

BRINGING THE RAIN BACK TO SPAIN

Pilot project proposal at Almería for water cycle restoration

TIDAL RECONNECTION

INFILTRATION

WATER BEGETS WATER

EVAPOTRANSPIRATION

Summary

Climate change is putting pressure on societies, and it’s made worse by how we use land. Humanity has damaged key ecosystems, making areas more vulnerable to heat, drought, and floods, creating a dangerous cycle of climate impacts.

The proposal: a pilot project to spray saltwater at the coast in order to evaporate moisture in the air during summer. The sea breeze will blow the moisture plume into the mountains, where orographic lift will cause additional rainfall.

With the additional rain vegetation can be restored. More vegetation will lead to more evapotranspiration, trigger more summer rain events and improve overall climate and water resilience in the region.

Potential result: We expect that to increase annual rainfall with 30-40 mm in year 1 to +300 mm in year 20 (total annual rainfall is ~600-800 mm, as currently there is 300-500mm in the nearby mountains).

Economic benefit to local horticultural economy: The saltwater evaporation will cool the air around the existing horticultural business at Almería by an average of 4°C and increase humidity to 70–80%. This leads to cost savings in freshwater use and/or extends the growing season.



Beyond emissions: The water cycle is the missing lever

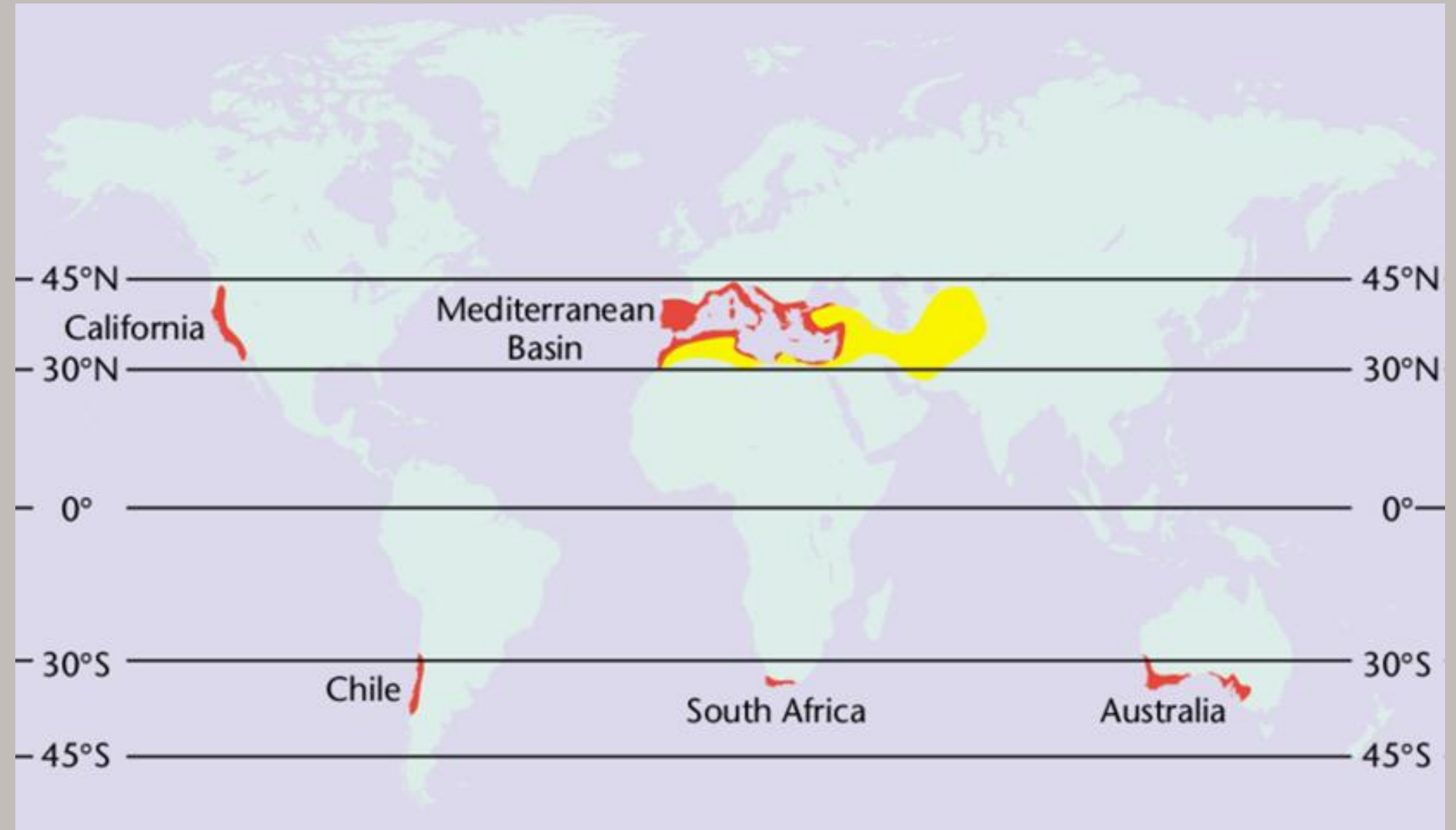


Climate change manifest strongly in mediterranean-type climates

Especially countries within Mediterranean-type climates are facing the impact of climate change.

Severe heat waves, prolonged droughts, high water stress, and increasing wildfires are already being felt today and are projected to worsen in the future.

Overall well-being, water security, and agricultural and tourism businesses are under threat.



Spain's heat, drought, fire, flood answered by the Climate Pact



**Pacto de Estado frente a la
emergencia climática**
Propuesta del Gobierno de España

**POR UN PACTO DE STADO
FRENTA A LA EMERGENCIA CLIMÁTICA**



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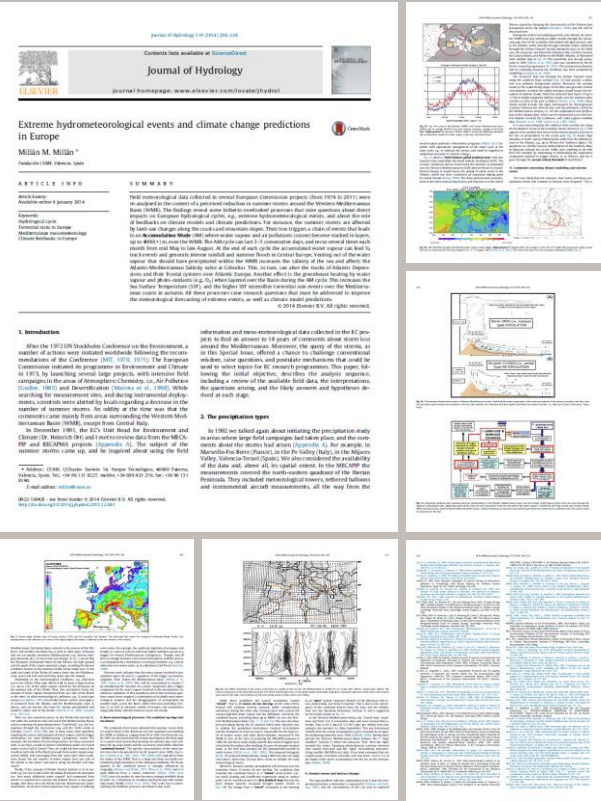
WHAT CAN WE DO IN SPAIN?

