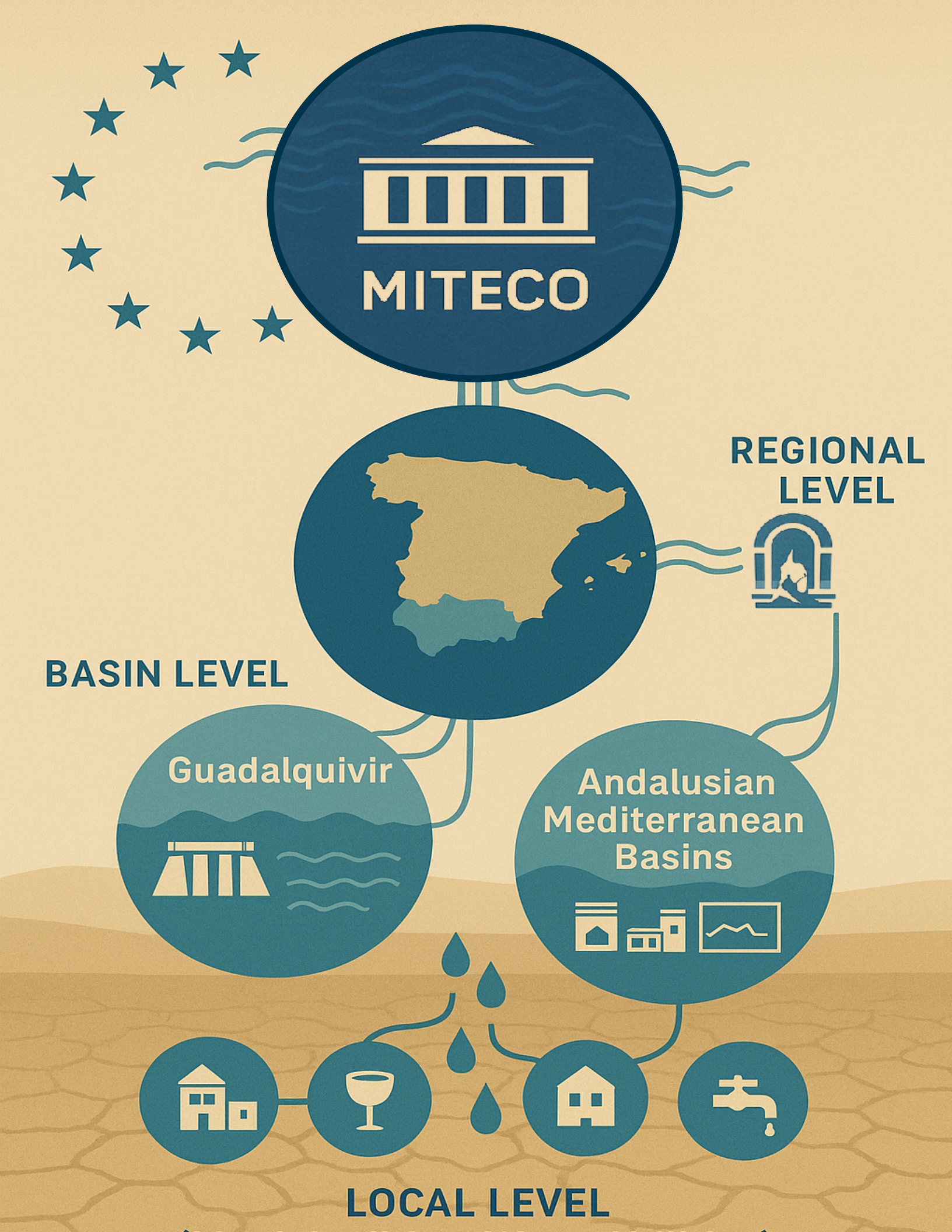
MITECO
REGIONAL LEVEL
BASIN LEVEL
Guadalquivir
Andalusian Mediterranean Basins
LOCAL LEVEL

UNDER A MAGNIFYING GLASS: THE GOVERNANCE RESPONSE TO INCREASING DROUGHT RISK IN SPAIN, ANDALUSIA, AND MÁLAGA.

A Case Study in the Andalusian Mediterranean River Basins

EXECUTIVE SUMMARY. This report addresses a critical question: Why has water governance in Spain failed to adapt despite decades of scientific knowledge about escalating drought risk? Focusing on Andalusia and Málaga province as a case study, the analysis reveals that the challenge is not primarily one of information or technical capacity, but of political economy and institutional inertia. Using a Nested Socio-Ecological Governance (NSEG) framework, the report conceptualizes the crisis as a fundamental misalignment between a rapidly changing biophysical reality (the Resource System) and the human systems of governance and resource use contained within it. The core finding is that well-designed plans exist, but powerful stabilizing forces – economic incentives, institutional path dependency, and scalar mismatches – systematically prevent their implementation.

The report finds that while Spain has developed a sophisticated formal framework for proactive drought management since the pivotal 1991-1995 drought, most notably the Special Drought Plans (PES), its effectiveness is severely undermined by a series of deep-rooted structural failures. At the core of the crisis is a profound misalignment between the human systems of governance and the biophysical system they inhabit. The inner rings of this system, the actors, their political arena, and the governance rules, continue to operate based on outdated assumptions of water availability, failing to adapt to the outer ring: a biophysical reality increasingly defined by permanent aridification.

This misalignment manifests as a persistent implementation gap, where well-designed plans are not fully enacted due to a lack of political will, the disproportionate influence of powerful economic lobbies (agriculture and tourism), and the insufficient funding and capacity of regulatory bodies. It is amplified by significant policy incoherence, particularly between the EU's Water Framework Directive (WFD), which calls for sustainable water use, and the Common Agricultural Policy (CAP), whose subsidy structures can inadvertently incentivize water-intensive agriculture, creating contradictory signals for water users.

Furthermore, the analysis reveals that the historical legacy of concentrated land ownership (*latifundios*) in Andalusia, amplified by modern policy drivers, concentrates both land

and water resources. This entrenches an agricultural model often at odds with the region's diminishing water availability and marginalizes smaller farms, creating significant social inequity.

The report details the escalating biophysical challenge, synthesizing scientific projections that point towards a future of increasing aridification, with more frequent, severe, and prolonged droughts that will further stress the region's finite water resources. It maps the complex web of actors at the national, regional, basin, and local levels, analyzing their competing interests and divergent perceptions of risk, which fuel ongoing social and environmental conflicts over water allocation within a constrained "action arena".

Key recommendations focus on realigning the nested systems by moving beyond reactive crisis management towards a truly transformative governance model. This includes strengthening proactive governance by closing the implementation gap; prioritizing comprehensive demand management through effective economic instruments and legal reforms; rigorously integrating climate projections into all planning to force the inner human rings to adapt to the outer biophysical ring; enhancing ecosystem resilience; and facilitating a long-term adaptation of the region's economic model to a future of structural water scarcity.

The report concludes that achieving long-term water security in Andalusia requires not only technological solutions but also the sustained political will to address these deep-seated institutional and structural failures and fundamentally realign the region's socio-economic aspirations with its environmental reality.

Key words: *Drought Risk Management, Water Governance, Spain, Andalusia, Málaga, Climate Change Adaptation, Aridification, Special Drought Plans (PES), Water Scarcity, Multi-Level Governance, Socio-Ecological Systems, Institutional Analysis, Water Allocation Conflict, Demand Management, Document Analysis.*

Table of Contents

Table of Figures

Table of Tables

Part 1 – The Foundation Context and Framework

This first part of the report establishes the analytical and empirical foundation for the subsequent analysis. Chapter 1 introduces the core problem of water stress in Andalusia, outlining the report's central analytical themes. Chapter 2 details the nested Socio-Ecological Governance (NSEG) framework, which conceptualizes the problem as a hierarchy of constraints and provides the theoretical backbone for the entire report. Chapter 3 is dedicated to a comprehensive examination of the outermost ring of this framework – the Resource System itself – detailing the biophysical reality of drought, its historical occurrence, and the scientifically projected trends of future intensification and aridification.

Chapter 1 – Introduction

1.1. The Challenge: Water Stress in a Climate Change Hotspot

Andalusia, occupying the southernmost extent of the Iberian Peninsula, represents a critical European region facing escalating water resource challenges. Its geographical location within the Mediterranean basin places it squarely within a recognized global climate change hotspot, signifying heightened sensitivity to climatic shifts (Ali et al., 2022; Bednar-Friedl et al., 2022). The region's inherent climatic profile, which is strongly influenced by large-scale atmospheric patterns that control rainfall delivery to the peninsula (Nieto et al., 2021), is characterized by pronounced seasonality with hot, arid summers and mild, comparatively wet winters, rendering it naturally susceptible to drought phenomena. This innate vulnerability, which has historically shaped landscapes and societies, is undergoing significant amplification due to the accelerating effects of anthropogenic climate change (Bednar-Friedl et al., 2022). Observable trends and robust climate projections point towards substantial future warming exceeding global averages, coupled with marked reductions in average annual precipitation and significant alterations towards more erratic, extreme rainfall events. These converging climatic trends strongly indicate a fundamental trajectory towards aridification, projecting a marked increase in the frequency, duration, and severity of meteorological, hydrological, and agricultural droughts (MedECC, 2024).

Compounding these climatic pressures is a substantial and historically growing demand for water resources. Andalusia's extensive agricultural sector is the dominant consumer, accounting for approximately 81% of total regional water use, significantly exceeding urban and industrial needs (MAPA, 2023). This demand is driven by the need to sustain vast areas of irrigated land, including traditional crops and, increasingly, water-intensive subtropical fruits like avocados and mangos, particularly in coastal provinces like Málaga (Alvarez et al., 2024; Hervás-Gámez & Delgado-Ramos, 2019). Furthermore, considerable pressure arises from a globally significant tourism industry, which serves as a primary pillar of the regional economy, concentrated primarily along coastal zones such as Málaga's Costa del Sol, which exhibits high seasonal and per capita water demands (Cardenete et al., 2024; Florido-Benítez, 2024). The domestic requirements of a substantial resident population add further strain. This confluence of increasing climatic susceptibility and high, often competing, water demands creates a precarious and increasingly stressed water balance across Andalusia, making effective water governance paramount.

1.2. Thematic Focus: Policy Incoherence, Institutional Inertia, and Social Equity

The evolution of water governance in Spain, particularly since the pivotal 1991-1995 drought, reflects a formal attempt to address this growing crisis. The shift away from a purely reactive, supply-sided 'hydraulic paradigm' (Sánchez, 2007) towards a proactive, risk-based management approach, codified in national law (Jefatura del Estado, 2001a), represents significant progress in planning. However, the outcomes on the ground reveal a system struggling with deep-seated structural challenges. This report will argue that the effectiveness of the governance response is fundamentally constrained by three interconnected themes. First, significant **Policy Incoherence**, most notably between the European Union's water and agricultural policies, creates contradictory incentives that undermine sustainability goals. Second, **Institutional Inertia** within the multi-level governance system, coupled with a persistent gap between planning and implementation, hinders the timely and effective application of necessary measures. Third, issues of **Social Equity**, rooted in historical patterns of land and water distribution, continue to shape modern conflicts and influence whose interests are prioritized in water allocation decisions, creating differentiated vulnerabilities to drought across society. Analyzing the governance response through these thematic lenses is essential to understanding the root causes of its failures and identifying pathways toward a more resilient and equitable future.

Chapter 2 – The Guiding Analytical Framework: A Nested Socio-Ecological Approach

To To systematically analyze complex environmental challenges like water governance, a robust analytical framework is required. The challenge in Andalusia is not simply one of resource management, but of the interaction between a dynamic natural system and the multi-level human systems that depend on it. This report therefore develops and applies a **Nested Socio-Ecological Governance (NSEG) framework**. This model is a deliberate fusion of two seminal theories from Elinor Ostrom's school of thought: the Socio-Ecological Systems (SES) framework and the Institutional Analysis and Development (IAD) framework.

The SES framework is a diagnostic tool designed to map the essential components of a situation where humans and nature are intertwined. Its primary strength is its holistic structure, forcing an analysis that explicitly connects the changing natural world (the Resource System) with the human

world (the Governance System and Actors). However, while brilliant for mapping components, the SES framework is less explicit about analyzing the dynamics of power, conflict, and decision-making.

The IAD framework, its intellectual predecessor, excels precisely where the SES is less focused. It provides a detailed playbook for analyzing the decision-making process itself, zooming in on how and why actors make choices within an "Action Arena" shaped by rules and biophysical conditions. Its limitation, however, is that it can sometimes treat the "Biophysical Conditions" as a relatively static backdrop. In a case of escalating aridification, the biophysical system is not a backdrop; it is a dynamic, rapidly changing protagonist.

The NSEG framework was developed to harness the strengths of both while overcoming their individual limitations. It uses the component-mapping of the SES framework but embeds it within the process-oriented core of the IAD framework. Most importantly, it applies a nested structure to these components. This is a critical theoretical choice. A nested hierarchy visually and analytically establishes that the human systems are not merely interacting with the environment; they are contained within it. This structure posits that the biophysical realities of the Resource System impose the ultimate, non-negotiable constraints on the human systems of governance and action that operate within it. This is essential for analyzing a problem like aridification, where the fundamental "container" is shrinking.

