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# TOWARDS TRANSFORMATIVE ADAPTATION OF AGRICULTURE TO CLIMATE CHANGE IN THE MEDITERRANEAN REGION

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## Introduction

Agriculture holds a pivotal role as the primary land use, the primary consumer of water, and a central activity for rural communities across extensive areas within the Mediterranean region. It employs more than a fifth of the population in 50% of the countries and represents more than 10% of GDP in eight countries alone (International Centre for Advanced Mediterranean Agronomic Studies [CIHEAM] & Blue Plan, 2009). The availability of water resources plays a vital role in maintaining a consistent agricultural output and is equally crucial for catering to the needs of rapidly growing urban centers.

Climate change in the Mediterranean region has had a profound impact on agriculture. Rising temperatures, altered rainfall patterns, and increased water scarcity have placed immense stress on farming systems. Heat stress affects crop yields and livestock, while changing precipitation patterns disrupt planting and irrigation schedules. Droughts and desertification threaten arable land, leading to soil degradation and yield losses. Extreme weather events like wildfires and heavy rainfall can devastate crops and infrastructure, and the spread of pests and diseases poses further challenges.

These climate-induced disruptions exacerbate economic and food security risks, making **adaptive measures** essential for the long-term sustainability of agriculture in the Mediterranean region.

## What are the adaptation strategies of agriculture to climate change?

Adaptation in agriculture to climate change includes a spectrum of strategies, ranging from incremental adjustments to transformative changes. At the incremental level, farmers make gradual, small-scale modifications to their existing practices. This might include adjusting planting dates, choosing more drought-tolerant crop varieties, or adopting efficient irrigation methods. Systemic adaptation takes a broader approach, involving integrated changes within farming systems. It often encompasses diversification of

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crops, agroforestry practices, and improved water management techniques. These adjustments aim to enhance the overall resilience of the agricultural system. Moving towards the transformative end of the spectrum, adaptation becomes more radical. It entails substantial shifts in farming practices, sometimes involving entirely new approaches. Examples include transitioning from conventional to organic farming, adopting cutting-edge digital technologies for precision agriculture, or altering land use patterns to reduce vulnerability to climate risks. Transformative adaptation aims not only to address immediate climate challenges but also to build a more sustainable and resilient agricultural system for the long term. These various levels of adaptation collectively contribute to the agricultural sector's ability to thrive in the face of climate change.

### Irrigation as an adaptative strategy to cope with water scarcity in the Mediterranean region

The progress of irrigation in Mediterranean nations has been remarkable in the past 50 years. However, the expansion of irrigated land and the adoption of irrigation technologies vary between northern and southern Mediterranean countries. These technologies have boosted water productivity by up to 30 to 40% (Causapé et al., 2006; Luquet et al. 2005), providing a competitive edge to numerous Mediterranean crops. The optimal results from these technologies are achieved when coupled with efficient irrigation timetables and supplemental irrigation.

Several Mediterranean countries rely on ground water for irrigation in response to growing demand for water. The increased pressure on groundwater resources in recent decades is, in part, a consequence of the rapid expansion of intensive irrigated agricultural areas and the explicit growth of urban developments. Groundwater resources play a vital role in meeting water demands, not only in terms of quality and quantity, but also in space and time, and are of critical importance for alleviating the effects of drought (Llamas, 2000; Llamas and Martinez-Santos 2005). However, incentives provided by several countries have resulted in the overexploitation and degradation of the groundwater quality due to multiple stresses: excessive pumping in relation to average natural recharge, return flow from irrigation water with intense use of agrochemicals, and leakage from urban areas. In addition, drought episodes contribute in a significant way to the degradation of groundwater quality (Iglesias et al., 2006).

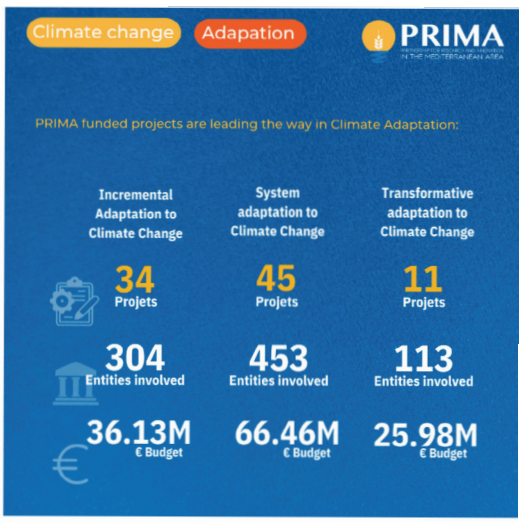
### Adaptation of agriculture at regional level

Multiple Mediterranean countries are interconnected by freshwater and groundwater resources, much like the Nile River, which serves as a prominent example of such shared resources. This interdependence often gives rise to water-sharing arrangements within individual countries, and disputes, particularly in times of drought, can emerge as a result. As water imbalances continue to escalate, so does the potential for conflicts. It is crucial to acknowledge that addressing these challenges solely through the policies of a single government or water basin unit may prove

insufficient, considering the divergent local interests involved. International institutions play a pivotal role in providing formal mechanisms to resolve water-related conflicts in the region. However, a common challenge faced by Mediterranean countries is the limited cooperation among various institutions responsible for agricultural and water management, compounded by fragmented roles between the central government and its administrative regions, which can further exacerbate conflicts.