Why Southern Spain's water cycle matters

The late Millán M. Millán (1941–2024) former Director of CEAM and EU climate advisor showed how land-use change, layered on warming, disrupts Mediterranean rainfall.

His Valencia studies traced the chain: lost vegetation → loss of evapotranspiration → fewer summer rain events → longer droughts and frequenter flash-flood extremes.

Understanding this mechanism is the key to restoring resilience in southern Spain.

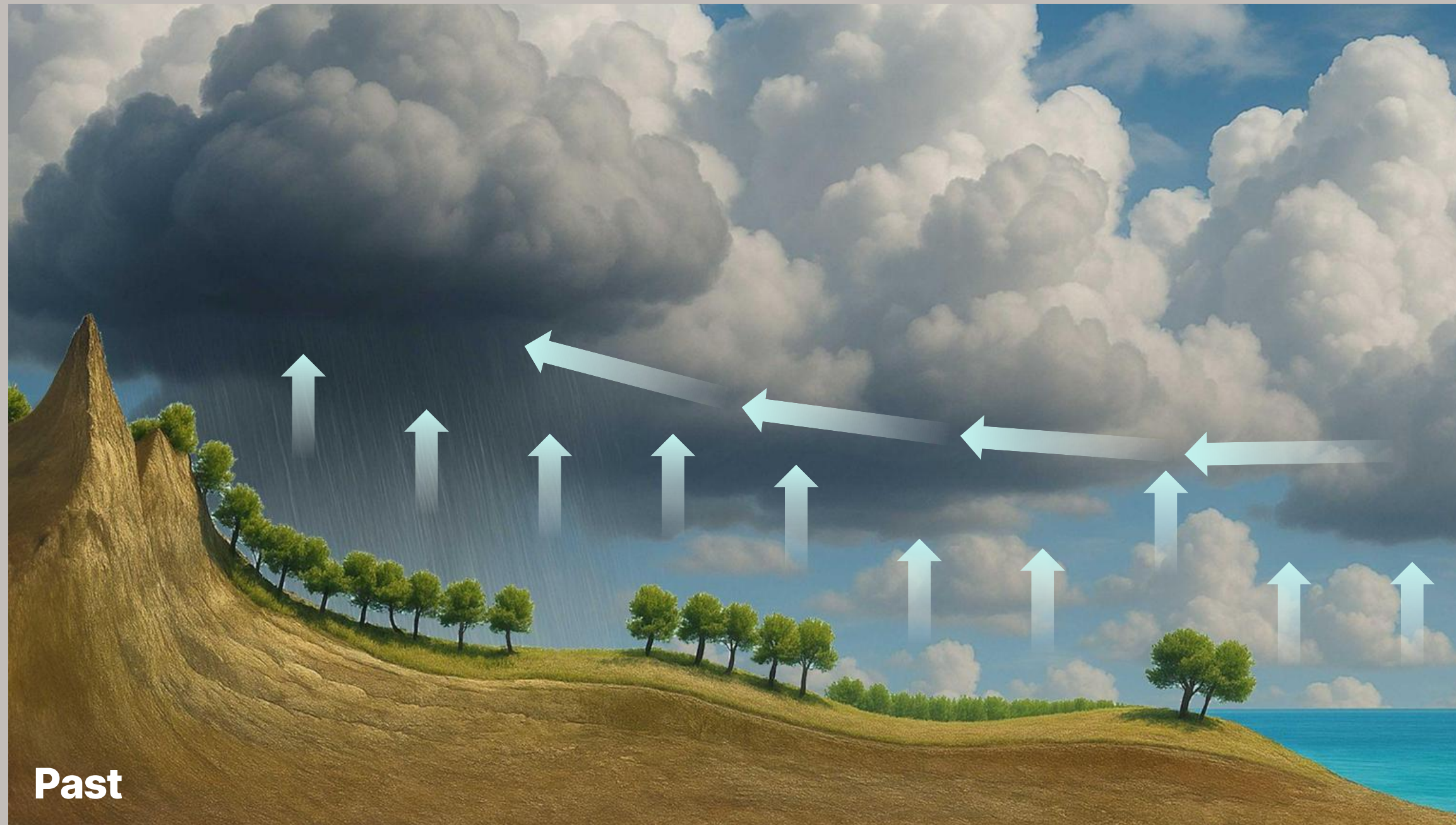


<https://doi.org/10.1016/j.jhydrol.2013.12.041>



Millán Muñoz Millán (1941 – 2024)
Former director of the Mediterranean Environmental Studies Centre (CEAM) and advisor on climate change for the European Union

Lessons from Millán Millán



During summer there is a standard humidity of the air at sea. During the day, when the land warms by the sun, a sea breeze starts to blow the moist air into the land.

Over land more moisture is added to the air through evapotranspiration and at the same time cools the air. Due to the mountains relatively close to the coast, the air rises and further cools down until condensation and rain occurs.



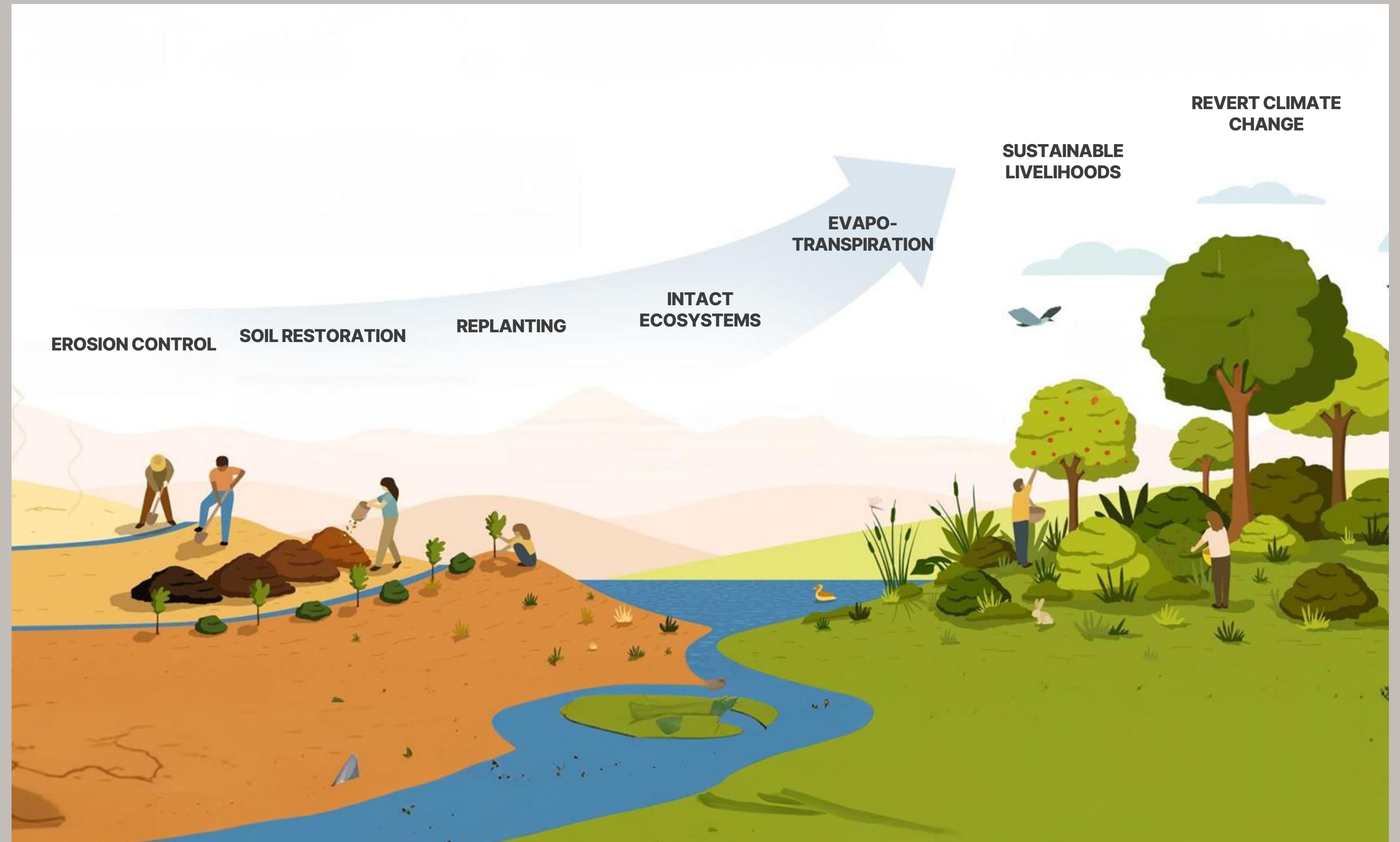
Still there is standard humidity of the air at the sea and still the land warms by the sun during the day and drives the sea breeze into the land.