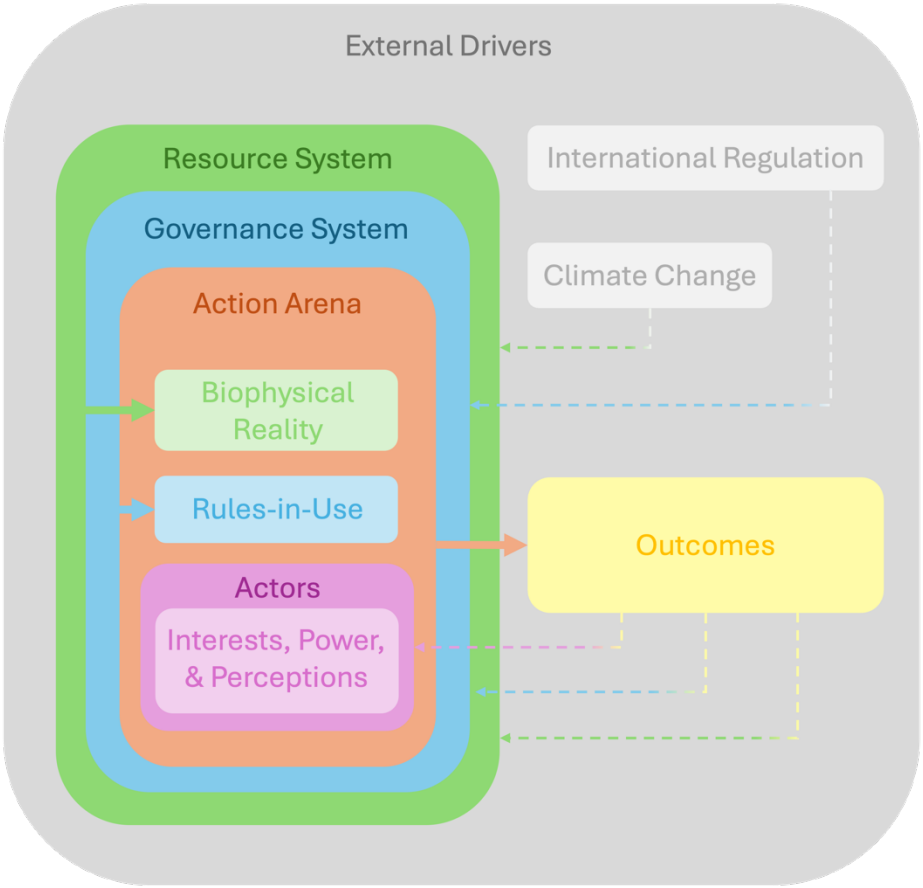

Figure 1. The NSEG Framework

Figure 1 visualizes this nested framework. It is structured as follows:

- **The Resource System (RS):** The outermost ring, representing the biophysical container. It encompasses the climate, hydrology, and ecosystems that establish the physical boundaries within which the human system must operate.
- **The Governance System (GS):** The second ring, comprising the formal and informal rules, laws, and policies designed to manage the resource. This includes the multi-level web of institutions that structure human interaction.
- **The Action Arena:** The third ring, representing the dynamic social space where governance happens in practice. It is here that actors interact, conflicts are mediated, and resources are allocated based on both the formal Rules-in-Use (provided by the Governance System) and the immediate Biophysical Reality (imposed by the Resource System).

- **The Actors (A):** At the core are the human actors – individuals and groups with diverse Interests, Power, & Perceptions – whose choices and strategies are the ultimate drivers of outcomes.

The framework's utility lies in its ability to model dynamic interactions. As the diagram shows, the nested system is influenced by **External Drivers**. These can include large-scale biophysical shifts like **Climate Change**, which acts upon the Resource System, or broader institutional pressures like **International Regulation**, which can influence the Governance System.

The interaction between the framework's components generates **Outcomes**. As the diagram's arrows indicate, these outcomes are not an endpoint. They create **feedback loops** that influence the original system. Depending on the nature of the outcomes, these feedback loops can reinforce existing conditions or lead to change, for example by altering the state of the Resource System or shifting the perceptions and strategies of the Actors.

This NSEG framework is superior for this report because it moves beyond a simple inventory of factors. Its nested structure provides a clear analytical lens to diagnose misalignments between the rings – for instance, when the "Rules-in-Use" are no longer adapted to the "Biophysical Reality." By explicitly modeling constraints, external pressures, and feedback loops, it provides a comprehensive and dynamic tool to understand not just what is failing in Andalusian water governance, but why.

The remainder of this report is structured to systematically utilize this framework. Part 1 will define the outermost Resource System ring. Part 2 will map the inner Governance System and Actor rings. Part 3 will analyze the interactions and outcomes within the Action Arena. Finally, Part 4 will propose recommendations based on the findings of the analysis.

Chapter 3 – The Outermost Ring: A History and Future of Drought in Andalusia's Resource System

This chapter analyzes the outermost ring of the NSEG framework: the **Resource System**. Understanding the biophysical container – its history, its current state, and its projected future – is the foundation for analyzing the governance response to it. We must first define the nature of the

challenge itself, distinguishing between temporary emergencies and a permanent shift in the system's baseline.

3.1. From Temporary Drought to Chronic Aridification

A critical distinction must be made at the outset. A **drought** is traditionally understood as a temporary, cyclical deviation from normal rainfall patterns. It is a multi-faceted hazard that propagates through the environment. It begins as a **meteorological drought**, a simple deficiency of precipitation. This can evolve into an **agricultural drought**, where soil moisture deficits impact crops, and then a **hydrological drought**, marked by falling reservoir and groundwater levels. Finally, it becomes a **socioeconomic drought** when water shortages affect economic goods and human activities (Stahl et al., 2016). The governance tools developed in Spain, such as the Special Drought Plans (PES), are fundamentally designed to manage these temporary emergencies.

However, the scientific evidence points towards **aridification**: a permanent, structural shift to a drier baseline climate, driven by anthropogenic warming. This process of "global-warming-induced aridification" is not just about less rain; it is critically driven by rising temperatures and the resulting increase in atmospheric evaporative demand, which pulls more moisture from the land and water bodies (Vicente-Serrano et al., 2020). This represents a transition from managing a temporary hazard to confronting a chronic condition of **structural water scarcity**, where long-term average water demand consistently outstrips sustainable supply. A central argument of this report is that many of the governance failures stem from applying tools designed for temporary droughts to this emerging chronic condition – a fundamental mismatch between the problem as perceived by the governance system and the reality of the resource system.

3.2. Historical Drought Analysis in Andalusia and Málaga (Post-1995)

The history of recent droughts provides the context for the current governance approach and illustrates the escalating pressure on the Resource System.

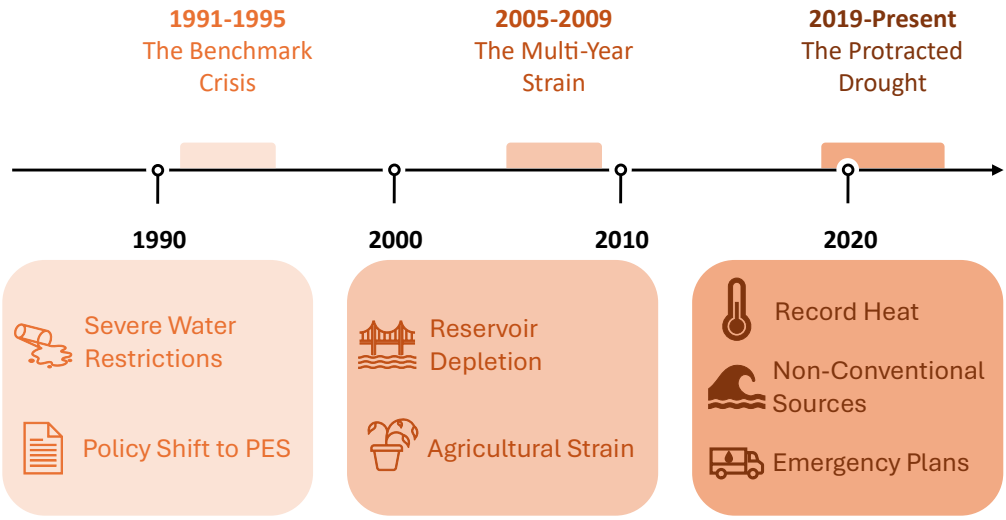

Figure 2. A visual timeline of major drought periods in Andalusia from 1995 to the present, highlighting key impacts for each event.

The 1991-1995 Benchmark Drought: This remains the most severe and prolonged drought in recent Spanish history, serving as a critical reference point. National reservoir storage fell to approximately 15% of capacity. Meteorological indices like SPEI showed intense drought in Málaga during the mid-90s, and reservoirs in the Guadalhorce system supplying the city reached unprecedented low levels (Márquez-García et al., 2024). Nationally, the reduction in farm income was estimated at €1.8 billion, with significant losses in hydroelectric production (Tsiakiris et al., 2024). Over 10 million people faced supply cuts. In Andalusia, impacts were particularly acute: Málaga capital endured significant, highly disruptive water supply cuts, while Seville faced extreme restrictions (water available only 8 hours/day), prompting consideration of evacuation plans (EMASESA, 2025). Ecologically, it led to an increased risk of large wildfires due to vegetation stress (Ruffault et al., 2013). This benchmark event exposed profound vulnerabilities and was the primary catalyst for shifting from reactive crisis management to proactive planning (Albiac et al., 2014).

The 2005-2009 Drought: This multi-year event re-tested the new planning frameworks. Extensive impacts were felt across Spain and Andalusia. By 2005, concerns were high regarding declining levels in key reservoirs like La Viñuela in Málaga's Axarquía region. Nationally, it contributed to reduced EU cereal yields and a significant decrease in hydroelectric production (Vélez-Nicolás et al., 2022). In Andalusia/Málaga, irrigation capacity was limited, reducing agricultural yields and

straining water-intensive industries. Málaga city activated its municipal emergency plan from 2005 to 2008. Ecologically, it contributed to ongoing drying trends and reservoir depletion; the complete drying of Las Tablas de Daimiel National Park was reported during this period. Governance responses included continued emphasis on PES implementation and the enactment by the Junta de Andalucía of specific Drought Decrees imposing restrictions on Málaga municipalities.

The 2019-Present Long-Duration Drought: This ongoing period marks a particularly concerning protracted drought phase, characterized by an accumulating rainfall deficit and unprecedentedly warm and dry years. The 2022-2023 agricultural year was recorded as the warmest and driest on record for Andalusia. By May 2023, reserves in the critical Guadalquivir basin had fallen to just 24.5% of capacity (Gobierno de España, 2023b). Standardized indices confirmed extreme drought in Málaga province (Márquez-García et al., 2024). Socioeconomic impacts were severe: significant agricultural losses were reported by farming organizations (COAG, 2023), and widespread urban restrictions were implemented in Málaga province. This event's longevity and intensity, which attribution studies link directly to anthropogenic warming (Vicente-Serrano et al., 2021), provide compelling real-world evidence of the shift towards aridification.

3.3. Future Projections: An Era of Intensification and Aridification

The scientific consensus is unequivocal: the Resource System is undergoing a fundamental transformation. This is not a cycle; it is a regime shift.

Temperature and Evapotranspiration: Robust projections show that **temperature** increases in Spain are set to exceed the global average, with a potential rise of roughly 2.7°C by mid-century compared to the 1971-2000 baseline (González-Pérez et al., 2024). Higher temperatures directly increase Potential Evapotranspiration (PET), which acts like a straw, pulling more moisture from soils, plants, and reservoirs. This means that warming alone accelerates the onset and severity of hydrological drought even without changes in rainfall (Tramblay et al., 2019).

Precipitation: A general decrease in average annual **precipitation** is widely anticipated, with projections for Andalusia suggesting declines of 18% to 38% over the 21st century. Compounding this, rainfall is expected to become more erratic, occurring in intense, short bursts that are less effective for recharge and are separated by longer dry spells.

Impact on Water Resources: The combined effects will be catastrophic for water availability.

Surface Water: Average annual river flows (runoff) are projected to decline markedly, with southern regions like Andalusia potentially experiencing reductions of 30-40% or more by end-century (Lazoglou et al., 2024). This directly reduces inflows to reservoirs, while higher temperatures will simultaneously increase evaporative losses from their surfaces, fundamentally decreasing the reliability of surface water systems.

Groundwater: Natural aquifer recharge is expected to decrease substantially, mirroring the decline in runoff, with some projections for Southern Europe indicating decreases of over 30% by the end of the century under high-emission scenarios (Feyen et al., 2020). This is occurring while many Andalusian aquifers are already suffering from intense overexploitation, causing alarming declines in water levels and risking irreversible saltwater intrusion in coastal areas (Márquez-García et al., 2024). Climate change creates a vicious cycle: reduced surface water increases reliance on groundwater during droughts, while simultaneously diminishing the rain needed to replenish these vital reserves. This unsustainable trajectory poses severe risks of further depletion, quality degradation, and potential land subsidence (García et al., 2024).

This evidence confirms that the outer ring of the NSEG framework – the Resource System – is shrinking and becoming more fragile. The governance challenge is no longer about managing cyclical scarcity, but about adapting the entire socio-economic system to a permanent state of increased aridity.

Part 2 – The Inner Rings: Governance Systems and Actors

Having defined the biophysical container set by the outer ring in Part 1, this section moves inward to map the human systems nested within it: the Governance System (GS) and the Actors (A) who operate at the system's core. These chapters dissect the complex, multi-level institutional landscape in Spain, from foundational principles to the specific roles and interests of actors at the national, regional, basin, and local levels, populating the inner rings of the NSEG framework.

Chapter 4 – The Multi-Level Governance Landscape in Spain

4.1. Foundational Principles and Concepts in Spanish Water Governance

Several core principles and concepts underpin Spain's approach to water and drought governance. The tradition of **Integrated River Basin Management (IRBM)** uses the river basin as the fundamental unit for management, a principle enshrined in the Water Law and reinforced by the EU Water Framework Directive (WFD). The **public domain principle**, established by the 1985 Water Law, declared water resources public property, shifting from previous private ownership and establishing a system of administrative concessions for water use rights (Moreno-Ortega, 2019). **Hydrological planning** is a cornerstone, involving mandatory, cyclical River Basin Management Plans (RBMPs or *Planes Hidrológicos*) that assess resources, set environmental objectives including ecological flows, and define measures for sustainable management.

Public participation is formally emphasized, with historical roles for user communities like **Irrigation Communities** (*Comunidades de Regantes*) (Sanchis-Ibor et al., 2022) and WFD mandates for stakeholder involvement through bodies like River Basin Councils. However, the effectiveness and equity of participation are often debated, with critics arguing that formal processes have not overcome the traditional dominance of established interests and that public input often has limited influence on final decisions (Schütze, 2025). Policy has evolved towards embracing a **drought risk management cycle**, moving beyond reactive crisis response to include risk assessment, prevention/mitigation, preparedness (PES, PEM development), response during events, and recovery/learning afterwards (Albiac et al., 2014). The **EU WFD** has been a major driver of reform, mandating the achievement of "good status" for water bodies and promoting cost recovery principles, significantly shaping planning processes and environmental objectives (European Parliament, 2000; Vargas, 2013).

4.2. The Multi-Level Structure and Key Actors

Spain's water governance is distinctly multi-level, creating a complex web of authority and interaction.

