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DPSIR analysis of the closure of water resources in Axarquía region (southern Spain)

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ABSTRACT

Axarquia region (36°50′00″N 4°10′00″W) Southern Spain is the main producer of avocado and mango in Europe, crops that are suffering the consequences of a long drought. The combination of population growth and the increase of the cultivated area with subtropical crops is leading to groundwater overexploitation. This work applies the European Environment Agency's DPSIR (drivers, pressures, state, impact, and response model of intervention) framework to analyze closure process in this region. The water crisis has impacted citizens (urban supply), farmers (losses of yields and crops) and environment (decreasing water reserves). Supply has increased by incorporating reclaimed wastewater, and the upcoming building of a desalination plant, but demand control and proper governance are required to reach sustainability.

1. Axarquia region and water resources closure

Axarquia is a region located in Southern Spain, limited by a range of mountains at the north, east and west, and by the Mediterranean Sea at the south. Annual sunshine is around 2.600 hours, and the annual average temperature is 19ºC. The plain and the coastal area make subtropical crops possible, and tourism is present all year round. Our case study applies the European Environment Agency's DPSIR (drivers, pressures, state, impact, and response model of intervention) framework to analyze closure process in Axarquia.

1.1 Driving forces

Two driving forces explain the increase in water demand. First, population has grown from 140.000 (1998) to 220.000 (2020) (around 2,5% annually). Besides resident population, tourism (secondary residences, hotels, etc.) increases urban demand pressure. The second driving force is the search for agricultural profitability as the low income obtained from traditional cultivation of rainfed pasture and herbaceous forces farmers to look for alternatives. Thus, the irrigated area in the region has increased from 5.200 ha (1999) to 13.300 ha (2021). Most of this growth is due to avocado and mango, which account for 9.500 ha (71% of irrigated area).

1.2 Pressures

Urban demand of water in the area is very high compared to Spanish standards, with inhabitants consuming 322 L/person·day, i.e., 2,5 times the Spanish average (132 L/person·day). Part of this excessive consumption is due to huge losses in the water distribution networks (40%) and part is due to seasonal tourism.

The most important pressure in quantitative terms is water for irrigation, which has grown from 34 hm^3 (1999) to 97 hm^3 (2021), according to our estimations based on standard irrigation doses and the crop cultivated area, which implies supplying crops below maximum need. This estimate is lower than the 111 hm^3 resulting from the application of FAO's irrigation water needs formula (FAO assumes maximum yield and related irrigation needs). Furthermore, the estimated irrigation water use of 97 hm^3 is higher than the 78 hm^3 of irrigation water rights established in the region's hydrological plan indicating a water supply that forces deficit irrigation practices similar to neighboring Guadalquivir River (

1.3 Status

Following a typical closure trajectory, public response to scarcity in the 80's was the construction of the "La Viñuela" dam (capacity160 hm^3) coming into operation in 1998. However, the high demand combined with a long drought (2018-present) has produced a water crisis in the region. Figure 1 shows the estimated abstraction from different sources and the piezometric level in the aquifer.

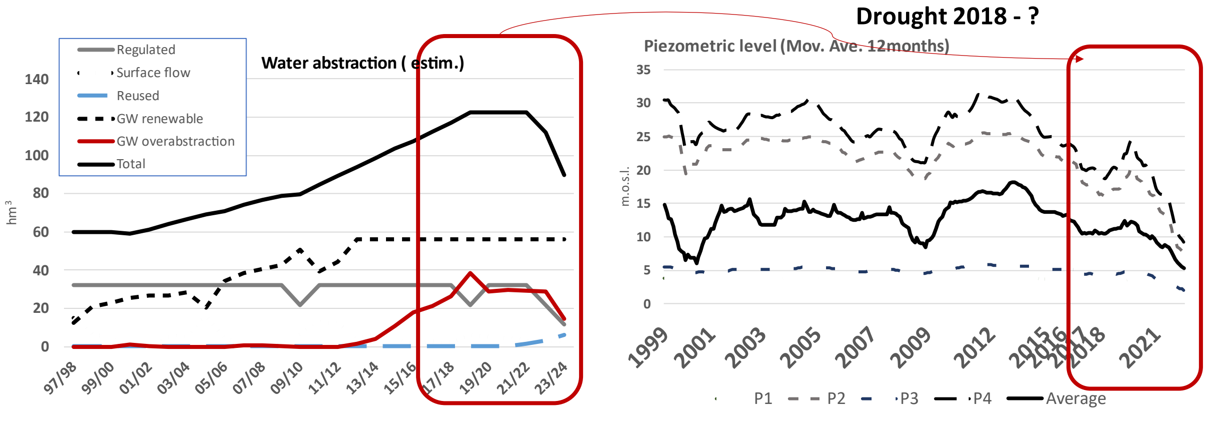

Fig. 1. Estimated water abstraction (1996-2023) and piezometric level in the Velez-Malaga aquifer.

1.4 Impact

The current conditions have led the "La Viñuela" reservoir with 7% of its capacity (Jan 2024) and water authority has reduced urban water supply and limited irrigation. The lack of surface water has driven farmers to resort to both legal and illegal groundwater abstraction, and the piezometric levels (Fig. 1 right) show the existence of high abstraction rate, with the risk of seawater intrusion and subsequent impact in groundwater dependent ecosystems. Farmers have seen trees die and are resorting to 'radical pruning' (leaving almost no leaves in the tree) or even to uprooting. Regional mango and avocado yields in 2023 decreased to 20-30% of annual average, while other crops such as olive trees adapt better to deficit irrigation (Expósito et al., 2016).

1.5 Responses

Private sector response to crisis has involved reducing water supply to crops and even eliminating subtropical crops area. Some projects are now in place to implement precision irrigation and reduce water use. Public response has included the investment in urban wastewater reclamation plants, with around 20 hm^3 of reclaimed water entering the system from the Axarquía municipalities including reclaimed wastewater from Malaga city (neighbor basin). In addition, the construction of a desalination plant has recently been approved.

2. Conclusions and future actions

The process of water closure in Axarquia region shows a typical 'closure' trajectory where increased supply has not been able to meet growing demand. This scenario is due to a combination of population growth and a three-fold increase of the area cultivated with water-intensive subtropical crops, which is leading to groundwater overexploitation. The public-private response of increasing non-conventional water supply (currently through reclaimed wastewater, and a desalination plant coming soon) will not solve the problem unless demand control and proper governance schemes are implemented. DPSIR framework is a useful tool to understand the dynamic of socio-hydrological systems and attempt to adequate public and private responses to avoid perverse effect that eliminate in the long term the gains obtained at short term. To support the transition to a scenario of sustainable governance in the region. Additionally, our team is developing hydro-economic models, building a database, and conducting analyses of wastewater reclamation costs, we hope that this improves long term sustainability and governance in the region.

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