But there is insufficient evapotranspiration due to land use changes, like deforestation, destruction of wetlands. Cloud condensation and rain do not regularly occur anymore. Millán Millán demonstrated that the moist air causes extreme weather events elsewhere in Europe. As a result, groundwater levels drop and further drying and erosion occurs, intensifying the effects.

The solution is in theory utterly simple..

We need to make the land transpire again, such that rain can return and the land restored!

Ecosystem restoration at the right locations is a way to increase evapotranspiration again and reverse the downward spiral...



But ecosystem restoration on a landscape scale is not taking off...

Financial challenges

- Non-traditional business case: delayed or non-linear benefits with long timelines mean slow financial returns
- Large initial investments for infrastructure, planning, testing, and stakeholder engagement.
- High monitoring and Verification Costs

Social challenges

- Long time horizons vs. short-term needs
- Local resistance or mistrust
- Uneven distribution of benefits
- Land tenure and governance Issues
- Cultural and identity impacts
- Job displacement or labor transitions

Ecological challenges

- Ecosystem complexity and unpredictability
- Vulnerability to invasive species
- Degraded Soils and Low Fertility
- Water Availability and Salinity Risks
- Loss of Native Biodiversity
- Mismatch Between Historical and Current Conditions
- Fragmentation and Edge Effects
- Time Lag for Recovery

Knowledge gaps

- Lack of Awareness or Understanding
- Difficulties in quantifying and monetizing benefits like biodiversity, reduced damage costs, carbon credits mechanisms, or payment-for-ecosystem-services
- Lack of references for long term outcomes and or feedback loops



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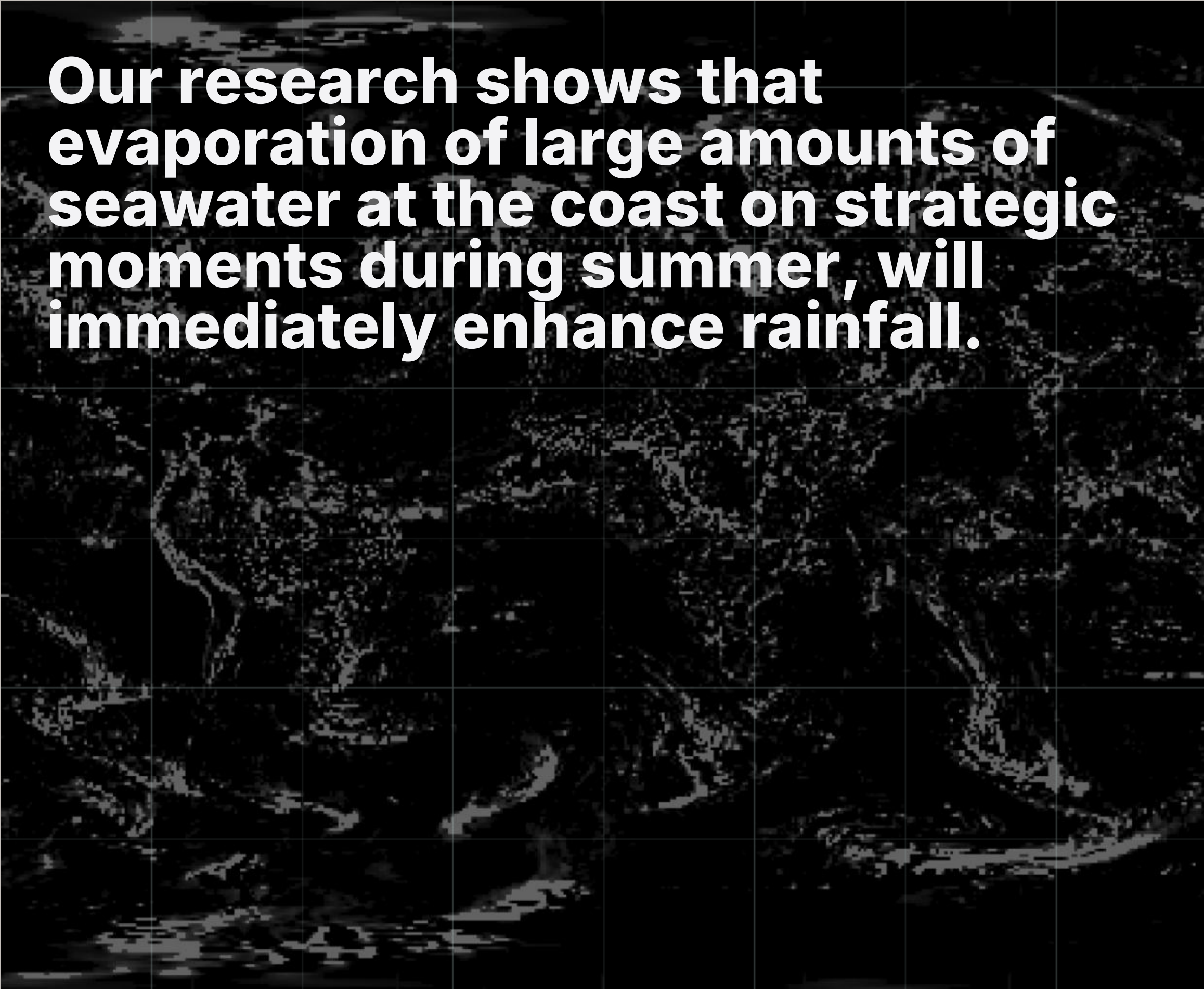
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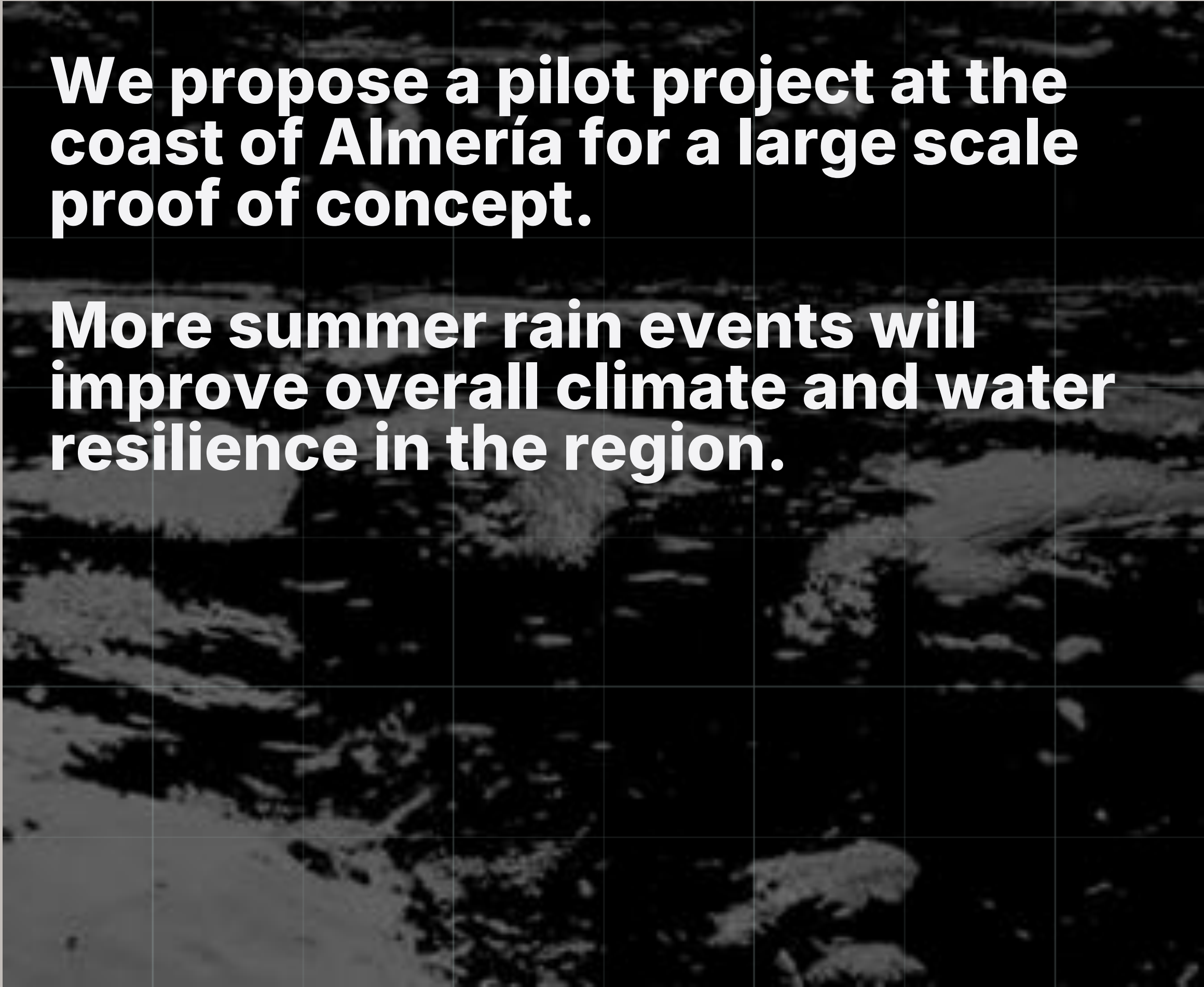
EVAPOTRANSPIRATION

