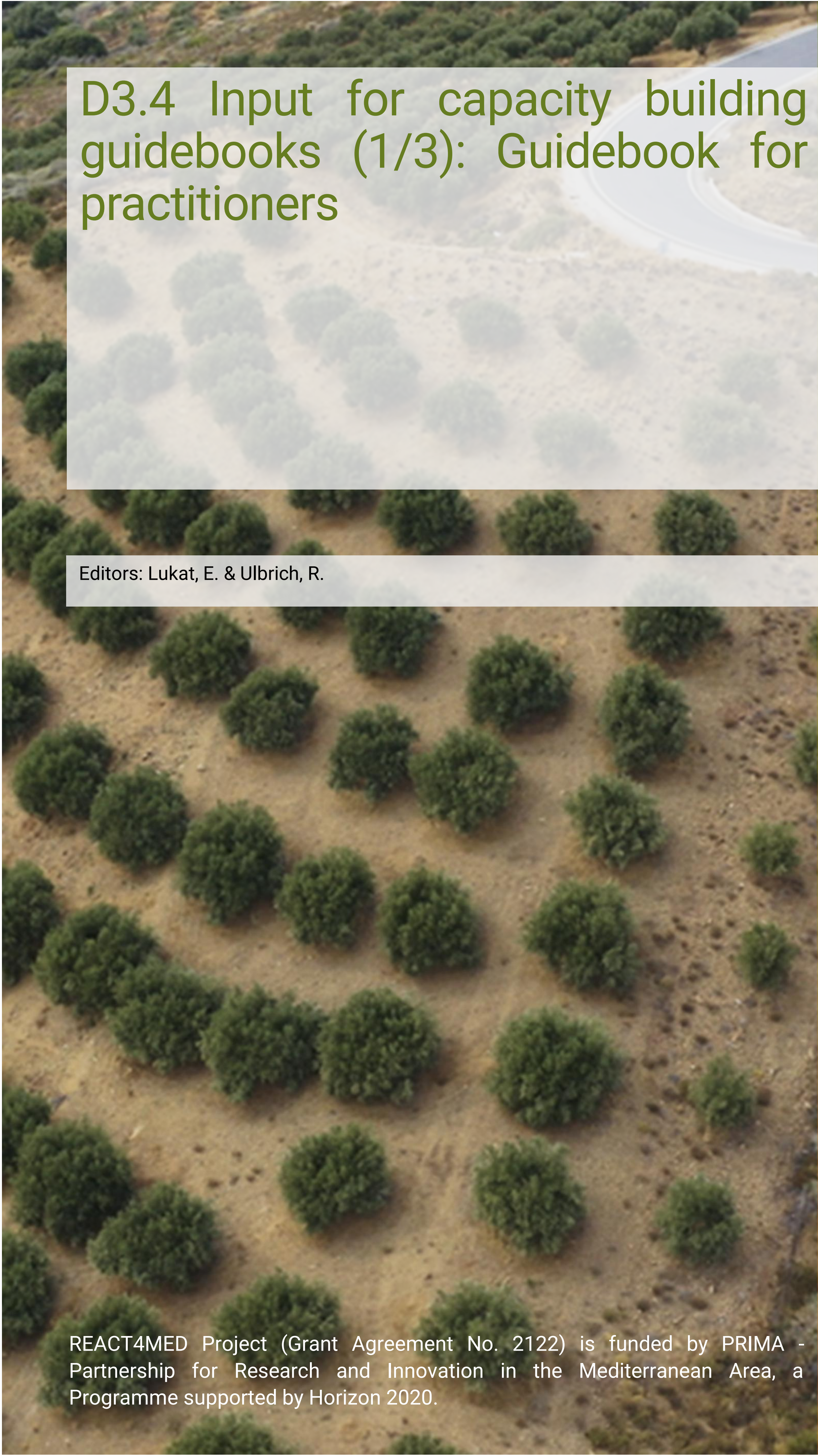

D3.4 Input for capacity building guidebooks (1/3): Guidebook for practitioners

Editors: Lukat, E. & Ulbrich, R.

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Executive Summary

This document, developed collaboratively by the REACT4MED project partners under guidance and coordination of WP 3 (UOS), contains a collection of useful information and inspiring implementation stories of the eight restoration actions in eight pilot areas. It is especially targeted at practitoiners such as farmers, land owners and farm advisers.

This document offers a comprehensive guide to restoring Mediterranean landscapes, designed to empower practitioners with proven techniques and implementation knowledge as well as stories by real farmers serving as role models. Its structure is carefully crafted to facilitate understanding and practical application.

It beginns with an Executive Summary and acknowledgement of Contributors. A thoughtfully written Foreword introduces the core philosophy of the work – translating knowledge into tangible momentum for lasting change. The document unfolds in two primary sections. Section 1, “Preparing the Ground: Introduction,” sets the context for the detailed exploration that follows in Section 2, “Planting the Seeds of Change: Restoration Actions.” This section presents the diverse portfolio of restoration actions with in-depth descriptions. These include natural water retention strategies in viticulture, effective drainage and soil improvement practices, restoration of salt-affected lands, innovative approaches to olive orchard management, preservation of agricultural terraces, adoption of conservation agriculture, implementation of agroforestry systems, and the benefits of food forests.

Finally, Section 3 shifts focus to “Spreading the Fruits of Knowledge,” demonstrating how the LanDS platform, that was co-developed in the course of the project, can support informed and data-driven land management decisions. The document concludes with anticipated Back Matter (currently under development) and a Back Cover.

This structure provides a clear and logical progression from foundational principles to practical interventions and ultimately, to the tools needed for sustainable and scalable land restoration across the Mediterranean region. With a combination of accessible descriptions and informative data on implementation criteria and background it is a vital resource poised to ignite large-scale restoration of Mediterranean lands and livelihoods.

Agro-ecological restoration actions for the Mediterranean

Guidebook for practitioners

REACT 4MED

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

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Foreword

Open this book anywhere and you will notice the same guiding impulse: turning hard-won knowledge into practical momentum. The pages that follow are neither a conventional scientific report nor a glossy collection of success stories; they are a working manual for everyone committed to restoring Mediterranean lands and livelihoods at scale.

What sets this volume apart is its refusal to treat land degradation as a purely biophysical phenomenon. Every chapter reminds us that soils are living systems embedded in equally living communities. Whether describing conservation agriculture in Morocco or food forests in Israel, the human dimension is in the foreground: brave women taking decisions for their families' health and livelihood, young land managers and entrepreneurs that experiment with agrotourism or investing in organic agriculture. The result is a narrative of hope rooted in tangible, replicable experience.

As coordinators of REACT4MED, we are particularly encouraged by three features that run through the book:

- Evidence before prescription: each practice is backed by quantitative indicators allowing readers to weigh trade-offs transparently.
- Interdisciplinary rigour: Agronomy, Hydrometeorology, Computer Science, Economics, and Social Sciences cross-pollinate each other on every page, mirroring the complexity of the real world.
- Scalability and feasibility by design: from the very first pilot plot, scientists and stakeholders asked not only "Were do we want to be in 50 years from now?" but also "What will this take and who must be involved to achieve this vision?"

For policymakers, this book offers a menu of shovel-ready interventions tied to measurable co-benefits: carbon sequestration, biodiversity gains, sustainable yields and long-term livelihood security. For investors, public or private, it lays out the business case for land restoration grounded in robust cost-benefit analysis. For land managers, extension officers, and community leaders, it is a practical handbook written in accessible language and illustrated with real-world successes.

But perhaps the book's greatest contribution is less technical and more cultural: it rekindles the Mediterranean tradition of stewardship. By honouring ancient techniques - now widely recognised agroecological practices - while embracing cutting-edge digital tools, it charts a path that is at once innovative and rooted in place. In doing so, it invites every reader to see themselves not as passive observers of environmental decline, but as active agents of renewal.

We commend our REACT4MED teammates, the contributing stakeholders, the many researchers who collaborated for this book, and PRIMA for making this project possible. May the insights gathered here inspire bold action - on the farm, in the marketplace, and in the halls of government - so that Mediterranean landscapes remain fertile, resilient, and vibrant for generations to come.

On behalf of the REACT4MED Consortium,

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July 29, 2025

1 Preparing the ground: Introduction

The Mediterranean region stands at a crossroads. Farmers, land users, and communities across the region are grappling with increasingly difficult conditions. Hotter summers, unpredictable rainfall, degraded soils, and mounting pressure on water resources. These are not isolated events. They are part of a larger transformation, driven by both climate change and long-term changes in how people live and work that are altering landscapes and livelihoods from the coastal plains of Morocco to the mountain slopes of Cyprus.

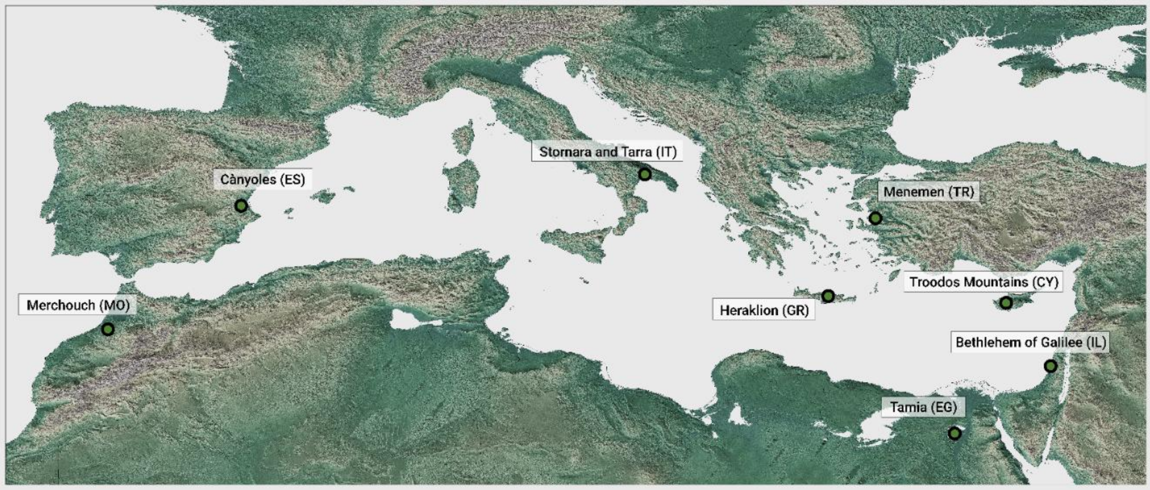
In recent years, parts of the Mediterranean region have already warmed by up to 3°C compared to preindustrial times. Rainfall patterns have shifted, with some areas facing prolonged dry periods and others experiencing more intense storms. These trends are not just meteorological as they carry real consequences for the land. Soils are drying out, erosion is accelerating, and salinity is becoming a growing problem. These changes mean greater uncertainty, reduced yields, and more difficulty sustaining agricultural land.

