Specific combined actions in Turia River during 2005-2007 drought

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SUMMARY – The last extreme drought that affects the Júcar River Basin Authority, occurs during 2005-2007 and it expands to the Turia river too. This is an important hazard to the Turia river environment, Valencia urban supply and traditional irrigation areas of this system. A combination of different measures, from the Jucar River Basin Authority, starts during year 2005, such as important water saving in irrigation areas, with the establishment of irrigation turns, an important urban wastewater reuse in irrigation areas, by Local and Regional Government, the possibility of drought wells use, by the users, and the follow-up of the river flows and channel flows for irrigation. The start of this set of drought management measures needs important co-ordinated efforts with the different administrations involved and users, with the objective of minimizing the environmental, economic and social impact of the drought. More than 40 cubic hectometres have been used in environmental or agricultural uses during the last year, and it has been possible reduce in less than fifty percent the regulation reservoirs outflows, that supposes and important guarantee for this and future years to keep the environmental flows maintenance and urban supply. In this paper the set of measures established during this drought in the Turia system is detailed.

Key words: Drought, water resources management, wastewater reuse, drought wells.

Introduction

Droughts are very frequent in climates corresponding to southern latitudes, such as that of Spain. The main characteristics of such climates are variability and irregularity, with conditions changing from one extreme (periods of flooding or very heavy rains) to another (droughts or dry periods) in a short period of time. In fact, the first half of 2004 was very rainy throughout much of Spain and was not until the summer of 2004 that the drought period began. The drought existent in the water resource systems is related to unusually low levels of rain fall, as well as with water use for agricultural and industrial purposes and human consumption. In accordance with usage given to a system's water resources, the consequences of an initial meteorological drought and posterior hydrological drought may be very considerable.

Between the 1992/93 to 1995/96 hydrologic years, Spain suffered the most serious droughts of recent years. This period in turn formed part of dry period covering the 1991/92 to 2000/01 hydrologic years.

In the case of the Júcar River Basin Authority (CHJ), the most affected exploitation systems by the relative reduction in water contributions were the Rivers Turia and Jucar, with drops of 44% and 35%, respectively. Among the less-affected zones – with precipitations superior to 900 mm – we find the Lower Júcar, whilst the most affected include Mancha Oriental (Jucar), with precipitations of less than 300 mm.

According to the data employed in the drafting of the CHJ Hydrological Plan (CHJ, 1998), the total volume demanded by the Turia system was 661 hm^3/year. The balance between the theoretical demand and the total contributions during the driest year of the cycle was 29% of the existing demand.

The drop in precipitation and contributions began in the 1992/93 hydrological year. At no time during the analysed dry-cycle was a normal situation registered, whilst two, almost successive, emergency phases were registered (July '94-January '95 and May '95-December '95).

There is still no official calculation on the effects that a drought produced by a shortage in rainfall may have on Spain, although agricultural organisations speak of losses in terms of thousands of millions, above all in herbaceous crops and large-scale livestock farming.

The considerable economic and environmental losses caused by the drought during the 1992-1996 period throughout the whole of Spain, combined with the difficulty of introducing the approved emergency measures in such a short period, led to the need for the establishing of Drought Action Plans covering pre-drought periods. The resulting plans are known as "Special procedural plans for situations of alert and temporary drought".

Hazard to the Turia river environment, Valencia urban supply and traditional irrigation areas of this system

Droughts have been occurring persistently in eastern Iberia dryland regions for over a century. The impacts of droughts on people, their domesticated animals, wildlife, rangelands and cropped lands have been shown to be astronomical. If left alone the rangelands often recover after the calamity, however human occupation has led to irreversible damage. Even though some communities have evolved viable and sustainable coping mechanisms, recent times have seen weakened coping strategies leading to loss of life in most of the countries in Mediterranean Area. While land degradation has many inter-related causes and effects, drought-related effects have proven most difficult to manage and/or overcome. Drought-related land degradation or desertification poses a huge threat to sustainable land and resource management in the region. The CPS examines appropriate drought mitigating initiatives, linking them to land tenure and land management practices. Numerous interventions targeted at reducing poverty and improvement in resource management have failed to achieve desired effects due to rigidity and imposition, and failure of the external interveners to recognise and incorporate native peoples' preferences and coping strategies. Non-governmental organisations and authorities' willingness to institute drought and desertification combating measures are reviewed, highlighting the role that community action plays in reducing adverse effects in the region. Linkages to trade patterns that perpetuate poverty and unwise use of resources are discussed. Adopting "people centred" mitigating measures is emphasised. What is required is an informed global action.