PILOT PROJECT PROPOSAL FOR A NEW PERSPECTIVE

Strategic evaporation: trigger rain, restore water cycles



Our research shows that evaporation of large amounts of seawater at the coast on strategic moments during summer, will immediately enhance rainfall.



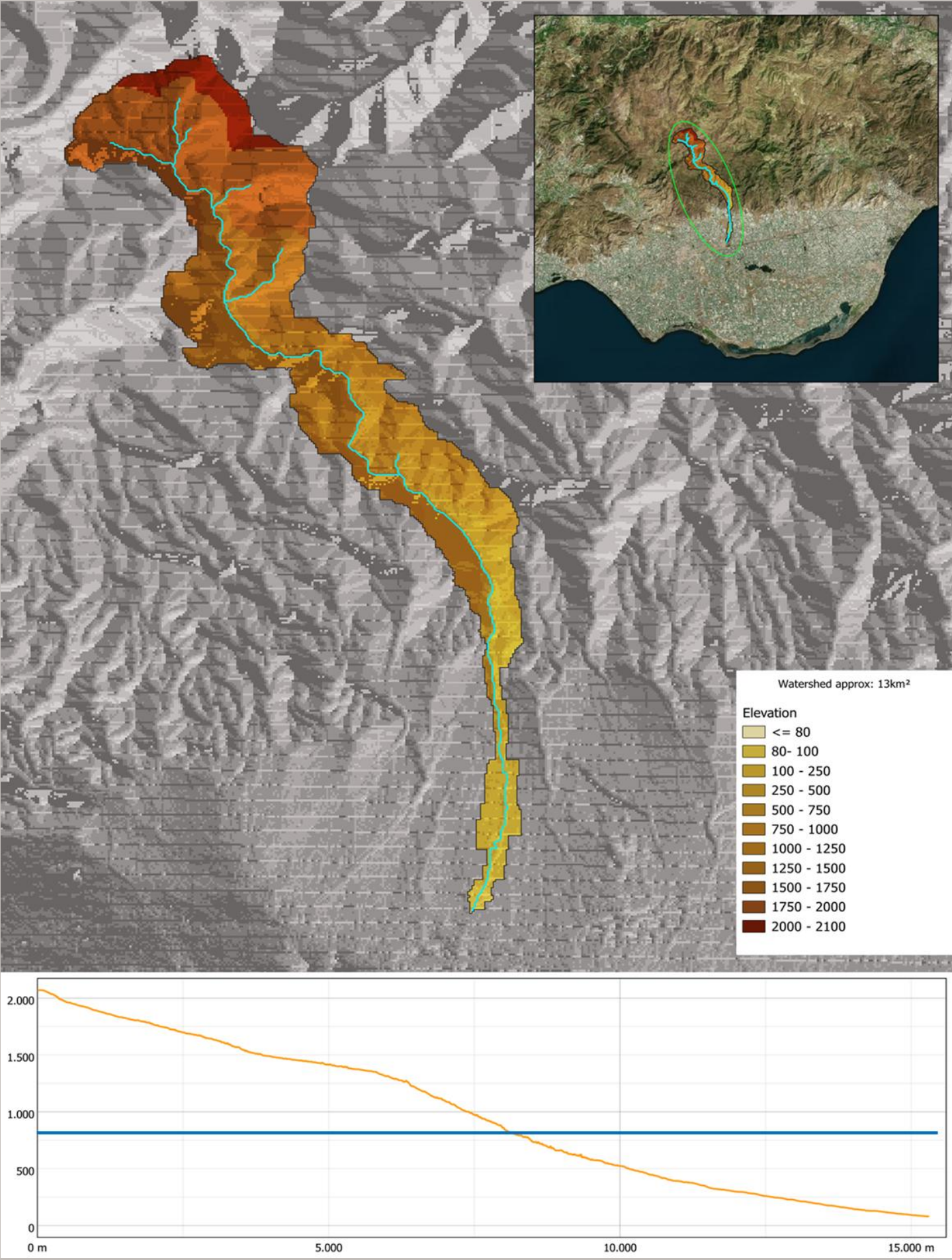
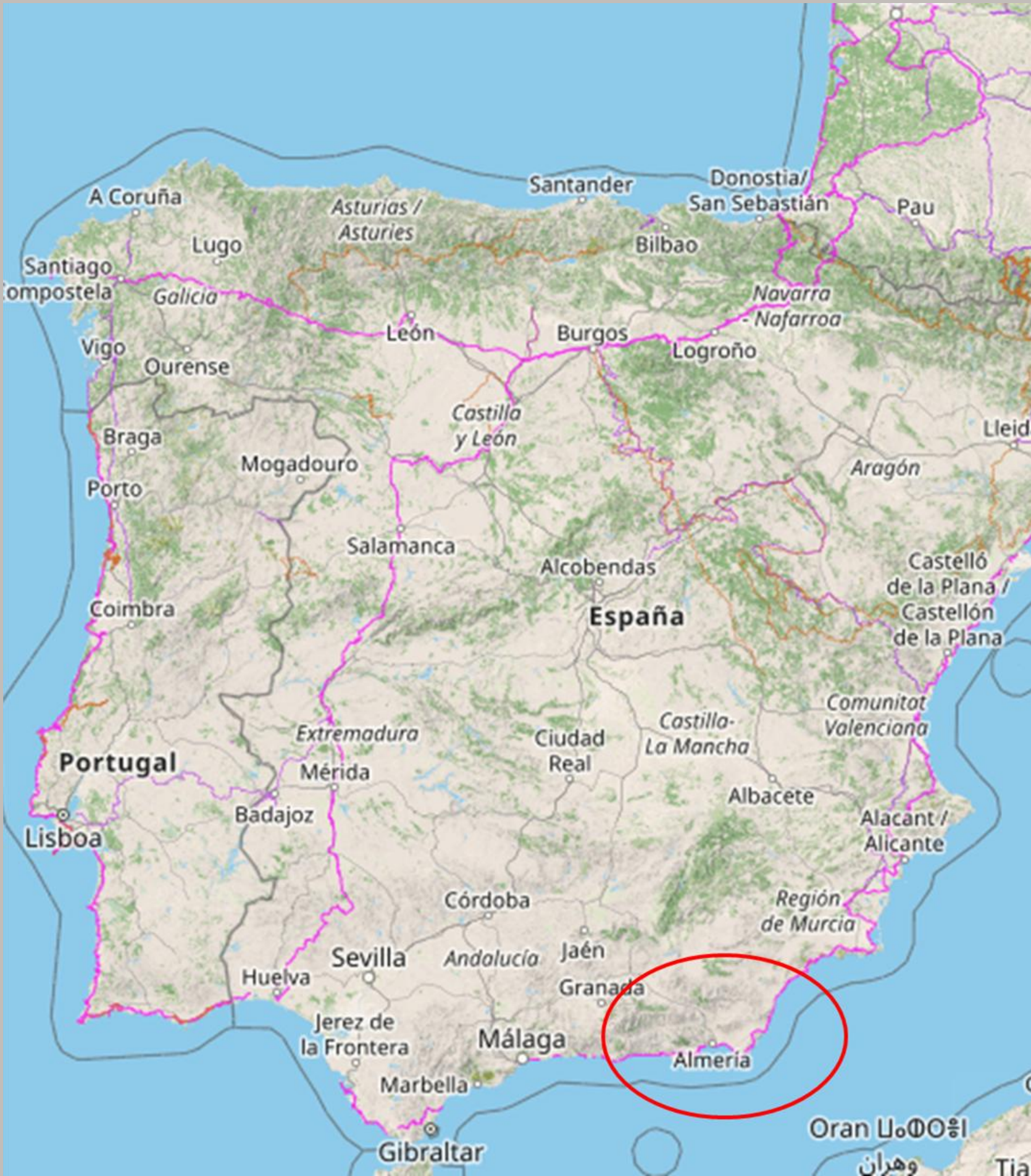
We propose a pilot project at the coast of Almería for a large scale proof of concept.

More summer rain events will improve overall climate and water resilience in the region.

The perfect location

We found the perfect location near Almería. Only 25 km distance between coast and mountains with an elevation above 2000m.

The same geo-climatic system prevails here as the one Millán Millán studied near Valencia.





32,000 hectares of greenhouses are the results of massive land use change.

Summer rain events drastically decreased over the last decades.



The pilot

The pilot would entail multiple sea-spray installation at the coast, near the lagoon

Seawater is evaporated by spraying; the freshwater moisture is carried inland by the sea breeze.

Rain will form in the mountains, where more water will fall than was added through evaporation.

The salt remains in the sea and has negligible effect on its salt concentration.

The area has sufficient infrastructure, such as drainage channels and reservoirs, to manage the rain.

Large-scale evaporation of seawater will directly reduce temperatures at the coast, providing benefits to:

- local horticultural businesses: heat stress is reduced, growth season can be extended and costs can be saved;
- inhabitants: heat waves are mitigated leading to improved well-being.

The methodology can in the future be optimized by additional evaporation of water further inland at set times to generate even more rain.



Conclusions

We propose to setup a pilot project of large-scale evaporation near Almería to bring back rain events

The concepts of large scale strategic evaporation can be demonstrated at this location against relatively low costs and local horticultural business directly benefit

