



## **Monitoring and management of groundwater resources in a vulnerability context related to human activity – Case of the city of Marrakech (Morocco)**

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According to the World Tourism Organization (UNWTO), Morocco is a leading tourism destination in Africa in the last 5 years (2017-2012) and in this context, Marrakech is thought of as the figurehead of this sector with almost 3 million international arrivals in 2017. The city is also considered as a must-see by tourists arriving via airports in other cities, in addition to a significant proportion of domestic tourism. This attractiveness of Marrakech is due to its historical heritage, but also, and particularly, for its hot semi-arid climate.

Low precipitations and high temperatures characterize this city and area climate, involving a deficit between rainwater supply and the potential evapotranspiration. Consequently, the groundwater recharge is inadequate, and year after year, the water-table lowered gradually leading to a risk of the total exhaustion of the shallow aquifer.

In parallel to this, and in order to meet the tourist's expectations in this sunny and hot environment, real-estate promoters and economic players embarked in the last 20 years on the construction of various recreational centres, some of them are big fresh water consumers such as golfs and waterparks.

Furthermore, the rise on power of tourism sector in Marrakech created a strong labour market and a substantial economic growth, causing a rapid urbanization and a population increase. To meet the increasing water needs, the local agriculture sector has become increasingly greedy, and many farms have sprung up recently in the immediate vicinity of Marrakech, in the west especially. This activity requires a great amount of water for irrigation.

The aim of this study is to determine the impact of urbanization and population growth on groundwater in a water vulnerability context, and to propose ways to reflect on solutions for the water resources monitoring and management.

By using hydrological data from previous studies (since the 60' of the last century) and data collected during a recent campaign, it was possible to determine the spatial and temporal variations on groundwater quantity and quality, to identify the most seriously affected areas and to link this impact with the human activity. In addition to the old and recent hydrological data, Geographic Information Systems and satellite imagery were used.

As this situation becomes unsustainable because that could lead to a total depletion of the local groundwater resources, it is necessary to take preventive measures by adopting a water management and monitoring system. Example of possible options is recycling wastewater and the direct reuse of greywaters for non-potable needs, and the implementation of an intelligent sensor network to monitor the level of the water table.

**Key words :** Semi-arid climate, groundwater, water-table, urbanization, population growth, Marrakech.