At the same time, the region is experiencing demographic and economic growth. Urban areas are expanding, and competition for natural resources is increasing. While agricultural landscapes have remained largely stable in terms of surface area, their character is changing. The pressure to produce more on the same land is rising, while the cost of land degradation is becoming harder to ignore.

Looking ahead, the situation is likely to get more challenging. Projections show that if greenhouse gas emissions continue on their current path, average temperatures could rise by as much as 4.6°C by the end of the century. Droughts will likely become more frequent and intense. Soil degradation could significantly reduce productivity and resilience of farms across the region, putting both farmers' livelihoods and food security at risk. At the same time, economic scenarios range from modest growth to rapid expansion, adding further complexity to land and water use decisions.

But within these challenges lies opportunity. The REACT4MED project advocates for good agricultural practices that rebuild soil health and deliver reliable harvests, securing productivity and profits while preserving vital natural resources. Across the eight pilot areas of the REACT4MED project, in Türkiye, Morocco, Israel, Egypt, Cyprus, Greece, Spain, and Italy, farmers, local authorities, businesses and researchers are working together to identify what works, what needs to change, and how to build resilience from the ground up. These areas represent a mosaic of conditions: from family-run vineyards in Italy facing water shortages, to olive groves in Spain battling erosion, to silvopastoral systems in Crete reviving depleted soils.

Here: Infographic of Pilot Areas - Depict location of Pilot areas, naming the restoration action and the main problem context



Pilot Areas	Category of restoration action (to be depicted with symbol)	Restoration action	Main problem
Stornara and Tara, Apulia, Italy (IT)	Water management and irrigation	**Organic farming and integrated crop management**	High water consumption
Lower Gediz River Basin, Türkiye (TR)	Water management and irrigation	**Drainage and soil melioration**	Salinisation of soil
Tamia region, Fayoum, Egypt (EG)	Water management and irrigation	**Drainage and soil melioration**	Salinisation of soil
Canyoles River Basin, Valencia, Spain (ES)	Soil and erosion protection	Mulching	Water erosion
Troodos Mountains, Cyprus (CY)	Soil and erosion protection	Terracing	Soil erosion
Zaër, Morocco (MO)	Soil and erosion protection	Conservation agriculture	Soil depletion
Crete, Greece (GR)	Multifunctionality and biodiversity	Agroforestry	Biodiversity loss, soil erosion
Bethlehem of Galilee, Israel (IL)	Multifunctionality and biodiversity	Food forest	Biodiversity loss

Together with farmers, REACT4MED aims to regenerate soils, use water more efficiently, and restore local biodiversity so that farmland remains productive and resilient. As the climate grows hotter and drier, these benefits become essential to secure harvests and protect livelihoods.

In this guidebook, you will find portraits of suitable practices under various conditions in the eight pilot areas accompanied by information on implementation. Join us as we explore these solutions and witness the positive change happening on the ground!

2 Planting the seeds of change: Restoration actions

2.1 Natural water retention: Organic farming and integrated crop management in table grape production

Case: Stornara and Tara, Puglia, Italy

Restoration action category:

irrigation management (incl. water supply, drainage)

Measures included:

- Soil cover
- Soil fertility
- Soil surface treatment
- Change in management
- Layout according to natural and human environment

Description of technology:

Implementing a production system that minimises disease and pest incidence reduces pesticide use without sacrificing crop productivity. This approach views the vineyard as an ecosystem, optimising resources to enhance cultivar biodiversity and decrease pest and disease pressure. Plant diversity is increased through local wild plants typical of the Mediterranean Basin along field edges, which help control pathogen populations.

Main purposes:

- prevent (avoid) or reduce land degradation; restore/rehabilitate land (reverse land degradation) (soil, water, vegetation)
- conserve ecosystem
- preserve/ improve biodiversity

Main benefits

- Increased water retention
- Decreased risk for salinisation
- Higher market prices for organically grown produce

2.1.1 Agriculture in a changing climate

In Southern Italy, farmers are likely to face rising temperatures and declining summer rainfall, with projections indicating more frequent and severe droughts by mid-century. This is expected to impact water availability for viticulture and other crops, while exacerbating soil degradation in already vulnerable areas. Socioeconomic projections suggest moderate urban expansion and shifts in labour markets that may further pressure traditional agricultural systems. Adapting irrigation practices and enhancing soil moisture retention will be vital for sustaining yields and quality.

2.1.2 The pilot area in the Stornara and Tara region: A profile

In the Stornara and Tara region, agricultural practices are shaped by a maritime Mediterranean bioclimate characterised by average annual rainfall of 550 mm, predominantly occurring in winter and autumn. The main crops cultivated include citrus, table grapes, stone fruit, olives, and summer vegetables, which are produced for large market chains and export markets. Irrigation is essential from April to September due to frequent summer droughts and sandy soils with low water retention capacity.

The farming landscape is fragmented, with small farms averaging two to three hectares, larger farms spanning 10 to 30 hectares, and a few exceeding 100 hectares. Many farms are family-run as side businesses, with aging farmers often lacking successors. While agricultural activities are predominantly managed by men, women frequently assist during harvests or in food processing.

The irrigation consortium *Consorzio di Bonifica Stornara e Tara* manages the water distribution using a pressurised and gravity-fed system. Farmers rely on irrigation from April to September, but the current delivery schedule (water provided every 10 days) is inadequate, as sandy soils lose water within two to three days. Consequently, aquifer irrigation and unlicensed wells are widely used, worsening groundwater depletion and salinisation. Farmers and the consortium face conflicts over water allocation, as the schedule currently does not meet farmers' needs. The region faces significant challenges related to water scarcity, exacerbated by an inadequate irrigation schedule and resulting conflicts.

Climate	
Annual rainfall	584 mm
Average annual temperature	15.8°C
Reference meteorological station	Castellaneta (Taranto),
Agro-climatic zone	semi-arid
Topography	
Slopes on average	gentle (3-5%)
Landforms	valley floors
Altitudinal zone	< 100 m asl
Soils	
Soil depth on average	very deep (> 120 cm)
Soil texture (topsoil)	medium (loamy, silty) fine/ heavy (clay)
Topsoil organic matter	medium (1-3%)
Soil texture (> 20 cm below surface)	medium (loamy, silty) fine/ heavy (clay)
Water	
Water supply for the land on which the	full irrigation

technology is applied	
Groundwater table	5 - 50 m
Availability of surface water	medium (e.g. not available year-round)
Water quality (untreated)	for agricultural use only
Water quality refers to	both ground and surface water
Salinity	is a problem
Biodiversity	
Species diversity	low
Habitat diversity	low
Further information	
Plant biodiversity is currently limited to weed species due to intensive management practices on the studied farms. Nearby areas showcase a variety of plant communities, including meadows, garrigues, and oak forests. To address these issues, we propose introducing green infrastructures that are rich in native plants, specifically adapted to the region's climatic conditions.	

Figure 1: Bare soil in table grape production increases soil erosion and water evaporation

Within the REACT4MED project, the research team of CIHEAM collaborated with several family businesses to optimise water retention to improve water availability on the farms. The restoration action aims to improve soil water-holding capacity by focusing on organic agricultural production and integrated crop management. Through organic farming practices, soil organic matter is increased, enhancing water retention. Integrating native species into the farming system increases resilience for pests and diseases. The ultimate goal is to transition from traditional cultivation systems to organic farming while promoting biodiversity conservation within agricultural production.

2.1.3 In practice: The example of the Diomede family in the Consortium Stornara and Tara

The Marinella farm, owned by the Diomede family, is managed by two young agricultural entrepreneurs who cultivate table grapes. With their strong belief in organic farming, they chose table grape varieties that have a lower water demand and at the same time respond to the growing demand in high-quality grapes.

In the area of Stornara and Tara, most farmers are members of the consortium that manages their water supply. The consortium also serves as an institutional hub for coordinating action and decision-making with the Apulia region local Government and research institutions. Dr.

Giovanni Merlino, Director of the consortium, supported the REACT4MED project with his place-based knowledge and facilitated collaboration with local farmers.

Figure 2: Farmer Mr. Diomede (left) and researcher Pandi Zdruli

2.1.4 Organic farming and integrated crop management: Implementation steps

Effective management should treat the vineyard as an agro-ecosystem, where all resources are used efficiently to support a diverse range of plant species. To address the limited water availability, integrated crop management and a shift towards organic production are viable restoration actions.

Both management options require information about how the farming system can be supported through natural means. For that, substantial knowledge of natural processes is essential and requires a high willingness to learn. Establishing contact with farmers already using organic methods is crucial in the initial stages. Furthermore, engaging with farm advisors and organic farming networks facilitates the transition and provides a valuable support system for addressing any questions or challenges.

Once the knowledge base is built, the most appropriate practices should be tested on a small scale to ensure their suitability for local conditions. Following successful trials and the design of a management plan, the entire farm can be converted.

2.1.5 Benefits of organic farming and integrated crop management

Organic viticulture emphasises environmentally friendly practices to support a balanced ecosystem, which includes a diversity of fauna, flora, plant species, and microorganisms. This approach contrasts with conventional viticulture, which relies on synthetic pesticides to maintain balance in monoculture systems, such as vineyards dominated by table grapes.

Organic farming methods help reduce the use of approved pesticides and enhance soil health by applying mulches, cover crops, organic enrichments, and cultivation techniques. These practices improve soil structure, foster beneficial interactions among soil components, and contribute to long-term productivity. The Marinella farm exemplifies this effort, employing measures such as minimal tillage, high-quality fertilisers, and efficient irrigation management.

Key benefits of the restoration action include:

- Improved ecosystem health and reduced reliance on synthetic inputs through biodiversity conservation, mitigating the domination of single species.
- Enhanced soil health through improved soil structures, water retention and nutrient cycling.
- Increased market value for organically grown produce, providing economic advantages to farmers.

The included measures (see table) not only support environmental sustainability but also provide a model for responsible agricultural practices in vineyard management.

