NR 202 - Assignment #2 - Analysis and proposed solution to the Guadalupe Valley and Ensenada Water Availability problem - Final Synthesis Assignment

ANGELA RUNNELS
6/10/2025
UID: 934640980

Summary
The Guadalupe Valley and the city of Ensenada, Baja California, are facing a growing water scarcity crisis due to chronic over-extraction of groundwater, limited surface water availability, and weak institutional oversight. The region relies heavily on a single, overdrawn aquifer system that is recharged slowly and unevenly, with rising salinity levels indicating seawater intrusion in some areas (TNC, 2013; Rev. TyCA, 2021). Agricultural activities—particularly the booming wine industry—consume the largest share of water, while Ensenada's urban population continues to grow, increasing pressure on already limited supplies (SDSU, 2024; UC Davis Water Management, 2020).

This crisis is driven by a complex combination of physical and social factors. Precipitation in the region is highly variable and trending downward, resulting in lower aquifer recharge rates and increased reliance on extraction during drought years (Nature, 2024; Rivas et al., 2020). Regulatory institutions like CONAGUA have high-level authority but limited local enforcement capacity, while CESPE struggles with outdated infrastructure and insufficient funding (TNC, 2013; García-Santos et al., 2023). Inadequate monitoring, unclear water rights, and economic resistance to change from powerful stakeholders further exacerbate the issue. Without coordinated, science-based management, the Guadalupe Valley risks long-term aquifer depletion, economic decline, and conflict among users.

Stakeholder Summaries (Power / Interest / Impact)

1. **Baja California State Government**
   Holds high power and strong interest due to its authority over regional water policy, directly shaping infrastructure investment and allocation (The Nature Conservancy [TNC], 2013; UC Davis Water Management, 2020; Revista TyCA, 2021).
2. **CESPE (Municipal Water Authority)**
   Has moderate to high power and high interest as the agency responsible for delivering water to Ensenada, directly affected by infrastructure limitations and urban demand (TNC, 2013; UC Davis Water Management, 2020; SDSU, 2024).
3. **Vineyard Owners / Wine Industry**
   Wield high economic power and very high interest due to their dependence on water for irrigation, significantly impacting groundwater extraction (SDSU, 2024; García-Santos et al., 2023; TNC, 2013).

4. **CONAGUA (National Water Commission)**
   Possesses high regulatory power but lower local interest, influencing water policy implementation and oversight from a federal level (TNC, 2013; Revista TyCA, 2021).
5. **Desalination Plant Operators / Private Contractors**
   Hold moderate power through infrastructure solutions and moderate interest driven by contracts, potentially expanding water availability but driven by profit (UC Davis Water Management, 2020; Rivas et al., 2020).
6. **Urban Residents of Ensenada**
   Have low power but high interest as daily water users, heavily impacted by shortages but with limited decision-making influence (SDSU, 2024; TNC, 2013).
7. **Farmworkers / Agricultural Laborers**
   Exert little power but have high interest due to their reliance on agricultural water access for employment and vulnerability to pollution (SDSU, 2024; Revista TyCA, 2021).
8. **Environmental NGOs (e.g., The Nature Conservancy)**
   Have low formal power but strong interest and moderate impact through advocacy, education, and policy pressure for sustainable water use (TNC, 2013; García-Santos et al., 2023).
9. **Academic Institutions (e.g., UC Davis, SDSU)**
   Hold low power but high interest, influencing decisions indirectly by producing critical research and sustainability recommendations (UC Davis Water Management, 2020; SDSU, 2024; García-Santos et al., 2023).
10. **Indigenous Communities (e.g., Kumeyaay)**
    Have very low formal power but very high interest and cultural connection, offering ecological knowledge yet often excluded from decision-making (Revista TyCA, 2021; TNC, 2013).
11. **Real Estate Developers**
    Hold moderate economic power with low direct interest in sustainability, but contribute to long-term demand and infrastructure strain through land development (UC Davis Water Management, 2020; Revista TyCA, 2021).