Rain will add freshwater to the system and mitigate the negative impacts from climate change: a new future is born

The potential is enormous research shows that this could work in all regions worldwide with a Mediterranean climate.



Plan of approach

PHASE 1 Month 0-6

Lab testing & stakeholder engagement

Lab test with 1 katabatic tower (10 m tall) at representative greenhouse:

- Includes 1 atomizer (max 150l/min)
- Includes 1 centrifugal vaporizer
- Includes MVP of operational control software
- Includes monitoring (RH, temperature, wind speed crop yield)

Stakeholder engagement

- Communication
- Engagement meetings
- Capacity building

PHASE 2 Month 6-12

Field testing, validation & design

Lagoon test:

- 5 atomizers (max 750 l/min total)
- Lagoon: 0.2 × 0.5 km
- Potentially cools 10 ha of greenhouses
- Dams capture 50% of rainfall (165,000 m³ in year 0), with 20% reuse (33,000 m³)
- 20 IoT sensors (NDVI, rainfall)

Validation & design

- Model calibration
- Proof of concept design

Stakeholder engagement

- Continues

PHASE 3 Year 1 - 3

Proof of concept, governance

Scale up of 70 atomizers:

- (lagoon + katabatic towers), 1260 l/s total
- Expected additional rainfall: +30–40 mm/year
- +20% greenhouse yields, +15–25% vegetation increase
- Environmental impact assessment

Governance

- Institutional frameworks
- Legal frameworks
- Financial model

PHASE 4 & 5 Year 3 - 20

Upscaling and ecological restoration

Valley Integration with hydro dams

- Atomizers near dams (250–700 m), fog nets if required;
- Rainfall increase: +75 mm in year 10, +221 mm in year 15
- Vegetation increase: +50–60%, groundwater +20%
- Potential carbon credits

Ecological Restoration & Convective Rain

- Valley regeneration, infiltration basins as needed
- Thunderstorms: 5–8 per year (+25–50 mm per season)
- Rainfall increase: +300 mm by year 20 (total ~700–900 mm)
- Vegetation +50–60%, biodiversity +25%, groundwater +20%



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Advanced Strategic Evaporation Consortium

CATABATICS



Catabatics is one of the research and development partners of the Consortium.

