Global Assessment Report
on Disaster Risk Reduction

Assessing drought risk and identifying policy alternatives for drought risk management

Risks, impacts and social meaning of drought: Characterization of the vulnerability in Sonora, Mexico

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2010

2011 United Nations Global Assessment Report on Disaster Risk Reduction (GAR11)

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Risks, impacts and social meaning of drought: Characterization of the vulnerability in Sonora, Mexico

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Patterns and trends of the meteorological drought, both agricultural and hydrological in Mexico and Sonora: From the national to the state scale.

Drought represent a historical part of the climate in Mexico (Image 1) but have caused harsh losses and are even related with facts which marked outstanding transformation procedures in the socioeconomic sectors such as the agricultural and the hydrological ones. When the precipitation amount during the rainy season is not enough to satisfy the needs of a whole town or area, a water deficit originates giving rise to the different kinds of drought. This condition may extend for several years, and will not end until rainfall satisfies such water deficit. The long term drought, those which last two or more years, are the most harmful and seriously affect those unprepared productive sectors.

Among the references in regard to other historical drought in Mexico, it is worth noting the works of García Acosta (1974), Sánchez (1980), Florescano and Swan (1995) and Contreras (2005), which share chronological data in regard to drought from the year 1500 B. C. to the 20th century. Other works describe in detail the impact of drought during the prehispanic age (Therrel et al., 2004), specially emphasizing that the collapse of the Mayas has been partially attributed to an extended period of drought (Sabloff, 1995). For the colonial times and to present, in works such as the one from Castorena *et al.*, (1980), Reyes (1997), Castorena *et al.*, (1980), Reyes (1997), García Acosta et al., (2003) and Mendoza *et al.* (2006) it is shown that the effects associated with drought go from the drop in the water level of lakes, to the dry up of rivers, decrease of fauna and flora, forest fires, crop losses, shortage of water, losses of life both in people and animals, massive migrations and interruption of religious ceremonies, among others.

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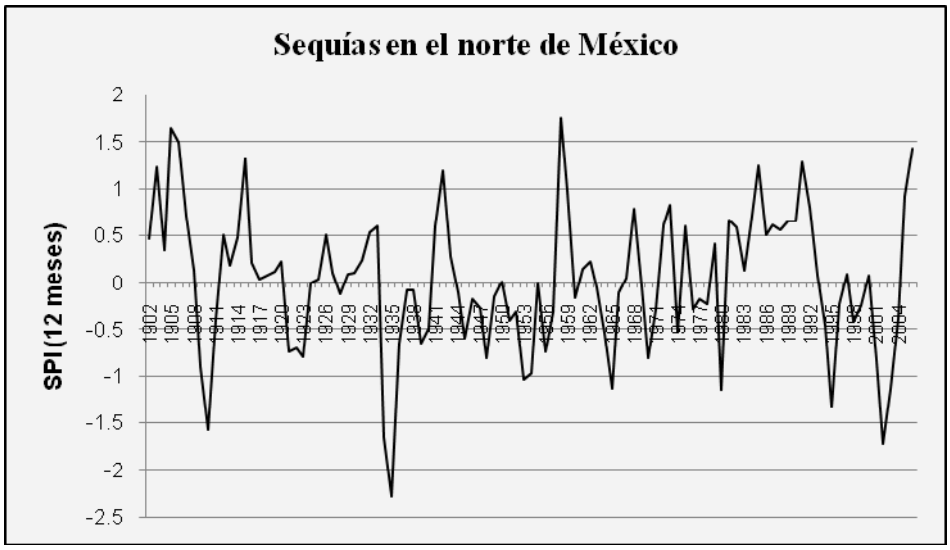


Image 1. Time series of the Standardized Precipitation Index (SPI) for the north of Mexico. The SPI represents the number of standard diversions that each precipitation registry diverts from the historical average. Years with values inferior to -1 represent harsh drought. Data: National Database of Climatic Change (CLICOM), 2009.

More recent examples of the impact of associated with water deficit were presented during the drought which took place in 1997 due to the climatic phenomenon called El Niño, which was considered one of the most harsh ones ever recorded, which affected most of the country generating losses on the order of 204 million dollars on account of damaged crops, and the additional grain imports with a 1,300 million dollars cost as a result of this product shortage registered in the national production (Magaña, 1999).

Between 1998 and 2002, a period of drought took place in the northern part of the country (Seager *et al.*, 2009), which combined with the increases in the water demand prevented Mexico from complying with the agreement in the 1944 Water Sharing Treaty with the United States of America (USA), which states that Mexico shall transfer a certain amount of water through the river Río Grande in cycles of five years, which gave rise to a well-known diplomatic conflict.

In a general sense, drought may be defined as a conventional relationship, arising from the deficiency in precipitation for a considerable period of time, it is therefore, an anomaly determined by numerical differences which can determine and average an average, resulting in a water shortage for the development of several socioeconomic activities (Neri, 2010). However, for assessing the impacts of such water shortage, it is necessary to understand that the impact of those drought are *sequential*, in other words, they result from the frequency interaction, harshness and space degree of such drought,

(the physical nature of the drought) and the degree of socioeconomic vulnerability of the town or affected sector.

