RECONSTRUCTION OF THE AQUIFER HISTORY OF GRAN CANARIA

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Abstract. A study on the recent history and current state of the aquifer in the Island of Gran Canaria (Canary Is., 28ºN, 15ºW) is performed. Though rainfall is scarce on the island, traditional agricultural practices and small population were able to keep the aquifer in a constant state for centuries. Nevertheless, at the beginning of the 20th Century, culture of several water-consuming species was introduced on a commercial basis due to the relative proximity of the Canaries to continental Europe and to the possibility of more than one yearly harvest. This led to generalised well digging (more than 300m deep in many cases) and to the appearance of a chronic hydraulic deficit, as well as to spoiling vastcoastal areas of the aquifer through intrusion of brackish water. In the mid 1960's, coincident with the apex of agricultural exploitation, massive tourism appeared in the scene. This new activity soon became a susbstitute for Agriculture, but it attracted more new labour force to the island, and a fast growth of population was the main result. Moreover, new water use practices entered the scene. As a consequence, the main causes for the aquifer decline are population growth and extensive Agriculture practices in use during the last half of the 20th Century. Some remarks on sustainability issues in order to cope with Climate Change are also offered.

1 Introduction

Droughts and the lack of water for agricultural purposes, as well as scarcity of natural drinking water, are main features of Climate in the Canary Islands.

Therefore, from the 16th Century onwards, building of infrastructure for water recollection and distribution has been a constant in the islanders' culture. Nevertheless, during the first decades of the 20th Century extensive and intensive agricultural exploitation was undertaken, with species such as tomatoes, bananas, cucumbers, and several other fruits whose greed for water is well known. The result was a dramatic reduction of the water-table levels in all islands. In Gran Canaria, a number of dams were built in order to prevent runoff waters to go directly into the sea, but this solution was only a temporary one.

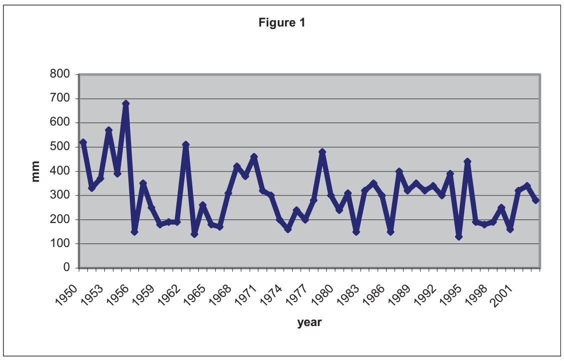
Population growth and the development of Tourism in the last 50 years became responsible for the overexploitation of the aquifer once Agriculture started to decline. In whole, the diminishing rate of the water-table level has been more than 10m/year for some time in several locations, when wells digged to depths over 300m became common. Legal restrictions on these matters can be found in [2], [3]. A most important sequel, the salination of aquifers, finally led to the installation of desalination plants both for the treatment of these brackish waters and for the obtention of human usage water directly from the sea: the first one entered service in 1967. Moreover, programs on the reutilisation of wastewater have frequently taken into consideration, but the high salinity of water makes it difficult and expensive, so these projects had little success. A history of the water supply problem in Gran Canaria can be found in [6], [9], [10].

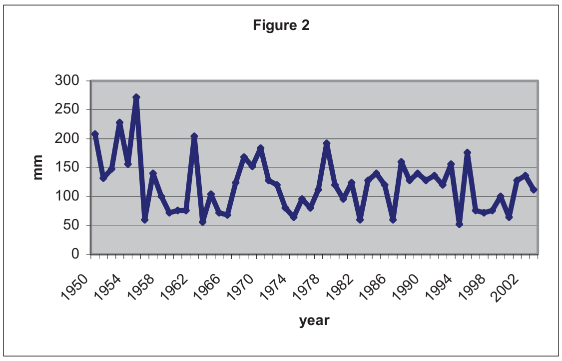
2 Theoretical framework.