Image 1: Stakeholder Power-Interest Chart

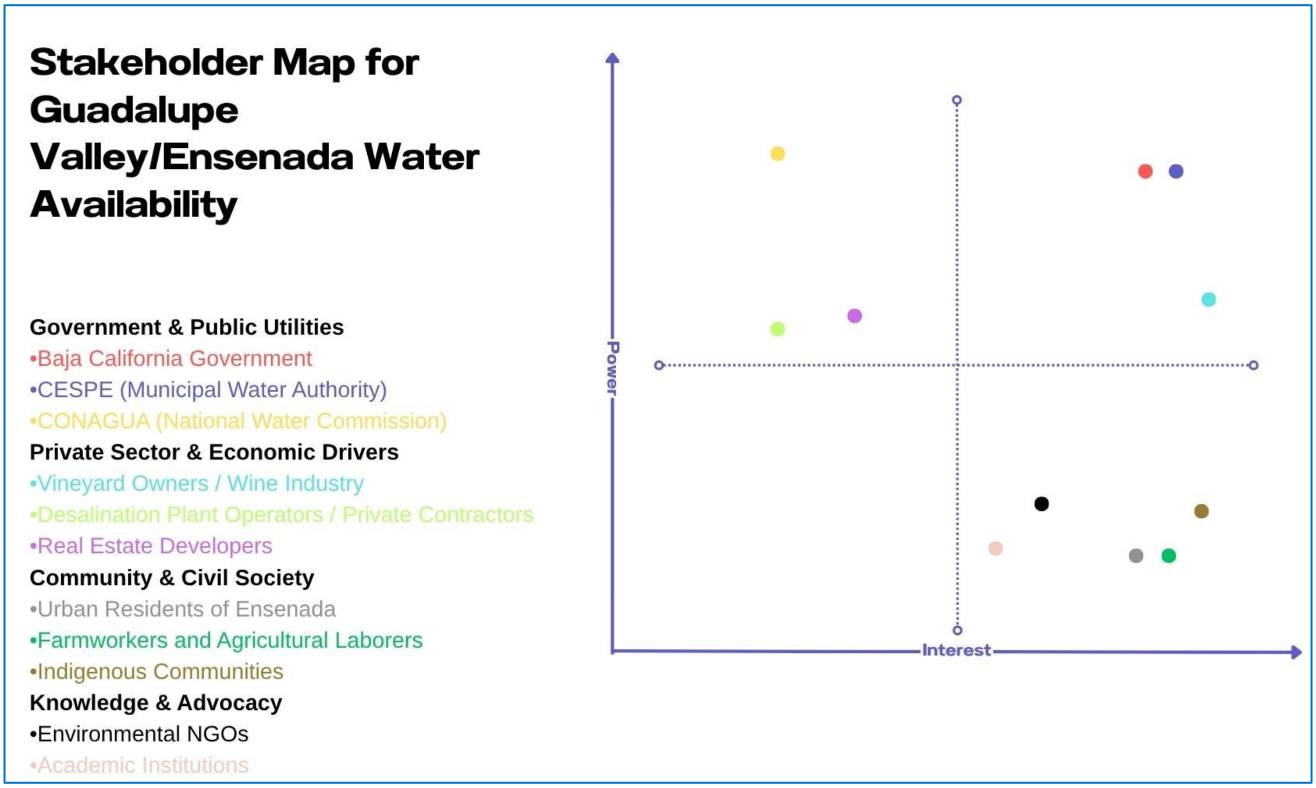