Measure	Benefit
Reducing soil-turning activities	Maintains the natural soil structure and leads to increased water retention.
Enhancing plant diversity by planting local aromatic and medicinal plants along field edges	Reduces harmful pathogens and avoids chemical inputs to the farm. This, in turn, lowers the risk of salinisation.
Abstinence from mineral fertilisers	Lowers the risk of salinisation.
Using compost and manure as fertilisers	Increases soil organic matter and water retention. Lowers the risk of salinisation.
Covering bare soils by intercropping or mulching	Decreases evaporation. Increases soil organic matter, water retention and overall soil health.
Preventing excessive water accumulation in the fields through the adoption of canalisations and well recovery	Lowers the risk of salinisation.

2.1.6 Contact

Practitioners interested in the restoration action can contact the Diomede farm with the help of the Consortium of Stornara and Tara (Director: Dr. Giovanni Merlino)

Consorzio di Bonifica Stornara e Tara. Viale Magna Grecia 240, 74121 – Taranto. Tel. (+39) 099 7357111. e-mail: consorzio@bonificastornaratara.it. Sito web: http://www.bonificastornaratara.it/

Azienda Diomede. https://www.instagram.com/marinellafrutta/

Istituto Agronomico Mediterraneo di Bari. https://www.iamb.it/. Via Ceglie 9, 70010 Valenzano (Bari). e-mail: iamdir@iamb.it

2.1.7 Further information

https://feder.bio/

https://www.regione.puglia.it/web/osservatorio-agricoltura-biologica/linee-guida

https://www.agricolturaorganica.org/

2.2 Effective drainage and improvement practices

Case: Lower Gediz River Basin, Türkiye
Restoration action category: Irrigation management, water diversion and drainage, surface water management **Measures included:** • Design of drainage system adapted to field slope and soil • Change in management: crop rotation, improved irrigation/drainage schedule **Description of technology** Installation of a subsurface drainage system, application of leaching water, and introduction of crop rotation on agricultural land in the lower Gediz River Basin to reduce soil salinity and waterlogging. This restoration action improves soil and crop health and increases yields, rehabilitating salinity-affected degraded land.
Main purposes • Improve production • Prevent, reduce land degradation; rehabilitate land • Create beneficial economic impact • Reduce risk of disasters • Adapt to climate change
Main benefits • Soil restoration and improvement • Increased agricultural productivity • Improved water management • Reduced risk of crop loss due to floods and excessive soil moisture

2.2.1 Agriculture in a changing climate

In Türkiye's Mediterranean region, future climate scenarios point to hotter, drier summers and increased variability in rainfall. These shifts could intensify salinisation and reduce freshwater availability, especially in lowland agricultural zones. At the same time, demographic changes and moderate economic growth are anticipated, influencing land use patterns and water demand. For farmers, these trends mean a pressing need to improve drainage systems, manage salinity, and explore drought-resilient crop options.

2.2.2 The pilot area in the lower Gediz River Basin: A profile

Figure 3: A section of the field before the restoration activities, displaying uneven plant growth due to soil salinity

The Menemen Plain experiences a Mediterranean climate, with hot, dry summers and mild, rainy winters. Total annual precipitation is 531 mm, with half of its amount occurring in winter and only 3 percent in summer. The average temperature is 16°C, and the average relative humidity is 57 percent. Humidity peaks in December and reaches its lowest levels in July.

The Menemen district lies downstream of the Gediz River, where the main agricultural challenges are soil salinity and alkalinity, caused by irrigation practices and saltwater intrusion. Most farmers in the area grow cotton. However, none have yet been able to successfully implement measures to combat soil degradation.

A key issue is the absence of an effective drainage system, which would remove water before it evaporates and leaves salts behind. Responsibility for drainage infrastructure lies with the Department of Agriculture. To address alkalinity, some farmers have applied gypsum, with limited success.

Climate	
Annual rainfall	501-750 mm
Reference meteorological station	UTAEM Meteorological Station
Agro-climatic zone	sub-humid semi-arid
Topography	
Slopes on average	flat (0-2%)
Landforms	plateau/ plains valley floors
Altitudinal zone	< 100 m asl
The technology is specifically applied in	not relevant
Soils	
Soil depth on average	very deep (> 120 cm)
Soil texture (topsoil)	medium (loamy, silty)
Topsoil organic matter	medium (1-3%) low (<1%)
Soil texture (> 20 cm below surface)	medium (loamy, silty)
Further information	
Water	
Water supply for the land on which the technology is applied	full irrigation
Groundwater table	< 5 m
Availability of surface water	good (e.g. available year-round)
Water quality (untreated)	for agricultural use only
Water quality refers to	surface water
Salinity	is a problem
Further information **Water salinity is a significant problem, especially in irrigation return flows and during dry periods. High electrical conductivity (EC) values in both soil and irrigation water contribute to soil salinisation.**	
Flooding	occurs episodically
Further information Seasonal fluctuations in both surface and groundwater levels occur due to irrigation practices and rainfall variability. Main sources of pollution are agricultural runoff and return flow from irrigation, leading to increased salinity in surface and groundwater. Flooding may happen episodically after heavy irrigation or rainfall, especially when drainage is insufficient.	
Biodiversity	
Species diversity	low
Habitat diversity	low
Further information Species and habitat diversity in the demonstration field are low due to intensive agricultural use and monocropping. Natural vegetation is almost absent, with the land mainly planted with crops such as cotton or tomato. Occasional field margins and irrigation ditches may support some weedy or ruderal plant species, but overall biodiversity is well below the regional average for natural or semi-	

2.2.3 In practice: The example of Mehmet

Figure 4: Farmer Mehmet on his field.

Mehmet is a dedicated farmer from Menemen, Izmir. On 30 hectares of arable land, he cultivates wheat, cotton, corn, peas, melons, and tomatoes. For three generations, his family has relied on farming, facing persistent challenges due to the region's arid climate and saline coastal soils. Mehmet's family farm is a small to medium-sized business, but he distinguishes himself through his openness to new ideas and enthusiasm for research. Since the 1980s, Mehmet has worked to restore unproductive land for agriculture. Always seeking innovation, he collaborates with UTAEM in the React4Med project, serving as a role model for fellow farmers.

2.2.4 Effective drainage and improvement practices: Implementation steps

To implement this restoration action elsewhere, the first step is to assess the severity of soil salinity and identify areas with inadequate drainage. Flat landscapes with a high groundwater level or proximity to the sea are particularly at risk. Installing a subsurface drainage system is essential to remove excess salts and lower the groundwater level. After drainage is established, washing the soil with high-quality water is necessary to leach accumulated salts.

Next, incorporate well-composted farmyard manure to rebuild organic matter and improve soil structure. This supports microbial activity and enhances nutrient availability. In the following years, the introduction of a drip irrigation system is recommended to deliver water precisely to the root zone, preventing further salt accumulation and reducing water use.

Figure 5: A view of the installation process of a subsurface drainage system using specialised machinery. The yellow drainage trencher is laying perforated pipes underground to improve soil conditions and prevent waterlogging and salinity problems in the field.

Ongoing maintenance includes regular inspection of drainage functionality, avoidance of over-irrigation, and annual application of organic matter to sustain improvements. Success depends on careful monitoring, farmer engagement, and adaptation to local conditions such as soil texture, water availability, and crop selection.

2.2.5 Benefits

This restoration action provides multiple short- and long-term benefits for both farmers and the environment. In the short term, the installation of proper drainage systems and application of soil improvers such as well-composted manure immediately enhance soil aeration, reduce salinity, and increase crop productivity. Improved irrigation efficiency through drip systems also lowers water use and input costs.

In the long term, the build-up of soil organic matter leads to better soil structure, higher water retention, and increased resilience to drought. Reduced dependence on chemical fertilisers supports healthier soils and limits environmental pollution. For land users, these improvements mean more stable yields and a more sustainable farming system.

Ecologically, restoring soil health supports biodiversity, particularly beneficial soil organisms and pollinators. Cleaner water drainage improves water quality in nearby ecosystems. The combined improvements promote sustainable land use, preserve landscape aesthetics, and open the door to future opportunities like agritourism. This restoration approach contributes to climate resilience and long-term food security in Mediterranean farming systems.

2.2.6 Contact

Contact details	Name: Dr. Funda Kıdoğlu E-Mail: funda.kidoglu@tarimorman.gov.tr Name: Dr. Perihan Tarı Akap E-Mail: perihan.akap@utaem.gov.tr **International Agricultural Research and Training Center (UTAEM)**, Address: Camikebir Mah. Maltepe Yolu No: 27/1 Menemen-İzmir/Türkiye.

2.2.7 Further information

Information about training programs, ongoing research, and agricultural innovation support in Türkiye. https://www.utaem.gov.tr

Information on available agricultural subsidies and soil improvement supports in Türkiye. Tarım ve Orman Bakanlığı – Tarımsal Desteklemeler: https://www.tarimorman.gov.tr/Konular/Tarimsal-Desteklemeler

2.3 Restoring salt-affected agricultural lands

Case: Tamia, Fayoum, Egypt

Restoration action category:

Integrated soil fertility management, improved plant varieties, water diversion and drainage

Measures included:

- Monitoring and analysis of soil
- Change in management: adapted varieties, organic fertilisation, mulching, improved drainage

Description of technology

The restoration action takes a comprehensive approach to tackling soil salinisation, including assessment of soil and water quality, installation of drainage systems, selection of salt-tolerant crops, use of organic and biofertilisers, mulching, and active farmer involvement. These measures aim to improve soil health, boost crop productivity, and promote sustainable land use under saline conditions.

Main purposes

- Improve production
- Prevent, reduce land degradation; rehabilitate land

Main benefits

- Enhanced crop performance under saline conditions
- Improved soil structure and organic content
- Improved water retention and drought resistance
- Improved water quality through cleaner drainage

2.3.1 Agriculture in a changing climate

Egypt's Nile Delta is expected to experience compounded pressures from rising temperatures, reduced precipitation, and sea level rise, all threatening agricultural productivity and soil quality. Intensified salinisation and water scarcity will pose significant risks for smallholders. Coupled with rapid population growth and urbanisation, the competition for land and water resources will increase sharply. This calls for more efficient irrigation, drainage infrastructure, and integrated land use strategies to safeguard agricultural livelihoods.

2.3.2 The pilot area in Tamia in Fayoum: A profile

The Fayoum governorate, situated approximately 90 kilometres southwest of Cairo, Egypt, is a geographically unique and increasingly important agricultural region. This large depression occupies a portion of the Eocene limestone plateau, marking the northern edge of the western desert. Fayoum's agricultural lands hold significant economic and environmental value, effectively extending the fertile environment of the Nile River – both in terms of soil formation and water resources. However, this delicate ecosystem, shaped by the interplay between the Nile and the surrounding desert, is facing increasing pressures.

