Deliverable 5.1
Restorations technologies tested and validated

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PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

REACT4MED

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List of acronyms

CY: Cyprus

D: Deliverable

CM: Decision Maker

DoA: Description of Action

EG: Egypt

ERLL: Ecosystem Restoration Living Lab

GA: Grant Agreement

SP: Spain

IL: Israel

IT: Italy

GR: Greece

GE: Germany

LanDS: Land Degradation Decision-Support

M: month

ML: Machine Learning

MO: Morocco

MS: Milestone

PA: Pilot Area

PAL: Pilot Area Leader

PP: Project Partners

SH: Stakeholder

SLWM: Sustainable Land and Water Management

TR: Turkey

WP: Work Package

W: Workshop

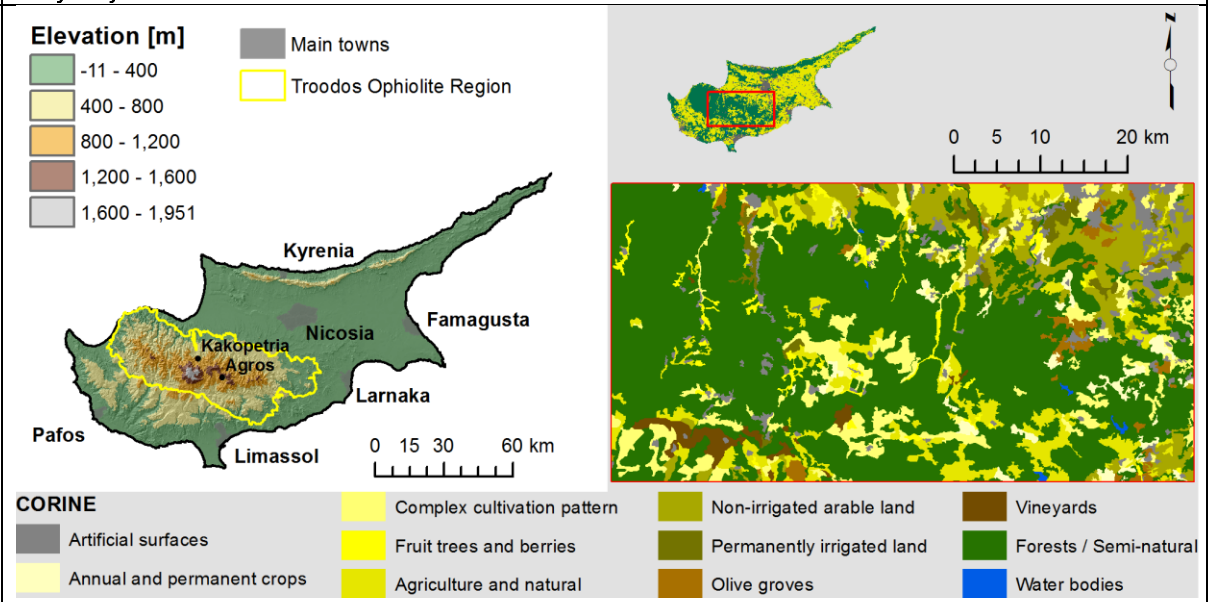
Summary

REACT4MED aims to extend the potential application of the land restoration action(s) promoted in the Ecosystem Restoration Living Labs (ERLLs) by upscaling the information gathered in the different pilot areas at the Mediterranean scale. Within the Project, WP5 is devoted to the implementation of restoration outscaling actions in the 8 Pilot Areas and assessment of cost-effectiveness. In the first top-down approach (in collaboration with WP2) the wide scale biophysical indicators chosen, must be adapted in order to assess the effectiveness and impact of past/ongoing projects. In the second bottom-up approach the indicators and the metrics co-developed with WP3 and formalized in the LanDS with WP4, are used to assess the impacts of new restoration actions and their outscaling in areas with similar bio-physical and socio-economic conditions.

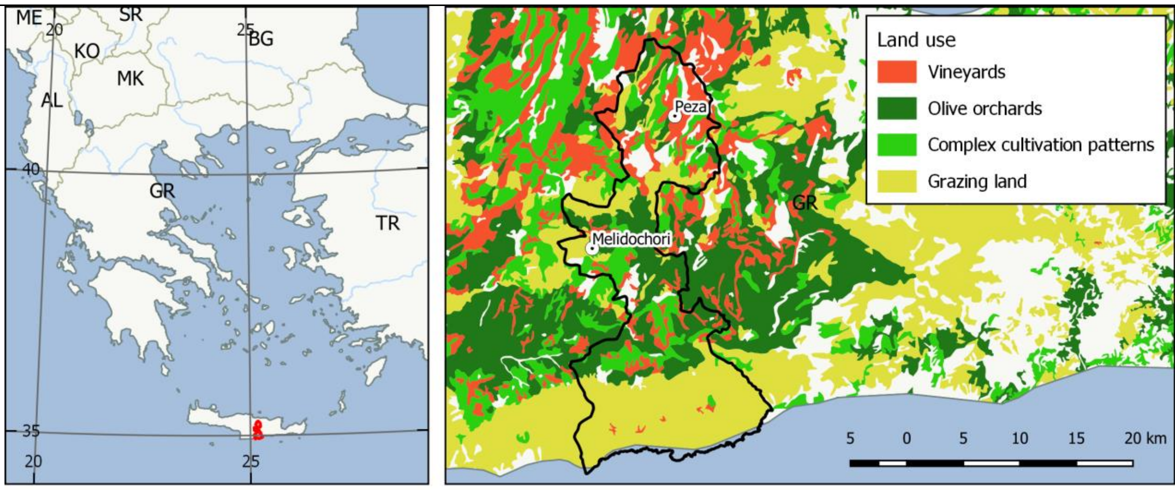
The present report summarizes the information gathered in 8 Pilot area (Cyprus, Greece, Italy, Spain, Israel, Morocco, Turkey, and Egypt), regarding the tested technologies, their validation, and their practical dissemination. Based on the information collected within WP2 and data arriving from WP3 this task offers resource base information on the implementation process of the restoration actions. Much of work was done in close collaboration with farmers, local extensions staff and researchers involved in all the ERLLs. Finally, this deliverable shed light on the proposed monitoring system to be able to assess and monitor the effectiveness of the assessments.