From the center and up to the north of Mexico there are arid and semi-arid climates (Image 2). Given its geographical situation, Mexico has a climate characterized by having a summer rainfall pattern for most of the country in comparison with a relatively dry winter. During the summer the climate is regulated mainly by the activity in the tropical systems such as the position in the Intertropical Convergence Zone, the Mexican monsoon, hurricanes in the Pacific, Gulf of Mexico and the Caribbean and the waves from the East. During winter, the climate is by regulated systems such as the cold fronts.

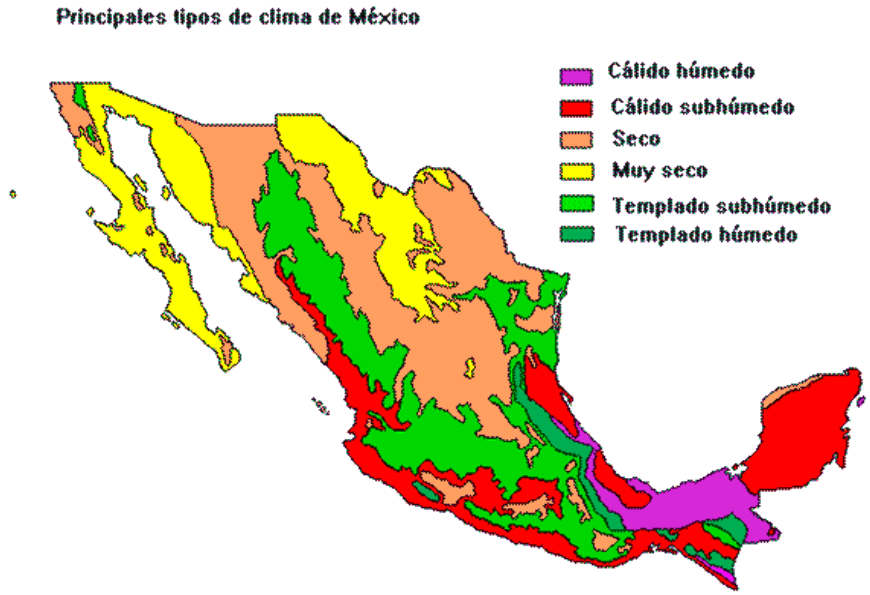


Figura 2. Main kinds of climate in Mexico. Source: INEGI, 2010.

There are climatic factors that exacerbate the harshness of the drought such as high temperatures, strong winds and low relative humidity. For example, the presence of El Niño causes an increase in the drought intensity. El Niño—and its counterpart La Niña—, are anomalous conditions in the temperature of the ocean in the Eastern Tropical Pacific. During the summer of El Niño years, there is a drop in the precipitation in most of the country which may be considered as a drought, according to its intensity. This drop in the summer precipitation reflects in lower soil humidity for the spring of the following year, resulting in a higher incidence of forest fires associated with agricultural practices. During La Niña years, the summer rainfall is close to the

normal average and may even be above it. This positive precipitation anomaly during La Niña summer is due to a higher activity in the waves from the East and hurricanes in the Caribbean and the Gulf of Mexico (Magaña, 1999).

As for the extended drought (which last more than 1 up to 2 years) some studies reveal that they are related with the phases of the Pacific Decadal Oscillation (PDO) and the Atlantic Multidecadal Oscillation (AMO). Examples of this are the drought which took place during the thirties, fifties and nineties (Schubert *et al.*, 2004, Cook *et al.*, 2007, Méndez and Magaña, 2009).

When a meteorological drought takes place, the first affected sectors are the agricultural and livestock ones, dependant almost entirely on rainfall water. On a second level, other sectors are affected as well, as a consequence of the reduction in the water levels of the storing sources. This unavoidable process occurs when there is shortage of precipitations, however there are times in which the rainfall levels drop to a certain level that they could be regarded as normal and damages occur in certain sectors as a consequence of the lack of water or, the meteorological drought simply does not take place and damages arise as well. This leads us to deduct that the measures that the society develops in regard to the use and storage of water, that is the administration and distribution of such natural resource, are essential variables for the declaration of drought.

Availability and water use in Sonora

The natural average availability of water is a useful indicator in the country, especially for international comparisons; however it only reflects partially the reality when taking into consideration that precipitation is unequal both in time and space. While in the northern part of the country it is a limiting factor with only 1336 km^3 per capita a year in Baja California peninsula, in the southern part its abundance generates other kinds of issues; in Chiapas for example, the natural availability reaches 24674 m^3 per capita a year (CNA, 2004).

If the distribution of the population, the economical activity and the increase rates per region are taken into account, it turns out that water is a limiting factor in those areas where the economical activity and the majority of the population is concentrated. As for the center of the country, north and northeast (more than 80% of the country), where

only 31% of the national runoff takes place, most of the population is concentrated (77%) and the economical activity represents 87% of the Gross Domestic Product (GDP); the natural availability of water reaches 1734 km^3 per capita a year (CNA, 2008). Subterranean water represents the most important supply source—and frequently the only one—in the arid areas and different parts of the country. In contrast, the southeast (less than 20% of the country) has the higher percentage of runoff: 69%. However, only 23% of the population lies in this part of the country and the economical activity represents only 13% of the Gross Domestic Product (GDP) (CNA, 2008). The paradox is that despite the fact that water, key development engine, is not a limiting factor in the southern part of the country, this region where most of the localities with a high or very high level of marginalization are located (Carabias and Landa, 2005).