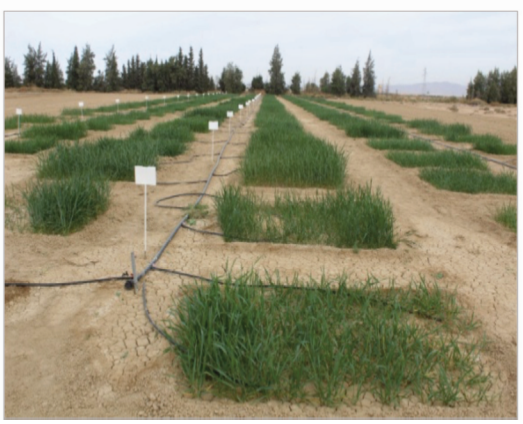
## PRIMA Funded Projects: Leading the way in Climate Adaptation

PRIMA (Partnership for Research and Innovation in the Mediterranean Area) has financed a total of 90 projects that contribute to the adaptation of farming systems to climate change in the Mediterranean region in which 870 research teams from both shores of the Mediterranean participate. A total budget of around € 128 Million has been allocated to the 90 projects. These projects have been implemented in more than 100 demonstration sites on both shores of the Mediterranean.




## Incremental adaptation

A total of 34 projects of the projects funded by PRIMA are classified as incremental adaptation efforts. Among these projects, IMPRESA (IMProving RESilience to Abiotic) has been instrumental in testing and identifying wheat varieties highly resilient to heat and salt, benefiting farmers in regions with adverse climates. Additionally, PRIMA has supported projects focused on developing smart irrigation systems, which enable precise monitoring and control to conserve water in agriculture. Furthermore, PRIMA has funded projects aimed at implementing integrated pest management techniques and reducing reliance on chemical pesticides by promoting sustainable pest control through biological controls and other innovative methods.



## System adaptation


In the second level of adaptation of farming systems to climate change, 45 projects have been funded to enhance adaptation through agroecology practices, conservation agriculture, biodiversity, soil management, and improvement of agropastoral systems.

One of the funded projects, called 4CEMed, is testing camelina as a cash cover crop, assuring short-term economic profit to Mediterranean farmers. Trials have been successfully established and harvested in all seven experimental sites, including African countries, where camelina was grown for the first time.

## Transformative adaptation

PRIMA has funded 11 projects of transformative adaptation. Transformative adaptation in agriculture necessitates significant changes to address the profound challenges posed by extreme climate conditions. One approach to achieving this is through WEFE Nexus Projects, which concentrate on the Water-Energy-Food-Ecosystems nexus. These projects seek to improve sustainability and resilience by implementing substantial alterations to current systems, promoting a holistic approach to resource management. Another transformative adaptation strategy is agroforestry, which enhances the capacity of farming systems to withstand extreme weather events and diversifies income sources, contributing to increased climate resilience and sustainability in agriculture.

## Added value of cooperation in building resilience and implementing adaptation strategies

The added value of cooperation in building resilience and implementing adaptation strategies for agriculture in the context of climate change is very significant. Collaboration fosters knowledge exchange and shared expertise, allowing for the development of more effective and tailored adaptation measures. It enables resource pooling from diverse stakeholders, magnifying financial and technical capabilities to implement large-scale projects. By avoiding duplication and fostering coordinated efforts, cooperation ensures greater efficiency and maximizes the impact of adaptation initiatives. Furthermore,

it garners increased political and institutional support, enhancing advocacy for climate-resilient agriculture. Social cohesion, cross-sectoral integration, and the facilitation of innovation and research are also byproducts of collaboration, contributing to the long-term sustainability of adaptive practices. In essence, cooperation is the linchpin for building agricultural resilience, equipping the sector to withstand the challenges presented by climate change comprehensively and effectively.

The PRIMA Foundation is an excellent example of cooperation between the two shores of the Mediterranean. The solutions of climate adaption implemented in agriculture in the South could be replicated in northern Mediterranean countries.

### Could adaptation strategies lead to maladaptation?

Sectoral adaptation strategies can inadvertently increase vulnerability or erode overall resilience by reducing capacity or elevating risks in other areas or sectors, resulting in maladaptation (Lele et al., 2013). For instance, excessive use of pesticides in food production could have a detrimental impact on public health and negatively affected both on-farm and off-farm biodiversity (Norse et al.,2001), subsequently impacting food production.

Similarly, the provision of subsidies for irrigation in several countries, has paradoxically led to groundwater overexploitation, the wastage of limited water resources, and increased demand for energy, ultimately undermining food and energy security.

### The WEFE Nexus approach: An important tool to facilitate the adaptation of agriculture to climate change

The Water-Energy-Food-Ecosystems (WEFE) Nexus approach plays a pivotal role in the adaptation of agriculture to climate change in the Mediterranean region. This integrated framework recognizes the interdependencies among water, energy, food, and ecosystems, offering a holistic perspective that aligns with the complex challenges posed by climate change. By focusing on the WEFE Nexus, stakeholders can develop and implement adaptation strategies that optimize resource use, enhance resilience, and mitigate environmental impacts. For instance, it enables the development of efficient irrigation systems that conserve water and energy, thereby supporting sustainable agricultural practices. Moreover, this approach fosters collaborative efforts, knowledge sharing, and the creation of adaptive solutions that transcend individual sectors, promoting the region's ability to address climate change impacts effectively and ensure long-term food security.

### Conclusion

Transitioning to transformative adaptation is imperative in the face of severe climate change impacts in the Mediterranean region. There is a pressing need for both North-South and South-South cooperation

to facilitate knowledge sharing and the dissemination of best practices. Effective implementation of adaptation solutions in agriculture should be a top priority for policymakers. The ability to adapt is a crucial factor in determining the extent of climate change's repercussions on food production in the future.

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