Drought is the natural hazard affecting the most people globally. Disasters involving drought are among the most devastating. Due to the complexities of drought disasters, however, the study of drought has largely focused on limited-area case studies. The lack of a global perspective on what constitutes a drought hazard event is a current limit on our understanding of how drought disasters can be mitigated, and on the general applicability of early warning systems.

A drought disaster is caused by the combination of both a climate hazard – the occurrence of the drought– and a societal vulnerability (the characteristics of groups of people or socio-economic systems that make them susceptible to damage during droughts).

CHJ proposed a local analysis of the incidence of recorded drought disasters as related to a range of climatic measures of drought. OPH expected to provide an initial assessment of which climatic measures of drought constitute drought hazard events most relevant to the occurrence of disasters, as well as an assessment of the largest spatial extent to which the climatic measures are relevant.

Relevant phenomenological and data analysis are currently in progress. Additionally, a threshold-based index of drought severity is under development (Fig. 1). This index is based on precipitation deficits in the context of the long-term statistical behavior of the local precipitation, and so can be meaningfully calculated at local and regional scales. The societal relevance over the range of possible thresholds remains to be explored.

The primary goal of the proposed effort is to: develop climatic measures of drought hazard – magnitude, duration, location and timing – that are relevant to the occurrence of drought disasters and assess the degree to which these measures are meaningful at the local and regional scales. Given the complexity of drought disasters, a further goal is to provide a basis for future investigations through construction of a drought hazard database and identification of regions for additional targeted research.

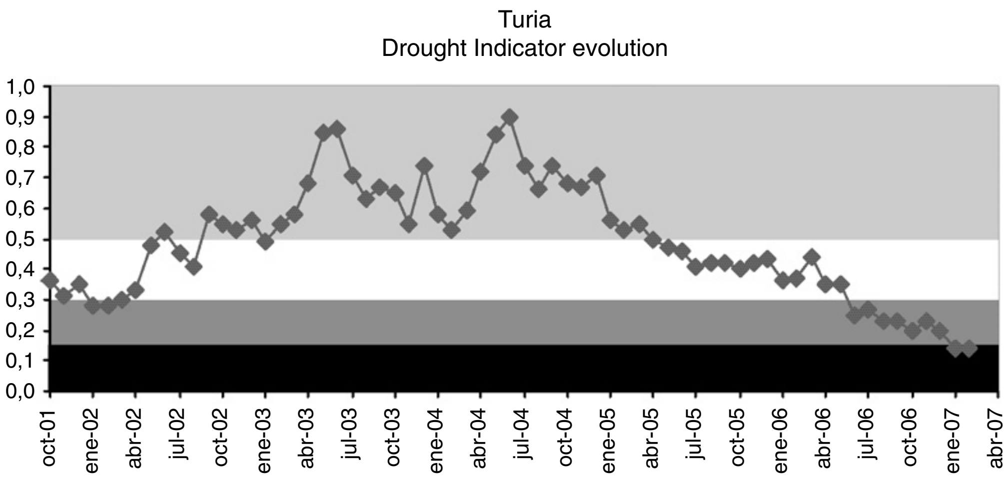

Fig. 1. Index of drought severity.

The proposed effort will be a collaboration among drought experts, based on data with which the investigators are already familiar. As such, resource needs are expected to be modest.