An example of a region vulnerable to drought is the State of Sonora, due to its low water availability. Historically Sonora has had a privileged position within the country in terms of economic development, mainly based on the agriculture and livestock. The city of Hermosillo has undergone a continuous growth along the last century and the scope shows that this trend is to continue (INE, 2004). The State of Sonora is located in the most arid area of the country (Image 3). The average temperature in the capital city, Hermosillo, ranges between 15 and 25ºC. However, most of the year the maximum temperatures are above the 30º and sometimes may reach 45º C. Evaporation exceeds precipitation, therefore there are important humidity deficits in the soil for most of the year. The annual average precipitation is around the 428 mm, and in the capital city of Hermosillo it goes from 250 to 300 mm a year. Most of the precipitation happens around the summer months (July, August and September) and it is associated with the so-called Mexican Monsoon. During winter, some cold fronts may produce rainfall and snowfalls in the higher grounds of the State.

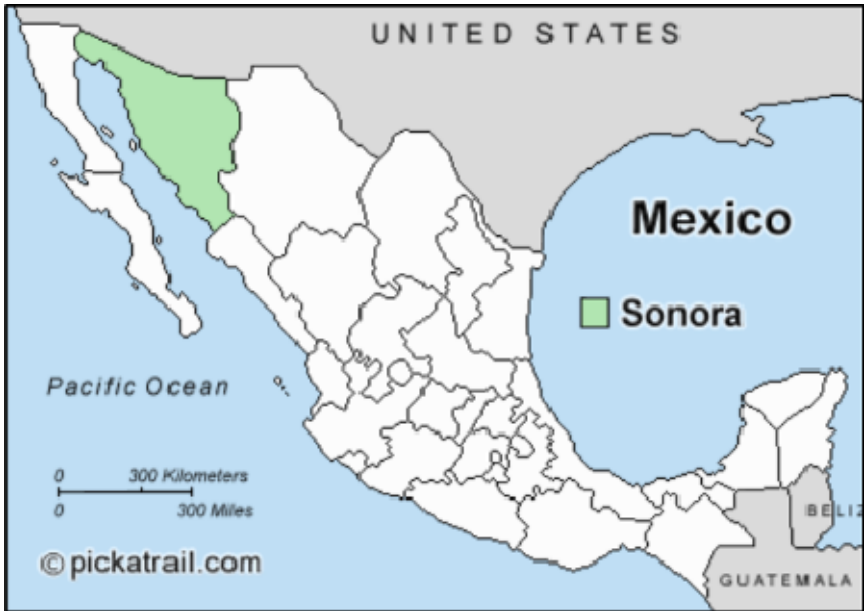


Fig. 3. Location of the Sonora State.

The results of a study performed in Sonora (INE, 2004) show that the regulating mechanism of the winter rainfall is the known phenomenon of El Niño, which results in a trend of higher winter rainfall, while La Niña leads to a drop in the winter precipitation. However, it is not clear what regulates the winter rainfall. Apparently, El Niño does not have a considerable influence over the storms of the Mexican monsoon; this is why the climate predictability is low in this region of Mexico. Most of the difficulty in predicting the seasonal rainfall in Sonora lies in the fact that if a hurricane hits ground in this region, it may cause a rainy year.

One of the most interesting aspects of rainfall in the Hermosillo region is that, not only it seems to rain more than before, but the rainfall style has changed as well, therefore heavier rainfall takes place year by year, that is to say, there are more rainstorms. Such trends in the city of Hermosillo along with the increase of urbanization have made the street flooding more frequent every time. The year-to-year climate variations have an important effect over the water availability in the region. The levels of water in dams reflect whether an optimal or a deficient rainy season, even when apparently there is a group of people in charge of the management and administration of this natural resource. The drop in the rainfall of the nineties resulted in a drastic reduction of the water levels in the Abelardo L. Rodríguez dam, that is the reason why it has been practically dry in the recent years. Nowadays the water availability in Hermosillo

depends upon other supplying sources, which places this city in a worrying water supply situation, in addition to an increase in the public demand.

The measures of the government seldom consider the climatic variable, and even less the possible effects associated with the climate change. The discouraging climate change scenarios for the northeast of Mexico show that the average temperature will increase up to 1ºC by 2020 and up to 2ºC by 2050, whereas in the case of the annual accumulated precipitation, the scenarios show that rainfall will drop up to 10% towards the middle and end of the current century (INE, 2009). A combination of both possibilities leads to the probability that around the middle of this decade, the climate in Hermosillo will be warmer and with less rainfall as such, but with more rainstorms. This is to say, more evaporation with less soil humidity, less water availability and an increase both in the water extraction from the water tables as well as in the energy consumption on account of air conditioning devices, in order to maintain the comfort. The level of pressure over water resources is extremely high, that is why a precipitation deficit will lead more frequently to harsh drought conditions.