Figure 6: Description of the problem situation

Intensive agricultural practices, coupled with several contributing factors, are leading to the degradation of both soil and water quality within the Fayoum depression. The alluvial aquifer is under considerable stress from agricultural runoff, the widespread use of agrochemicals (fertilisers and pesticides), and the disposal of wastewater. Specifically, issues like mismanagement of agricultural inputs, the practice of reusing drainage water for irrigation, improper wastewater disposal, and a lack of comprehensive land use planning all contribute to this degradation.

This is particularly evident in the Tamia area, covering approximately 344.4 km^2, where a recent assessment revealed a widespread issue of soil salinity. Analysis indicates that Electrical Conductivity (ECe) levels in Tamia soils range from 1.22 to 22.4 dS m^{-1}, with a staggering 91.5 percent of soils exhibiting ECe levels exceeding 4 dS m^{-1}. This confirms that salt-affected soils are prevalent throughout the region.

Further complicating matters, approximately 94.5 percent of Tamia soils are calcareous – containing over 10 percent calcium carbonate (CaCO3) – due to the underlying geological parent material. A small but significant portion of soils (3.25 percent) have a pH above 8.00, and nearly 4 percent have a pH exceeding 8.5, indicating alkalisation. Critically, organic matter content remains consistently low, seldom exceeding 1 percent, further diminishing soil health. Soil texture varies, ranging from clay to sandy, but is generally classified as sandy-loam.

These factors – salinisation, alkalisation, high calcium carbonate content, low organic matter, inadequate drainage, a high groundwater level, and the resulting root-zone salinity – collectively represent the key constraints to sustainable agriculture in Tamia, severely limiting crop production. The widespread practice of irrigating with a mixture of Nile water and agricultural drainage water exacerbates these problems.

2.3.3 Restoring salt-affected agricultural lands: Implementation steps

In the Tamia District, a combination of measures needs to be implemented in order to counteract the ongoing salinisation of agricultural soils and to increase overall productivity:

1) Characterisation of the soil and water quality, where different samples from the soil and water are analysed to determine the present state of the soil. This provides insights into the soil's texture and structure, as well as its water-holding capacity.
2) Dealing with soil salinisation, the installation and proper maintenance of a functioning subsurface drainage system is paramount to leach accumulated salts from the soil and to prevent salt built-up.
3) Selecting appropriate crops is crucial: Specifically, salt-tolerant varieties and genotypes that can grow economically under soil salinity conditions and are suitable for the pilot area. Suitable crops are for example sugar beet, Napier grass, sunflower, barley, sorghum and wheat that can be cultivated in different seasons to increase the soil productivity and profitability.
4) The application of organic and biofertilisers can increase the tolerance of the cultivated crops to the saline water. Added during soil preparation and cultivation, organic and biofertilisers improve the soil texture, microbial activity, aeration and soil minerals content as well as their availability. Increasing the tolerance of the cultivated crops to the saline conditions can yield a higher productivity.
5) Mulching: Organic mulches can suppress annual weeds and offer important benefits, such as organic matter, nutrients, moisture conservation, soil protection, and moderation of soil temperature. Hay, straw, and cover crops are among the most versatile and widely used organic mulches. They can suppress weed germination and emergence when applied at reasonable rates, are easy to apply and reduce evaporative losses of soil moisture.
6) Diligent monitoring and active involvement of farmers is required to respond to the conditions on site and steadily improve the quality of the soil.

2.3.4 Benefits

The described restoration action delivers several benefits to both farmers and the local ecosystem. Installing appropriate subsurface drainage systems helps leach accumulated salts from the soil, reducing salinity levels and improving soil aeration. This, combined with the use of salt-tolerant crops and genotypes, enhances plant resilience to saline conditions and abiotic stress, leading to improved crop performance and higher short-term productivity.

The application of organic and biofertilisers during soil preparation and cultivation improves soil structure, increases organic matter, enhances microbial activity, and boosts the availability of soil nutrients. These changes contribute to better water retention and increased drought resistance. Organic mulching further supports these outcomes by conserving soil moisture, suppressing weeds, and moderating soil temperature.

Cleaner drainage water resulting from appropriate water management improves the quality of water entering surrounding ecosystems. Together, these measures support more sustainable land use and contribute to long-term productivity and resilience in Mediterranean farming systems.

2.3.5 Contact

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2.4 Revitalising olive orchards: The impact of chipped pruned branches in Mediterranean groves and vineyards

Case: Valencia, La Costera and La Safor districts, Spain

Restoration action category:

Improved ground/ vegetation cover, ecosystem-based disaster risk reduction

Measures included:

- Soil cover
- Soil fertility
- Change in management: No tillage

Description of technology:

Chipped branches from pruning in plantations are used as mulch to cover the soil surface instead of burning them. This alternative management technique

Main purposes

- avoid or reduce land degradation; restore degraded land
- improve biodiversity
- reduce risk of disasters (droughts, floods, landslides and fires)
- adapt to climate change (resilience to droughts, heavy rainfall events)
- mitigate climate change and its impacts

Main benefits

- Reduces surface runoff and protects from erosive rainfall
- Improves soil qualities (organic matter, aggregate stability, water infiltration, moisture retention, biodiversity)
- Moderates summer temperatures
- Decreases management costs
- Adapted to legal fire restrictions
- Enhanced aesthetic and cultural value of the landscape
- Creates habitats

2.4.1 Agriculture in a changing climate

Southern Spain faces escalating challenges from climate change, particularly higher temperatures, reduced precipitation, and greater drought frequency. These stressors will exacerbate soil erosion and threaten the viability of dryland farming systems. Economic trends suggest a dual movement of rural decline and tourism-driven growth, which may shift priorities away from traditional land uses. Farmers will need to adopt erosion control measures and diversify income sources to remain resilient.

Climate	
Annual rainfall	600-350 mm
Specifications on rainfall	Mediterranean, drought in summer
Name of the reference meteorological station	Moixent, Font de la Figuera Xativa, Canals; Montesa
Specifications/ comments on climate:	16-12 °C average annual temperature
Agro-climatic zone	sub-humid
	semi-arid
Thermal climate class	temperate (Transition zone between semi-arid and sub-humid)
Topography	
Slopes on average	applied on all slopes
Landforms	applied on all landforms
Altitudinal zone	101-500 m asl
	500-1,000 m asl
The technology is specifically applied in	convex situations (ridge – diversion of water flow) concave situations (depression – conversion of water flow)
Soils	
Soil depth on average	very shallow (0-20 cm)
	shallow (21-50 cm)
Soil texture (topsoil)	coarse/ light (sandy)
	medium (loamy, silty)
Topsoil organic matter	medium (1-3%)
	low (< 1%)
Soil texture (> 20 cm below surface)	coarse/ light (sandy)
	medium (loamy, silty)
Soil types	Cambisols, Luvisols, Terra Rosa, Litosols
Water	
Water supply for the land on which the technology is applied	rainfed drip irrigation
Groundwater table	5-50 m
	> 50 m
Availability of surface water	poor/ none
Water quality (untreated)	for agricultural use only
Water quality refers to	surface water
Salinity	increased due to irrigation
Flooding of the area	occurs episodically
Biodiversity	

Species diversity	high
Habitat diversity	high
Further information	
High biodiversity due to mosaic-type landscape	

2.4.2 The pilot area in the Canyoles River Basin: A profile

Figure 7: The soils in many orchards are uncovered. Exposing the soils to the impact of erosive climate conditions.

The Canyoles River Basin is situated in the region of Valencia, Spain. Over the past thirty years, a shift from a traditional Mediterranean rainfed agriculture to mechanised production of citrus and persimmon coupled with drip irrigation and the application of herbicides led to a critical degradation of the soils. Soil compaction increased and soil erosion and runoff were enhanced by the uncovered soils. At the same time, the increased water demand and use of wells for the drip irrigation has resulted in aquifer depletion. Furthermore, the traditional agriculture terraces were removed, resulting in larger fields on slopes with bare soils which additionally exacerbated soil erosion. Already, climate change affects the seasonal distribution of the rainfall. More frequent heavy precipitation events further add to current soil erosion rates.

Nestled in the upper reaches of the Canyoles River watershed, the municipality of Font de la Figuera sits at an elevation of 588 m asl (38.80ºN, 0.88ºW) and basks in a Mediterranean dry climate. The region receives an average annual rainfall of just 432 mm and has a potential evapotranspiration rate of 1350 mm/year, thus, this semi-arid region presents unique challenges for agriculture. During the year, temperatures in Font de la Figuera average around 14 ºC, with July and August bringing summer highs of 25 ºC, while January sees cooler winter lows of about 8.5 ºC. A long summer drought lasting approximately four months, combined with frequent drought periods, adds to the challenges faced by local farmers striving for productivity. While irrigation might seem to be a viable solution, the threats of salinisation and groundwater depletion make it essential to explore alternative water management strategies.

The technique of applying chipped pruned branches as mulch has proven effective in enhancing soil water availability. The application case described here comprises over 1,000 sites evenly spread over an area of about 100 km². Mulching with chipped pruned branches was introduced through recent land users' innovation and research activities. In 2023, new experimental areas were implemented, while others exist since 1993. The agricultural landscape is a mix of large properties, typically used for cereals and vineyards, and smaller farms with olive, almond, and vineyard plantations.

2.4.3 In practice: The example of the Asensi family

In the sun-drenched fields of Font de la Figuera in the València Province of Eastern Spain, the Asensi family is forging a new chapter in sustainable agriculture. Manuel Asensi and his son Manel manage a sprawling estate with 51 hectares of olive plantations and 202 hectares of cereals and sunflowers, cultivated on land belonging to family and friends. Without their unwavering commitment, these agricultural fields might have fallen into neglect.


Figure 8: The Asensi family in their orchard

Both are full-time farmers specialising in rainfed agriculture, producing premium organic olive oil without the use of irrigation. Over the past 30 years, they have planted more than 12,000 trees, primarily olives, as well as hedgerows with forest and fruit trees to enhance local biodiversity. Manuel began farming 40 years ago, amid the aftermath of intensive chemical farming that had left the soils degraded and weary. Faced with challenges like over-ploughing, soil crusting, and a stark lack of organic matter, he set out on a path to soil restoration. Today, these same soils have transformed into a lively ecosystem. Innovative practices such as mulching with chipped pruned branches, incorporating weeds and catch crops, and applying manure - while maintaining a pesticide-free approach – have continuously revitalised the local traditional Mediterranean mosaic landscape.