Drought is a natural hazard, it has a slow onset, and it evolves over months or even years. It may affect a large region and causes little structural damage. The impacts of drought can be reduced through preparedness and mitigation.

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to society's ability to produce goods and provide services.

Impacts are commonly referred to as direct and indirect. Direct impacts include reduced crop, rangeland, and forest productivity, increased fire hazard, reduced water levels, increased livestock and wildlife mortality rates, and damage to wildlife and fish habitat. The consequences of these direct impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs.

Economic Impacts: Many economic impacts occur in agriculture and related sectors, because of the reliance of these sectors on surface and groundwater supplies. In addition to losses in yields in both crop and livestock production, drought is associated with insect infestations, plant disease, and wind erosion. The incidence of forest and range fires increases substantially during extended periods of droughts, which in turn places both human and wildlife populations at higher levels of risk.

Income loss is another indicator used in assessing the impacts of drought. Reduced income for farmers has a ripple effect. Retailers and others who provide goods and services to farmers face reduced business. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and eventual loss of tax revenue for local, state, and central governments. Prices for food, energy, and other products increase as supplies are reduced. In some cases, local shortages of certain goods result in importing these goods from outside the drought-stricken region. Reduced water supply impairs the navigability of rivers (rafting, trekking, etc.) and results in increased transportation costs because products must be transported by alternative means. Hydropower production may also be significantly affected.

Environmental Impacts: Environmental losses are the result of damages to plant and animal species, wildlife habitat, and air and water quality, forest and range fires, degradation of landscape quality, loss of biodiversity, and soil erosion. Some of these effects are short-term, conditions returning to normal following the end of the drought. Other environmental effects last for some time and may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity.

Social Impacts: Social impacts involve public safety, health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. Many of the impacts identified as economic and environmental have social components as well. Population migration is a significant problem in many countries, often stimulated by a greater supply of food and water elsewhere. Migration is usually to urban areas within the stressed area, or to regions outside the drought area. Migration may even be to adjacent countries. When the drought has abated, the migrants seldom return home, depriving rural areas of valuable human resources. The drought migrants place increasing pressure on the social infrastructure of the urban areas, leading to increased poverty and social unrest.

Measures

During dry season, water reserves of the dams and reservoirs can not anymore supply the needed volume of water for household, commercial and agricultural uses.

Reuse of wastewater for agriculture

In rural and peri-urban areas, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas, as "Sequia de l'Or" irrigation channel. Even in areas where other water sources exist, small farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers.

Concern for human health and the environment are the most important constraints in the reuse of wastewater. While the risks do need to be carefully considered, the importance of this practice for the livelihoods of countless smallholders must also be taken into account.

The Reuse of Wastewater temporary rose in use still 184% on July 2007, due to local and regional Government initiative to create delivering facilities.

Possibility of drought wells use

In times of drought when the surface water dries up, groundwater supplies become even more important.

The purpose of the shallow tubewell is to utilize and manage potential shallow aquifer to augment surface water in providing adequate water for sustained productivity. It is described as a tube or pipe vertically set into the ground at depth of 6 to 30 meter for the purpose of suction lifting of water from shallow aquifers. When fully developed and equipped with appropriate pumping units, it can serve a contiguous area of 3 to 5 hectares owned by an individual or groups of farmers. The pumping unit consists of a centrifugal pump powered by a 5-10 diesel engine or electric motor.

A well is any excavation that is drilled, driven, dug, jetted or otherwise constructed when the intended use of such excavation is for the location and acquisition of ground water.

The quality and quantity of groundwater varies from place to place. However, water in some quantity can be found beneath the ground almost everywhere. As a result, 97 percent of the world's available fresh water is groundwater.

Major reservoirs of groundwater are called aquifers. Conditions for good water-bearing formation are high permeability, which is the measure of ease with which water can flow through a soil profile, and high drainable porosity, which indicates that large amounts of water can be removed from the water-bearing formation. These features are best characterized by sand and gravel, although fractured rock formations and solution caverns in limestone are also good aquifers.