Our mission is to contribute to the protection, defence, promotion, conservation, and preservation of the environment. Catabatics believe strongly that Nature Based Solutions are an answer to the climate crisis.

In this respect we have developed techniques of enhanced evaporation.

WETSUS & WUR & UU



Wetsus, Europe's centre of excellence for sustainable water technology, is the science partner of the Consortium.

We unite companies, universities and public bodies in a trusted innovation community, delivering peer-reviewed research, PhD talent and world-class labs to turn ideas into validated pilots accelerating breakthrough water-cycle solutions from bench to field, and at scale.

THE WEATHER MAKERS



The Weather Makers is one of the research and development partners of the Consortium.

We work with nature to develop solutions that regenerate landscapes, restore water cycles, and create thriving environments for biodiversity and communities. TWM aims at fostering economic growth, environmental sustainability, and social development by consolidating knowledge and scaling up efforts to maximize the impact on ecological regeneration, water cycle restoration and build a sustainable, secure future

WEATHER MAKERS FOUNDATION



Weather Makers Foundation is a nonprofit catalyst for large-scale ecological regeneration and the initiator of the Consortium.

We convene scientists, policymakers, farmers, engineers and investors to design, pilot and scale water-cycle solutions that cool places, revive ecosystems and strengthen community resilience. From deserts to city streets, we turn evidence into action fast, measurable, financeable, and globally replicable today.

Advanced Evaporative Cooling

Turning sea breeze into rain. Cooling landscapes, growing yields.

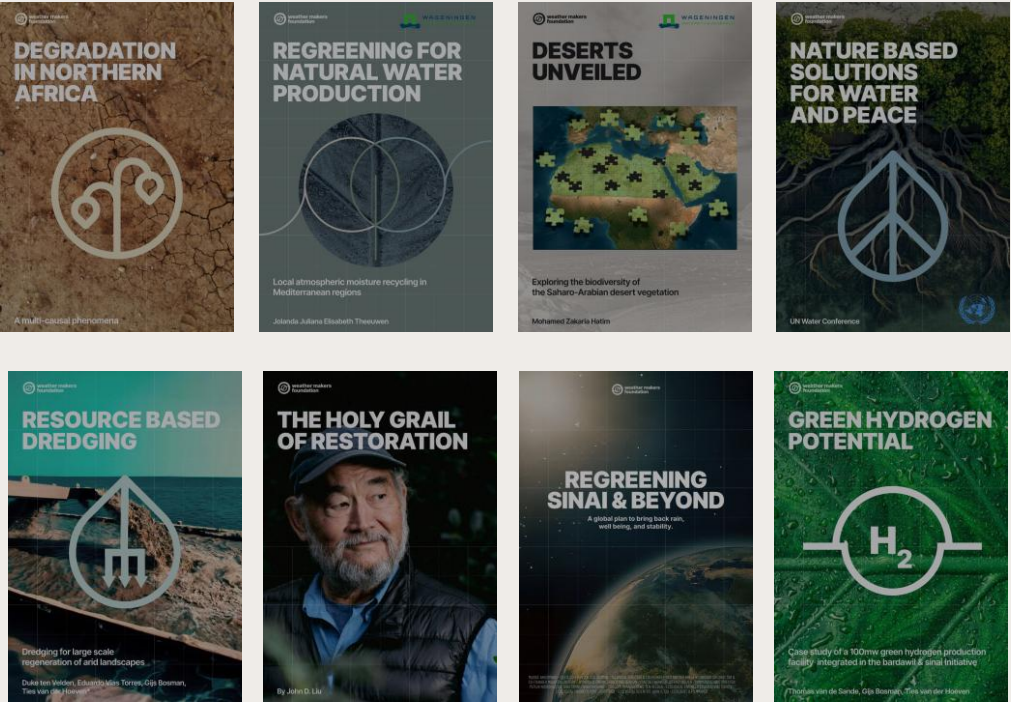
We mist seawater along the coast; only the fresh fraction evaporates while salt returns to the sea.

The sea breeze carries this cool, humid air inland, where it rises over hills and mountains, forms clouds, and releases rain often exceeding the water we added as vapor.

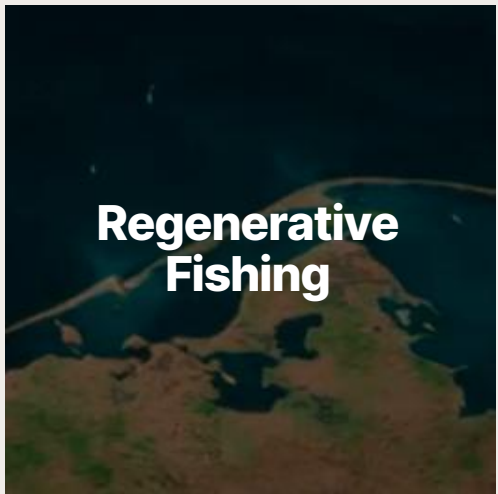
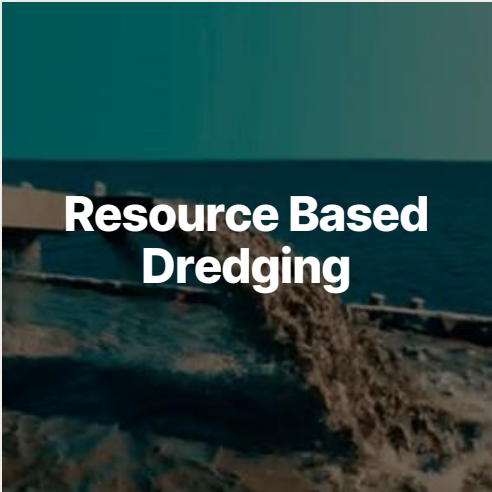
Existing drains, canals, and reservoirs capture and manage the rainfall, while large-scale evaporation cools the area, cutting heat stress and boosting agricultural yields.

When conditions align, timed freshwater misting farther inland can further amplify cloud formation and rainfall.