Each and everyone with his/her own drought: Characterization of the social vulnerability

Can one kind of drought have different impacts in different places due to the fact that some people and places are more vulnerable to extreme events than others? This question which Liverman (1966) developed in a study for Mexico contemplates that the changes in the peoples' vulnerability and regions are the key to understanding how risks affect society. Within the context of agricultural practices in Mexico, Liverman came to the conclusion (1996, 2000) that drought with the same physical intensity may have less harsh effects on large irrigated and insured plots of land, with good pieces of land and subsidized prices, in comparison to small season plots without institutional support. Throughout time, the agricultural systems have protected themselves against the adverse climate conditions by means of irrigation systems, crops diversification, changes in regard to land use and flexible management strategies. However, the new economical policies demand higher productivity levels. In the case of Mexico there are still historical structural problems to solve, such as communal land policies and the implementation of assistance, credit and insurance mechanisms, which would allow as a consequence, the development and maintenance of the irrigation systems and crops diversification.

In order to determine the vulnerability of the agricultural sector in the event of drought occurrence, one must take into consideration that the orographic, climatic and geologic complexity of the country,: around 52% of the country are arid lands, desert or semi-desert (mainly the northern and southern part of the country) where agriculture is feasible only by means of the construction of irrigation works. The rainfall is not enough in another 30.5% of the total surface, that is why most of the times it is necessary to implement irrigation systems; whereas, 10.5% of the country is constituted by the compound of semi-humid regions in which rainfall is regularly enough for obtaining season crops (it would be necessary to water the lands every year, in spite of harsh drought which only take place every 5 or 6 years, preventing from harvesting the regular volume). Finally, only for 7% of the country, rainfall is sufficient for the crops season, however, irrigation helps during the drought period to overcome the precipitation differences (Bassols, 1995). According to data from the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food [Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA)] every year nearly 16.1 million of hectares are cultivated out of which 87% (10.8 million of ha.) are cultivated during the raining season (May to October) which generates 70% of the yearly agricultural production.

In order to reduce the vulnerability of the climate fluctuations, the famers have taken some adaptation measures like drip irrigation, windbreak lines, production of combustion fumes or the straw and manure protective layers. On the other hand, technologies such as the hybridization and the improved seeds selection have been developed broadening the phenological limits of the crops. Nowadays different and more resistant varieties to drought and frosts are cultivated and important amounts of fertilizers and chemical products are used. But many of these options represent an investment which is not within reach of the majority of the farmers' budget, and they do not guarantee success in the event of extreme climatic events either.

Water shortage is a determining factor for the production both in agriculture season and irrigation regions. In the northern part of the country, where the climate is dry, small plots of land are for farming due to the scarce precipitation. The irrigation works have been one of the main challenges to the institutions; despite the fact that there are nearly 196 storing dams, 989 diverters and 75% of the water is sent to this sector, are not enough for the irrigation. This reflects both in the production figures and in the crops'

value (Téllez, 1994); the agricultural sector contributes only in 5% to the Gross Domestic Product (GDP) of the country. In the course of the last century, the weight of agriculture and livestock sector decreased in relation to the total economy, which in 1900 represented 30% of the Gross Domestic Product (GDP) (INEGI, 2000).

This context encourages the concentration of population in the urban centers; during the 20th century, the rural population increased 2.5 times in comparison with the urban population which increased 20 times; in terms of number inhabitants the rural areas decreased drastically. Migration was the most important factor affecting the behavior of the fields, since more than a half of the ones born in rural areas did not stay in them. The lack of investment in the agricultural survival sector as long as political and social problems have led the season production to lose importance within the national economy, creating dependency upon the food products sector. In spite of everything, agriculture is the economical activity that occupies the largest surface in the country and employs the largest number of people, despite the fact that one out of four Mexicans that lives out of agriculture lives in abject poverty (Neri, 2004). It is certain that the farmers' vulnerability is a consequence of the combination of the climate impacts and the opportunities associated to historical, political, economical factors and the availability of resources before, during, and after the moment of crisis (Eakin, 2006).

Everyone has specific relations, needs and dependencies upon this natural resource which entails a certain meaning of the term "drought" and which changes according to the operation conditions or particular requirements of such water user. When referring to meteorological drought, its characterization essentially depends on the physical aspects of the region where it takes place. It is not the same to discuss the topic of drought in places where it usually rains, like in the southeast of Mexico, as opposed to places where the *usual or regular* situation is that it does not rain at all, like in the north of Mexico.

In the case of Sonora, regardless of the physical and technical definitions, the term "drought" may have different meanings and impacts according to the productive sectors, but it bears two fundamental ideas: water availability and political will play a significant role in the increase of prevention and recovery capabilities in the event drought. One cannot separate water administration from drought. It could be claimed that *water* is one of the guiding means of development in the State of Sonora. The

availability of water resources is directly related to three essential factors: climate, institutions and the use of it by each social group such as stockbreeders, farmers, dam fishermen and urban centers.