Wells can be classified as gravity wells, free flowing artesian wells, or a combination of artesian and gravity (pumped artesian wells). The well type depends on the type of aquifer containing the water. Gravity wells penetrate unconfined aquifers. As a result, the static water level in a gravity well is the same as the level of the water table (piezometric surface of the unconfined aquifer).

Wells can also be classified as shallow or deep. In many areas good irrigation water can be obtained from shallow aquifers. Careful investigation of the shallow water aquifers should be performed prior to well construction. In some instances, when the shallow water table is due to a perched water table, pumping for irrigation can quickly exhaust the water supply.

In general, wells can be classified into three major types according to the method of construction: driven, dug or drilled.

A dug well is a pit dug to the ground water table. These wells usually do not penetrate the groundwater deep enough to produce high water yield. A dug well pit is often lined with masonry, concrete, or steel for support.

Deeper wells are usually constructed by drilling. Cable-tool or rotary equipment is commonly used. In the first method, a heavy bit is dropped repeatedly to the bottom of the well using cable tools and crushed material is periodically removed with a bailer. Rotary drilling equipment consists of a bit rotated by a string of pipe. Cuttings are removed by continuous circulation of a drilling fluid as the bit penetrates the formation. Drilling fluid is pumped down through the drill pipe and out through the ports or jets in the bit. The cuttings are brought to the surface by a mud slurry outside the drill pipe.

An irrigation well should penetrate the water-bearing formations quite deeply while keeping costs within economical limits. In Valencia, the depth of a well will also be limited by water quality since saline water underlies potable water throughout the state. In coastal areas of Valencia, salt water intrusion into the aquifer is frequently encountered. Keeping water quality problems in mind, a well should be sufficiently deep to avoid running dry during drought or during increased drawdown periods such as pumping for freeze protection during winter months. It is also important to remember that deeper wells will usually produce a greater yield of water per meter of drawdown.

Newly constructed wells should be developed and tested. The purpose of well development is to provide sand-free water at maximum capacity. The drilling operation alters the hydraulic characteristics of a water-bearing formation in the immediate vicinity of the well caused by compaction, relocation of natural fine materials and/or migration of drilling fluids into the formation. As a result local permeability and hydraulic conductivity may be severely reduced, restricting water flow into the well.

After a well is developed, a pumping test should be performed in order to determine potential well yield, to select an efficient pump, and to determine the drawdown which can influence pump location for submersible or deep turbine pumps.

The well test is performed by measuring the yield and drawdown at certain time intervals during pumping. A capacity/drawdown curve can be developed that allows efficient selection of a pump for given conditions. Since the drawdown for the required yield is known, the location of the submersible or deep turbine pump can be determined from the chart.

A pumping test can also provide data necessary to determine the hydraulic parameters of an aquifer. An aquifer pumping test requires the measurement of drawdown in nearby observation wells in addition to the capacity/drawdown data from the well. An aquifer test determines the effect of newly installed wells on existing wells, the radius of influence of the well, and the drawdowns in the well for different discharges. The results from this type of test are necessary for proper well spacing and for groundwater investigation and management.

Monitoring groundwater levels is used to enhance environmental protection at landfills, tracking water supply to plan for future water supply. Water levels are measured monthly at water supply wells.

Follow-up of the river flows and channel flows for irrigation

The Turia is one of the largest rivers of the Jucar River Basin Authority, being a major tributary of the Valencia Drinking Water; its source lies in Valencia, Spain. The Turia enters Valencia just upstream of the rim station Titaguas.

The pilot area mostly comprises agricultural land. Over the past 30 years, the area under cultivation has decreased due to industrialization and urbanization. The area under change is outside the riverbanks, and there have been no encroachments and narrowing or modification of the river channel. Although this area lies in the river flood plain in cases of exceptionally high floods, dams protect it. Breaching sections have been defined so as to reduce the pressure on the protection bank of this area when floods occur.

During 2006-07, the OTS (Technical Drought Department) released the draft Turia river Study for CPS (Permanent Drought Commission) comment (Figs 2 and 3). The summary report and the OTS's follow-up action plan were finalized following the consultation.