The family's agricultural success is closely tied to the forward-thinking ideas of Gabriel Asensi, the, 94-year-old grandfather. Manuel Asensi introduced modern practices such as catch crops, cover crops, and mulching with pruned branches, all while carefully integrating mechanisation and continuous improvements on the farm. His insightful guidance, combined with his father's innovative spirit, has created a farming legacy for Manel, the eager 24-year-old heir to the Asensi farming tradition. Through their collective efforts, they have shifted land management practices, turning once-degraded land into a thriving ecosystem that flourishes under rainfed conditions.

For the Asensi family, incorporating chipped pruned branches is only one part of a broader initiative to develop sustainable olive oil production under the guidance of the "La Viña" cooperative. Producing organic olive oil has not only supported environmental goals but also earned premium prices, contributing to the economic success of their agricultural practices.

Today, the agricultural landscape supports not only profitable olive production, but also a picturesque blend of cereals, sunflowers, vineyards, almonds, and patches of Aleppo pine forest. Together, these elements form a scenic and biodiverse traditional Mediterranean landscape, demonstrating the Asensi family's commitment to sustain both their heritage and the land they cherish.

2.4.4 Applying chipped pruned branches: Implementation steps

Figure 9: Tractor chopping the tree branches.

The use of chipped pruned branches in rainfed olive plantations requires a tractor equipped with chipping machinery. After pruning, the cut branches are collected in the spaces between the rows of olive trees, forming a line. The tractor then processes the branches, typically requiring two passes to effectively chop them.

This method is well suited to rainfed agricultural systems, where the low tree density and open spaces between rows provide sufficient room for the machinery to operate. The resulting mulch incorporates litter from weeds, catch crops, cover crops, and the leaves and branches of the olive trees, contributing to soil health and moisture retention. Chipping usually occurs after the pruning season in winter, and farmers have the flexibility to chop the branches either immediately or weeks later. This allows them to manage the timing of the operation efficiently.

Traditionally, cut branches used to be burnt in order to prevent pests and maintain a bare soil appearance, which many considered to be more aesthetic. However, rising labour costs for burning, the dependence on specific weather conditions as well as municipal restrictions against open fires (to prevent wildfires) rendered this approach unviable. Initially, one challenge for mulching with chipped pruned branches were the costs of the machinery. Nowadays, subsidies for acquiring such equipment have significantly reduced the financial burden, making this strategy more accessible.

2.4.5 Benefits

Using chipped pruned branches as mulch offers numerous benefits for sustainable agriculture. As a nature-based solution, it imitates natural processes, such as the formation of a litter layer found in forest soils. It adds organic matter to the soil, provides habitats for microorganisms, moderates soil summer peak temperatures, and enhances soil moisture retention. The mulch layer improves infiltration rates, reduces surface runoff and soil erosion, and fosters soil biodiversity by supporting soil biota.

Chipped pruned branches play a critical role in restoring agricultural soils and ecosystems in the Valencia region but also in other semi-arid regions in the Mediterranean. Beyond soil health, these practices benefit local wildlife, providing improved habitats for birds, rodents, amphibians, insects, reptiles, and especially bees. They also enhance the aesthetic and cultural value of the landscape, reviving the beauty of traditional rainfed agricultural land cultivated since Roman times. This restored landscape has additionally fostered recreational activities, including agritourism, further integrating sustainability with economic and cultural development.

2.4.6 Contact

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2.4.7 Further information

Soil erosion and degradation research group: https://soilerosion.eu/

SEDERero contact: https://x.com/SEDERero/

Videos:

- https://x.com/SEDERero/status/1902905153390272892
- https://www.apuntmedia.es/noticies/societat/artemi-cerda-l-abandonament-massiu-mon-rural-duent-als-incendis-vivint_1_1538200.html

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2.5 Grounded in heritage, growing for the future: Agricultural mountain terraces with drystone retention walls

Case: Troodos Mountains, Cyprus
Restoration action category: Cross-slope measure **Measures included:** • Terraces **Description of technology** Establishment and restoration of agricultural drystone terraces in mountainous regions involves repairing and maintaining drystone walls to fulfil their agro-ecological and hydrological functions, i.e., to prevent soil erosion, retain soil moisture, and support sustainable agriculture on steep mountain slopes. This technology is critical in Mediterranean mountain areas, including the Troodos Mountains in Cyprus, where it helps in land conservation and agricultural productivity.
Main purposes: • prevent or reduce land degradation; • restore/rehabilitate land (reverse land degradation) (soil, water, vegetation)
Main benefits • Provide arable land • Reduce soil erosion and surface runoff • Increased agricultural productivity • Improved water management

2.5.1 Agriculture in a changing climate

Cyprus is projected to warm considerably, with rainfall becoming even more erratic and concentrated in short periods. These changes increase the risk of both drought and flash flooding. Water availability for irrigation will become less reliable, especially in upland agricultural areas. At the same time, land abandonment and urban sprawl are expected to alter land use dynamics. Traditional water-saving techniques and landscape restoration approaches will be key to adapting effectively.

Climate	
Annual rainfall	500 - 750 mm
Specifications on rainfall	main rainfall season: October to May
Further information Subtropics (< 1000 m asl) – temperate (> 1000 m asl) Troodos experiences a wide range of temperatures, from daily averages as low as −2°C in the winter months at the highest altitudes to peaks of 32°C during summer at lower elevations.	
Agro-climatic zone	sub-humid semi-arid
Topography	
Slopes on average	hilly (16-30%) steep (31-60%)
Landforms	mountain slopes hill slopes
Altitudinal zone	501 - 1000 m asl 1001 - 1500 m asl
Soils	
Soil depth on average	shallow (21-50 cm) moderately deep (51-80 cm)
Soil texture (topsoil)	coarse/ light (sandy) medium (loamy, silty)
Topsoil organic matter	high (> 3%) medium (1-3%)
Soil texture (> 20 cm below surface)	coarse/ light (sandy) medium (loamy, silty)
Further information Soil carbonate is rare on the Ophiolite lithologies of the Troodos mountains, pH values of the top 25 cm soil mainly range between 5.0 and 8.0 in a diversity of land cover units (Cohen et al., 2012) and soils are dominated by coarse (> 2 mm) fragments (Camera et al., 2017).	
Water	
Water supply for the land on which the technology is applied	mixed rainfed–irrigated: traditional vineyards were rainfed; new vineyards are equipped with irrigation systems and grapes are irrigated at critical growth stages
Groundwater table	> 50 m
Availability of surface water	medium (e.g. not available year-round)
Water quality (untreated)	good drinking water
Water quality refers to	both ground and surface water
Biodiversity	

Species diversity	medium
Habitat diversity	medium
Further information	
The Troodos Mountains, especially the Troodos National Forest Park, span 9,147 hectares and host around 750 plant species, including 12 endemics, alongside notable fauna like the Griffon Vulture, Bonelli's Eagle, Cyprus Warbler, and Cyprus mouflon. Its varied habitats and geology make it vital for biodiversity conservation in Cyprus.	

2.5.2 The pilot area in the Troodos Mountains: A profile

Figure 10: Collapsing drystone wall

With an average slope of 31 percent, agriculture in the Troodos Mountain region typically relies on drystone terraces. Farmers produce grapes, apples, cherries, peaches and nuts (e. g. almonds and hazelnuts) and, to a lesser extent, citrus and olive. Cyprus' agriculture is challenged by an ageing farm population, with an average farmer age of 59 years. Due to small farm sizes (around three hectare), land fragmentation also poses a challenge. The ageing farming population and land fragmentation are more profound in the Troodos Mountains than in the plain. The remaining farmers are unable to maintain production on existing farmland, leading to widespread abandonment of fields. Owing to the lack of maintenance, soil erosion and degradation of abandoned drystone terraces can be observed throughout the mountains, sometimes leading to the complete collapse of once productive hillsides. A recent development is the use of diggers and bulldozers to construct new terraces in many areas in the Troodos Mountains. This new technique is not regulated and the absence of guidelines for designing sustainable terrace slopes sometimes results in costly construction and maintenance as well as increased costs for agricultural production. In some cases, the mechanised construction of terraces leads to adverse environmental impacts. As a consequence, despite the fact that drystone constructions are on the list of Intangible Heritage recognised by UNESCO, current developments lead to soil erosion and the loss of traditional knowledge.

2.5.3 In practice: Reviving the slopes of the Troodos Mountains

Drystone terraces are applied throughout the Troodos Mountains, characterised by steep slopes and a semi-arid climate with seasonal rainfall ranging from 500 to 750 mm per year. They reflect the area's agricultural heritage and exemplify a well-adapted nature-based solution. However, the Troodos Mountains face the critical issue of agricultural abandonment, highlighted by a sharp decline in cultivated land in recent decades, driven by urbanisation and high farming costs. Consequently, many mountain terraces have been abandoned, and drystone walls remain unmaintained, sometimes causing a domino effect of collapsing terraces. The abandonment of terraced plots also implies a gradual loss of the indigenous and intangible knowledge regarding the construction and maintenance of drystone walls. Despite these socioeconomic challenges, drystone terraces remain a vital part of the landscape, reflecting a long-standing tradition of sustainable land management. Over the past decade, there is a gradual, renewed interest in terrace farming especially for wine grape production. Unlike traditional drystone terraces, modern terraces established by wineries are built using heavy machinery. They tend to cover large, uniform parts of slopes. In addition, drystone walls are often constructed by winery workers that may lack the expertise required, and consequently the walls are prone to collapsing after intense rainfall events. These new practices are currently the research focus of the Cyprus Institute research team as part of PRIMA-REACT4MED project, especially the hydrological and structural stability characteristics.

The primary purpose of the drystone terraces is to mitigate soil erosion, enhance soil moisture retention, and create viable agricultural land on steep slopes. At the same time, these terraces serve secondary purposes, such as conserving the cultural heritage of the local communities, supporting biodiversity by creating habitats for various species, and maintaining the productive capacity of the soil.