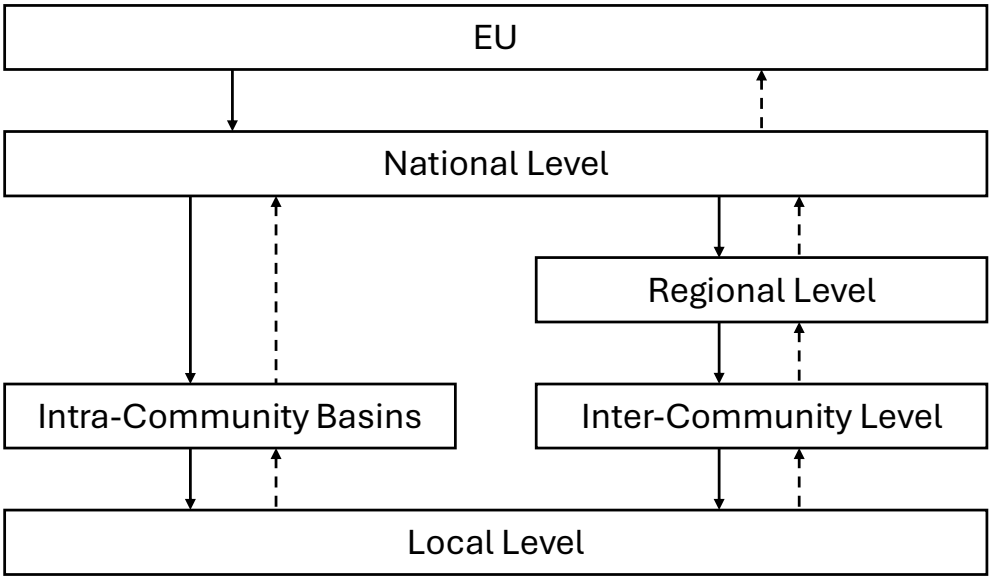

Figure 3. A diagram visualizing the multi-level water governance structure in Spain and Andalusia, showing the relationships between the EU, MITECO, the Junta de Andalucía, the CHG, the CMA, and local actors like municipalities and water utilities.

The European Union Level sets overarching directives like the WFD. The National (State) Level, led by the Ministry for the Ecological Transition and the Demographic Challenge (MITECO), establishes the primary legal framework and oversees inter-community basins. The Regional (Autonomous Community) Level, represented by the Junta de Andalucía, holds significant competencies, particularly for intra-community basins. The Basin Level is the operational heart of IRBM, managed by River Basin Authorities (Confederaciones Hidrográficas – CHs) like the CHG for the Guadalquivir, and regional bodies for intra-community basins like the CMA. Finally, the Local (Municipal) Level is responsible for urban water supply, with key actors being the Municipalities (Ayuntamientos) and Water Utilities like EMASA and Acosol.

In this complex system, MITECO sets the national rules and oversees the state-level authorities like the Confederación Hidrográfica del Guadalquivir (CHG). The Junta de Andalucía acts as both a regional government and as a basin authority itself, directly managing the intra-community basins such as the Andalusian Mediterranean Basins (CMA), which are critical for Málaga. At the local level, these basin authorities interact with a diverse set of users, allocating water to and

regulating the powerful Irrigation Communities, and providing bulk water to municipal utilities, creating a chain of command but also potential for conflict and coordination failure.

Chapter 5 – National Governance Response (Spain)

5.1. Key Institutions and Actors

At the national level, the primary responsibility for water policy and drought management lies with the **Ministry for the Ecological Transition and the Demographic Challenge (MITECO)**. Within MITECO, the Directorate General for Water (DGA) plays a central role in policy formulation, budget management, coordination, and overseeing concessions. Strategic decisions require approval from the Council of Ministers and potentially the Spanish Parliament (*Cortes Generales*). State-owned companies like ACUAES and ACUAMED are involved in the planning and construction of significant water infrastructure. Technical expertise is provided by bodies like CEDEX. The **National Water Council** (*Consejo Nacional del Agua*) serves as the top advisory body, facilitating consultation among government levels and stakeholders. National environmental NGOs like WWF and Greenpeace also act as key watchdogs and advocates, influencing policy debates and holding authorities accountable.

5.2. Mandates, Policies, and Strategies

The national government holds exclusive competence over inter-community basins. Its core mandates include formulating overarching national water policy, most notably the **Water Law** (*Ley de Aguas*) (Jefatura del Estado, 2001b). The State is responsible for the National Hydrological Plan (PHN) framework and the legislation that mandated the development of **PES** for all basin districts (Jefatura del Estado, 2001a). The PES framework is the cornerstone of operational drought risk management, establishing the system of indicators, thresholds, and staged measures (Ministerio de Medio Ambiente, 2007). National strategies like the **National Climate Change Adaptation Plan (PNACC)** guide long-term efforts (MITECO, 2020). There is a stated national policy direction towards promoting demand management and non-conventional resources, although critics often point to slow implementation of demand measures (OECD, 2023). During severe droughts, the national government can enact **Emergency Drought Royal Decrees** to expedite funding and infrastructure works (e.g., Gobierno de España, 2023a; 2023b). The international context, particularly water-sharing agreements with Portugal for transboundary rivers

like the Tagus and Guadiana (e.g., the Albufeira Convention), also shapes national policy by placing legal constraints on water management in those basins.

5.3. Interactions, Coordination, and Conflicts

National level governance requires interaction with multiple levels. Vertical coordination occurs with the Autonomous Communities, and MITECO coordinates directly with the CHs it oversees. Horizontal coordination involves engaging with other ministries (e.g. Agriculture, Industry, Tourism) to strive for policy coherence, although achieving this remains a significant challenge (Schütze, 2023). Conflicts at the national level often revolve around major infrastructure decisions, allocation principles between regions (e.g., the historical Tajo-Segura transfer) (Moreno et al., 2022), the balance between environmental protection and economic uses, and the adequacy of funding for different management approaches (Islem et al., 2024). Political polarization between the national government and regional governments can also hinder effective coordination.

Chapter 6 – Regional Governance Response (Junta de Andalucía)

6.1. Key Institutions and Actors

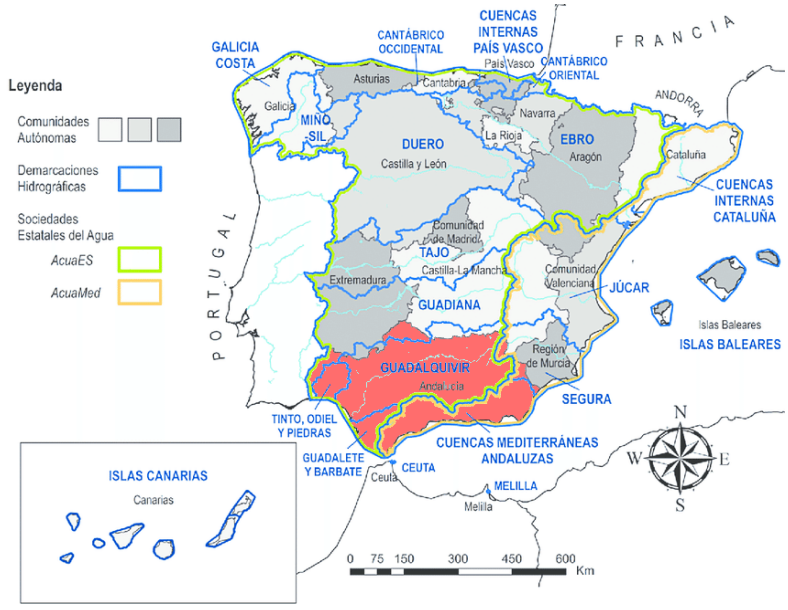

Figure 4. A map highlighting the Autonomous Communities, as well as the river basin districts of Spain. Highlighted in red: The region of Andalucía. [Map: (del Moral & Hernandez-Mora, 2016); Own edit]

The **Junta de Andalucía**, the regional government, is the central institutional actor for water governance within Andalusia (as highlighted in Figure 4). Competencies are largely consolidated under the *Consejería de Agricultura, Pesca, Agua y Desarrollo Rural*. Agencies like the Environment and Water Agency of Andalusia play key execution roles. The Andalusian Parliament approves regional legislation. Regional stakeholder groups, including farmer associations (like COAG), business confederations, and environmental NGOs, actively participate in policy debates. Civil society networks like the **Red Andaluza de la Nueva Cultura del Agua (Red Agua Pública)** play a crucial advocacy role, promoting public, sustainable, and equitable water management.

6.2. Mandates for Intra-Community Basins (CMA)

The Junta has exclusive competence over intra-community river basins, such as the **Andalusian Mediterranean Basins (CMA)**. For these, it assumes roles analogous to the CHs: developing and approving the respective RBMPs and PES, managing water allocations, operating regional water infrastructure, and declaring drought status. It also plays a key role in regional climate change adaptation planning through instruments like the **Andalusian Climate Action Plan (PAAC)** (Junta de Andalucía, 2020). Notably, Andalusia lowered the population threshold requiring PEMs to 10,000 inhabitants for municipalities within its intra-community basins, a more stringent requirement than the national standard of 20,000 (Junta de Andalucía, 2021).

Chapter 7 – Basin-Level Governance Response (CMA)

7.1. Operational Mandates: Developing RBMPs and PES

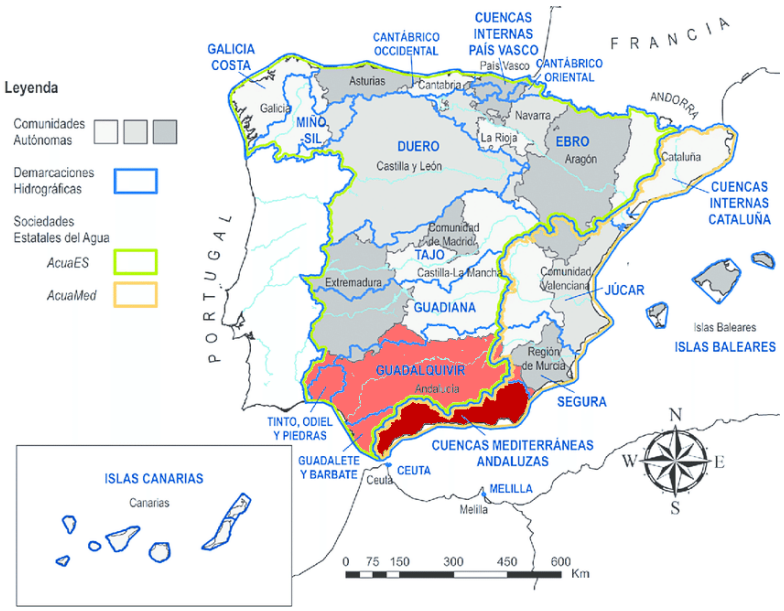

Figure 5. A map highlighting the Autonomous Communities, as well as the river basin districts of Spain. Highlighted in dark red: The Mediterranean Basins. [Map: (del Moral & Hernandez-Mora, 2016); Own edit]

Both the CHG and the Junta (for CMA) hold the primary mandate for integrated water resource management. Their core responsibilities include developing, implementing, and reviewing the **RBMPs** and the **PES**. They manage water allocation via concessions, operate and maintain major public water infrastructure, and monitor hydrological conditions. Ensuring compliance with legally mandated **ecological flows** is another crucial, though often contentious, mandate. They are also responsible for enforcing water regulations, although their capacity to do so effectively is often constrained by budget dependency on the central government and a lack of sufficient resources (Vargas, 2020).

7.2. Decision-Making: Declaring Drought Stages and Triggering Measures

Basin authorities possess significant operational decision-making power. The authority to formally declare drought status (Pre-alert, Alert, Emergency) and trigger corresponding PES measures rests with the competent body within the CHG or the Junta's water agency (Junta de Andalucía, 2024). Decisions on implementing specific PES measures, such as imposing restrictions on water use or

activating emergency resources, fall within their remit based on the declared drought stage. The primary policy instruments at the basin level are the RBMPs, which establish the long-term strategic framework (MITECO, 2022), and the PES, which provide the operational rulebook for drought periods, defining indicators, thresholds, and staged actions (Garrote et al., 2007).

Chapter 8 – Local Governance Response (Málaga)

8.1. Local Actors, Roles, and Interests

Málaga province exemplifies the complexities of local drought governance. The **Municipalities** (*Ayuntamientos*) hold the primary legal responsibility for ensuring urban water supply and sanitation services. **Water Utilities** like EMASA and Acosol are crucial operational actors. The **Provincial Authority** (*Diputación de Málaga*) supports smaller municipalities. The **Agricultural Sector**, represented by powerful Irrigation Communities (*Comunidades de Regantes*), has a core interest in securing sufficient irrigation water. The **Tourism Sector**, including hotel associations like Aehcos, is a dominant economic force with high water demand. Other actors include the **Industrial Sector** (e.g., Cepsa), **Domestic Users**, and Citizen and **Consumer Groups** like FACUA.

8.2. Local Risk Perceptions Across Different Sectors

The perception of drought risk varies considerably among these actors. For the **agricultural sector**, drought is perceived as an immediate threat to economic survival. The **tourism sector** perceives significant risk to its business model and profitability (Florido-Benítez, 2024). **Water Utilities** perceive operational risks, including the challenge of ensuring compliance with drinking water quality standards as raw water quality degrades (Schmidt et al., 2023). **Municipal Authorities** face political and economic risks from managing public discontent. **Environmental Groups** perceive risks in terms of ecological damage to rivers, aquifers, and terrestrial ecosystems (Peñuelas et al., 2018).

8.3. Local Responses and Measures in Recent Droughts

The recent prolonged drought prompted a significant mobilization of local responses. **Water Use Restrictions** were widely implemented, including bans on non-essential uses, per capita consumption limits, and, in severe cases, nightly supply shutoffs. **Infrastructure Management**

and Supply Augmentation efforts were intensified. Utilities prioritized leak detection, and emergency groundwater sources, such as the Fahala and Aljaima well fields, were activated. Major efforts focused on **non-conventional resources**, with plans to expand desalination capacity and increase water reuse for agriculture. Smaller, portable desalination units were also planned (SWM, 2024). **Communication and Awareness** campaigns were launched to encourage voluntary water-saving, a strategy most effective when sustained and providing clear guidance (Marx, 2018).

Case Study: The La Viñuela Reservoir and the Axarquía Crisis

The Axarquía region in eastern Málaga provides a stark case study of the convergence of these pressures. Dominated by highly profitable but water-intensive subtropical crops like avocados and mangos (Hervás-Gámez & Delgado-Ramos, 2019), the region relies almost entirely on the La Viñuela reservoir. During the 2019-present drought, the reservoir fell to critically low levels (below 10% capacity), forcing the basin authority to impose drastic cuts to irrigation allocations (up to 80%). This led to severe economic losses for farmers, intense social conflict, and the emergency deployment of reclaimed wastewater to save permanent orchards. This crisis highlights the extreme vulnerability created by an agricultural model misaligned with local water reality.

Case Study: EMASA′s "Digital Twin" in Málaga City

In contrast to supply-side crises, the urban utility EMASA has focused on technological solutions for demand management. It has invested in a "digital twin" of its water distribution network a sophisticated computer model that simulates the entire system in real-time. By using sensors and AI, the utility can rapidly detect leaks, optimize water pressure to reduce losses, and manage flows more efficiently, representing a state-of-the-art approach to improving the resilience of urban water infrastructure.