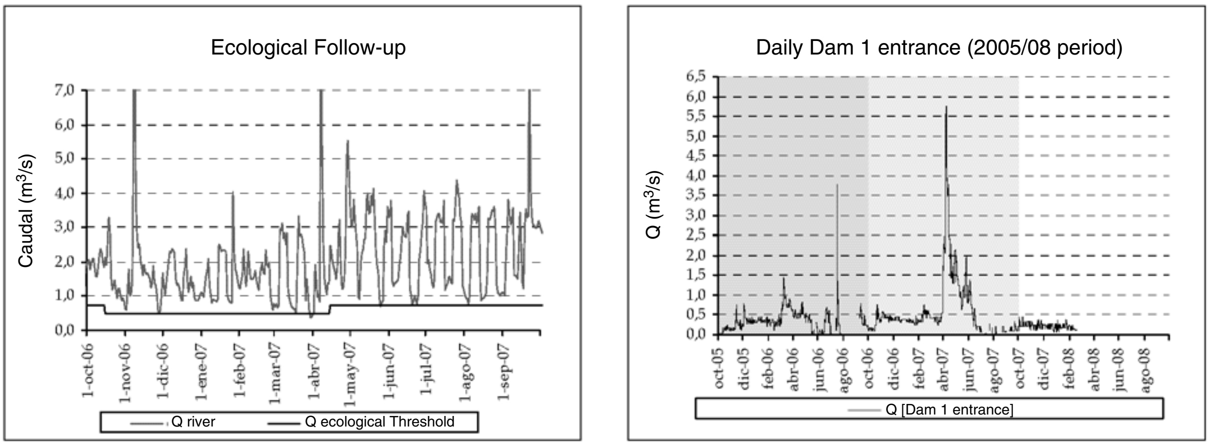

Fig. 2. Ecological follow-up and an example of a dam daily entrance.

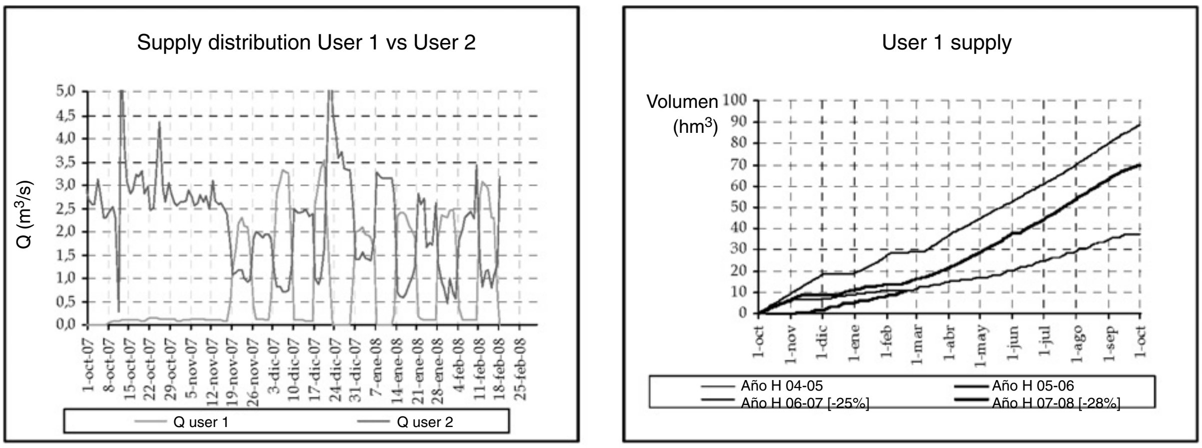

Fig. 3. Supply distribution accordance and its effect over the annual consumption.

The Turia River Study provides a useful snapshot of the current state of the river before completion of the 2005-06 season at the La Vega de Valencia Site, and confirms that despite significant historical scarcity of the Turia River, conditions have been steadily improving and will likely continue to do so. The study made a number of recommendations based on the resources. In response to these, the CPS committed to the follow-up actions outlined below. Many of these actions are already complete.