RESEARCH



TECHNOLOGY



PILOTS



Dedicated research WETSUS theme 'Natural Water Production'

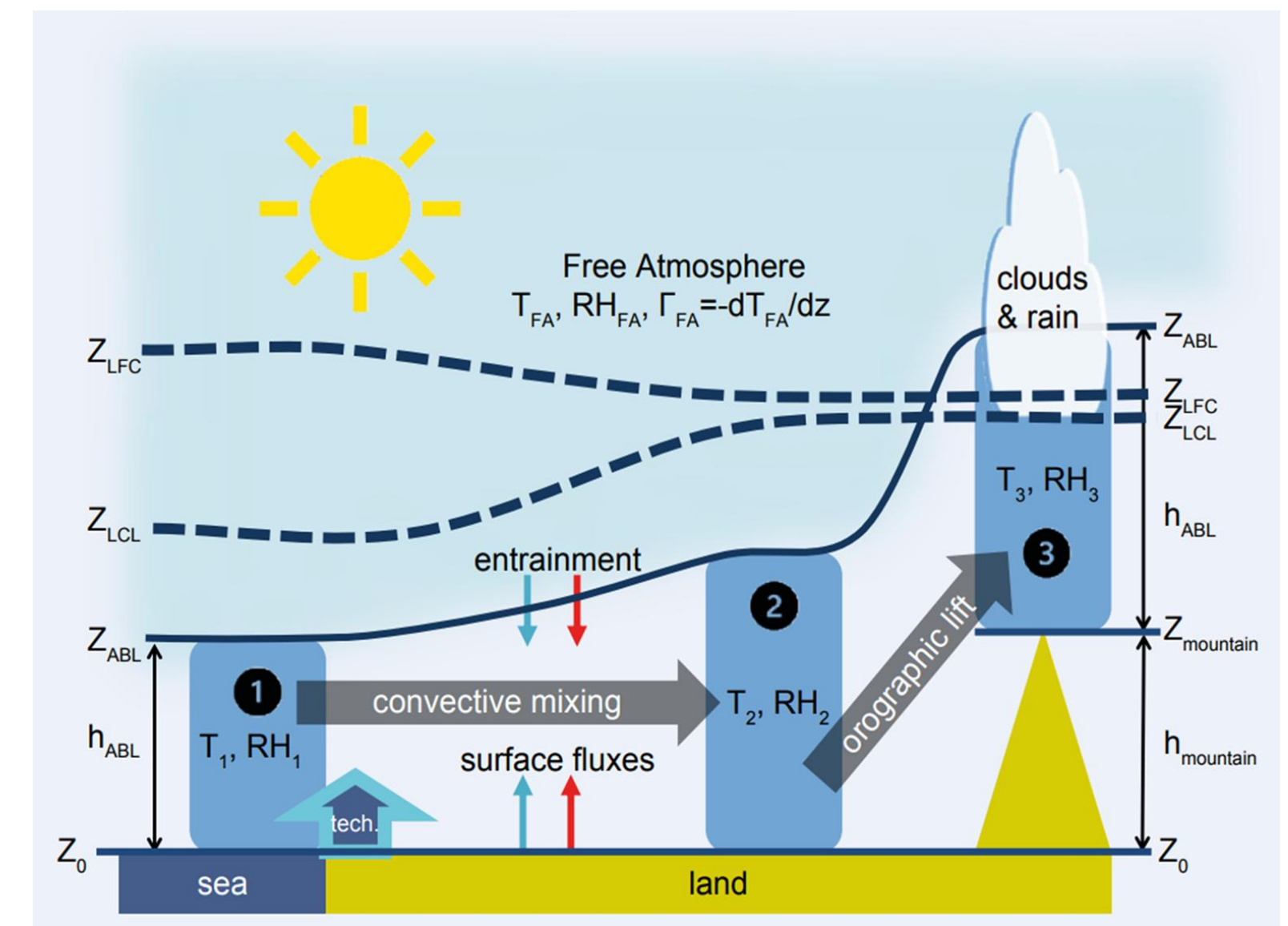
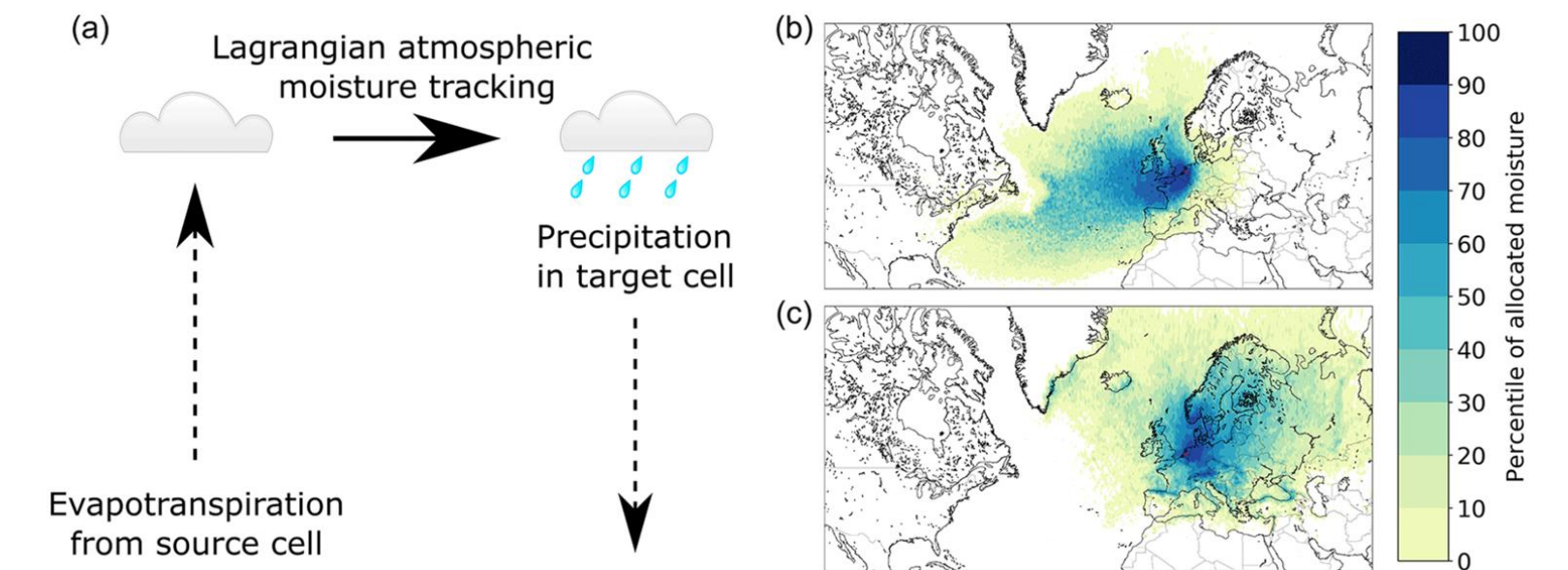
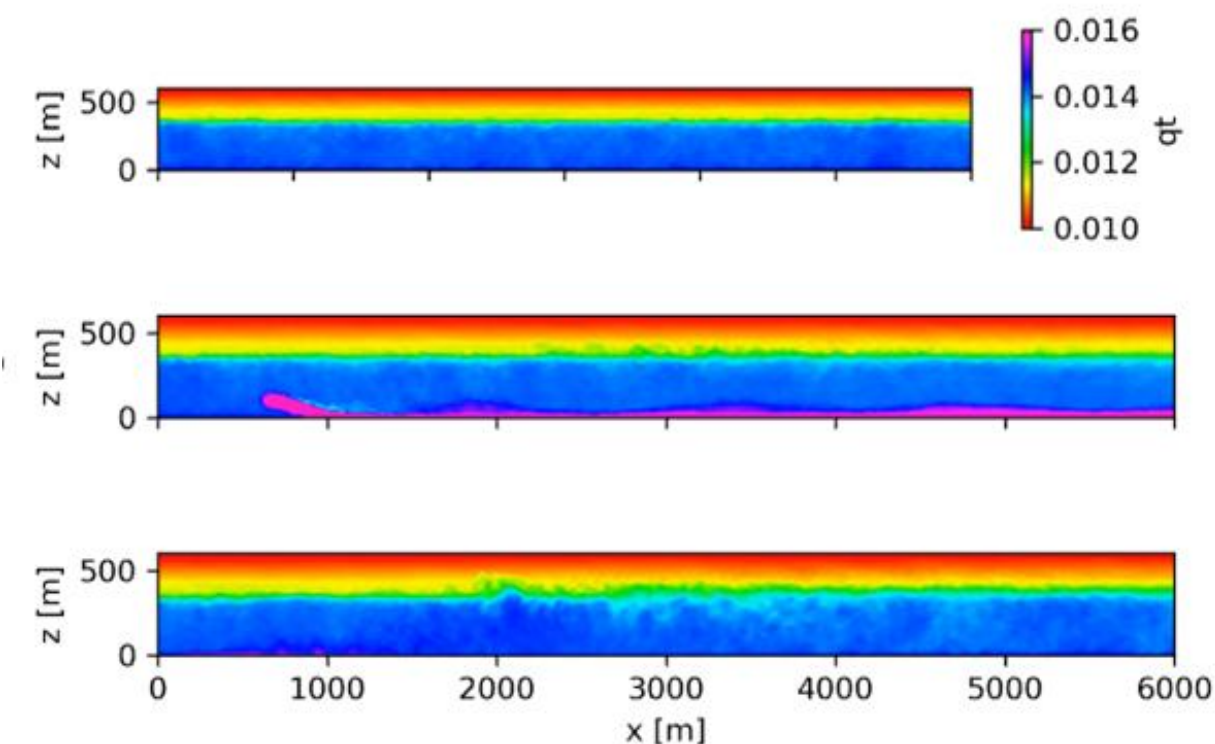
Over the past decade, we have developed an integrated strategy that unites cutting-edge science with practical engineering to regenerate local water cycles.

