classification scheme of the SPI proposed by Agnew (1999).

Under this classification scheme, it is considered that a drought event begins when the values of the SPI are inferior to -0.7 (Mckee *et al*. 1995; Edwards *et al*., 1997a). On the other hand, Wilhite (2000) points out that the period that normally required by a drought period for its establishment fluctuates from two to three months.

6. It has as a complement the annual pursuit of the hydrological drought on the level of the basin of the Conchos River through three of the main dams, an index of the deficits of the glide volume is employed and one index of the hydrological drought tendency employed in different parts of the world.
7. This systems should be validated in terms of spatial representative ness and source data, as well as complementing it with the Palmer index, the deficit drought and advance in terms of prediction and prevention of risks.
8. The establishment process of the State Commission of Mitigation of the Drought must end to allow the evaluation of risks and issue recommendations in regard with the impact of the drought and towards a better handling of the water resource in the municipality.

6 Mentioned Literature

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