Image 2: Summary of Biophysical and Socio-Political factors

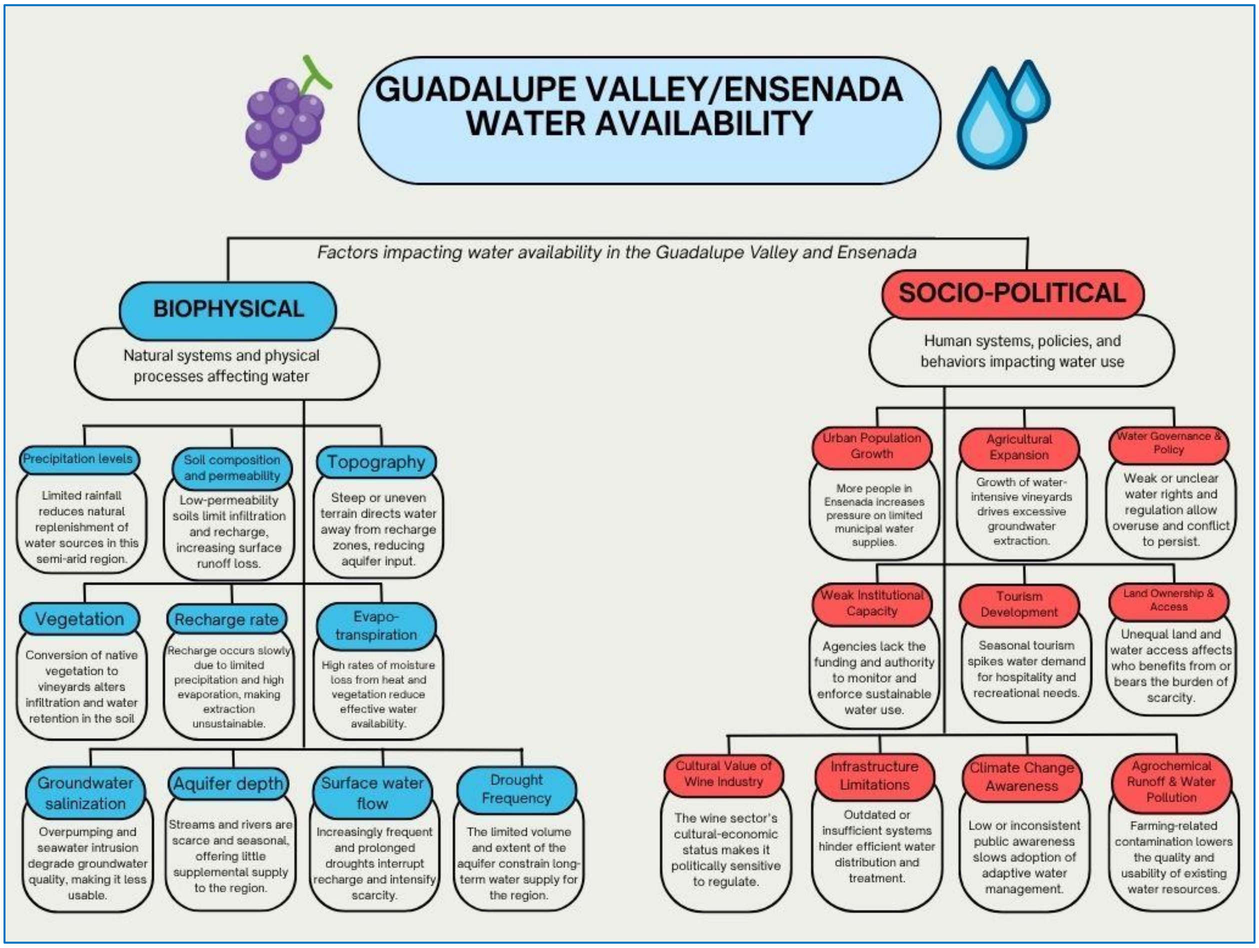
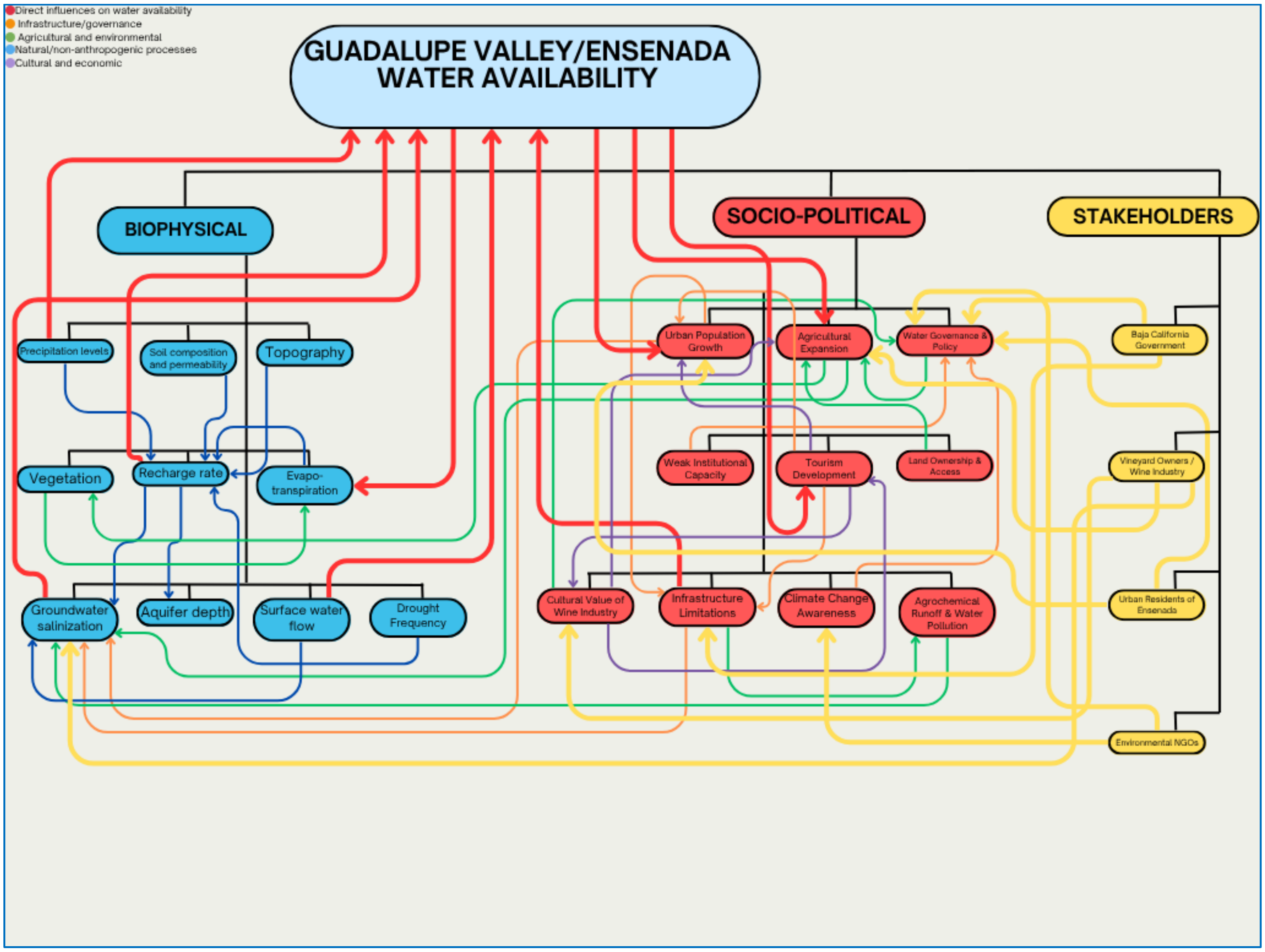