While traditional atmospheric models focus on weather, climate, or small-scale technologies, what was missing were tools specifically tailored for water cycle restoration.

These models have been tested, calibrated, and published in scientific research. They form a proven concept that scales from pilot sites to regional application, guiding where and how to intervene for maximum impact.

- We use moisture tracking models to analyse the local water cycle dynamics
- We developed Boundary Layer Models in which we determine the Atmospheric Boundary Layer (ABL) and the Lifted Condensation Level (LCL)
- We developed a 1D Turbulence Model to capture small scale dynamics
- We developed a 2D Machine Learning to validate predictions with true-ground data.

<https://www.wetsus.nl/research-themes/natural-water-production/>



Spain is leading the way, reversing the Global Climate Crisis

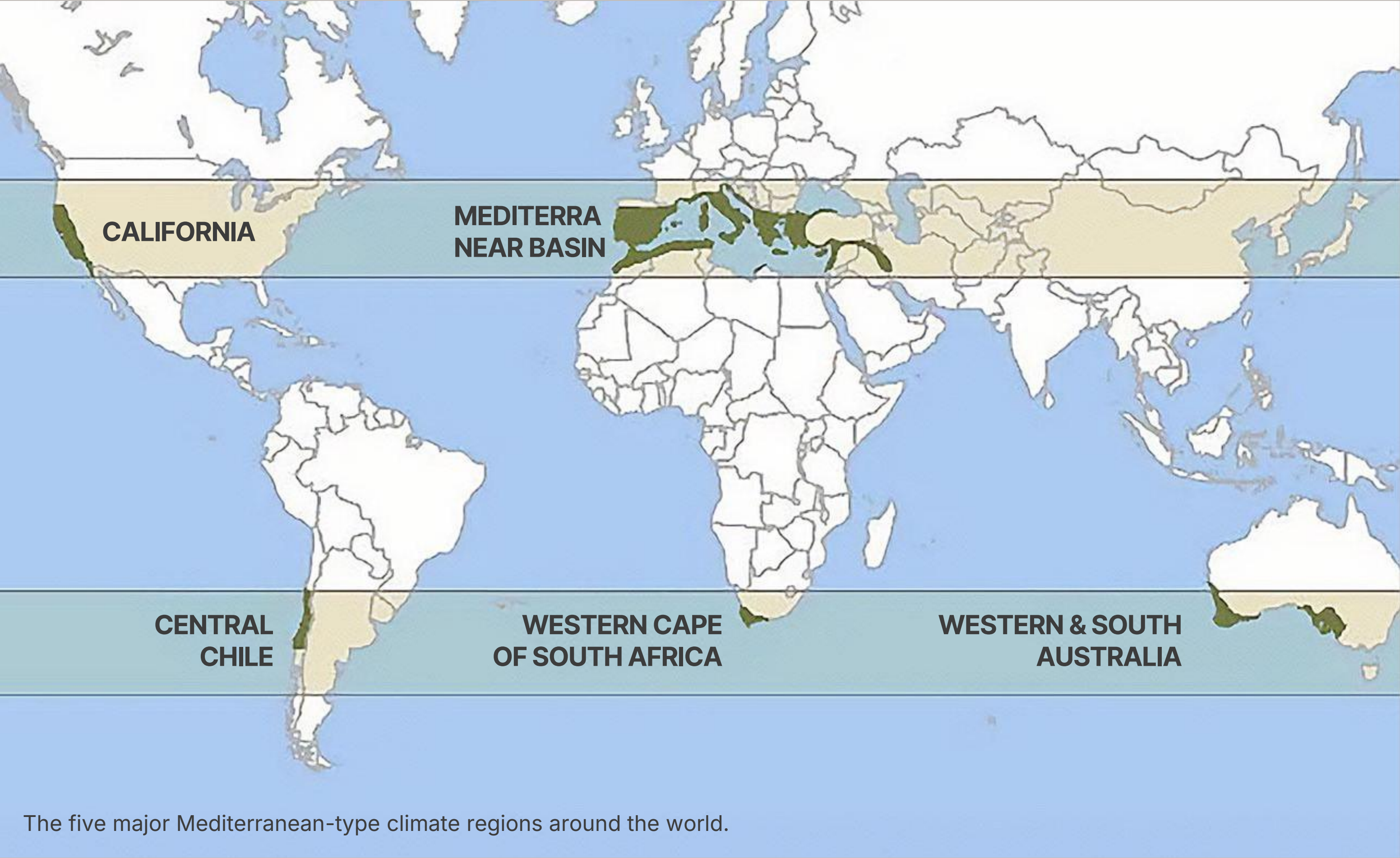
The potential is enormous: research shows that this could work in all regions worldwide with a Mediterranean climate.

Local moisture recycling is the process by which evaporated water returns as precipitation over land.

Research demonstrate that Mediterranean-type climate regions are particularly suitable for strategic evaporation to enhance local rainfall.

Recycling is highest in coastal and mountainous areas.¹

1) Theeuwes, J. J. E. (2025). Regreening for natural water production: Local atmospheric moisture recycling in Mediterranean regions. [Doctoral thesis 1 (Research UU / Graduation UU), Universiteit Utrecht]. Utrecht University. <https://doi.org/10.33540/295>





Weather Makers Foundation

Restoring water cycles on a large scale takes teamwork. Contact us today to explore how we can join forces to rejuvenate our ecosystems.

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