A rainy season within the average and some winter rainfall guarantee the recharging the water tables[1] and dams; however the public institutions are the ones in charge of regulating both use and water distribution. On the one hand, the needs of each group face the public institutions with need of taking *priorities*, which translates into development, directed at the supply in urban centers in the first place, then livestock and finally agriculture. Evidently, there is no agreement among the different groups of water users; each and every group of water users considers itself strategic, even tough agriculture is the most water-consuming sector. On the other hand, a very important part of the agricultural production goes to the feeding of cattle and forage production, which creates *competition* for the best arable lands and forests. Contrary to popular belief, the most important division in the *loving* of water resources is not among the users but between regions: The southern part of the State concentrates the most plentiful basins, while the northern part has more deserts and arid ecosystems. Likewise, if the biggest threats in the coast are tropical cyclones, so is drought within the State.

The unbalance in regard to water resources availability has directed the water administration policy at the development of infrastructure that would allow primarily the supply of Hermosillo city, and in a parallel way, the irrigation for farming and stockbreeding use. During the seventies, the hydraulic policy was directed at the agricultural sector with the development of channels, aqueducts or water pipes, and irrigation sections (not profitable at the time). Nowadays, most of the cultivated lands are intended for forage and hay for livestock, but there are also agribusiness centers where vegetables, fruit trees and wheat are grown. However, the priority of the hydraulic development projects nowadays is the water supply to the city of Hermosillo, which concentrates 701 thousand inhabitants (INEGI, 2005). Its growth—in 1990, the city had 406 thousand habitants—is the result of industrialization, its closeness to the United States (270 km from the border with Arizona) and migration, collateral consequence of the decaying farming.

[1] Except for the ones that are highly degraded.

In general terms, semi-structured interviews were performed during the field work with public servants and the representatives of water users groups, and we were able to reinforce that drought has different meanings, making a difference between the characteristics that each group attributes to drought, as opposed to the perception of the damages it may cause. This is important since the prevention and recovery measures based on the expectations that each group has for the term "damage". In the livestock sector, damages are completely different from the ones of water users within urban centers. Livestock dispersion within the State, along with low supply probabilities in the event of a contingency makes them highly vulnerable. In that sense, it is necessary to elaborate a *vulnerability characterization* of each water user group, in the understanding that vulnerability entails the lack of economical, political and technical means for mitigating risk[2]

Stockbreeders and farmers

Even though the primary sector (agriculture, livestock and fishing) contributes with only 8% of the GNP of the State, as a consequence of the historical role and political power of the stockbreeders, many actions in regard to water management have been directed at this particular sector. There has been a lot of interest, particularly from the big proprietors, in developing more advanced drought mitigation strategies. Some ranchers, whether individually or by means of associations[3], aim to optimizing the water resources and in some cases they look for meteorological information that would help them to prevent risk scenarios. In general, livestock is profitable; however the losses in the event of drought may be considerable. Big proprietors usually have better means; some of them even have meteorological stations bought in the United States. Big stockbreeders prepare themselves with more anticipation, which allows them to calculate the water reserves and make better decisions, like administering food, or selling a percentage of head of cattle before the prices drop.

[2] Wilches-Chaux (1993:17) defines vulnerability as the "inability of a community to "absorb" by means of the self-adjustment, the effects of a certain change within his/her own environment, that is, the "inflexibility" or inability to adapt to that change, which, f or all the reasons previously stated, entails risk for the community. Vulnerability establishes the intensity of damages that the effective occurrence of risk may produce over the community.

[3] Just as the Local Livestock Organization of Sonora [Unión Ganadera Regional de Sonora], which has played a significant role within the economy and political negotiations of the State since the thirties.

Another important aspect is the use of land and the control mechanisms over it. The dispersion of the livestock activity in a state which has 184.934 km and with more than three quarters of its territory devoted to shepherding makes the control over the land use and water resources somewhat difficult. The surface calculation mechanism necessary for the fattening of cattle is known as rangeland index. According to information from the Technical Comission for Stocking Rates [Comisión Nacional para la determinación de Coeficientes de Agostadero (COTECOCA)] and the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food [Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA)] the minimum recommended rangeland index is 13 ha per animal unit[4], with a maximum of 46 ha and the adjusted index is 22.36 hectares, despite the fact that some of the interviewees estimate that the accurate rangeland index ranges between 5 and 10 hectares per animal unit. A recurrent pattern in regard to livestock is the excessive exploitation. Within the context of low supervision of the rangeland index, when a considerable amount of head of cattle is concentrated, there is more pressure over the land and water resources, which contributes to the context of ecosystem degrading and puts at risk the whole production system. Some of the small and medium size proprietors tend to have more head of cattle per hectare than allowed. In this case the bet goes to accumulation; however, the risk of drought may represent considerable losses and indebtedness.

The big size proprietors (with around 300 head of cattle) constitute less than 5% of the producers of Sonora State approximately, whereas 20% would own between 100 and 200 head of cattle. Only 75% represents the small size proprietors with less than 50 head of cattle. Without a doubt, the small size proprietors are the most vulnerable group, since they have limited access to meteorological information and even less economical worthiness for investing in the hydraulic infrastructure that would allow the accumulation and administration of water during the annual dry season (November to May) as is the case of an extended drought. In some cases, the poorest stockbreeders—so as the farmers—rent out their lands as a way to *assure* an income. This practice, where the medium and big size proprietors are the ones who pay for the land use, is equivalent to an insurance, which guarantees a modest risk-free income in the event of drought.

[4] Such index varies as function of factors such as the kind of animal, feeding.