Part 3 – The Action Arena: Analysis of Friction, Conflict, and Outcomes

---

With the framework's nested rings defined, this part provides the core analysis. It delves into the **Action Arena** to diagnose how the Resource System, Governance System, and Actors interact, generating friction, conflict, and ultimately, systemic failures. It addresses the core of the research, to understand ongoing and emerging conflicts, and deconstructs the structural roots of governance failure, revealing why the nested rings of the system are so profoundly misaligned.

Chapter 9 – Water Conflicts in the Action Arena: The Friction Between Rings

The Action Arena in Málaga is a space of intense conflict, driven by the friction between the competing interests of the Actors at the core, the often-inadequate Rules-in-Use imposed by the Governance System, and the harsh, non-negotiable constraints of the Biophysical Reality imposed by the Resource System.

These conflicts illustrate the core dynamic predicted by the IAD framework: outcomes in the Action Arena are shaped by the interaction between the formal Rules-in-Use (provided by the Governance System), the Biophysical Reality (imposed by the Resource System), and the strategic choices of Actors with divergent interests and power. When these three elements are misaligned – when rules assume water availability that biophysical reality no longer provides, and when powerful actors resist adapting their strategies – conflict and unsustainable outcomes inevitably result.

A primary source of conflict stems from **water allocation between competing sectors**. The agricultural sector, historically the largest consumer, faces increasing pressure to reduce its water use, particularly for thirsty crops in the Axarquía (Alvarez et al., 2024). This creates tension with the demands of the densely populated urban areas and the economically crucial tourism industry along the Costa del Sol (Pedregal et al., 2020). During drought periods, decisions to curtail irrigation allocations to safeguard urban supply frequently led to protests from farmers. This dynamic is not merely a technical dispute but a political struggle over whose livelihood and economic model is prioritized. Some scholars frame these dynamics as a form of 'water grabbing', where powerful economic interests, legitimized by the state, effectively capture scarce water resources at the expense of other users or the environment (Duarte-Abadía & Boelens, 2019).

Geographical and environmental conflicts also expose friction between the rings. Plans to transfer water between areas to alleviate shortages can face opposition. More fundamentally, water abstractions required to meet economic demands directly impact ecological flows in rivers like the Guadalhorce, affecting downstream ecosystems such as the protected river mouth wetland (Pedregal et al., 2020). This represents a direct clash between the economic interests of the Actors and the health of the Resource System, a conflict the Governance System struggles to mediate.

Conflicts also arise directly from **drought management measures and governance processes**. The perceived fairness and equity of restrictions are often contested. The effectiveness of participatory mechanisms is questioned, with concerns about the dominance of traditional powerful actors. The increasing use of legal challenges, a process known as **judicialization**, indicates the high level of contention and a failure of other mechanisms to mediate disputes, pushing conflicts from the political arena into the courts (Hurtado et al., 2024; Vargas & Paneque, 2025).

Chapter 10 – The Structural Roots of Governance Failure: Why the Rings are Misaligned

The conflicts and unsustainable outcomes observed in the Action Arena are not merely the result of temporary crises or individual actor failures. They are symptoms of deeper, structural misalignments between the nested rings of the socio-ecological system. This chapter applies the NSEG framework diagnostically to reveal why the inner human rings (Governance System and Actors) have failed to adapt to the transformed outer ring (Resource System).

10.1. The Implementation Gap: A Failure of the Governance Ring

A persistent and critical failure is the gap between policy as planned and its actual implementation. This is not a simple administrative oversight but a politically driven phenomenon. The documented delays in declaring official drought stages as defined in the PES are directly linked to the political and economic influence of powerful agricultural and tourism lobbies that resist changes to the status quo (Sánchez et al., 2023). This represents a clear lack of political will to enforce unpopular but necessary restrictions, causing the **Governance System** ring to fail in its primary function of regulating the **Action Arena**. While some analyses emphasize the direct political influence of powerful lobbies as the primary driver (Sánchez et al., 2023), others place greater weight on the chronic underfunding and insufficient staffing of the very regulatory bodies tasked with enforcement (Vargas, 2020), suggesting a failure of state capacity as much as political will.

10.2. The Economics of Water Management and Policy Incoherence

The economic drivers within the system often run counter to sustainability goals. The EU Water Framework Directive's **"cost recovery principle"**, which mandates that the price of water should

reflect the full cost of its provision, is weakly implemented, particularly in agriculture (Vargas, 2013). Agricultural water tariffs are often heavily subsidized and do not reflect the true environmental and resource costs, providing little economic incentive for conservation (OECD, 2023). This creates a difficult trade-off between high-cost, high-energy supply augmentation solutions like desalination (Junquera et al., 2024) and the more sustainable but politically difficult path of raising prices for powerful user groups.

This is intensified by a major **policy incoherence** with external drivers, most notably the EU's **Common Agricultural Policy (CAP)**. While one EU policy (the WFD) pushes for sustainable water use, the CAP, as the main financial driver of agricultural activity, can create sustained conflicting incentives. By channeling subsidies in a way that favors large-scale production, the CAP can inadvertently encourage the continuation or expansion of water-intensive agriculture in a water-scarce region, directly undermining the WFD's objectives and placing regional authorities in a difficult position (Schütze, 2023; Borras et al., 2013).

10.3. Historical Legacies: How Land Ownership Shaped the Actor Ring

The challenges of water allocation are deeply intertwined with the historical structure of land ownership in Andalusia, which has shaped the power dynamics within the **Actor** ring. The region has long been characterized by the predominance of large estates, or **latifundios**, a legacy of the institutional arrangements established during the Christian Reconquest which concentrated land in the hands of a small elite (Tapia et al., 2021). This historical concentration of land created a powerful class of large agricultural landowners. Today, this structure interacts with modern policy drivers. The CAP's subsidy system, which often allocates payments on a per-hectare basis, disproportionately benefits these larger holdings, further concentrating economic and political power and marginalizing smaller farms (Borras et al., 2013; Peña-Rodríguez et al., 2023). This concentration of land and capital directly translates into a concentration of control over water resources, reinforcing a system that prioritizes the demands of large-scale, often export-oriented agriculture over other uses.

10.4. Social Equity and Differentiated Vulnerability

These structural issues create significant social inequities, meaning that the burdens of drought are not shared equally across society. The concentration of land, capital, and water access in the hands of large agribusinesses makes smaller, traditional farms more vulnerable to drought restrictions

and economic shocks (Borras et al., 2013). These smaller farms often lack the capital to invest in highly efficient irrigation technologies or alternative water sources, and their marginalization is accelerated during drought periods, contributing to rural depopulation (Peña-Rodríguez et al., 2023). In urban areas, the response to scarcity can also have regressive impacts. For example, flat-rate increases in water tariffs, often proposed to fund new infrastructure or encourage conservation, disproportionately affect low-income households, for whom water bills represent a larger percentage of their disposable income (OECD, 2023). This highlights a critical failure to integrate social equity considerations into the design of drought management policies, leading to outcomes that can worsen existing inequalities via feedback loops.

Voices from the Crisis: The Human Face of Structural Change

The abstract dynamics of land concentration and water scarcity translate into profound disruptions of rural livelihoods. In regions like the Axarquía, the expansion of water-intensive subtropical crops has created what researchers describe as processes of "land dispossession" and "hydro-territorial transformation," where traditional small-scale agriculture becomes economically unviable (Duarte-Abadía & Boelens, 2019). The 2022-2023 drought imposed particularly severe hardship: agricultural organizations documented that the combination of lost harvests and water restrictions created "immense economic hardship and stress" with severe impacts on the mental health of farmers and rural communities (COAG, 2023). These impacts are differentiated by scale: smaller operations lacking capital reserves to weather multi-year droughts face impossible choices between abandoning perennial crops representing decades of investment or continuing unsustainable water use in hopes of survival (Peña-Rodríguez et al., 2023). This differentiated vulnerability helps explain why collective action for transformation remains elusive – those with the greatest urgency to change (small farmers, dependent rural communities) lack the political and economic power to force it, while those with power (large agribusinesses, well-capitalized actors) lack urgency because the current system continues to serve their interests (Borras et al., 2013).

Chapter 11 – Assessing Broader Systemic Risks

The outcomes of these governance failures extend beyond immediate water shortages, creating broader systemic risks that threaten the long-term viability of the entire socio-ecological system.

11.1. Maladaptation Risk

Some of the "solutions" being implemented carry a risk of **maladaptation**, where short-term fixes could increase long-term vulnerability. For example, an over-reliance on energy-intensive desalination without corresponding measures to reduce demand can lock the region into a high-cost, high-carbon water supply model, increasing its vulnerability to future energy price shocks and undermining climate mitigation goals. Similarly, improving on-farm irrigation efficiency can lead to a **"rebound effect,"** where the water saved is used to expand irrigated areas or switch to more profitable but thirstier crops, resulting in no net water savings at the basin level (Pérez-Blanco & Gómez, 2014). This is a classic example of a well-intentioned policy within the **Governance**

System producing a perverse **Outcome** because it fails to account for the adaptive behavior of the **Actors**.

11.2. Public Health Dimensions

Drought poses significant risks to public health that are often overlooked in governance plans. Prolonged low reservoir levels can lead to a deterioration of raw water quality due to higher concentrations of pollutants and the potential for algal blooms, placing significant stress on water treatment plants (Schmidt et al., 2023). An analysis of the PES and PEM frameworks reveals that they are primarily focused on hydrological and supply metrics, and often lack explicit public health triggers. Furthermore, the immense economic hardship and stress of losing crops or facing water restrictions can have severe impacts on the **mental health of farmers** and rural communities (COAG, 2023). Finally, the increased risk of large wildfires associated with drought conditions leads to severe air quality problems, posing a direct threat to respiratory health for the wider population.

Part 4 – Pathways Forward: Realigning the System

This final part of the report synthesizes the preceding analysis into a set of robust, evidence-based recommendations for improving water governance. It explicitly frames these recommendations as strategic interventions designed to **realign the nested rings of the socio-ecological system**. The goal is to modify the inner human rings – the Governance System and the Actors – to make them compatible with the new reality of the outer biophysical ring, the Resource System, thereby fostering a more sustainable and resilient future.

Chapter 12 – Why the System Resists Change: The Stabilizing Forces

The conflicts and unsustainable outcomes observed in Andalusia's water governance are not the result of ignorance or lack of technical solutions. The previous chapters have documented sophisticated planning frameworks, extensive scientific knowledge, and well-defined management tools. Yet the system persistently fails to adapt to the escalating challenge of aridification. This chapter diagnoses the structural forces that stabilize the current misalignment, preventing transformation despite mounting evidence of its necessity.

12.1. Political-Economic Stabilizers: The Material Lock-In

The most visible stabilizing force is the network of economic incentives that materially rewards maintaining the status quo. The Common Agricultural Policy creates a powerful lock-in effect by channeling substantial subsidies toward agricultural production based on land area rather than water sustainability. In water-deficit regions like Málaga's Axarquía, farmers cultivating water-intensive subtropical crops receive CAP payments that are tied to maintaining these crops in production. Transitioning to less water-intensive alternatives would mean forfeiting both the market premium for avocados and mangos and the associated subsidy eligibility, creating what can be characterized as a financial "death valley" that few farmers can cross without bridge financing (Schütze, 2023; Borras et al., 2013).

This economic structure is compounded by the temporal mismatch between political accountability cycles and climate adaptation timelines. Regional and national politicians face elections every four years, while meaningful agricultural transitions require 5-10 year investment cycles, and climate adaptation planning must operate on 20-30 year horizons. Agricultural employment – particularly in provinces like Málaga and Almería – is politically sensitive, creating strong incentives for elected officials to delay unpopular restrictions even when hydrological indicators clearly warrant action (Sánchez et al., 2023). Analysis of drought declaration patterns reveals this political calculus at work: authorities frequently delay moving from "Alert" to "Emergency" status in the PES framework, despite indicator thresholds being crossed, until the crisis becomes undeniable and politically unavoidable (Alfonso et al., 2025; Vargas, 2020).

The concentration of land ownership further entrenches this dynamic. The historical legacy of latifundios has created a class of large agricultural landowners who wield disproportionate political influence. When combined with the CAP's per-hectare subsidy structure, this concentration means

that both economic resources and political power to resist change are held by those actors who benefit most from the current system (Borras et al., 2013; Tapia et al., 2021).

12.2. Institutional Stabilizers: Capacity Constraints and Path Dependency

The governance system itself exhibits structural rigidities that impede adaptation. Basin authorities responsible for enforcement – both the state-level Confederaciones Hidrográficas and the regional CMA – operate under chronic resource constraints. Their budgets are dependent on central government allocations, and they face persistent understaffing relative to their monitoring and enforcement mandates (Vargas, 2020). This creates a state capacity gap: even when political will exists to enforce restrictions on water use or penalize illegal abstractions, the institutional apparatus lacks the resources to do so effectively across vast agricultural regions.

Participatory governance structures, while formally inclusive, exhibit path dependency that favors established interests. River Basin Councils and Water Councils were designed to incorporate diverse stakeholder voices, but their composition and decision-making procedures tend to replicate existing power imbalances. Powerful economic sectors – large-scale agriculture and tourism – are systematically overrepresented relative to environmental organizations, consumer groups, or small-scale farmer associations. This structural imbalance means that even well-intentioned participatory processes frequently produce outcomes that protect established uses rather than drive transformation (Schütze, 2025; Paneque et al., 2009).

The professional culture and technical expertise within water management institutions also create inertia. Spain's water governance tradition has deep roots in what scholars term the "hydraulic paradigm" – an engineering-centered approach that views water management primarily as a supply-side challenge requiring infrastructure solutions (Sánchez, 2007). While formal policy has evolved to embrace demand management and ecosystem protection, institutional memory, training programs, and career advancement pathways within basin authorities continue to favor large infrastructure projects. This creates organizational resistance to the comprehensive demand management approaches that the new climatic reality necessitates.

12.3. Socio-Cultural Stabilizers: Identity, Norms, and Collective Action Problems

Deeply rooted cultural narratives about water, agriculture, and regional identity create powerful, if less visible, stabilizers. Andalusia's agricultural heritage – particularly the centuries-old tradition

of citrus cultivation and the more recent success of export-oriented horticulture – is intertwined with regional identity and local economic narratives. Proposals to fundamentally restructure agricultural production are experienced not merely as economic adjustments but as threats to community identity and intergenerational land stewardship traditions. This cultural dimension helps explain why implementation gaps persist even when economic incentives alone might not fully account for resistance (Duarte-Abadía & Boelens, 2019).