For the purpose of this work, the aquifer in Gran Canaria can be considered as a single reservoir. Its time evolution is described by the balance equation $\Delta V = V(t+\Delta t) - V(t) = \left[\Phi_{in} - \Phi_{out}\right]\Delta t$, where time is expressed in years and volume in Hm^3 $(10^6\, m^3 = 10^9\ liters)$. In this equation, the input flux Φ_{in} is obtained from the precipitation time series, while the output flux Φ_{out} is the time series of extractions performed for agricultural or human consumption. There exist quite reliable records for precipitation, but the data for output fluxes are fragmentary and have been computed through proxy measures.

3 The study

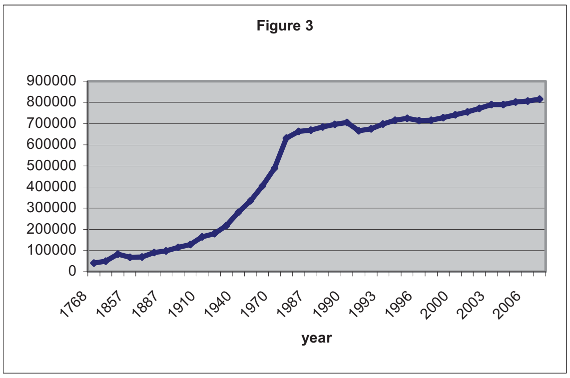
The rainfall series is shown in Figure 1.

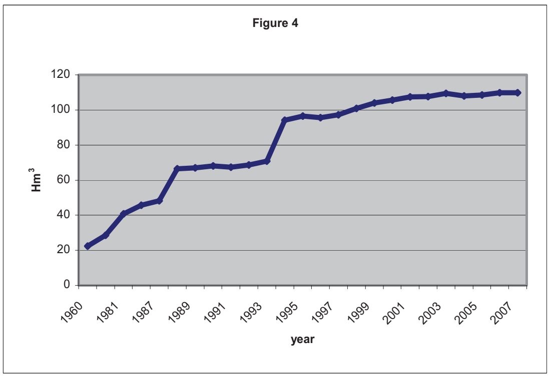




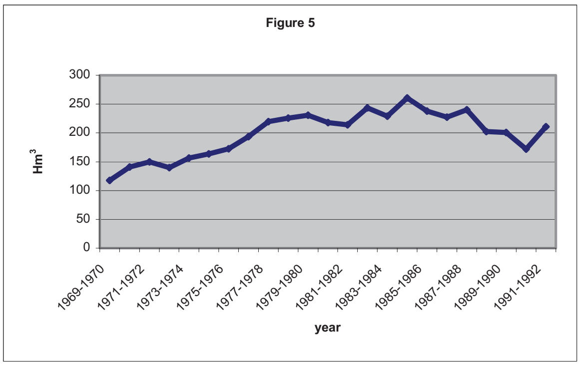
In average, the yearly precipitation amounts to 300mm, equivalent to 466 cubic Hectometers. A general descending trend is observed in the last 50 years, and two periodic components of 20 and 8 years can be observed in a periodogram analysis. The eight year period is easy to observe and has a certain importance: After a series of drought years in the 1990’s, abandonment of Agriculture was markedly increased. Due to the impervious structure of volcanic rocks and to the steep profile of the Island, it has been estimated that over 60% of the total rainfall is lost into the sea through runoff. Imperviousness is also responsible of the very long times of charge and discharge for the aquifer under natural circumstances. Therefore, with no artificial water supplying techniques, only some 40% of the total rainfall had to cater for Agriculture, population, and aquifer recharge. Observe in Figure 2 the vertical scale in order to have a glimpse of the actually available rainfall water.

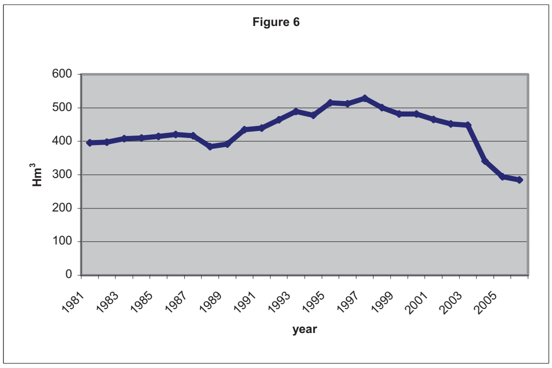
Water consumption has evolved in a complex way, depending both on population and on cultural constraints. During the last 30 years, urban consumption switched from a mere 80 liters per person per day to some 200. Moreover, the semi-rural landscape island has changed into a highly urbanised one, following the population doubling in the same period. The evolution of population is shown in Figure 3.



