SALAM-MED sustainable approaches to land and water management in mediterranean drylands

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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Outscaling of Salam Med Technologies for sustainable land and water management in the Mediterranean

KEY MESSAGES

1. Increasing climate variability undermines water-harvesting systems' reliability, persistent overgrazing continues to degrade drylands, and soil acidification poses a significant challenge to forage systems, though soil amendments can effectively restore productivity.
2. Across all LLs, communities and farmers show a clear preference for low-cost, nature-based and indigenous knowledge solutions and expressed strong interest in digital monitoring tools
3. Stakeholders emphasized the need for training, technical support, and service-based delivery models.
4. All LLs acknowledged that technical, economic, and sociocultural barriers to innovation adoption remained, with behavioural change proving to be a long-term process.
5. Financial support is key for the implementation and maintenance of water-management and sensor-based monitoring systems
6. While locally focused, SALAM-MED LLs demonstrated significant po-tential for regional scaling to similar socio-ecological systems with some project's approaches already applied at wider scale.

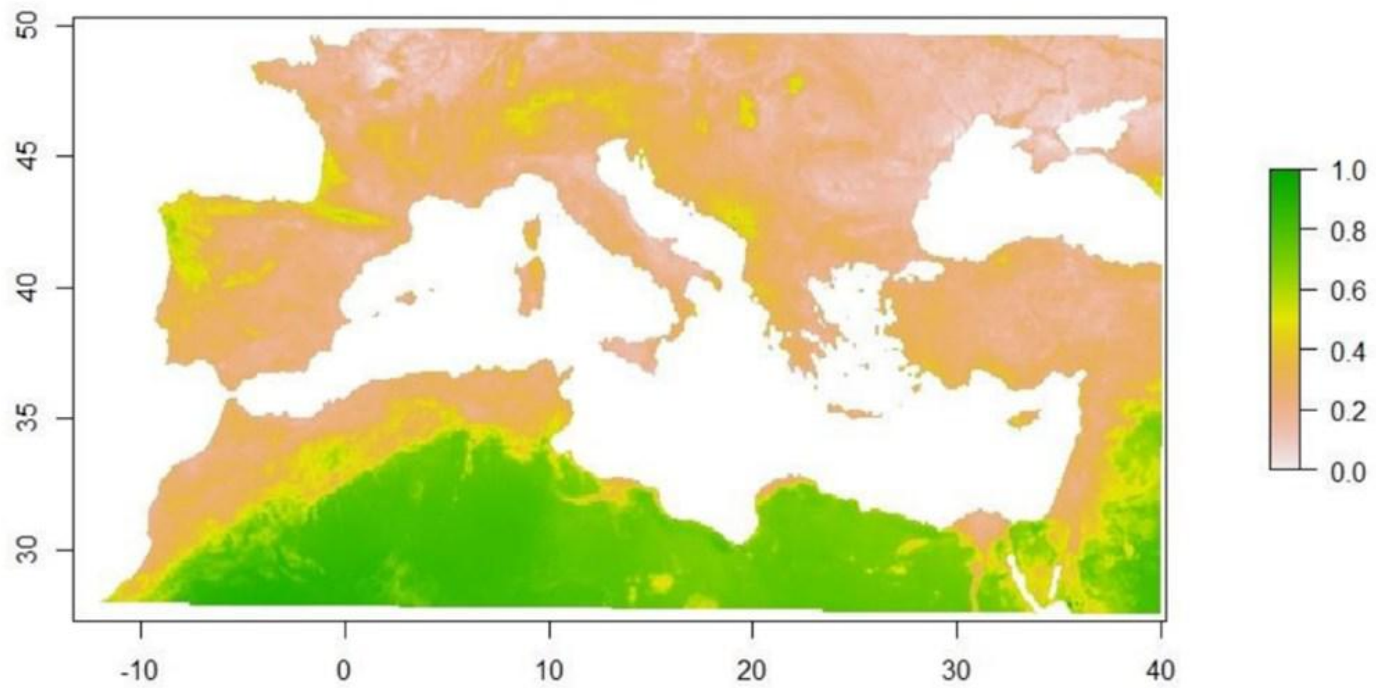
SUMMARY

Mediterranean drylands are undergoing rapid and interlinked transformations driven by intensifying water scarcity, recurrent droughts, advancing desertification, soil degradation, and growing competition over limited natural resources. These pressures threaten not only ecological stability but also agricultural productivity, rural livelihoods, and the longterm resilience of water–agriculture–ecosystem systems across the region. In response, the SALAM-MED initiative introduces a comprehensive, community-centred approach, mobilizing Living Labs (LLs) across the North and South Mediterranean to co-design, test, and refine innovative and scalable nature-based and technological solutions. These LLs bring together farmers, local authorities, scientists, NGOs, and private-sector actors to ensure that proposed interventions are grounded in local realities, socially acceptable, and environmentally sound. Its objectives include