Figure 11: Victoras Finoloulos

Victoras Finopoulos is a passionate winemaker and vineyard manager in the high Marathasa valley of the Troodos Mountains, Cyprus. On steep, south-facing terraced slopes, supported by newly developed and traditional drystone retention walls, he is patiently establishing modern vineyards and awakening old ones that once flourished. After first discovering wine as a child in Hungary, Victoras trained in Agronomy, Viticulture and Oenology in Montpellier and Bordeaux, before working on harvests in Alentejo (Portugal), Chablis (France) and Marlborough (New Zealand). Today he manages the Marathasa Wines vineyards, growing mostly indigenous varieties such as Xynisteri and Maratheftiko alongside carefully chosen international grapes. His guiding principles are constant sensory contact with the wine, the terraced land and the vines; regular tasting of the wine and multiple visits to the same terraces throughout the day to understand how vines respond to varying conditions – from morning dew, midday heat and cool mountain nights. This hands-on approach informs low-input practices that conserve scarce water and sustain the vines in stony soils. His broader vision is to enhance soil health and stability in newly developed terraced vineyards by following different agro-ecological practices. Other than maintaining the drystone walls, he has been applying cover cropping and chopped vine prunings to improve soil health, prevent soil erosion and retain water in the terraced vineyards.

2.5.4 Agricultural mountain terraces with drystone retention walls: Implementation steps

Figure 12: Construction of drystone walls

The establishment and restoration of agricultural terraces with drystone walls is a technology applied in many mountain regions, including the Troodos Mountains of Cyprus. This involves the construction and maintenance of terraces supported by walls built with natural stones arranged without the use of any mortar. The basic principles of establishing terraces with drystone walls are similar across the region, while the exact size and form of terraces and walls are determined by site-specific characteristics; slope, elevation, geology (type of available stones as construction material), soils, crop type, etc. These terraces are essential for creating arable land on steep mountain slopes, reducing soil erosion, and retaining soil moisture, thus supporting sustainable agricultural practices in mountain environments.

Establishing and maintaining these terraces involves several major activities and inputs. The key activities include land levelling, foundation preparation, stone collection and transfer, and the actual construction of the stone walls. These activities are typically carried out in early autumn or late spring. Manual labour is the main input, making the process very costly. Based on the latest (2024) estimates, the establishment of drystone terraces per square metre ranges between €64.29/m^2 (for plots < 500 m asl) and €107.97/m^2 (for plots ≥ 800 m asl and slope gradient ≥30°).

The main characteristics of this technology include the use of locally sourced rocks, typically gabbro and diabase, to construct drystone walls that support the agricultural terraces. The terraces are built along contour lines to form nearly level platforms, which vary in width from 1 to 3 metres for narrow terraces to 3 to 6 metres for medium-base terraces, while the height ranges from 0.75 to 2 metres. Occasionally, terraces can be wider (e.g., 20 metres in gentler slopes) and higher (i.e., more than 2 metres in steep slopes), depending on the slope's steepness and morphology. The construction process involves careful selection and placement of stones: large, irregular stones are used for the foundations, while more regular stones form the walls. Smaller stones are inserted between the larger stones to enhance the structure's stability, while long and relatively flat stones are used at the upper end of the walls, i.e. what locals call the “crown” of drystone walls. The walls are built with a slight inward incline to ensure stability and facilitate water drainage through the structure.

Land users and farm managers often cite the high labour and maintenance costs as significant disadvantages. Community-based approaches have been promoted, encouraging collective efforts in terrace maintenance. Skill development and professional training of younger mountain farmers, farm workers and terrace builders is lacking and needs to be provided by agricultural extension services and technical schools in collaboration with drystone experts, geo-engineers and landscape architects.

2.5.5 Benefits

The benefits of this technology are multifaceted. Environmentally, the terraces significantly reduce soil erosion and surface runoff, improve soil moisture retention, and enhance sediment retention. This leads to increased agricultural productivity and improved water management. Socioeconomically, they provide vital arable land to sustain farm income and crop yields. Culturally, the terraces preserve a part of the local heritage and landscape aesthetics; in the past, this practice was used to foster community engagement in sustainable land management practices.

2.5.6 Contact

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2.5.7 Further information

Manual for the construction of mountain drystone terraces in Cyprus (in Greek): https://3pro-troodos.cyi.ac.cy/images/deliverables/D2.3c_ManualDrystoneTerraces.pdf

Information on available agricultural subsidy schemes under Cyprus' Common Agricultural Policy Strategic Plan 2023-2027: http://www.cap.gov.cy/moa/cap/cap.nsf/home/home?openform

Scientific publications related to agricultural mountain terraces in Troodos, Cyprus:

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2.6 Tradition meets the future: Conservation agriculture for healthy soils and healthy livelihoods

Case: Zaer, Morocco

Restoration action category: improved ground/ vegetation cover, minimal soil disturbance

Measures included:

- Soil surface treatment
- Change of management: no-till

Description of technology

Morocco's current climatic conditions significantly impact the management of water resources and soil fertility in agriculture, posing challenges for lands that are degraded or at risk of degradation. In response, the Green Generation 2020-2030 national agricultural program emphasises the expansion of direct seeding techniques. This approach aims to enhance soil conservation, improve water efficiency, and support sustainable agricultural practices amidst increasing environmental pressures.

Main purposes:

- prevent or reduce land degradation;
- restore/rehabilitate land (reverse land degradation) (soil, water, vegetation)

Main benefits

- Increase in farmers' profits
- Improvement in natural resources and productivity
- Sustainability of soil biological activity
- Time-saving and work efficiency

2.6.1 Agriculture in a changing climate

In Morocco's Mediterranean coastal zone, farmers are likely to face more frequent heatwaves, reduced rainfall, and prolonged dry periods. These climatic changes, paired with rapid population growth and land fragmentation, could reduce agricultural viability and exacerbate rural poverty. Future projections highlight the need for soil conservation, water harvesting, and the revival of agro-silvopastoral systems to build long-term resilience and retain youth in rural areas.

Climate	
Annual rainfall	< 250 mm 251 – 500 mm Unstable precipitation
Reference meteorological station	INRA's station
Agro-climatic zone	The climate is semi-arid, with a Mediterranean-type rainfall regime that is characterised by a dry summer and a rainy winter. The average rainfall over 40 years was 394 mm, with a maximum of 665 mm and a minimum of 181 mm.
Topography	
Slopes on average	moderate (6-10%)
Landforms	plateau / plains
Altitudinal zone	101 - 500 m asl
The technology is specifically applied in	concave situations (depression – conversion of water flow)
Soils	
Soil depth on average	moderately deep (51-80 cm) deep (81-120 cm)
Soil texture (topsoil)	fine/ heavy (clay)
Topsoil organic matter	medium (1-3%)
Soil texture (> 20 cm below surface)	fine/ heavy (clay)
Further information	

Soils in the region are generally low in organic matter and have varying levels of essential nutrients like nitrogen, phosphorus and potassium. The soil of Merchouch experimental station is a vertisol with possible external drainage, hydromorphic (Aquic Chromoxerert).

pH (Water)	pH (KCl 1 N)	OM (%)	P_2O_5 (ppm)	K_2O (ppm)	EC (mS/m)
7.5	6.5	2.2	30.0	265.1	0.2

Water	
Availability of surface water	poor / none The region relies on rainfed agriculture.
Water quality (untreated)	for agricultural use only
Water quality refers to	both ground and surface water
Biodiversity	

Species diversity	medium
Habitat diversity	medium
Further information The direct seeding strategic plan integrates habitat preservation, agricultural productivity, and resource sustainability, fostering long-term soil conservation and resilience.	

2.6.2 The pilot area in the Zaër region: A profile

Morocco's agricultural sector relies heavily on its 9.2 million hectares of arable land, with around 65 percent dedicated to cereal cultivation. However, a growing population, limited availability of arable land, and soil degradation are placing increasing pressure on the country's food systems. Intensive agricultural practices, especially conventional tillage, have led to problems such as soil erosion, water and soil pollution, and desertification. Additionally, climate change further worsens these issues by reducing the availability of rainwater in arid and semi-arid regions.

The Zaër region, with its plateau landscape and irrigation from the Bouregreg River and its tributary, the Grou River, is well suited for cereal and food legume production. At the same time, the region’s sloped topography is particularly vulnerable to drought and soil erosion, making effective soil and water conservation practices essential.

Conservation Agriculture is pivotal in mitigating the effects of extreme events such as drought and heat stresses. Research demonstrates that Conservation Agriculture can increase and stabilise food production for Morocco’s growing population Accordingly, it is a key component of Morocco's national agricultural strategies, such as the "Generation Green 2020-2030" strategy, which aims to promote direct seeding on one million hectares by 2030.

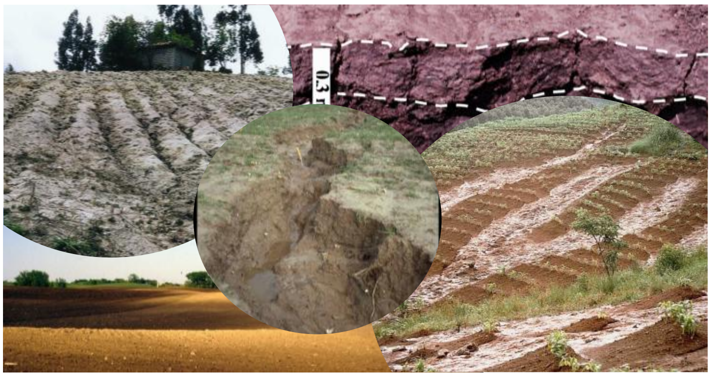

Figure 13: Signs of soil degradation in the Zaër region

Conservation Agriculture is based on three key principles:

(1) maximising crop diversity (crop rotation with diversified crop species),
(2) minimising soil disturbance (no-till systems with direct seeding),
(3) and keeping soil cover through crop residue management (e.g., using straw as mulch)).

To facilitate the implementation of Conservation Agriculture, the National Institute of Agronomic Research in Morocco (INRA) developed a No-Till Technology system, combining direct seeding with crop residue management.

2.6.3 Conservation agriculture: Implementation steps

At the core of the No-Till Technology is a specialised no-till drill that simultaneously seeds and fertilises annual crops. This machine carefully cuts through existing crop residues, opens a 20 cm wide slot, places the seeds and N/P fertilisers, and reseals the soil to ensure optimal seed-soil contact. Row spacing can be adjusted to suit different crops – 20 cm for wheat and barley, and 40 cm for lentils and chickpeas. By avoiding ploughing, harrowing, and other aggressive tillage methods, soil disturbance is minimised, protecting its natural structure. In fact, minimising disturbance and maintaining a protective mulch cover mimics natural processes, creating healthier, more resilient, and productive agricultural systems.

Figure 14: Field which has not been tilled and were plant residue is left as a ground cover.