Image 3: Processes/Factors/Connections Process Map with Four Stakeholders Included



Policy Solution

A viable policy solution for the Guadalupe Valley is to implement a Managed Aquifer Recharge (MAR) program using treated wastewater, tailored to the valley's hydrogeologic characteristics. This approach is supported by geochemical tracer research and recharge mapping that identifies high-potential zones for aquifer replenishment (García-Santos et al., 2023). The program would integrate legal water accounting, seasonal extraction caps, and economic incentives to support user compliance and long-term groundwater sustainability (Revista TyCA, 2021; UC Davis Water Management, 2020).

Engineering Solution

An engineering complement to the MAR policy would be the construction of decentralized treatment and injection wells located near key recharge areas. These systems would utilize tertiary-treated municipal wastewater from Ensenada or surrounding communities and direct it into upland alluvial aquifers—some of which have demonstrated up to 20 m rises in groundwater levels following focused recharge events (García-Santos et al., 2023). This distributed system would help address both water scarcity and aquifer degradation while improving infrastructure resilience.

Chosen Focal Solution: Managed Aquifer Recharge with Treated Wastewater

This solution directly engages the Aquifer Recharge Rate, Infrastructure Limitations, and Water Governance & Policy nodes on the concept map. It serves as a biophysical intervention with a socio-political dimension, bridging engineering infrastructure with participatory management. Compared to high-cost alternatives like seawater desalination—which require intensive energy use and produce brine waste—MAR is more cost-effective, energy-efficient, and adaptable to local infrastructure (UC Davis Water Management, 2020; Rivas et al., 2020).

Trade-offs

Trade-off 1: Immediate Recharge vs. Infrastructure Investment

- **1a) Benefit:** Aquifer storage can increase rapidly—up to 20 m—in targeted recharge zones, delivering relief to overdrawn groundwater systems (García-Santos et al., 2023).
- **1b) Drawback:** Requires substantial investment in treatment facilities, injection infrastructure, and long-term operations and maintenance (TNC, 2013).

Trade-off 2: Local Water Security vs. Regulatory Oversight

- **2a) Benefit:** Empowers local actors like CESPE to manage recharge systems, reducing dependency on external sources (SDSU, 2024).
- **2b) Drawback:** Without robust oversight and monitoring, mismanagement or inequitable access could reduce system effectiveness (Revista TyCA, 2021).

Possible Next Steps

- **Map and prioritize recharge zones** using geochemical tracer data and GIS (García-Santos et al., 2023).
- **Pilot small-scale MAR projects**, expanding based on results and community acceptance (UC Davis Water Management, 2020).
- **Enact legal frameworks** linking treated wastewater reuse to well permits and extraction rights.
- **Engage local stakeholders** (residents, vineyard owners, CESPE, and Indigenous groups) in system design and monitoring to ensure equity, transparency, and success (TNC, 2013; Revista TyCA, 2021).

References

García-Santos, I., López-López, M., & Patiño, A. (2023). Water resource use in semi-arid regions: Impacts and management strategies. *Water, 11*(2), Article 16. https://www.mdpi.com/2306-5338/11/2/16

Revista Tecnología y Ciencias del Agua. (2021). Groundwater governance challenges in Baja California: A case study of the Guadalupe Valley. *Tecnología y Ciencias del Agua*. https://www.revistatyca.org.mx/index.php/tyca/article/view/1592/2777

San Diego State University. (2024, November). *Student research examines water scarcity's impact among Mexico's wine producers*. https://www.sdsu.edu/news/2024/11/student-research-examines-water-scarcitys-impact-among-mexicos-wine-producers

Rivas, D., Pérez, G., & Ortega, L. (2020). Aquifer vulnerability in coastal regions under climate stress. *Science of the Total Environment, 712*, 135678. https://doi.org/10.1016/j.scitotenv.2020.135678

The Nature Conservancy. (2013). *Water sustainability in the Guadalupe Valley: A framework for collaboration and conservation*. https://watershed.ucdavis.edu/sites/g/files/dgvnsk8531/files/products/2021-11/TNC%20Report%2021%20June%202013%20FINAL%20VERSION.pdf

UC Davis Water Management. (2020). *Integrated water strategies for Baja California: Challenges and opportunities*. https://watermanagement.ucdavis.edu/download_file/view_inline/516