One of the structural problems of vulnerability [5] is the land property regime. As a result of the 1910 Revolution in Mexico, a communal land system known as *ejido* was developed, which due to several problems has ended up favoring single-crop farming, making these crops less productive at times. There are pros and cons to this ejido situation; on the one hand, the ejidos met the needs of a historical endowment, but nowadays they represent an undervalued unit within the public policies of land. On the other hand, the amendments of 1992[6] allowed the fragmentation of these territorial units which contributed to the increase of individual users and a hydraulic service demand that now exceeds the capacity of the institutions. The small proprietors—formerly ejido farmers—are simply not able to compete against the big and medium size producers, which end up accumulating cattle in small plots of land with the aim of surviving.

In order to reduce the vulnerability of the whole sector, it is necessary to develop more efficient control mechanisms in relation to the rangeland index and consider that livestock has a very close bond with agriculture. The creation of public policies should consider that what really guarantees the correct growth of cattle is food, this is the reason why agriculture plays a key role: it is necessary to break with the old-fashioned paradigm of cattle accumulation as a symbol of wealth. What really guarantee the complete productive system are, in the first place, the forage reserves, since its production depends directly on the intensity and length of the drought during extreme periods of time and, on the yearly water reserves. Given the risk of drought, some of the agricultural and livestock strategies that are necessary to develop are the reviewing of the faunal carrying adjustment plans, improved management and restoration of paddocks or pastures, maintenance of the hydraulic structures and paying close attention to the optimization in the forage and hay production.

Urban centers: Water, performer of development and conflict

With the expected effects of climate change and the increase in the population rates, water availability per capita will be inevitably reduced and competition for such natural resource may provoke social problems. Recent conflicts among the states with shared dams on the basis of access to water are just an example of this situation. Even one of the diplomatic problems with the United States of America, which generates much concern, is related to the water topic: the border region of Mexico is highly vulnerable

[5] *Causas de fondo* as called by Blakie et al.1996
[6] From the Article 127 of Political Constitution of the United Mexican States

to extended drought periods, this is the reason why the climatic change represents an important threat for millions of people (Coles et al., 2009) in both countries.

Water shortage and the growing demand of the urban centers have promoted water resources rationing programs. One of the objectives in Hermosillo has been to develop an exploitation culture by cutting the supply of this liquid in an alternation system known as *tandero*[7]. However, water continues to be insufficient without considering extreme drought among the possible scenarios. In general terms the development plans of the hydraulic infrastructure respond to political situations, but are commonly held back due to the lack of agreements and participation. Nowadays the plan *Sonora Sí* has the objective of *balancing* the water availability between the southern part of the State (border with Sinaloa) by means of the optimization of the existing hydraulic systems and, particularly, the construction of an aqueduct that is able to transport water from the El Novillo dam (basin of the Yaqui River) to the city of Hermosillo (Image 4).

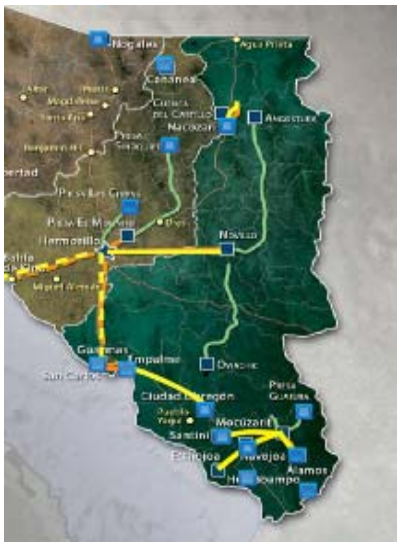


Figura 4 .Works in the *Sonora Sí* Plan in the Mountains to the south of Sonora State. Source: www.ceasonora.gob.mx/

Sonora Sí Plan

Given the water shortage that the city of Hermosillo undergoes, the Government of the State of Sonora promotes a project in which the efforts are concentrated on the construction of hydraulic infrastructure: 5 dams, 1 desalination plant, several aqueducts, and 1 water treatment and channel covering plant. The *Sonora Sí* plan will have an

[7] **Translator's note: rationing system consisting of taking turns**

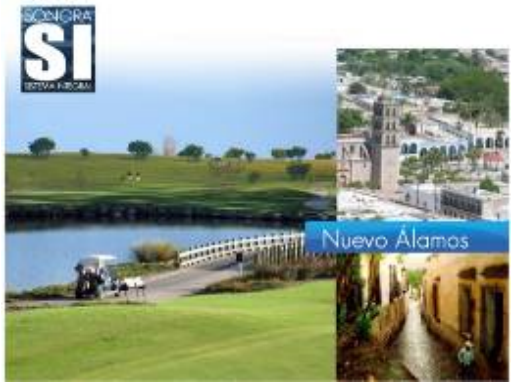
investment of $11,246.10 millions[8] from which 40% comes from the private sector, 34% from the federation and 13% from the Government of the State*.

Water supply measures for Hermosillo are based on a traditional vision that states, *if water is need, we must bring it, transport it, and/or get it from wherever it is* [*si falta agua, hay que traerla, acarrearla y conseguirla de donde se encuentre*] (Pineda and Salazar, 2010). On the assumption that the function of the Government is to act as water supplier, some aspects of the project are not explicit. Such is the case of the water rights purchase by the farmers of the basin in the Yaqui River, which would put at risk the profitability of crops like wheat.