Public attitudes toward water governance reveal a paradox documented in research on Andalusian communities: while citizens express concern about drought and support for water conservation in principle, there is markedly less support for permanent, transformative policies that would impose lasting constraints on water use compared to temporary, crisis-driven measures (Paneque et al., 2018). This preference for "temporary emergency" framing over "permanent scarcity" framing creates political space for authorities to avoid the difficult structural reforms, instead relying on short-term restrictions that can be lifted once immediate crises pass.

A fundamental collective action problem compounds these dynamics. Water conservation at the individual or farm level provides minimal benefit if neighbors continue intensive use; the resource is shared at the basin scale, creating a classic "tragedy of the commons" dilemma. Individual farmers face strong incentives to maintain high water use – particularly for high-value crops – because unilateral conservation would impose costs on them while providing diffuse benefits to others. This dynamic persists despite the existence of irrigation communities, which theoretically could coordinate collective management, because these bodies themselves often represent the interests of the most established and water-intensive users (Sanchis-Ibor et al., 2022).

12.4. Scalar and Hierarchical Mismatches: The Differentiated Capacity to Transform

The capacity and incentives for transformative action vary dramatically across different types of actors, creating scalar barriers to change. Small and medium-scale farmers operate under what might be characterized as a hierarchy of immediate needs: when facing financial precarity – whether from crop failures, market volatility, or debt – their decision-making horizon necessarily shortens to focus on short-term economic survival. In this state, long-term climate adaptation becomes a luxury they cannot afford, even when they rationally understand its future necessity (Peña-Rodríguez et al., 2023; Iglesias et al., 2007). This dynamic reflects what might be characterized as a **hierarchy of immediate needs** operating at different actor scales. Small-scale

farmers facing financial precarity from crop failures, market volatility, or accumulated debt necessarily prioritize short-term economic survival over long-term climate adaptation, even when they rationally understand the trajectory toward unsustainability (Iglesias et al., 2007; Peña-Rodríguez et al., 2023). Their decision-making horizon compresses to the current growing season or debt repayment cycle. In contrast, large-scale agribusinesses and well-capitalized actors possess both the financial buffers and planning horizons that would theoretically enable long-term strategic thinking – yet they also benefit most from current institutional arrangements and therefore lack strong incentives to drive change (Borras et al., 2013). This creates a perverse inverse relationship between capacity to act long-term and motivation to do so. Conversely, large-scale agribusinesses and well-capitalized actors possess both the financial resources and planning horizons to think strategically about transformation, but they also benefit most from the current system and therefore lack strong incentives to drive change.

This creates a critical gap in the coalition structure needed for transformation: the actors with the greatest vulnerability and urgency (small farmers, dependent rural communities, downstream ecosystems) lack the political and economic power to force change, while those with power lack urgency. Environmental organizations possess motivation but limited leverage in decision-making structures dominated by economic interests. Municipalities face immediate constituent pressures and lack authority over basin-level allocation decisions (Prieto et al., 2021).

The question of coalition formation – who could build a sufficiently powerful alliance to overcome these stabilizers – remains largely unaddressed in Andalusian water governance. Research on collective action in other contexts suggests that such coalitions typically require: (1) a crisis severe enough to shift cost-benefit calculations for powerful actors, (2) bridging organizations that can translate between different stakeholder languages and interests, and (3) institutional entrepreneurs willing to challenge established norms (Tilly, 2019). The threshold at which these conditions might emerge in Andalusia is uncertain, raising a critical research question: How severe must the impacts become before the stabilizing forces weaken sufficiently to enable transformation?

12.5. Recursive Reinforcement: The Self-Perpetuating Nature of Maladaptation

Perhaps most concerning is the way these stabilizers reinforce one another through feedback loops, creating a recursive trap. The implementation gap persists because powerful lobbies resist enforcement, which undermines the credibility of planning frameworks, which reduces incentives

for actors to comply, which further weakens enforcement capacity. Policy incoherence between the WFD and CAP persists because no single EU institution is held accountable for reconciling them, and national governments benefit from the ambiguity, which allows them to defer difficult distributional choices, which perpetuates the contradictory incentives facing farmers, which generates continued unsustainable outcomes, which demands further policy intervention, completing the cycle.

Each cycle through this recursive system has three pernicious effects. First, it ratchets the physical system deeper into unsustainability – aquifers decline further, ecosystem damage accumulates, and the baseline state shifts. Second, it normalizes crisis – what was considered an emergency state in one decade becomes the accepted baseline in the next, raising the threshold for action. Third, it erodes trust in governance institutions – when plans repeatedly fail to prevent or adequately respond to crises, public confidence in formal processes declines, making collective action even more difficult (Aggarwal & Anderies, 2023; Pahl-Wostl et al., 2020).

The analysis suggests these stabilizers are not primarily technical failures or information deficits. They are structural features of the socio-ecological system that, from the perspective of certain powerful actors, are functioning as designed. The implementation gap is not accidental; the policy incoherence serves political purposes; the concentration of decision-making power reflects deliberate institutional design choices. Acknowledging this reality is uncomfortable but essential: transformation will require not merely better planning tools or more scientific data, but a fundamental shift in which actors have power and how distributional conflicts are resolved.

Chapter 13 – Recommendations for Transformative Water Governance

Based on the socio-ecological governance analysis and the diagnosis of stabilizing forces, achieving long-term water security and resilience in Andalusia and Málaga necessitates strategic interventions designed to disrupt these stabilizers. The following recommendations explicitly target the structural barriers identified in Chapter 12, acknowledging that incremental adjustments will prove insufficient given the magnitude of the challenge and the depth of resistance to change.

These interventions are designed using the logic of the NSEG framework: they target specific misalignments between the rings. Automated triggers address the failure of the Governance System to respond to Biophysical Reality. Dedicated enforcement funding addresses the Actor ring's capacity to resist compliance. Participatory reform addresses the concentration of power within the Action Arena that systematically favors established interests over transformation.

13.1 Strengthening Proactive and Adaptive Governance

The implementation gap driven by political delays, insufficient institutional capacity for enforcement, and participatory structures that systematically favor established interests represents a fundamental barrier to effective water governance. Despite clear indicator thresholds being crossed in PES frameworks, drought status declarations are frequently delayed due to political pressure from agricultural and tourism lobbies. Basin authorities lack sufficient staff and budget to effectively monitor and enforce regulations against illegal water abstractions, which are estimated to represent 20-30% of total use in regions like the Axarquía (MAPA, 2023; Miró, 2023).

To address these challenges, MITECO should mandate that drought status declarations be automated based on objective indicator values, removing discretionary political decision-making from the Pre-alert and Alert stage declarations. While Emergency stage declarations would remain subject to executive approval due to the need for broader governmental coordination, early-stage responses must be depoliticized to enable timely action before crises escalate. This requires establishing politically independent trigger mechanisms that operate without interference from sectoral interests.

Rather than relying on general budget allocations subject to annual political negotiations, a dedicated enforcement fund should be established and financed by a surcharge on water concessions in over-allocated basins. This creates a direct link between water use and enforcement

capacity, ensuring that authorities in the most stressed basins have resources proportional to their challenge. Substantially increasing enforcement capacity through such dedicated funding mechanisms would enable basin authorities to effectively monitor and sanction illegal abstractions that currently undermine water management objectives.

Furthermore, the Junta de Andalucía should mandate that Water Councils include minimum guaranteed representation of at least 30% combined for environmental NGOs, consumer organizations, and small-scale farmer associations. Current structures allow these groups to be systematically outvoted by large agricultural and industrial water users, effectively capturing participatory processes to serve established interests. Proportional representation that ensures genuine stakeholder diversity would prevent this systematic marginalization and create space for alternative perspectives in water governance.

The implementation of these reforms requires coordination among MITECO, which holds rule-making authority for the PES framework; the Junta de Andalucía, which governs intra-community basin structures; the European Commission, which could initiate infringement proceedings if WFD implementation continues to lag; and civil society organizations, which must mobilize to demand reform. Large agricultural users will likely oppose automated triggers as removing their ability to negotiate delays, while basin authorities may resist being perceived as subordinate to automatic processes, and political parties may be reluctant to cede discretionary power. To manage this resistance, pilot implementation in one severely-stressed basin such as the Guadalhorce would demonstrate feasibility before mandatory national rollout, using a two to three year pilot period to refine indicator specifications and address implementation challenges.

13.2 Prioritizing Comprehensive Demand Management

The CAP subsidy structure rewards water-intensive agriculture while weak cost recovery implementation fails to create conservation incentives, producing the classic "rebound effect" where efficiency gains enable expansion rather than net water savings. The CAP provides per-hectare subsidies that make water-intensive crops like avocados financially attractive even in water-deficit regions. Agricultural water tariffs are heavily subsidized and do not reflect the true environmental and scarcity costs, providing weak price signals for conservation (OECD, 2023; Vargas, 2013). Research has documented that irrigation efficiency improvements, when not

coupled with binding volumetric caps, lead to agricultural expansion rather than water savings at the basin level (Pérez-Blanco & Gómez, 2014; Schütze et al., 2020).

To neutralize the rebound effect, MITECO must create a clear legal framework requiring basin authorities to implement caps on total irrigation abstractions in any basin officially declared to be in structural deficit. These caps should be set based on scientifically determined sustainable yield, accounting for projected climate change impacts on recharge. Critically, caps must be implemented at the basin or aquifer level rather than merely on individual concessions to ensure that efficiency gains by some users genuinely reduce total extraction rather than freeing water for use by others or enabling expansion. Binding volumetric caps at the appropriate scale represent the only effective mechanism for preventing efficiency improvements from paradoxically increasing total water consumption.

Basin authorities should implement progressive tariff structures for irrigation water that include a base rate recovering operation and maintenance costs, a resource scarcity component that increases with the severity of basin deficit, and an environmental cost component reflecting ecosystem impacts. Tariffs should be indexed to drought status declarations, automatically increasing during Alert and Emergency stages to provide clear price signals for conservation. To address equity concerns, the progressive structure should protect small-scale subsistence users while charging scarcity-reflecting prices to large commercial operations, ensuring that conservation incentives do not disproportionately burden vulnerable farmers.

At the European level, Spain should formally propose in the next CAP reform cycle that Pillar I direct payments be conditional on demonstrated water use within sustainable basin limits in deficit regions. This would require significant political negotiation at the EU Council, but the WFD provides legal grounding for such conditionality. The requirement to achieve "good status" of water bodies is legally binding under the WFD, and the CAP should not subsidize activities that undermine this obligation (Schütze, 2023; Vargas, 2013). Eliminating these contradictory incentives at the European policy level would remove a major structural barrier to sustainable water management in Spain.

These reforms target the core economic interests of the most powerful actor coalition, and large-scale irrigated agriculture will mobilize intense political opposition. The Spanish Ministry of Agriculture must advocate for CAP reform at the EU Council, while the European Commission's

DG Agriculture holds authority over CAP design. MITECO and CMA possess authority to set basin-level abstraction caps and water pricing structures, but irrigation communities, which possess local control over water distribution, must cooperate for effective implementation. Timing will be critical, as implementation during a severe drought when public opinion supports action may be more feasible than during wet periods. Resistance will also emerge from regional governments like the Junta concerned about agricultural employment and regional economic competitiveness.

Volumetric caps and significant tariff increases cannot be implemented before transition support mechanisms are established, as abrupt changes would force small farmers out of business and concentrate land ownership further. Phased implementation over three to five years is necessary, beginning with clear announcement of future cap levels to allow planning, followed by gradual tightening. CAP reform advocacy should begin immediately given that CAP operates on seven-year cycles, requiring long lead times for policy change.

13.3 Facilitating Transformative Adaptation of the Agricultural Sector

Farmers face a "death valley" that prevents transition to less water-intensive systems, lacking financial and institutional support for structural economic change while cultural identity remains tied to traditional agricultural models. In regions like the Axarquía, farmers have invested substantial capital in perennial subtropical crops such as avocados and mangos. Transitioning to less water-intensive alternatives requires abandoning these capital-intensive investments mid-production cycle, with no compensation mechanism to bridge the transition period. The combination of the CAP's per-hectare structure, the market premium for subtropical exports, and the absence of support for agricultural diversification creates powerful lock-in effects (Hervás-Gámez & Delgado-Ramos, 2019; Alvarez et al., 2024).

The Junta de Andalucía, with co-financing from FEADER, should create a dedicated Agricultural Water Transition Fund providing income support payments for five to seven years for farmers who voluntarily convert from high water-intensity to low water-intensity crops in deficit basins. The fund should also provide technical assistance for crop selection, market development, and irrigation system redesign, as well as compensation for the loss of perennial crop capital investments when removal is necessary for water sustainability. The payment structure must

ensure that farmers maintain or improve their economic position during the transition, eliminating the financial "death valley" that currently makes change impossible for most operators.

To prevent the fund from simply subsidizing the status quo, participation must require farms to demonstrate actual reductions in water use, verified through smart meter monitoring or audit of irrigation schedules. Critically, savings must be genuine at the basin level, with saved water retired from agricultural use and allocated to ecological flows or urban supply rather than simply reallocated to other farms. This ensures that the transition fund produces net improvements in basin water balance rather than merely shuffling water use among users.

Regional agricultural research institutes should establish demonstration farms showcasing viable alternatives including drought-resistant varieties of traditional crops, integration of dry-farming techniques, and transition to products with strong local markets that reduce export dependency. These models must be economically viable and not merely technically possible to gain adoption among farmers operating under tight financial constraints. Demonstrating profitability through concrete examples would help overcome skepticism about the feasibility of alternative agricultural systems.

The Junta de Andalucía serves as the primary implementing authority and controls agricultural extension services essential for delivering technical assistance. The European Commission's DG Agriculture must approve FEADER funding eligibility and use. Farmers' associations, including COAG and similar groups, must view this transition support as helping their members rather than threatening them, requiring careful engagement to build buy-in. Irrigation communities control local water distribution and must cooperate in reallocating saved water to environmental or urban uses. Market actors including retailers and exporters whose demand patterns drive crop choices will need to be engaged regarding changes in supply availability.

Farmers will demonstrate moderate resistance if the transition support is genuinely adequate but strong resistance if it appears inadequate or is perceived as "paying people to abandon farming." Large agribusinesses may resist because transitions threaten their supply chains, while export market actors depending on subtropical fruit supply will oppose supply contraction. The issue is politically sensitive because agricultural employment carries both economic and cultural importance in rural Andalusia. The fund must be fully capitalized and operational before mandatory volumetric caps or tariff increases are implemented. A pilot program in one comarca

such as eastern Axarquía for two to three years would refine payment levels and procedures before regional scaling, while concurrent investment in demonstration farms would prove the economic viability of alternatives.