Common rotations in the region, such as leguminous crops (lentils, chickpeas) with cereals (soft wheat, durum wheat), are readily integrated into Conservation Agriculture systems. Other wheat crop rotations include barley and fodder species, with fallow periods. Rather than tillage, farmers are using special herbicides to control weeds, allowing for an 18-month fallow period (a 'chemical fallow') following two crop cycles. Fallowing is essential for water conservation in this semi-arid area.

The no-till drill ensures minimal soil disturbance and precise phosphate fertilisation. Residue management varies depending on the site, ranging from low residue maintenance (stubble with controlled grazing) to medium surface cover (stubble/straw maintenance, forage crops with exclusion of grazing). Key outcomes include reduced erosion and evaporation, improved water retention, lower runoff, and enhanced infiltration. While herbicides are used for weed control, they can be reduced over time, focusing on environmental sustainability. Maintaining crop residues in the fields increases soil organic matter, enhances carbon stored, and boosts nutrient levels, potentially reducing the need for inorganic fertilisers.

Table 1: Sequence of activities of a Conservation Agriculture System

Activity	Timing (season)
1. Stubble maintenance (no grazing, only partial straw removal)	After harvest / annually
2. Direct seeding + fertiliser (N/P) banding using no-till drill	Early November annually
3. Chemical weed control	Dec/Jan annually
4. Nitrogen fertilisation	March annually
5. Harvest	May, after 6 months/annually
6. 18-month fallow period (with herbicide application if needed)	

Implementing No-Till Technology effectively requires a few key resources:

- Regular monitoring with farmers to ensure sustainable adoption.

- Delimitation tools, such as GPS, for precise land management.
- Rapid soil and crop analysis equipment to assess productivity.
- Adapted direct seeding equipment tailored to local farming needs.
- Training provided by institutions like INRA, ICARDA, and agricultural offices.

A significant challenge is balancing the need for crop residues as soil cover with the needs of livestock. Integrating direct seeding systems with livestock requires careful planning and targeted strategies.

2.6.4 Benefits

Adoption in regions like Zaër demonstrates significant economic advantages, with cost savings of 90-120 Euros per hectare and profit margin increases exceeding 55 percent. Long-term studies confirm that Conservation Agriculture can maintain and improve crop yields, providing greater stability for farmers. Enhanced soil biological activity ensures long-term soil fertility and health, supported by research linking no-till practices to increased soil carbon sequestration.

Direct seeding offers operational advantages including enhanced work efficiency, reduced labour costs, and lower fuel consumption through minimised tillage. Farmers consistently report reduced costs, improved yields, and effective soil conservation.

Environmentally, direct seeding promotes efficient water use, increases infiltration, reduces water loss, and mitigates erosion. Maintaining soil cover protects against rainfall impact and fosters pest-resistant crop varieties.

To maximise these benefits, it is essential to:

1. Keep soils covered with residues during planting and seeding to ensure sufficient soil moisture
2. Use appropriate equipment and inputs to maintain soil quality and prevent erosion
3. Control biomass removal and manage grazing to promote soil health

Conservation Agriculture represents a vital, sustainable approach to agriculture, enhancing the resilience of Moroccan farming systems in a changing climate. Continued focus on integrated crop and pest management is crucial to fully leverage these benefits. Supporting the wider adoption through ongoing research and the Department of Agriculture's Roadmap will ensure long-term success for both farmers and the environment, promoting sustainable and climate-resilient agricultural practices across Morocco. Reduction of machinery passes and diligent residue management ensure higher yields, lower costs, and the conservation of precious water resources.

2.6.5 Contact

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2.6.6 Further information

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2.7 Diverse yields: Agroforestry to protect soils and livelihoods

Case: Crete, Greece
Restoration action category: natural and semi-natural forest management, agroforestry, pastoralism and grazing land management **Measures included:** • Tree and shrub cover • Walls, barriers, palisades, fences **Description of technology** Ceratonia siliqua (carob) is established in grazing areas, transitioning the land into agro-pastoral systems after successful establishment. This restoration action enhances ecosystem health by stabilising soil, increasing biodiversity, offering fire resistance and market diversification
Main purposes • Improve production • Prevent, reduce land degradation; restore/rehabilitate land
Main benefits • Stabilising soil and mitigating land degradation • Market diversification • Drought tolerance

2.7.1 Agriculture in a changing climate

Crete is expected to see rising average temperatures, more frequent droughts, and declining rainfall, particularly during critical growing periods. These conditions will place pressure on water resources and contribute to soil degradation and wildfire risk. Demographic decline in rural areas and economic concentration in tourism will also affect farming communities. Strengthening agroforestry systems and improving water efficiency will be essential for climate-smart land use on the island.

Climate	
Annual rainfall	690 mm
Agro-climatic zone	sub-humid
Thermal climate class	subtropics
Topography	
Slopes on average	moderate (6-10%)
Landforms	hillslopes footslopes
Altitudinal zone	0 – 100 m asl 101 - 500 m asl
Soils	
Soil depth on average	very shallow (0-20 cm) shallow (21-50 cm)
Topsoil organic matter	medium (1-3%)
Water	
Ground water table	> 50 m
Availability of surface water	medium
Water quality (untreated)	good drinking water
Biodiversity	
Species diversity	high

2.7.2 The pilot area in Heraklion: A profile

In the past, the European Common Agriculture Policy supported an adequate income for farmers on Crete through structural policies, contributing to regional economic development, particularly in less favoured areas. However, these very subsidies also accelerated the agricultural intensification and specialisation, which in turn led to increasing degradation of agricultural soils. Production became export-oriented and homogenised, resulting in the loss of the island's self-sufficiency in products such as cereals, fruits, and vegetables. The rising market value of animal products further incentivised free-range livestock farming. Statistical figures for some of the mountainous communities show an increase of the total number of sheep and goats by over 200 percent between 1980 and 1990. The ecological impact of the introduction of domestic grazers on native species on Mediterranean islands since prehistoric times has been well documented.

Since the 1950s, large-scale migration from rural to urban areas took place, while the rural land was over-exploited by the few remaining farmers. Today, the rural population continues to decline, even though Crete's total population, especially around Heraklion, has grown significantly over the past four decades, increasing the pressure to convert agricultural land into residential or industrial areas.

In the Melidochori Area, the effects of overgrazing are particularly evident, disrupting the agricultural system and limiting its potential. The region has a sub-humid climate, with an average annual rainfall of 690 mm and average temperatures of 17.5°C. For about seven months each year, temperatures range from 5°C to 18°C, contributing to a subtropical climate.

2.7.3 In practice: The example of Kostas Karatzis

Kostas Karatzis co-owns Karatzis Estate, a 50-hectare silvopastoral farm in Melidochori. Since 1995, he and his team have planted over 10,000 trees, including broadleaf, carob, mulberry, pine, cypress, and others like walnut and fig. This change in land use has revitalisd degraded land affected by drought and overgrazing, turning it into a thriving ecosystem, rich in biodiversity.

The restored landscape now supports improved grazing through nuanced soil stability, enables new business opportunities through the production of new crops like carob, and serves as a model of sustainable land management for the local community. Though Kosta's financial resources are similar to those of his peers, his practical knowledge and strong engagement in community projects make him a local leader and role model.

2.7.4 Agroforestry: Implementation steps

A stand of *Ceratonia siliqua* (carob trees) is planted in grazing areas, typically in a six-metre grid. Initial structural measures are required, mostly related to preparing slopes and soil for sapling planting and establishing irrigation infrastructure. A protective fence must be maintained for the first 10 years to prevent livestock from damaging young trees. During the first three years, the two-year-old saplings are actively managed. This includes watering, fertilisation and replacement of dead or weak trees. Once established, intensive irrigation is no longer needed and grazing can resume with minimal restrictions.

Figure 15: Pruned stand of Ceratonia siliqua

The main drawback of this technology is a temporary reduction in livestock and other crop yields during the first decade of application until trees are mature.

2.7.5 Benefits

Silvopastoral systems offer significant environmental and economic benefits to land users, especially for grazing systems. They do not only combat land degradation but also promote soil health and local biodiversity. In particular, carob trees provide:

- Fodder from carob pods and cuttings for livestock
- Shade during hot summer months
- Increase in soil stability, organic matter content and water retention

The economic benefits extend beyond grazing. Carob can be utilised to create alternative income sources, such as carob honey and flour, serving as a viable business diversification strategy for farmers. Their moisture-rich trunks also make carob trees resistant to wildfires.

Aside from agricultural benefits, silvopastoral practices maintain high habitat quality for local wildlife, including birds and bees, enriching biodiversity. Native to the Mediterranean, *Ceratonia siliqua* blends well into the rugged agro-pastoral landscapes of the Mediterranean islands. The enhanced natural beauty of the landscape, coupled with ties to Cretan traditions, enrich the community's cultural and aesthetic values and make the area more attractive for agritourism and recreational activities.

2.8 Improving soils and biodiversity with food forests

Case: Bethlehem of Galilee, Israel
Restoration action category: Agroforestry **Measures included:** • Change in land use type • Change in management: Permaculture • Layout according to natural and human environment **Description of technology** A food forest embodies a restorative approach to land management, transforming degraded landscapes by utilising naturally occurring ground cover to preserve soil health and biodiversity while producing food. Established on previously degraded sites, such as the one initiated in 2017, food forests also serve as multifunctional spaces that provide diverse socio-cultural, environmental, and economic benefits.
Main purposes • prevent, reduce land degradation; restore/rehabilitate land • preserve/ improve biodiversity • mitigate climate change and its impacts
Main benefits • Sustainable food production • Community strengthening and local resilience • Biodiversity and ecosystem resilience • Soil restoration and improvement • Carbon sequestration and climate regulation

2.8.1 Agriculture in a changing climate

Northern Israel is forecasted to experience rising temperatures and decreasing rainfall, contributing to water scarcity and heightened evaporation rates. These shifts are likely to stress irrigation systems and increase salinity risks. With urban expansion and economic growth expected, land competition will intensify. For land users, integrating biodiversity-enhancing practices and efficient irrigation will be crucial to maintaining productivity and ecological health.