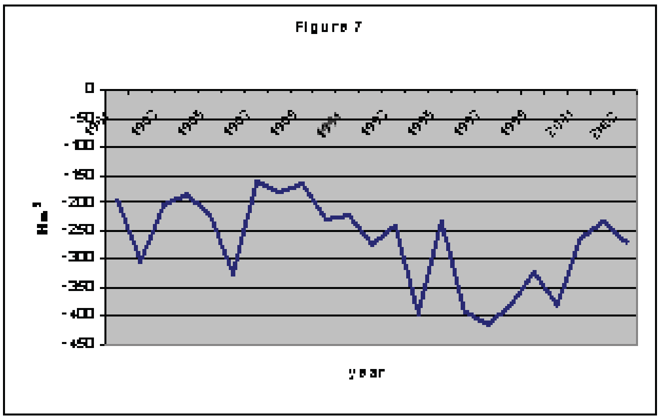


By assuming a logistic distribution, it is clear that the Island population is already in the asymptotic phase. The most optimistic computations for the carrying capacity, performed by one of the authors (Fernández, unpublished) point to a value around one million people. The population figures also include a number of tourists: with the usual fortnightly turnover rate it can be well over 100.000 people in peak months. Water used for human purposes, computed on an urban basis consumption scheme, is shown in Figure 4, where the evolution of consumption from 80 to 200 liters per person per day has been incorporated in the form of two clearly marked steps in the graph: The second one around 1990 shows the incorporation of continuous supply of urban water, which led to a sudden growth of water use. The volume of water used for Agriculture has been computed from global production data for the main export products: bananas, tomatoes, and cucumbers. Reliable time series are available since the 1930’s. Using a weight relationship fruit/water of 1/1000, the series of agricultural water consumption can be observed in Figure 5. The joint consumption (human+agricultural) appears in Figure 6.





Substraction of this series with the actually availabe rainfall one (Fig. 2) yields the deficit depicted in Figure 7.



This chronic hydraulic shortage, which has been traditionally quenched by subterranean water extraction, measures the extent of the aquifer depletion, which became apparent in the late 1960's, when high prices of tomatoes and bananas led to an overall extension of culture land which no longer could be watered with the classical natural supplies of small wells, water sources and little dams and ponds. At the same time, population growth was largely boosted through attraction of labour force to the new tourism industry, which in turn influenced patterns of human water consumption. Though Agriculture is no longer so water consuming (both because of better techniques and its decline as a business), population growth, tourism, and the introduction of more water-consuming practices (personal hygiene, golf courses, swimming pools and the like) contribute to maintain this deficit. The average deficit during the last 25 years is $268\,Hm^3$, an amount that has been obtained only in these last five years through the generalised use of desalination plants, whose joint production has been steadily growing up to an actual $240\,Hm^3$ (data for 2008). A deficit of $28\,Hm^3$ is still there, and recovery of the pre-1960 level seems a rather difficult task even accepting the mildest Climate Change scenarios for the next years.

4 Conclusions and views

Gran Canaria is rather close to its population carrying capacity, and actual water supply depends to a large extent on desalination procedures. The chronic hydraulic deficit –due to overexploitation of the aquifer and a large number of dry years during the period where fast population growth has taken place, *i.e.* the last 50 years- is still there, and mitigation of possible impacts of even moderate Climate Change scenarios will need a complete set of measures. Of foremost interest is that both desalination technologies and plants must be imported, thus making the future water supply to the island a completely dependent one on prices and availability of these artifacts. See references [1], [4], [5], [7], [8] for studies and comments on issues to this sort of problems.

5 Acknowledgements

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