Levels of anthracites in the Turia River were found to occasionally exceed Valencia drinking water standards, particularly in summer months, when water levels are lower. In July 2007, the Jucar River Basin Authority delays the use of Turia river water into Valencia drinking water in order to upgrade the plant to treat. The use of Turia River water began in January 2008, when the plant was able to reduce the anthracites levels until they were consistently below Valencia Drinking Water Standards.

Soil and Water Conservation

Conservation practices minimize the disruption of the soil's structure, composition and natural biodiversity, thereby reducing erosion and soil degradation, surface runoff, and water pollution. The following are established practices of soil and water conservation:

- Crop rotation;
- Contoured rowcrops;
- Terracing;
- Tillage practices;
- Erosion-control structures;
- Water retention and detention structures;
- Windbreaks and shelterbelts;
- Litter management;
- Reclamation of salt-affected soil.

Soil and water conservation can be approached through agronomic and engineering measures. Agronomic measures include contour farming, off-season tillage, deep tillage, mulching and providing vegetative barriers on the contour. These measures prevent soil erosion and increase soil moisture.

Engineering measures differ with location, slope of the land, soil type, and amount and intensity of rainfall. Measures commonly used are the following:

(i) *Contour bunds, trenches and stone walls:* these features prevent soil erosion and obstruct the flow of runoff. The retained water increases soil moisture and recharges the groundwater.

(ii) *Check dams and other gully-plugging structures:* check dams are temporary structures constructed with locally available materials. Types of check dams are the brush-wood dam, the loose-rock dam and the woven-wire dam.

(iii) *Percolation ponds:* these features store water for livestock and recharge the groundwater. They are constructed by excavating a depression to form a small reservoir, or by constructing an embankment in a natural ravine or gully to form an impoundment.

(iv) *Water-supply projects* can also be implemented for drought mitigation, with a view to strengthen drought preparedness. Activities such as water-use planning, rain-water harvesting, runoff collection using surface and underground structures, improved management of channels and wells, exploration of additional water resources through drilling and dam construction, are implemented as a part of a drought-mitigation plan.

To increase moisture availability, the following in-situ moisture-conservation practices can be adopted:

(i) For agricultural crops, measures include ridges and furrows, basins, and water spreading.

(ii) For tree crops, measures include saucer basins, semi-circular bunds, crescent-shaped bunds, catch pits and deep pitting.

(iii) Rainwater harvesting collects rainfall or moisture for immediate or eventual use in irrigation or domestic supplies. Part of the rainwater collected from roofs can be stored in a cistern or tank for later use.

(iv) Landscape contouring is used to direct runoff into areas planted with trees, shrubs, and turf.

Farmers can prepare for drought by developing plans which cover all aspects of farm management and take into account variable climatic conditions. Sustainable strategies include appropriate fencing to control overgrazing, pest-control measures, planting drought-resistant crops and pasture, stabilization of eroded soils, pruning plants to reduce leaf area, removing weak plants and thinning dense beds to reduce competition, and the protection of native plant species.

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Acronyms

CHJ, Jucar River Basin Authority (Confederación Hidrográfica del Júcar).
OPH, Hydrological Planning Department (Oficina de planificación Hidrológica).
DPH, Public Hydraulic Domain (Dominio Público Hidráulico).
CPS, Permanent Drought Commission (Comisión Permanente de Sequias).
EDAR, Waste Water Treatment Plant (Estación Depuradora de Aguas Residuales).
IGME, Spanish Geological and Mining Institute (Instituto Geológico y Minero de España).
OPAD, Public Bid for the Acquisition of Water Rights (Oferta Pública de Adquisición de Derechos).
OTS, Technical Drought Department (Oficina Técnica de Sequías).
SEPRONA, Civil Guard Nature Protection Service (Servicio de Protección de la Naturaleza de la Guardia Civil).