Climate	
Annual rainfall	251-500 mm
Average annual temperature	17°C to 20°C
Reference meteorological station	Neve Yaa'r meteorological station
Agro-climatic zone	sub-humid
Topography	
Slopes on average	gentle (3-5%)
Landforms	plateau/ plains
Altitudinal zone	501-1,000
Soils	
Soil depth on average	moderately deep (51-80 cm) deep (81-120 cm)
Soil texture (topsoil)	medium (loamy, silty)
Topsoil organic matter	medium (1-3%)
Soil texture (> 20 cm below surface)	medium (loamy, silty) fine/ heavy (clay)
Water	
Water supply for the land on which the technology is applied	raomfed
Groundwater table	> 50 m
Availability of surface water	medium (e.g. not available year-round)
Water quality (untreated)	for agricultural use only
Water quality refers to	surface water
Biodiversity	
Species diversity	high
Habitat diversity	high

2.8.2 The pilot area in Bethlehem of Galilee: A profile

Agriculture in Israel is a strongly developed, technology-oriented industry that produces both for domestic consumption as well as export. Since most Israelis, including the farmers, have served in the military, they are well trained in handling different technologies. Despite the presently increasing erosion of agricultural soils due to the intensive agriculture, the majority of farmers as well as the Ministry of Agriculture do not pay attention to soil health at the moment. The ministry's main focus is on research and farm support in the development and application of cutting-edge farm technologies. The lack of an explicit economic valuation of healthy soils, the short-term focus on profitability, the need for high productivity and a general lack of awareness for the various services that soils and biodiversity are providing are all reasons for the negligence of soil conservation practices in agriculture in Israel.

The food forest in Bethlehem of Galilee in Israel is a pioneering example of sustainable agricultural, drawing inspiration from the principles of permaculture and imitating services of natural forest ecosystems. Surrounded by hilly terrains in the Upper Galilee, the food forest integrates diverse edible plants, medicinal species, and ecological features like ponds and animal habitats. The food forest aims to revitalise degraded soils and enhance biodiversity, requiring minimal external inputs while developing self-sustaining ecosystems. Its design allows for versatility, making it suitable for various landscapes, whether as community spaces or educational hubs. Addressing local challenges such as water management and increasing ecological awareness, these projects play a crucial role in fostering sustainable livelihoods.

Over the last seven years, the owners carefully planned and worked to transform the wider landscape. This involved redesigning the topography, planting numerous trees, and introducing supporting plants. Their efforts required extensive planning and patience. Today, Bethlehem of Galilee food forest has evolved into an environmental and social business. Over 40 such projects have been established across both rural and urban areas in Israel, each contributing to a greener, more resilient environment. This plays a significant role in reversing land degradation and serves as an educational hub, promoting sustainable land and water management practices that benefit and improve the livelihoods of the local community in the long term.

Figure 16: Yuli and Nitzan Betzer, photo: Yuval Yanai, June 2023

2.8.3 In practice: The example of Yuli and Nitzan Betzer

When Yuli and Nitzan Betzer moved back to Nitzan's hometown Bethlehem of Galilee in the Northern part of Israel, they wanted to create a project with a tangible environmental and social impact. They envisioned a place where nature and community flourished hand in hand.

The couple identified the potential in a degraded piece of land that once belonged to Nitzan's old family farm. They explored and experimented with various agricultural models ranging from low maintenance forest gardening to high maintenance regenerative agriculture. Ultimately, they decided to create a food forest based on permaculture principles, a balanced approach combining elements of agriculture with the natural ecosystem.

2.8.4 Creating a food forest: Implementation steps

Creating a food forest begins with selecting a suitable location considering crucial factors such as soil quality, climate, and water availability. A thorough site assessment is essential to evaluate existing resources and limitations, including any major issues with degraded soil or water scarcity. Once a suitable site is chosen, preparation becomes the next priority. This involves improving the soil through methods like working in compost or cover cropping to ensure it is nutrient-rich and fertile. Furthermore, implementing effective water management systems – such as swales for directing runoff or rainwater harvesting setups – sets the foundation for a thriving micro ecosystem.

Figure 17: The team prepares the ground for the establishment of an ecological pond.

Choosing the right saplings and plants for a food forest - edible, medicinal, and ornamental species - requires careful consideration of their ecological compatibility and functions. Arranging the plants and designing the forest environment should mimic natural ecosystems and incorporate regenerative agriculture principles to create a balanced environment. This creative phase of development provides also an optimal stage to engage with the local community garnering support, fostering creative learning and ensuring long-term collaboration in the project.

Figure 18: The couple regards the degraded soil in 2017 where the food forest will be established.

During the first three years, the primary focus should be on maintaining soil health, promoting biodiversity, and ensuring the survival of the planted species. This involves regular watering, fertilising, and replacing any weak or struggling plants. To empower community members, educational programs on permaculture principles and maintenance techniques may be necessary.

Once established, the food forest will demand minimal intervention, as it will rely on self-sustaining processes. Ongoing maintenance will include routine observation, periodic pruning, monitoring plant health, and managing invasive species. Over time, the ecosystem will become more resilient to environmental challenges, such as droughts or pest invasions, while providing collective benefits to the community. Contextual factors, such as community needs, cultural practices, and available funding, should inform the design and implementation process. A context-sensitive approach allows food forest restoration actions to succeed across diverse environments, from rural to urban settings, enhancing local ecosystems while delivering long-term ecological and economic benefits.

2.8.5 Benefits

The establishment of food forests provides a range of immediate and long-term benefits for both land users and the environment. For land users, food forests provide sustainable food production, medicinal plants, and economic opportunities through the sale of produce or ecotourism. Additionally, they serve as educational and therapeutic spaces, strengthening community ties and local resilience. Besides the plentiful and diverse harvest, benefits include reducing the dependency on external resources, such as water, fertilisers, and energy, thanks to the ecosystem's self-sustaining nature. Additionally, permaculture systems including food forests create spaces for social engagement, recreation and education and fostering economic opportunities within local communities.

In the long term, food forests play a vital role in restoring degraded soils, improving water retention and enhancing biodiversity by creating stable, resilient ecosystems. They contribute to carbon sequestration and climate regulation, offering significant ecological advantages.

Incorporating ponds, wildlife habitats, and diverse plant species enhances ecosystem functions, such as nutrient cycling, pollination, and habitat creation. These benefits align with sustainable agriculture and social well-being principles, positioning food forests as productive and restorative landscapes. Ultimately, food forests increase ecosystem resilience against challenges like droughts and pests while providing collective benefits to communities.

2.8.6 Contact

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2.8.7 Further information

https://www.bethlehemfoodforest.com/

https://www.foodsystemsjournal.org/index.php/fsj/article/view/1043/1013

3 Spreading the fruits of knowledge: Supporting informed land management with LanDS

LanDS is an online toolbox developed as part of the REACT4MED project, with input from researchers, local experts, and restoration practitioners across the Mediterranean. Its goal is to help scale up the successful land restoration actions that were tested in the Pilot Areas to other regions facing similar challenges.

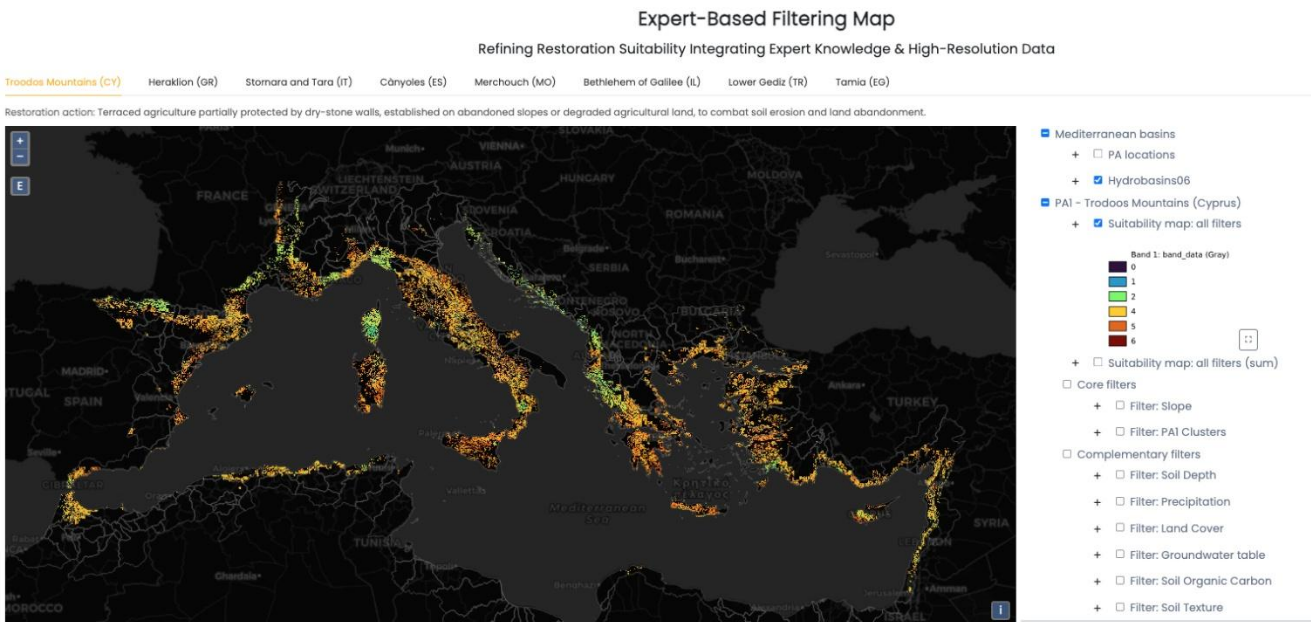
The platform is designed to support farm advisers, land managers, and policymakers. These users can access data and tools to assess land degradation risks, explore suitable restoration actions, and evaluate their potential impacts.

LanDS combines scientific data – such as soil, climate, and land use information – with on-the-ground experience from restoration projects. It offers maps and indicators to help identify which areas are most vulnerable to degradation and where restoration is likely to be most effective. This helps decision-makers develop tailored, cost-effective strategies for sustainable land and water management.

An integrated monitoring tool within LanDS also allows users to upload local data and resources, enabling farm advisers and land managers to track the performance of the implemented restoration actions over time.

By bringing together local knowledge and broader environmental and socioeconomic information, LanDS supports context-sensitive, evidence-based decisions that are effective in the long term. The insights it offers can inform policies and strategies aimed at building more resilient and productive landscapes, ultimately benefiting farmers and rural communities across the Mediterranean.

Figure 19: Excerpt from the suitability map for potential upscaling and outscaling of terraced agriculture (restoration action in Cyprus) across the Mediterranean region, displayed in the "Expert-Based Filtering Map" of the LanDS dashboard. The interactive suitability map indicates areas in the Mediterranean where terraced agriculture could present a viable solution to restore agricultural soils. Based on climate, land, socioeconomic and local knowledge, the user can explore how suitable different areas are (from 0 = not suitable to 6 = highly suitable).



Suitability maps are available for all restoration actions tested in React4Med. To explore the LanDS toolbox and learn more, visit: https://lands.soft-water.it