PIEZAGRO – Vulnerability Risk Assessment for the Agroforestry Sector in South Portugal under Climate Change: Impact of the Evolution of the Piezometric Level

Summary

Groundwater is a shrinking water reservoir predicted to decline significantly in geographical areas that will experience lower precipitation combined with higher temperature and thus higher evapotranspiration rates in the future. The Mediterranean basin is especially threatened (Vincente-Serrano 2014). In semi-arid areas of the Mediterranean region, plants have often adapted to avoid drought stress by building deep rooting systems which access groundwater sources. If, so far, phreatophytic traits have evolved for the vegetation to cope with the high inter-annual variability of the Mediterranean climate, plants might not be prepared to face the drastic changes imposed by climate changes on multiple water sources.

Recent studies have shown that extreme drought events have increased mortality rates for some tree species (AFN 2010) by driving trees closer to the threshold of fatal embolism (Kurz-Besson 2014). Beyond the direct impact of climatic variable, and soil moisture decline, we urgently need to better evaluate the impact of water table fluctuations on woody species relying on groundwater sources to cope with recurrent drought stresses.

Current knowledge of the impact of climate changes on the productivity and survival rates of dominant tree species are based on deterministic forest models based on carbon and water balance. However, forest water balance does not account for groundwater uptake or its benefit for tree productivity. Yet many authors have demonstrated that groundwater uptake was a significant proportion of the ecosystem water balance, and might involve deep soil layer reservoirs down to 15 m depth (David et al. 2013, 2007, Kurz-Besson et al. 2014, 2006).

There is a clear lack of knowledge on the effect of groundwater source availability and the physiology and productivity of phreatophytic species as well as on the potential consequences of water table drawdown on those species in response to climate changes. Cooper et al. (2006) provide one of the rare attempts of the investigations on the topic.

In this application we propose to develop an innovative approach based on geographic information system (GIS), remote sensing, and dendrochronology to assess the vulnerability of groundwater dependent and phreatophyte species and their respective ecosystems to climate change with respect to the evolution of the piezometric level.

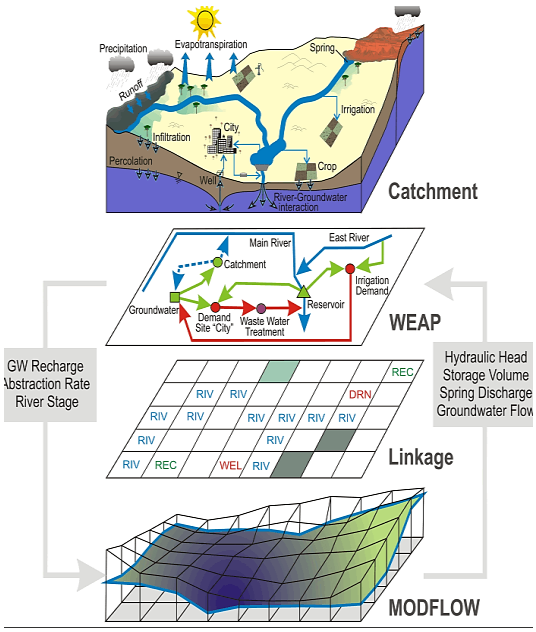

Figure 1. Groundwater modelling approach.

Based on recent work from (Pilas et al. 2003), we hypothesize that large water table oscillations have a significant impact on deep-rooted phreatophyte productivity. Thus, significant relationships should be found between tree ring width of woody species relying on groundwater source and the closest record of the piezometric level.

We plan to fill the existing gap of knowledge mentioned above by studying the semi-arid region of South Portugal particularly threatened by desertification: The Alentejo. This region is mainly covered agroforestry species of high economical interest and dominated by known and suspected phreatophytes woody species such as Cork oak, Holm Oak, Eucalyptus and Stone and Maritime pines.