synthesizing outcomes from all LLs, identifying shared challenges and enabling factors, and translating technical findings into actionable policy and investment recommendations. The project aims to harmonize efforts across the Mediterranean, offering a unified strategy for the next decade that supports climate adaptation, sustainable land and water management, and equitable community participation: a multi-layered methodology involving the review and consolidation of LL reports, comparative assessments of technology performance across diverse biophysical and socio-economic contexts, and structured engagement with stakeholders to capture local knowledge, needs, and expectations. Scenario-based analysis further strengthens the upscaling roadmap, helping anticipate future climate, economic, and governance conditions and tailoring recommendations accordingly.

RESEARCH AND RESULTS

SALAM-MED applied a formative, iterative approach based on efficacy, efficiency, and effectiveness criteria, integrating qualitative and quantitative data to assess LL processes, outcomes, and impacts over time. The evaluation aimed to assess the contribution of LLs in addressing complex socio-ecological challenges related to land and water sustainability in Mediterranean drylands. The LLs operated as open innovation social learning systems, combining scientific and local knowledge to co-create context-sensitive nature-based solutions (NBS) addressing land degradation, water scarcity, and socio-ecological resilience. Each LL focused on site-specific innovations, with diverse modeling and monitoring tools applied to guide sustainable land and water management: Tunisia carried out simulations of managed aquifer recharge (MAR) performance and future climate–water scenarios, Spain's CAFE (Carbon, Water, Fire and Eco-resilience) decision-support tool applied multi-objective optimization to forest thinning to balance water supply, carbon storage, and fire risk. The same approach was tested in the Italian and Moroccan LLs. Egypt's FLOWS–KWV framework optimized terrace number, spacing, and placement while enabling water distribution mapping and flood-protection scenarios. Morocco and Italy leveraged advanced digital monitoring hyperspectral, thermal, canopy reflectance, and LiDAR data to assess vegetation stress, monitor silvopastoral systems, and detect adaptive traits in forage species. Greece Living Lab integrated field data with remote sensing to track soil moisture, NDVI, erosion, phenology, and tree health. The results demonstrate that integrated approaches combining water-harvesting structures, managed aquifer recharge, adaptive vegetation management, soil amendments, microbial and digital monitoring tools,