[8] **Translator's note: All figures are expressed in Mexican pesos.**

Efforts conducted towards an efficient management of the water resources are insufficient in view of the loss of 2298 Mm^3, on account of leaks in the irrigation channels for agriculture, which consume more than 90% of the water given on concession. On the other hand, the distribution of the water resources under this project presents certain ambiguity in a place where the natural availability of water is scarce; a clear example of this, is the Nuevo Alamos would-be construction.

(Source: www.ceasonora.gob.mx/)



Even though the importance and need of water for the capital city is an indisputable argument[9], the project has provoked reticence among the inhabitants of the southern part of the State which doubt whether it sustainable. The opposed and vexed stances have given rise to tension among the defendants of the *developing* position, who at all cost justify the feasibility of the project and frequently regard their counterparts as *anti-progressive*. Among the opponents, are the cities in constant competition with Hermosillo such as Ciudad Obregón, farmers and members of the Yaqui ethnical group, who tend to distrust the water extraction measures from their basin. The participation, negotiation, and integration mechanisms at the extraction basins are limited to informative workshops which only justify a technical stance. A public servant advocating the project declared: "If we have to fight with the Yaqui Indians, then we will do so. We cannot wait until each and everyone reaches an agreement". Even though the hydraulic potential of the State is not completely exploited, the inflexibility to the projects seems to be related to the lack of trust in the public institutions. Without overlooking part of the need of taking innovative hydraulic measures, it is important to consider maintenance and optimization of the existing resources from a non-centralist but a regional integration perspective.

Civil protection and meteorological information

The institutions that generate and interpret the weather information are another key element in the risk and drought reduction. The limited budgets and the scant means for spreading their scenarios, make these social elements (mainly government employees) be aware of their limitations: The high maintenance cost of the meteorological stations, the lack of shared data from monitoring networks of other public institutions such as The Federal Electricity Commission (CFE), the lack of a strategy or integral planning, previously agreed definitions and the characterization of vulnerable groups. It is remarkable to say that in a State where drought has been historically present there is neither an early alert system nor any warning registry.

The State Water Comission of Sonora is the main responsible for the production of meteorological information. Some government employees affirm that it is not so much about the lack of information to do drought projections, but about the general context on

[9] 57% of the GNP comes from the tertiary sector: commerce, transportation, financial and real-state services.

the lack of *prevention culture* that would allow the understanding of the advantages and uses of meteorological information. Structural problems such as the low academic level of users (small and medium producers) often make this information abstract. The problem between the information transmitter and the receiver, however, is not only reduced to the message's accessibility and form, but also to the management of uncertainty. The information and meteorological forecast respond to a probability calculation with an obvious margin of error, while the users' expectations respond to a *cause and effect* logic.

On the other hand, the management institutions of emergency (Civil Protection) are facing prevention criteria that can be used under different contexts. For example, the National Fund for Natural Disasters (FONDEN) [Fondo de Desastres Naturales (FONDEN)] has regulatory times that make the access and application of resources difficult in case of emergency due to the nature of the drought, which presents long periods and low media reach compared to the emergencies produced by water excess. The confusion between *shortage* and *drought* can eventually favor an early or a late declaration of the emergency. It is possible to verify that each institution, government employee and user, perceives the risks of drought in function of his/her own priorities; for those in charge of emergency management, the problem does not rely in the loss of crops but in the side effects: forest fires, supplies by means of water tankers, and epidemic diseases such as dengue fever, which force to consider declaring a drought even when the water reserves are still above the optimum level. Therefore, declaring an emergency by drought is not related to the levels of water availability, but to specific social impacts. This situation is contrasted with other points of view where the definition of drought is basically related to millimeters of rainfall and to the refilling of storage systems, which generates differences and disqualification among government employees.

The lack of coordination among institutions makes the interpretation and distribution of meteorological information difficult. The efforts to prevent drought are often individual and not institutional, which results in inefficient training and planning, partly produced by the high turnover of staff in institutions that are completely renewed with each change of administration.[10] The absence of a prevention culture before drought at all

[10] The provincial administration period consists of 6 years, and 3 years in case of the municipal, without being able to reelect in either case.

levels favors the response in case of emergency and the improvisation of procedures for recovery.

Public Policies Recommendations

Nationwide, drought is not given the same value as other threatening disasters of greater media reach such as hurricanes and earthquakes. Drought does take place with direct or visible impacts, as for example in the communications infrastructure or housing. Assessing drought requires considering long term losses and side effects; generally provincial governments invest little resources in the creation of programs for mitigation, adaptation and resilience, even in regions where drought has been documented in a climatic and historical level. In a general way, the limits in the management of drought risks and the preventive decision makings are:

- The lack of agreements in regard to the use and definition of the "drought" term. Organization of knowledge-generating sectors with public institutions
- The little confidence in the accuracy of weather forecast
- The delay of operative procedures, technical factors and budgeting
- The scarce modernization of infrastructure, specially constant staff turnover that hinders the continuity of the programs