13.4 Rigorously Integrating Climate Projections into All Planning

Water planning tends to rely on historical hydrological baselines rather than projected future conditions, reflecting institutional separation between climate science production and water management decision-making as well as the political convenience of ignoring long-term projections that would require immediate action. Despite robust climate projections indicating substantial reductions in precipitation and runoff for Andalusia, with estimates of 18-38% decline by end-century and southern regions potentially experiencing 30-40% reductions in river flows, these projections are inadequately integrated into operational water planning (Lazoglou et al., 2024; González-Pérez et al., 2024). RBMPs and PES continue to use historical hydrological series as the baseline for calculating "available resources," systematically overestimating future water availability. The GOVAQUA research identified a persistent science-policy gap where climate impact knowledge is produced but not effectively translated into management practice (GOVAQUA, 2023).

MITECO should establish regulatory requirements that all basin-level plans must use climate-adjusted hydrological projections rather than historical series as the baseline for resource availability calculations. Specifically, RBMPs must incorporate ensemble climate model projections at minimum for RCP 4.5 and RCP 8.5 scenarios for the 2040-2060 planning horizon. Available water resources should be calculated as the lower bound of the projected range, applying a precautionary approach given model uncertainties. PES drought indicator thresholds must be recalibrated based on projected "normal" conditions rather than historical norms, recognizing that what was previously considered drought may become the new baseline under climate change.

Before approving funding for desalination plants, reservoir expansions, or inter-basin transfers, basin authorities must conduct climate vulnerability assessments examining whether investment assumptions about future water demand remain valid under projected climate scenarios, whether infrastructure could become stranded if demand patterns shift due to agricultural adaptation, and whether nature-based alternatives could provide equivalent water security at lower cost with

greater climate resilience. These assessments would prevent maladaptive investments that fail to account for changing hydrological conditions and shifting demand patterns.

The Junta de Andalucía should establish a Regional Water and Climate Service analogous to health surveillance systems with the specific mandate to translate academic climate research into actionable information for water managers, provide regular annual updates on climate projection refinements and their implications for water planning, offer capacity-building for basin authority staff on interpreting and applying climate projections, and monitor whether plans actually incorporate best available science while reporting publicly on gaps. This knowledge-broker institution would bridge the persistent gap between climate science production and policy implementation.

MITECO holds regulatory authority to mandate climate integration in planning requirements, while the Spanish Meteorological Agency and regional climate centers provide technical capacity for projections. Basin authorities including CHG and CMA bear responsibility for implementing revised planning, and research institutions such as universities and CSIC produce the underlying climate science. The European Commission could flag inadequate climate integration through WFD compliance assessment, creating external pressure for reform.

Basin authorities may demonstrate moderate resistance due to concern about the political implications of acknowledging reduced future water availability, as lower official "available resources" figures would necessitate difficult allocation decisions immediately rather than deferring them. Engineering-oriented staff may resist projections as "uncertain" compared to historical data, despite projections being more accurate for future planning purposes. Some resistance will emerge from water-intensive sectors who benefit from continued overestimation of availability.

This intervention can begin immediately as it primarily requires regulatory and technical capacity development rather than large financial investments or direct challenges to powerful economic interests. However, the implications of climate-adjusted planning, particularly recognizing reduced availability, will trigger the need for accompanying demand management measures, requiring coordination in sequencing these interventions. Phased implementation should proceed with Year 1 establishing requirements and providing training, Years 2-3 having basin authorities

develop climate-adjusted plans, and Year 4 onward monitoring compliance and refining approaches based on experience.

13.5 Developing a Diversified and Sustainable Water Portfolio

Path-dependent preference for large-scale grey infrastructure and supply augmentation over demand management or nature-based solutions creates energy and financial lock-in, particularly with desalination, while governance complexity hinders integration of non-conventional water sources. Faced with repeated supply crises, authorities have prioritized emergency desalination expansion and groundwater exploration over demand reduction or ecosystem-based approaches. While desalination provides supply reliability, it creates new vulnerabilities including high energy costs that make the system vulnerable to energy price shocks, substantial carbon emissions undermining climate mitigation goals, and complex brine disposal challenges (Junquera et al., 2024; Lizak, 2025). Critically, supply augmentation without binding demand caps enables continued unsustainable growth through the rebound effect.

MITECO and the Junta should establish a regulatory principle whereby approval for major supply augmentation projects including desalination plants, inter-basin transfers, and new well fields must be conditional on concurrent implementation of demand management measures that produce equivalent water savings. This prevents supply augmentation from enabling expansion rather than providing resilience. For example, approval for a 20 hm^3/year desalination plant should require measures such as pricing reform, efficiency standards, and volumetric caps that reduce demand by at least 20 hm^3/year elsewhere in the system, ensuring net improvement in water balance.

All desalination facilities should be required to source increasing percentages of their energy from dedicated renewable sources, with targets of 50% by 2030 and 100% by 2040. This can be achieved through co-location of solar installations with desalination plants in coastal areas with excellent solar potential, power purchase agreements with renewable energy projects, and investment in energy storage to manage the mismatch between solar generation peaks and water demand patterns. Prioritizing energy transition for existing and planned desalination infrastructure addresses the carbon footprint concern and reduces vulnerability to fossil fuel price volatility.

Despite demonstrated technical feasibility, Managed Aquifer Recharge remains marginal in Andalusian water management, with barriers primarily institutional rather than technical (Bahadir et al., 2025). MAR requires coordination across multiple landowners, regulatory clarity on water

rights for recharged water, and multi-year planning horizons. To overcome these barriers, authorities should establish clear legal framework defining property rights and allocation priorities for artificially recharged groundwater, create financial incentives for landowners who dedicate land to recharge zones similar to agri-environmental schemes, prioritize MAR investments in basins with suitable geology and demonstrated overexploitation such as coastal aquifers facing salinization risk, and integrate MAR into river restoration projects using floodplain reconnection to enhance natural recharge processes.

Treated wastewater represents a drought-resilient resource currently underutilized in agriculture. Expansion of water reuse should focus on upgrading treatment infrastructure to meet quality standards for agricultural irrigation, developing clear regulatory frameworks that address farmer concerns about crop quality and marketability, pricing reclaimed water competitively with conventional sources to incentivize adoption, and ensuring that reclaimed water genuinely substitutes for freshwater abstractions rather than enabling expansion through integration with volumetric caps.

MITECO and CMA hold approval authority for infrastructure investments and regulatory authority to set conditions, while the Ministry of Industry and Energy governs renewable energy policy and grid integration. Municipal water utilities operate wastewater treatment facilities and could become suppliers of reclaimed water. Landowners in potential MAR zones must cooperate, requiring incentive alignment, while the agricultural sector as end users of reclaimed water determines viability through their acceptance. The European Investment Bank and other infrastructure funders can make financing conditional on sustainability criteria.

Moderate resistance may emerge from engineering firms and utilities with expertise in conventional desalination who view conditions as complicating project approval and implementation. Renewable energy requirements increase upfront capital costs despite reducing long-term operating costs. MAR faces skepticism from farmers concerned about water quality and rights, as historical experience with poorly-designed recharge schemes has created wariness. Agricultural water reuse faces cultural resistance and market concerns about consumer perception of crops irrigated with "recycled water."

These interventions can proceed in parallel with other recommendations. Desalination renewable energy requirements should apply to all new projects immediately and be retrofitted to existing

plants on a ten-year timeline. MAR investment should begin with pilot projects in two to three high-priority basins such as coastal aquifers in Málaga province with severe salinization risk to demonstrate effectiveness and develop replicable models. Water reuse expansion requires three to five years of treatment infrastructure upgrading before significant volumes become available, providing time for farmer engagement and market assessment to address acceptance barriers.

13.6 Enhancing Ecosystem Resilience and Environmental Protection

The systematic subordination of ecological needs to economic uses, treatment of environmental flows as residual rather than priority allocations, and lack of economic valuation of ecosystem services that would reveal the costs of degradation collectively undermine environmental protection. Despite legal requirements to maintain ecological flows, enforcement is weak and environmental objectives are routinely sacrificed during droughts. Rivers like the Guadalhorce experience extended zero-flow periods causing severe ecosystem damage (Pedregal et al., 2020; Martin et al., 2016). Water-dependent ecosystems such as wetlands and riparian corridors have experienced progressive degradation. This degradation has measurable economic costs including loss of water purification services, reduced flood buffering, and diminished biodiversity that are typically not included in water management cost-benefit analyses (Campos et al., 2020).

MITECO should amend water law to explicitly establish ecological flows as the first priority allocation ahead of irrigation, urban supply, or industrial uses. Operationally, this means ecological flow requirements must be met before any concessions are honored, during drought Emergency stages restrictions on economic uses must be imposed earlier and more severely to avoid violating ecological minimums, and basin authorities face legal liability for ecosystem damage if they fail to maintain flows. This represents a fundamental shift from treating environmental flows as an optimization target to be balanced against other uses to treating them as a legal constraint representing a hard floor that cannot be crossed.

Current PES frameworks lack clear protocols for maintaining ecological functions during severe droughts when all water is scarce. Basin authorities should develop prioritization schemes that identify critical ecosystem refuges that must be maintained even in extreme scarcity, managed flow release schedules that concentrate limited water in time and space to maintain viable habitat patches rather than spreading inadequate flows uniformly, and trigger points for emergency interventions such as wildlife rescue or translocation of endangered aquatic species. These

scientifically-based emergency ecological flow protocols acknowledge the difficult reality that not all ecological functions can be maintained during extreme droughts, but strategic prioritization can preserve core biodiversity.

Before approving major water projects, authorities should conduct comprehensive ecosystem service valuations that quantify the water purification value of wetlands and riparian zones in reducing treatment costs, the flood regulation value of functional floodplains in reducing infrastructure damage, the biodiversity value and carbon sequestration of healthy aquatic ecosystems, and the recreation and cultural value of rivers and water bodies. These valuations should be conducted using standardized methodologies and included in cost-benefit analyses alongside conventional economic factors. In many cases, natural capital accounting will reveal that ecosystem protection is not a cost but an investment with measurable returns (Campos et al., 2020).

Rather than relying exclusively on engineered infrastructure, authorities should invest in floodplain reconnection projects that restore natural water retention capacity, wetland restoration that provides water quality improvement and biodiversity habitat, riparian forest restoration that reduces evapotranspiration and improves infiltration, and sustainable urban drainage systems that capture stormwater and reduce runoff. Prioritizing river restoration and nature-based solutions for water retention often provides multiple co-benefits including flood protection, biodiversity conservation, carbon storage, and recreation at lower lifecycle costs than grey infrastructure (Prieto et al., 2021; Ruiz et al., 2015).

MITECO holds legislative authority to change allocation priority rules and regulatory authority over RBMPs, while basin authorities bear operational responsibility for flow management and enforcement. Environmental organizations provide technical expertise on ecological requirements and monitoring pressure for accountability. Academic institutions possess capacity to conduct ecosystem service valuations and develop restoration designs, while municipal governments hold implementation authority for urban nature-based solutions. The European Commission could initiate infringement proceedings for WFD non-compliance regarding ecological status.

Strong resistance will emerge from irrigation communities and agricultural sectors who view guaranteed ecological flows as directly competing with their water access. Political resistance from elected officials facing pressure from economic interests may lead them to view ecosystem protection as lower priority than jobs and economic activity. Technical resistance from

engineering-oriented staff who are more comfortable with conventional infrastructure than nature-based approaches will also occur. Resistance may be particularly strong during drought emergencies when imposing restrictions to maintain ecological flows requires denying water to economic users.

Legislative change to establish ecological flow priority should occur early in Years 1-2 as it sets the framework for all subsequent allocation decisions. However, abrupt enforcement without transition support would cause economic disruption, requiring coupling with clear communication of a five-year timeline for full compliance allowing economic users to plan adaptations, concurrent investment in water efficiency and alternative sources for economic sectors to reduce their vulnerability to reduced allocations, and immediate development of emergency ecological flow protocols that can be piloted in current drought conditions. River restoration and nature-based solutions should be implemented on a ten to fifteen year timeline as they require extensive planning, land acquisition or agreements, and construction. Prioritizing sites where restoration costs are low and multiple benefits are high would build demonstration cases and political support.

13.7 Improving Data, Research, and Knowledge Systems

Information asymmetries benefit non-compliant users, while gaps between scientific knowledge production and policy application and lack of transparent, accessible data that could enable public accountability undermine effective governance. Despite investments in monitoring infrastructure, significant data gaps remain. Real-time agricultural water use data is limited, making it difficult to detect illegal abstractions or enforce volumetric allocations (MAPA, 2023). Groundwater monitoring networks are insufficient to track depletion and salinization in real-time. Socioeconomic impact data on which farmers are most vulnerable and what distributional consequences different policies would have is inadequate for designing equitable interventions. Water quality monitoring during droughts is insufficient to ensure treatment plant resilience (Schmidt et al., 2023).

MITECO should establish requirements for real-time monitoring of all irrigation abstractions above a 10,000 m^3/year threshold, automated data transmission to basin authorities creating transparent records of actual water use versus concession limits, and integration with satellite remote sensing to cross-verify irrigation activity. Mandating smart metering for all significant water users by 2030 addresses information asymmetry whereby users currently know their water

use while authorities can only estimate it, advantaging non-compliant users. Smart metering shifts this dynamic, enabling effective enforcement and accurate water accounting. The technology exists and costs have declined substantially, with barriers primarily regulatory mandate and implementation coordination.

To design equitable transition policies, policymakers need detailed data on farm size distribution, debt levels, and financial resilience in water-stressed regions, employment dependencies on water-intensive sectors at municipal level, and differentiated impacts of drought restrictions on small versus large operations. The Junta de Andalucía should integrate agricultural census data with water allocation records and financial data including tax records and subsidy payments to create a comprehensive water-economy database that can model the distributional effects of policy interventions. This socioeconomic monitoring system data should be anonymized and made available to researchers and civil society to enable independent policy analysis.

Priority investments should target expanded networks of monitoring wells with automated sensors providing real-time data on water levels and quality, geophysical surveys to map aquifer geometry and connectivity improving understanding of recharge dynamics, and regular sampling for salinity and contamination indicators providing early warning of degradation. Strengthening groundwater monitoring networks in overexploited aquifers should focus on coastal aquifers at risk of seawater intrusion where degradation can be irreversible and aquifers supporting critical urban or agricultural uses.

Building on the MITECO recommendation for a national water data platform (MITECO, 2020), authorities should consolidate data from all basin authorities into a standardized, interoperable format, provide public access to non-sensitive data including reservoir levels, flow rates, water quality, and allocation decisions, enable visualization tools that allow citizens, journalists, and researchers to track drought status and governance responses, and mandate that basin authorities publish explanations for key decisions including drought status changes, concession approvals, and restriction implementations. Creating transparent, publicly accessible water data portals serves multiple purposes by enabling public accountability, supporting informed stakeholder participation, and building trust in governance institutions through demonstrating that decisions are evidence-based.