Gathering a multidisciplinary panel of highly skilled scientists from Instituto Dom Luiz (IDL), University of Trás-os-Montes (UTAD) and the Instituto Superior Técnico (IST) in the fields of Ecophysiology, Geophysics, Meteorology, GIS, Remote sensing, and Hydrological modeling, our proposal gathers the following innovative challenges:

- Map the distribution of phreatophytes species of the region, including agroforestry species and focusing on the degree of dependency of those species to groundwater sources in the Alentejo region.
- Evaluate and model the relationships between climate, water table fluctuations and wood growth over the last 60 years

CERIS : Civil Engineering Research and Innovation for Sustainability

Project Reference

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Leading Institution

IDL-FCUL – Instituto Dom Luiz da Faculdade de Ciências da Universidade de Lisboa (Portugal)

Partners

FFC/FC/UL – Fundação da Faculdade de Ciências da Universidade de Lisboa (Portugal), IST – Instituto Superior Técnico (Portugal)

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and dendrochronology of the main woody species exploited in the region (Q. suber, Q. rotundifolia, P. pinea, P. pinaster, and E. globulus).

- Model the water table level and its evolution in response to climate and land use changes according to the scenario RCP 8.5.
- Map the ecological vulnerability of the entire Alentejo region exposed to the largest water table alterations in the future.

The project intends to serve the framework of the Portuguese strategy of adaptation of water sources for Agriculture and Forests to Climate change (ENAAC-RH, 2013). The expected scientific outcomes will provide a powerful decision tool for the elaboration of mitigation plans to reduce climate change impact on groundwater sources and to propose solutions to promote groundwater and aquifer recharge in the most endangered areas identified.

The project focuses on the fate of groundwater dependent ecosystems (GDEs) and rainfed deep-rooted agroforestry species in the Alentejo region of South Portugal. The project intends to delimit the most vulnerable areas to desertification with a high confidence level and provide mitigation solutions for the geographical area classified by priority.

Divided in 5 tasks, the project seeks to accurately identify geographical areas of the region that are most threaten by the combination of climate change and water table drawdown, by:

- Establishing the potential distribution of ground dependent species and their respective degree of dependency to groundwater source.
- Modelling the relationship between water table level and tree productivity.
- Predicting the impact of future climate conditions and water demand on the water table level 4/ integrating information to identify priority areas for water management adaptations.

The project presents a strong advantage in this kind of studies, as it relies exclusively on pre-existing available reliable datasets, reducing considerably the estimated costs and risk of failure. It also relies on an innovative approach gathering state-of-the-art methodologies which have been successfully used in former studies around the globe. We are thus extremely confident about the expected outcomes.

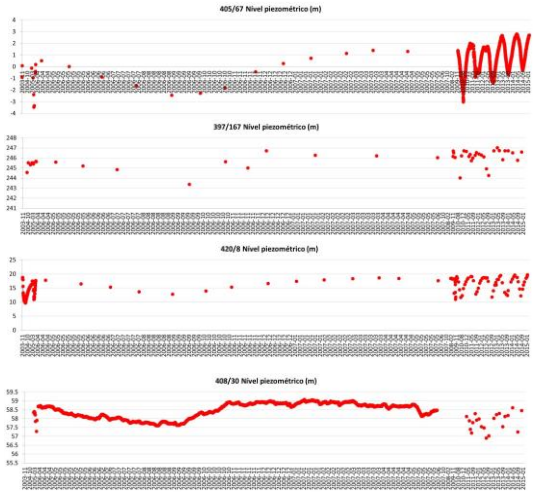

Figure 2. Available groundwater monitoring data from APA (SNIRH).

The Project Research Team present a solid scientific and technical expertise and has experience in sharing their expertise in several fields, ranging from Ecophysiology, Geophysics, Meteorology, GIS, Remote sensing, and Hydrological Modelling and belonging to two different institutions from Lisbon University (IDL and IST) with high scientific level in the research domains mentioned in the present proposal. Additionally, the project team is counting with the consulting expertise of two scientists from 2 well known Portuguese Institution in the field of Dendrochronology, such as UTAD and Coimbra University.

Using public available data, the team developed a GIS-based methodology that combine the climate characteristics of the region into a screening tool to identify critical geographical areas of Alentejo displaying a high potential to host a significant number of GDE.