Until today, the efforts on behalf of the government have been reactive instead of proactive, and they have focused on the mitigation and not on the prevention of the effects. Recent experiences have demonstrated that the losses in the agricultural and livestock sector have considerably increased. The post drought measures have shown that reacting before emergency (crisis management) takes to uncoordinated and inefficient responses. Furthermore, this type of responses influence in a limited way the decrease of the vulnerability of coming droughts and can even increase such vulnerability. The drought risk in Mexico is not a part of the political scorecards of the agricultural, livestock, water resources, nor the disaster control and civil protection sector. In a government level the institutional and social ability to face the drought impacts is underestimated. Such ability must be incorporated through a group of preventive strategies developed and adopted by society and government. Such strategies would gradually allow for the transition of the development for a better prepared society that can be well adapted to the varying conditions of weather. (Landa et al., 2008.)

The first step to develop an instrument of risk reduction for drought is to establish **a public definition of drought,** followed by a legal and political frame nationwide that provides an institutional basis for the implementation of programs, such as an early alert system. Such policy must define the functions and clear responsibilities for all government and non government offices, as well as the responsibilities and rights of those involved. The relationships and work alliances of all authorities must be institutionalized, as well as the mandatory coordination mechanisms agreement. At the same time, it is convenient to guarantee the financial resources through the institutionalization of a public financing mechanism.

Along side, it is necessary to **develop financial support mechanisms** such as benefits and insurances for the agricultural and livestock sectors. The division between both sectors is a daily practice that amongst other things, favors the accumulation of livestock units without the guarantee of forage's supply. It is convenient strengthening the means of **supervision and control of the rangeland index** in order to reduce the degrading of soils as a result of intensive livestock. It is desirable to design **alternatives such as fishing** in dams that allow for the better use of existent resources that are not being appropriately exploited. The development of agro industrial poles can be an opportunity for the innovation of irrigation systems, farming diversity and reactivation of the sector.

Challenges and needs in the weather information use and availability

Drought has a regular recurrence, within varying time spans, but there is a possibility of preventing, studying and monitoring them, that is why they must be attended in a preventive and institutionalized manner. It is convenient to count with risk studies that consider the dynamic character of drought and the social vulnerability that generates certain processes such as urbanization, changes in the use of land in rural areas, degrading of the environment and climate change. Mendez y Magaña (2009) point out that even though we have made progress in the understanding about the mechanisms that regulate the variation of the weather in Mexico, it is hard to establish when a long lasting drought will appear, for this reason it is of greater use to create the drought forecast on a year on year basis, as well as every ten years.

The use of weather information is essential in the disaster prevention matter. It is fundamental to improve the abilities to generate weather information of high quality.

The scientific and technological progresses constitute a chance to improve the weather diagnostics and forecasts that allow planning through the development and application of early alert systems. The weather information to which the decision makers have access to is not enough to implement prevention measures in the short and long term. To create diagnostic and forecast weather information, it is suggested to:

- Develop drought monitoring and forecasting systems based on weather models, indicating the predictability of weather by region, by period of forecast and by detail in regards to the dimension of the drought. This way, the reaches and limitations of weather forecast with models must be established beforehand.

- Identify and create weather information taking into account the needs of the different users.

- Continually assess the abilities to monitor and forecast.

- Assess and encourage the institutional abilities for the use of weather information.

The ideal way to implement the weather information is by means of an early alert system coordinated by an authority of high hierarchical level in the public administration that guarantees that the decisions made are carried out. On the other hand, the institution must be incorporated to the academy that will allow researchers to perform teaching tasks and training students in subjects related to drought. The application of the system will essentially require correcting the actual operation procedures of prevention and warning regarding drought. A program that is incorporated to a government dependency is generally limited by technical and budget factors. Technically, the little or none confidence of the authorities and the accuracy in weather forecasts, does not allow for firm decision making. This is partly due to the lack of organization of the generating knowledge sectors with the institutions in charge of risk management. For this reason, a weather forecast is rarely used in decision making. (Landa *et al.,* 2008).

Developing and applying an effective system of early alert requires the contribution and coordination of a great variety of groups and persons. It is necessary that communities, especially the most vulnerable ones, participate actively in all aspects of the establishment and functioning of such systems, that they get to know the threats and

possible impacts to which they are exposed and that they can adopt measures to keep the possibility of suffering losses or damages to a minimum.

There are great opportunities to achieve the reduction of vulnerability considerably through policies and strategies within the sectors that have been identified as highly vulnerable to drought. Therefore, it is necessary that the actions aimed to the reduction of risk of drought involve, by means of **group work, the government, academic, productive, civil society, non government organisms and media sectors.** It is of extreme importance that the decision makers bear in mind the risks faced before drought and the socio economical costs. Administrative abilities must be generated in the national and regional spheres. It is essential as well, that plans for risk management drought can be objects of practice and can be carried out. The population must be well informed about the options regarding the measures that will be developed and the best way to avoid damages and losses of properties, according to the case. For the process of communicating the information it is necessary to previously define a system of communication nationwide and to appoint **authorized speakers.** Such communication must be institutionalized in an organizational and decision making process establishing a chain of diffusion through a government policy (e. g. public authority message transmission to agricultural land owners, dependencies, etc.).

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