Priority research questions that would directly inform improved governance include comparative effectiveness of different demand management instruments such as pricing, quotas, and efficiency standards in the Andalusian context, evaluation of the distributional impacts of current and proposed water policies, assessment of nature-based solutions viability and scaling potential in different hydrogeological settings, analysis of drinking water quality challenges during prolonged droughts and treatment plant resilience strategies, and investigation of the social and economic thresholds that could enable coalition formation for transformative change. Funding applied research on policy effectiveness and adaptation pathways would provide the evidence base for refining interventions.

MITECO and CMA hold regulatory authority to mandate metering and budget authority for monitoring investments, while water utilities and irrigation communities are responsible for installing and maintaining meters. The Spanish National Statistics Institute and regional statistical services possess capacity for socioeconomic data integration. The Spanish Geological Survey and universities provide technical capacity for groundwater monitoring, while technology providers including smart meter manufacturers and data platform developers supply necessary infrastructure. Research institutions such as universities and CSIC can execute the applied research agenda.

Moderate resistance will emerge from some water users who prefer information asymmetry, particularly those currently using water beyond concession limits or engaging in illegal abstractions. Privacy advocates may express concern about detailed monitoring of agricultural activities. Budget resistance from authorities who view monitoring as lower priority than infrastructure will occur, along with some resistance from irrigation communities who may need to install and maintain infrastructure on private land.

Smart meter rollout should be phased by user size with Years 1-3 requiring meters for all users exceeding 100,000 m^3/year as the largest users are easiest to monitor, Years 4-7 extending to users exceeding 10,000 m^3/year, and Years 8-10 extending to remaining concession holders. This phasing allows infrastructure supply chains and installation capacity to scale up. Groundwater monitoring expansion can proceed immediately and should be prioritized in highest-risk aquifers. Data portal development should begin immediately with a two to three year development timeline as it primarily requires technical integration rather than new data collection. Socioeconomic

monitoring and applied research should be funded on an ongoing basis with priority topics reviewed annually based on evolving policy needs.

Chapter 14 – Conclusion: Confronting the Political Challenge of Transformation

14.1. What We Now Understand About Andalusia's Water Governance

This analysis reveals a socio-ecological system characterized by a profound and dangerous misalignment. The outer biophysical ring – the Resource System – is undergoing a fundamental, permanent shift toward greater aridity driven by climate change. The scientific evidence is unequivocal: the recurring droughts are not temporary anomalies but manifestations of a new normal. Yet the inner human rings – the Governance System and the Actors it structures – have failed to adapt. Despite sophisticated planning frameworks and extensive knowledge of the challenge, the system persists in patterns of resource use and economic development that were designed for a wetter past, not the drier future that is already arriving.

The research has demonstrated that this is not primarily a failure of information, technology, or technical capacity. It is a failure of political economy. The current system is stabilized by a network of mutually reinforcing forces: economic incentives that materially reward maintaining unsustainable practices, institutional structures that favor established interests, cultural narratives that resist acknowledging permanence of scarcity, and collective action problems that prevent coordination even when actors individually recognize the unsustainability. From the perspective of powerful actors – large landholders, established agricultural cooperatives, tourism industry associations – the current system is functioning reasonably well, delivering benefits that outweigh the costs they personally bear. The costs are displaced: onto small farmers who lack resources to adapt, onto ecosystems that cannot vote or mobilize politically, and onto future generations who will inherit depleted aquifers and degraded landscapes.

Several provocative insights emerge:

The implementation gap is a feature, not a bug. Delayed drought declarations and weak enforcement of restrictions serve clear political functions – they allow elected officials to avoid confrontation with powerful constituencies and to defer distributional conflicts to future administrations. Framing this as mere "lack of political will" is insufficient; it is rational political behavior within existing institutional constraints and electoral cycles.

Plans exist, but implementation requires changing who benefits. Andalusia does not lack sophisticated planning documents or policy instruments. The problem is that implementing these

plans requires reallocating resources and constraining activities in ways that threaten the economic position of the most politically powerful actors. This is fundamentally a distributional conflict, not a technical challenge.

Aridification is predictable; the governance response to predictability is the mystery. Climate projections for the region have been available for decades, with increasing precision. The failure to adapt is not a failure of foresight but a failure of political systems to act on foreknowledge when action requires challenging entrenched interests.

Small farmers cannot act long-term because they operate in survival mode; large actors can but won't because they're winning. This creates a cruel paradox: those with greatest urgency to transform lack power, while those with power lack urgency.

14.2. The Barriers to Transformation: Why It Hasn't Changed

Three interrelated barrier types make transformation extraordinarily difficult, even when the need is recognized:

Scalar mismatches define the first barrier. The problems – aquifer depletion, ecosystem degradation, cumulative water deficits – manifest at the basin and regional scale. But most powerful actors (individual farmers, municipalities, tourism businesses) operate and politically organize at the local scale. They experience their own water use as marginal relative to the basin total, weakening incentives for individual restraint. No institutional mechanism effectively aggregates local interests into basin-level collective action that could impose mutual restraint. The irrigation communities, which theoretically could serve this coordination function, are themselves often dominated by the most established and water-intensive users, reproducing rather than resolving the coordination problem.

Temporal mismatches compound the scalar problem. Climate adaptation planning requires 20-30 year time horizons to be effective – the lifetime of agricultural investments, the lag time for aquifer recovery, the duration of ecological restoration. But political accountability cycles are 4 years, farmer investment and debt repayment cycles are typically 5-10 years, and crisis response operates on timescales of weeks to months. Every institution in the system optimizes for the shortest cycle relevant to its immediate survival, creating systematic under-weighting of long-term

risks. Politicians who impose costly restrictions today to prevent crises two decades in the future are likely to be punished electorally before the benefits of their foresight become apparent.

Distributional conflicts present the most fundamental barrier. Any meaningful reallocation from unsustainable to sustainable water use patterns creates winners and losers. Critically, the current system diffuses costs – gradually declining aquifer levels, slowly degrading ecosystems, incrementally increasing drought frequency – while concentrating benefits in the form of agricultural subsidies, tourism revenues, and water access for high-value uses. Transformation requires reversing this political economy: concentrating transition costs on specific, identifiable actors (farmers who must abandon crops, tourism operators who must reduce activity, consumers who must pay higher water bills) while diffusing benefits across society and into the future (healthier ecosystems, reduced long-term risk, intergenerational equity). This is politically difficult even when the aggregate welfare calculation favors transformation, because the losses are immediate and concentrated while the gains are delayed and diffuse. The political economy of climate adaptation consistently disadvantages proactive action.

14.3. Open Questions: Pathways Forward Require Confronting Uncomfortable Truths

The analysis points toward potential pathways for transformation, articulated in the recommendations of Chapter 13. But implementing these pathways requires Andalusian society – its political leadership, economic elites, and citizens – to confront several uncomfortable questions for which there are no purely technical answers:

Is the current agricultural model compatible with the climate future? If the honest answer is no – if subtropical fruit cultivation at current scales in the Axarquía is not viable under projected water availability – then what constitutes a just transition for farmers who made investment decisions based on state incentives and policy signals that encouraged expansion? Does justice require compensation for stranded assets? If so, who pays, and how?

Who should bear the costs of adaptation? The distributional question is unavoidable. Should costs fall on water users through higher tariffs, on taxpayers through subsidized transitions, on future generations through continued degradation, or on private investors through mandated upgrades? Each answer has implications for equity and for feasibility. Diffuse taxpayer funding is politically easier but may be perceived as unfair (subsidizing those who profited from unsustainability). Direct user costs are economically efficient but may drive small operators out of

business. The "do nothing" option offloads costs onto the future and onto ecosystems – the constituency with the least political power.

At what point does managing scarcity require managing growth? Can the Costa del Sol continue expanding tourism infrastructure and residential development while facing structural water deficits? If ecological limits impose absolute constraints, then planning must set limits on economic activity – a profound challenge to the growth-oriented development model that has driven regional prosperity for decades. Who has the authority and the political courage to say "no more" to development that is individually profitable but collectively unsustainable?

What coalition configuration can overcome the stabilizing forces? Individual actors cannot transform the system alone. Small farmers lack power. Environmental groups lack leverage. Municipalities lack authority over basin allocations. What bridging organizations or alliance structures could unite actors with diverse interests around a transformation agenda? What crisis threshold might shift cost-benefit calculations sufficiently to make powerful actors prefer change to the status quo? Research on social movements and transformative change in other contexts (Tilly, 2019) suggests that coalitions require: a crisis severe enough to break existing political equilibria, bridging actors who can translate between different stakeholder languages, and institutional entrepreneurs willing to challenge norms and take personal risks to build new governance arrangements. Are these conditions present or emerging in Andalusia, or must the situation deteriorate further before they coalesce?

Research on transformative change in socio-ecological systems suggests that overcoming stabilizing forces requires specific coalition configurations and institutional conditions (Aggarwal & Anderies, 2023). Analysis of the Andalusian case reveals a critical gap: the actors with greatest vulnerability and urgency for transformation – small and medium farmers facing economic precarity, rural communities experiencing depopulation, municipalities confronting supply crises, and environmental organizations witnessing ecosystem degradation – currently lack sufficient political leverage to force systemic change (Prieto et al., 2021; Peña-Rodríguez et al., 2023). Conversely, actors with the greatest political and economic power – large agricultural landowners, established irrigation communities, and tourism industry associations – benefit sufficiently from current arrangements that they actively resist transformation (Sánchez et al., 2023; Schütze, 2023).

The formation of a transformative coalition would likely require: (1) a crisis severe enough to shift cost-benefit calculations even for currently powerful actors, making the status quo untenable; (2) bridging organizations capable of translating between different stakeholder languages and interests, potentially including reformed participatory institutions or new civil society networks; and (3) institutional entrepreneurs willing to challenge established norms despite personal political risks (Tilly, 2019; Pahl-Wostl et al., 2020). The threshold at which these conditions might emerge remains uncertain. The question is not whether adaptation will occur – the biophysical constraints guarantee it – but whether it will be proactive and managed, or reactive and chaotic.

14.4. The Central Political Challenge

The answer to "why hasn't governance changed?" may ultimately be: **because no coalition powerful enough to force change has yet found it in their interest to form one.** The current configuration of interests, while producing unsustainable outcomes, has not yet created sufficient pain for enough actors to overwhelm the benefits that accrue to those with power. The governance failures documented in this report persist not despite the interests of powerful actors but, in many cases, because of them.

Transformation will require building a coalition that bridges: small farmers vulnerable to climate change who need transition support, municipalities facing supply crises who need reliable allocations, environmental organizations defending degraded ecosystems, and forward-thinking segments of agriculture and tourism who recognize that the current path leads to long-term business failure. Such a coalition does not currently exist in a politically effective form.

The technical toolkit for transformation exists, articulated in the recommendations of this report: volumetric caps to prevent rebound effects, progressive pricing to create conservation incentives, transition funds to eliminate the financial death valley, participatory reform to break the dominance of established interests, climate integration to force planning to confront biophysical reality. These are not mysteries. The mystery is the political pathway to implementing them.

This report concludes not with false optimism but with clear-eyed acknowledgment: achieving long-term water security in Andalusia is possible, but it requires political choices that no institution has yet been willing to make. It requires accepting that the region's economy must adapt to permanent scarcity rather than continuing to treat each drought as a temporary emergency requiring short-term coping. It requires confronting the reality that some current uses will need to

contract or transform, and designing mechanisms to make that contraction economically bearable and socially just. Most fundamentally, it requires political leadership willing to prioritize long-term resilience over short-term expediency, and civil society mobilization powerful enough to make that prioritization politically viable rather than politically suicidal.

The alternative – continuing on the current trajectory – is predictable: recurring crises of increasing severity, progressive degradation of natural systems, deepening inequalities as vulnerable actors are displaced, and eventual forced adaptation under conditions of acute crisis that will be far more disruptive and less just than proactive transformation would be. The choice is not whether to adapt, but whether to adapt proactively or reactively. The window for proactive adaptation is narrowing as the biophysical constraints tighten. How Andalusian society responds to this narrowing window will determine not only the future of its water systems but the broader question of whether democratic governance can effectively address long-term environmental challenges that require immediate costs for diffuse future benefits.

Glossary

- ***Acosol:*** *The public water utility serving the municipalities of the western Costa del Sol in Málaga.*
- ***Action Arena:*** *A core concept in the IAD framework representing the social space where actors interact, make decisions, and outcomes are generated.*
- ***CAP (Common Agricultural Policy):*** *The European Union's agricultural policy, a major financial driver of farming practices in Spain.*
- ***CHG (Confederación Hidrográfica del Guadalquivir):*** *The River Basin Authority for the Guadalquivir basin, a state-level body under MITECO.*
- ***CMA (Cuencas Mediterráneas Andaluzas):*** *The Andalusian Mediterranean Basins, a group of intra-community river basins managed directly by the Junta de Andalucía.*
- ***Comunidades de Regantes:*** *Irrigation Communities; long-standing, powerful local institutions that manage the distribution of irrigation water among farmers.*
- ***EMASA (Empresa Municipal de Aguas de Málaga):*** *The municipal public water utility for the city of Málaga.*
- ***FACUA:*** *A prominent Spanish non-governmental organization focused on consumer rights.*
- ***IAD (Institutional Analysis and Development) Framework:*** *A theoretical framework for analyzing how institutions (rules) affect the behavior of actors and the outcomes they produce.*
- ***Implementation Gap:*** *The discrepancy between the policies and plans as written and their actual execution and enforcement in practice.*
- ***IRBM (Integrated River Basin Management):*** *A water management paradigm that treats the entire river basin as the basic unit for planning and administration.*
- ***Junta de Andalucía:*** *The regional government of the Autonomous Community of Andalusia.*
- ***Latifundios:*** *Large agricultural estates, historically characteristic of the land ownership structure in southern Spain.*
- ***MITECO (Ministerio para la Transición Ecológica y el Reto Demográfico):*** *The Spanish Ministry for the Ecological Transition and the Demographic Challenge, the primary national body for environmental and water policy.*
- ***PEM (Plan de Emergencia Municipal):*** *Municipal Drought Emergency Plan; a local-level plan required for urban areas to manage drought response.*
- ***PES (Plan Especial de Sequía):*** *Special Drought Plan; a basin-level strategic plan mandated by national law to proactively manage drought risk.*

- ***RBMP (River Basin Management Plan):*** *A comprehensive plan, required by the WFD, that sets out long-term objectives for the management of a river basin.*
- ***Red Agua Pública:*** *The Andalusian Network for a New Water Culture, a key civil society advocacy group.*
- ***SEG (Socio-Ecological Governance) Framework:*** *The fused analytical framework developed for this report, combining the SES and IAD frameworks.*
- ***SES (Socio-Ecological Systems) Framework:*** *A theoretical framework for diagnosing the components and linkages in systems where humans and nature are intertwined.*
- ***WEFE (Water-Energy-Food-Ecosystem) Nexus:*** *An analytical approach that considers the interconnectedness of water, energy, food, and ecosystem security.*
- ***WFD (Water Framework Directive):*** *The cornerstone of the European Union's water policy (Directive 2000/60/EC), establishing a framework for the protection and sustainable management of all water bodies.*

References

1. Aggarwal, R. M., & Anderies, J. M. (2023). Understanding how governance emerges in social-ecological systems: insights from archetype analysis. *Ecology and Society, 28*(2), 2.