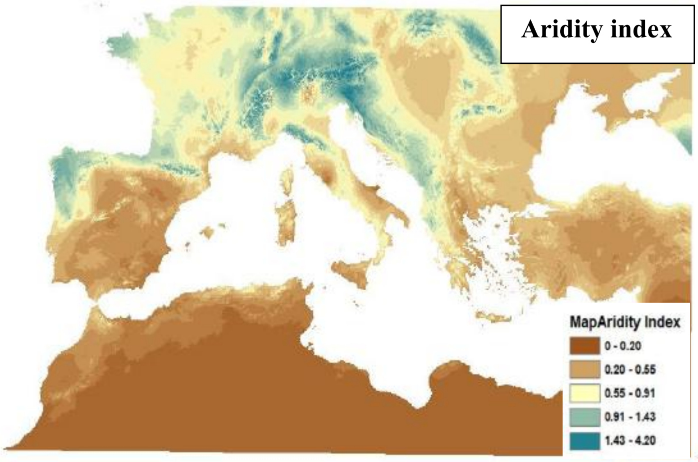


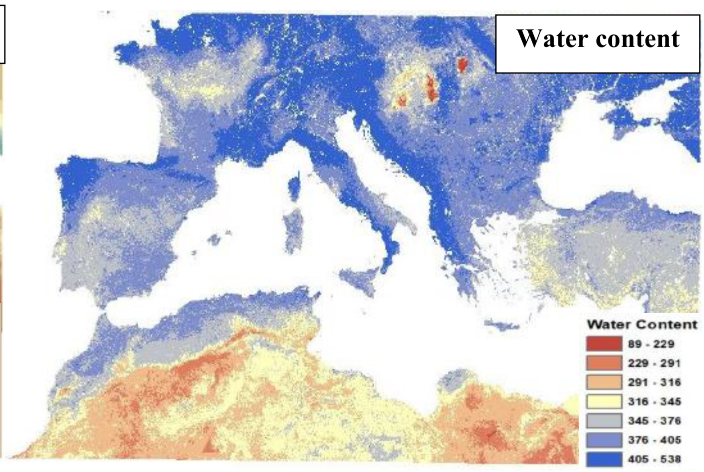
Map of suitability for Subsurface Water Retention Technology (SWRT) upscaling in the Mediterranean area

smart irrigation, and hydrological ecohydrological modelling can substantially enhance water productivity, soil health, ecosystem resilience, and climate adaptation across diverse Mediterranean drylands. The cross-LL analysis highlights that technical effectiveness must be complemented by strong stakeholder engagement, supportive policy frameworks, socio-economic incentives, and continuous monitoring to ensure sus-tained adoption.

RECOMMENDATIONS

- Support incentive mechanisms such as EU CAP and national subsidies to support adoption of the proposed technologies and ensure maintenance of the created systems. Moreover, without financial mechanisms or incentives tied to ecosystem services, operational sustainability may be compromised.
- Gaps persist in the availability and resolution of local data, especially for soils, vegetation, and historical management. Spatial extrapolation requires distributed modelling strategies and cross-calibration with remote sensing or open databases: technical and financial support can help to bridge these gaps
- A key priority is increased investment in applied and transnational research capable of responding directly to farmers' and pastoralists' needs. The goal is to develop precision farming applications that are scalable to local agricultural and forest conditions and accessible to different types of capital and investors, including small farmers and forest owners.
- The technology Adaptive Vegetation Management (AVM) has demonstrated its ability to translate ecological objectives (carbon, water, fire, resilience) into quantifiable management options, enabling decisions based on multiple eco-system services. Although the AVM, supported by the CAFE (Carbon, Water, Fire and Eco-resilience) decision support system narrows the gap between scientific modelling and decision-making, its operation still demands technical training in ecohydrological modelling, results interpretation, and interface handling. This can limit adoption by forest managers or non-specialist technicians. Policy makers are suggested to involve





technical/research staff to properly embed scientific results and feedback in policies.

– AVM implementation depends on alignment with existing policies and administrative frameworks. Differences among forestry, water, and conservation competences create fragmentation in decision-making, thus, coordination among experts and institutions for the efficient implementation of adaptive management practices is recommended.

– In the short term (1–2 years), actions to outscale the implementation of all validated technologies should focus on deploying new demonstration plots in regions with similar climatic and management constraints, training farmers and technicians on smart irrigation, Subsurface Water Retention Technology (SWRT), terrace design and AVM, establishing monitoring systems, and preparing user-friendly technical manuals.

– Over the medium term (3–5 years), efforts should shift toward integrating terrace-optimisation models into national planning, scaling phenology-based irrigation, expanding SWRT and AVM+CAFE applications, strengthening MAR institutions, developing local biochar value chains, and promoting cooperative-managed Unmanned Aerial Vehicles (UAV) services. In regard to these latter monitoring systems, enabling regulatory frameworks are required.

– – Longterm actions (5–10 years) should aim to fully mainstream Salam-MED solutions into national adaptation strategies, enhance cross-Mediterranean drought-resilience cooperation, embed DSS platforms into advisory services, and establish long-term UAV+AI silvopastoral monitoring systems.

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