2. Albiac, J., Calvo, E., & Esteban, E. (2014). River basin governance and water policies in Spain. In *Water Security and Federal Rivers*.

3. Ali, E., et al. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Cross-Chapter Paper 4: Mediterranean Region]. Cambridge University Press.

4. Alvarez, J., et al. (2024). The Expansion of Subtropical Agriculture and Water Stress in Southern Spain. *Journal of Agricultural Water Management*.

5. Anandhi, A., & Alles, D. (2017). A Review of Drought Indices. *Journal of Hydrology*.

6. Andronic, C., et al. (2020). *Research for AGRI Committee – The challenge of land abandonment after 2020 and options for mitigating measures*. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

7. Bahadir, M., et al. (2025). Managed Aquifer Recharge as a Climate Adaptation Strategy. *Water Resources Management*.

8. Bednar-Friedl, B., et al. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Chapter 13: Europe]. Cambridge University Press.

9. Beniaich, A., et al. (2023). On the Propagation of Drought from Meteorology to Hydrology. *Hydrology and Earth System Sciences*.

10. Borras, S. Jr., Franco, J., & van der Ploeg, J. D. (2013). *Land concentration, land grabbing and people's struggles in Europe*. Transnational Institute.

11. Campos, P., et al. (2020). Economic Valuation of Water-Related Ecosystem Services in Spain. *Ecosystem Services*.

12. Cardenete, M. A., et al. (2024). The Economic Impact of Tourism in the Andalusian Economy. *Tourism Economics*.

13. Castillo, J. M. (2024). Myths, Falsehoods, Paradoxes, Errors and Virtual Water in Mediterranean Europe: The

Case of the Iberian Peninsula. *Athens Journal of Mediterranean Studies*.

14. COAG. (2023). *Informe de la Sequía y su Impacto en el Sector Agrario*. Coordinadora de Organizaciones de Agricultores y Ganaderos.

15. Duarte-Abadía, B., & Boelens, R. (2019). Colonizing rural waters: the politics of hydro-territorial transformation in the Guadalhorce Valley, Málaga, Spain. *Water International*.

16. El-Askary, H., & Li, J. (2020). *Mediterranean Basin Case Study*.

17. EMASESA. (2025). *Drought Management in Seville: A Historical Perspective*. Seville Metropolitan Water Supply and Sanitation Company.

18. European Parliament. (2000). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*.

19. European Parliament. (2014). *Resolution on the environmental situation in the Doñana National Park*.

20. Feyen, L., et al. (2020). *Drought in Europe: current status and future projections*. JRC Technical Reports, European Commission.

21. Florido-Benítez, L. (2024). The Priority of Water Consumption in the Spanish Tourism Industry: A Dilemma for Residents and Researchers. *Applied Sciences*.

22. García, J., et al. (2024). Land Subsidence Induced by Groundwater Over-Abstraction in Spanish Coastal Plains. *Engineering Geology*.

23. García-López, A., et al. (2025). Drought Management in Spain: From Planning to Practice. *Water Policy*.

24. Garrote, L., et al. (2007). Application of Drought Management Guidelines in Spain. *Water Resources Management*.

25. Gobierno de España. (2023a). *Real Decreto-ley 8/2023, de 27 de diciembre*. Boletín Oficial del Estado.

26. Gobierno de España. (2023b). *Real Decreto-ley 4/2023, de 11 de mayo*. Boletín Oficial del Estado.

27. González-Pérez, J., et al. (2024). Climate Projections for the Iberian Peninsula. *International Journal of Climatology*.

28. GOVAQUA. (2023). *Governance innovations for a transition to sustainable and equitable water use in Europe.* Policy Brief.

29. Grillakis, M. (2019). Increase in severe and extreme soil moisture droughts for Europe under climate change. *Science of the Total Environment*.

30. Hervás-Gámez, F., & Delgado-Ramos, F. (2019). Water Demands of Subtropical Fruit Cultivation in the Axarquía (Málaga, Spain). *Water*.

31. Hurtado, M., et al. (2024). Water Resource Conflicts in the Province of Málaga. *Conflict Studies Quarterly*.

32. Iglesias, A., et al. (2007). Climate change and agricultural vulnerability in Europe. *Global Environmental Change*.

33. Islem, B., et al. (2024). Water Governance and Conflict in Spain. *Journal of Environmental Policy & Planning*.

34. Janssen, M. A., & Ostrom, E. (2006). Governing Social-Ecological Systems. In *Handbook of Computational Economics* (Vol. 2, pp. 1465-1509). Elsevier.

35. Jefatura del Estado. (2001a). *Ley 10/2001, de 5 de julio, del Plan Hidrológico Nacional*. Boletín Oficial del Estado.

36. Jefatura del Estado. (2001b). *Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas*. Boletín Oficial del Estado.

37. Junta de Andalucía. (2020). *Plan Andaluz de Acción por el Clima (PAAC) 2021-2030*. Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible.

38. Junta de Andalucía. (2021). *Decreto 234/2021, de 13 de octubre, por el que se aprueba el Plan Andaluz de Acción por el Clima*. Boletín Oficial de la Junta de Andalucía.

39. Junta de Andalucía. (2022). *DECRETO 178/2021, de 15 de junio, por el que se aprueban los Planes Especiales de Sequía de las Demarcaciones Hidrográficas Intracomunitarias de Andalucía*.

40. Junta de Andalucía. (2024). *La Junta declara la situación de sequía severa en la demarcación del Guadalete-Barbate*. [Press Release].

41. Junquera, V., et al. (2024). The Energy Footprint of the Urban Water Cycle. *Energy Policy*.

42. Lazoglou, G., et al. (2024). Climate Change Impacts on Mediterranean Water Resources. *Hydrological Sciences Journal*.

43. Lizak, P. (2025). Socio-environmental Conflicts of Desalination in the Mediterranean. *Environmental Science & Policy*.

44. MAPA. (2023). *Informe Anual sobre el Control de Usos del Agua y la Lucha contra la Extracción Ilegal*.

Ministerio de Agricultura, Pesca y Alimentación.

45. MAPA. (2025b). *Economic Impact Assessment of the 2022-2024 Drought on the Spanish Agrifood Sector*. Ministerio de Agricultura, Pesca y Alimentación.

46. Márquez-García, A., et al. (2024). Hydro-climatological Analysis of Droughts in Málaga Province. *Journal of Arid Environments*.

47. Martin, C., et al. (2016). Long-term trends in the ecological status of Spanish rivers. *Science of The Total Environment*.

48. Marx, S. (2018). The Effectiveness of Water Conservation Campaigns. *Journal of Environmental Psychology*.

49. MedECC. (2024). *First Mediterranean Assessment Report*. Mediterranean Experts on Climate and Environmental Change.

50. Ministerio de Medio Ambiente. (2001b). *Libro Blanco del Agua en España*.

51. Ministerio de Medio Ambiente. (2007). *Real Decreto 907/2007, de 6 de julio, por el que se aprueba el Reglamento de la Planificación Hidrológica*. Boletín Oficial del Estado.

52. MITECO. (2020). *Plan Nacional de Adaptación al Cambio Climático (PNACC) 2021-2030*. Ministerio para la Transición Ecológica y el Reto Demográfico.

53. MITECO. (2022). *Plan Hidrológico de la Demarcación Hidrográfica de las Cuencas Mediterráneas Andaluzas 2022-2027*. Ministerio para la Transición Ecológica y el Reto Demográfico.

54. Moreno et al. (2022). The Political Ecology of the Tajo-Segura Water Transfer. *Political Geography*.

55. Moreno-Ortega, R. (2019). The Public Domain of Water in Spain: A Historical-Legal Analysis. *Water History*.

56. Nieto, R., et al. (2021). *Estudio Ambiental Estratégico del Plan Andaluz de Acción por el Clima*.

57. Noguera, J., et al. (2022). Linking Land Use Planning and Water Demand in Coastal Spain. *Land Use Policy*.

58. OECD. (2023). *Environmental Tax Policy Review of Andalusia*.

59. OECD. (2025). *Global Drought Outlook: Trends, Impacts and Policies to Adapt to a Drier World*.

60. Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325*(5939), 419-422.

61. Pahl-Wostl, C., et al. (2020). Enhancing the capacity of water governance to deal with complex management

challenges: A framework of analysis. *Environmental Science and Policy*.

62. Paneque, P., et al. (2009). Participative multi-criteria analysis for the evaluation of water governance alternatives. A case in the Costa del Sol (Málaga). *Ecological Economics*.

63. Paneque, P., et al. (2018). Public Attitudes toward Water Management Measures and Droughts: A Study in Southern Spain. *Water*.

64. Pedregal, B., et al. (2020). Promoting Environmental Justice through Integrated Mapping Approaches: The Map of Water Conflicts in Andalusia (Spain). *ISPRS International Journal of Geo-Information*.

65. Peña-Rodríguez, F. J., Entrena-Durán, F., Ivorra-Cano, A., & Llorca-Linde, A. (2023). Changes in Land Use and Food Security: The Case of the De La Vega Agrarian Shire in the Southern Spanish Province of Granada. *Land, 12*(4), 747.

66. Peñuelas, J., et al. (2018). Assessment of the impacts of climate change on Mediterranean terrestrial ecosystems based on data from field experiments and long-term monitored field gradients in Catalonia. *Environmental and Experimental Botany*.

67. Pérez-Blanco, C. D., & Gómez, C. M. (2014). Drought management plans and water availability in agriculture: A risk assessment model for a Southern European basin. *Weather and Climate Extremes*.

68. Prieto, A., et al. (2021). Territory in conflict: land dispossession, water grabbing and mobilization for environmental justice in southern Spain. *International Journal of Water Resources Development*.

69. Qiu, Y., et al. (2024). Future risk of multi-year droughts in a warming world. *Nature Communications*.

70. Ricart, S., et al. (2023). Socio-political dynamics of water reuse for irrigation. *Journal of Rural Studies*.

71. Ricart, S., et al. (2024). Governance Challenges of Integrating Non-conventional Water Resources. *Water Alternatives*.

72. Ruffault, J., et al. (2013). Differential regional responses in drought length, intensity and timing to recent climate changes in a Mediterranean forested ecosystem. *Climatic Change*.

73. Ruiz, M., et al. (2015). Sustainable Drainage Systems for Stormwater Management in Mediterranean Cities. *Water Science and Technology*.

74. Sánchez, J. (2007). The 'Hydraulic Paradigm' in Spanish Water Policy. *Historical Social Research*.

75. Sánchez, C. A., et al. (2023). *Smart water management in Europe: lessons from Spain – Frugality, adaptation, mitigation and resilience*. IDDRI.

76. Sanchis-Ibor, C., et al. (2022). Water allocation in Spain. Legal framework, instruments and emerging debates. In *Water Allocation*.

77. Santos, E. (2025). Thirst for Change in Water Governance: Overcoming Challenges for Drought Resilience in Southern Europe. *Water*.

78. Schmidt, G., et al. (2023). *Stock-taking analysis and outlook of drought policies, planning and management in EU Member States*. European Commission.

79. Schütze, N. (2023). *Polycentric Water Governance in Spain: Understanding Determinants, Patterns, and Performance of Coordination*.

80. Schütze, N., et al. (2020). *Strengthening Coordination in River Basin Governance in Southern Spain – Cooperation, Incentives and Persuasion*. German Development Institute.

81. Schütze, M. (2025). Public Participation and the EU Water Framework Directive in Spain. *Journal of Environmental Law*.

82. Stahl, K., et al. (2016). Impacts of European drought events: insights from an international database of text-based reports. *Natural Hazards and Earth System Sciences*.

83. SWM. (2024). *Water Management in Spain and Ongoing Investments*. Smart Water Magazine.

84. Tanasijevic, L., et al. (2014). Impacts of climate change on olive crop evapotranspiration and irrigation requirements in the Mediterranean region. *Agricultural Water Management*.

85. Tapia, F. J. B., Díez-Minguela, A., Martinez-Galarraga, J., & Tirado-Fabregat, D. A. (2021). *The roots of land inequality in Spain*. Working Papers in Economic History.

86. Thiel, A. (2014). Developing an analytical framework for reconstructing the scalar reorganization of water governance as institutional change: The case of Southern Spain. *Ecological Economics*.

87. Tilly, C. (2019). Social Movements, 1768-2004. Routledge.

88. Toreti, A., et al. (2025). *Drought in Europe: June 2025*. GDO Analytical Report, European Commission.

89. Tramblay, Y., et al. (2019). Drivers of hydrological drought in the Mediterranean. *Climate Dynamics*.

90. Tsiakiris, R., et al. (2024). Economic Impacts of Drought on Mediterranean Agriculture. *Agricultural Economics*.

91. Vargas, J. (2013). El cambio climático y el problema de la sequía en Andalucía. *Actas de las Jornadas Internacionales Medios de Comunicación y Cambio Climático*.

92. Vargas, J. (2020). Análisis sobre el cumplimiento de los Planes de emergencia por sequía para abastecimientos urbanos en Andalucía. *Cuadernos Geográficos*.

93. Vargas, J., et al. (2021). Drought-related media analysis from Andalusia and São Paulo. *Journal of Arid Environments*.

94. Vargas, J., & Paneque, P. (2024). *Transición hídrica. Hacía una lógica de entender y gestionar el agua*.

95. Vargas, J., & Paneque, P. (2025). *Drought policy and Governance in Spain. New tools and remaining challenges*.

96. Vélez-Nicolás, M., et al. (2022). Precipitation Variability and Drought Assessment Using the SPI: Application to Long-Term Series in the Strait of Gibraltar Area. *Water*.

97. Vicente-Serrano, S. M., et al. (2020). The growing role of reference evapotranspiration in global drought. *Science*.

98. Vicente-Serrano, S. M., et al. (2021). Attribution of a recent major drought in the Western Mediterranean. *Environmental Research Letters*.