1 Outcomes

1.1 General information

Troodos Mountains (CY)	
Study area	The Troodos Mountain region covers an area over 2,000 km^2 with a mean slope gradient of 31%. The region includes 140 small communities with a total population of around 50,000 inhabitants. Cyprus agriculture suffers from an ageing farm population (average age 59 years) and a small farm holding size (3 ha) (Cystat, 2014). The ageing of the farming population and land fragmentation due to the small size of agricultural plots are profound issues in the Troodos region. The total agricultural area in the Troodos Mountains is approximately 113 km^2. It consists of apples, cherries, peaches, and nut trees and to a lesser extent of citrus trees, olives trees, and grapes. Agriculture is typically practised on dry-stone terraces.
Surface	2,332 km^2
Bioclimatic conditions	The average annual precipitation for the Troodos Mountains ranges between 400 mm in the foothills to 1050 mm at Troodos Square (1725 m above sea level). Average annual temperatures are around 17 °C in the northern foothills and 11 °C at Troodos Square. The majority of the mountain areas have a semi-arid and sub-humid climate.
Geology, morphology, vegetation and Land use	 *Land use map of the pilot area*

Heraklion (GR)	
Study area	Crete is the largest of the Greek islands, and the 5th largest in the Mediterranean, with a total area of 8,265 km^2. While retaining its own local cultural traits, the island shapes a significant part of the cultural heritage of Greece, but also contributes 5% of the national Gross Domestic Product (GDP), with agriculture and tourism as its main industries. The rapid development of Crete in the last 30 years has exerted strong pressures on many sectors of the region. The growth of agriculture in the Messara plain has strong impact on the water resources and ecosystem services of the area by substantially increasing of water demand. The economy of the region is based on agriculture with intensive cultivation mainly olive trees, grapes, citrus, and vegetables in green houses. The case study location is within the Municipality of Archanon-Asterousion (Peza) with a population of 16.692.
Surface	335,38 km^2
Bioclimatic conditions	A major part of the case study belongs to Messara Valley. The climate of Messara Valley is classified as dry sub-humid according to UNCED (Paris Convention on Desertification, 1994) definitions and its hydrological year can be divided into a wet and dry season (Tsanis & Apostolaki, 2008). Crete has a typical Mediterranean island environment with about 53% of the annual precipitation occurring in the winter, 23% during autumn and 20% during spring while there is negligible rainfall during summer (Koutroulis et al., 2010). Although the Valley receives on average about 650 mm of rainfall per year, it is estimated that about 65% is lost to evapotranspiration, 10% as runoff to sea and only 25% goes to recharging the groundwater store (Croke et al., 2000). Rainfall increases with elevation from about 500 mm on the plain to about 800 mm on the basin slopes while on the Ida massif the annual precipitation is about 2,000 mm and on the Asterousian Mountains it reaches 1,100 mm (Tsanis, 2006). The maxima of mean monthly precipitation generally occur during winter with the exception of Central South part of Crete (South of Messara Valley) where the maximum mean monthly precipitation is in November and September (Koutroulis et al., 2010).
Geology, morphology, vegetation and Land use	The Municipality is rural with a mix of agricultural land uses mainly including olive plantations, vineyards as well as grazing land. Free-range livestock, over time, degrades rangelands due to overgrazing. The rate of degradation depends on the density of the livestock population and the restoration rate of the natural flora. The relationship of those rates can be used as a tipping point index (Dimitrakopoulos et al., 2004). The direct effects of the introduction of domestic grazers on native faunas since prehistoric times are well described for the Mediterranean islands, where original faunas have been affected by species extinction and introductions promoted by humans. The Asterousia and Psiloriti mountains of Crete represent characteristic cases of degradation caused by intensive grazing and fires set by shepherds.



The Municipality of Archanon-Asterousion in Crete, Greece, and land uses in the area

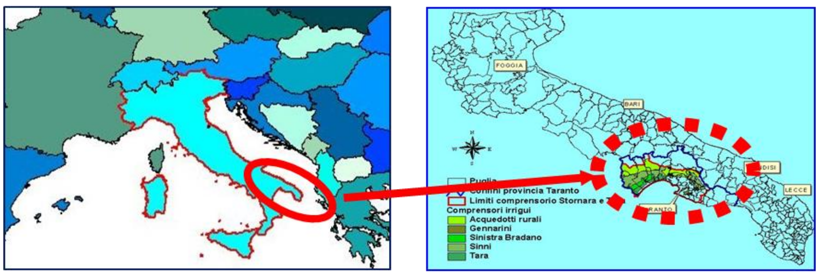
Stornara and Tara (IT)

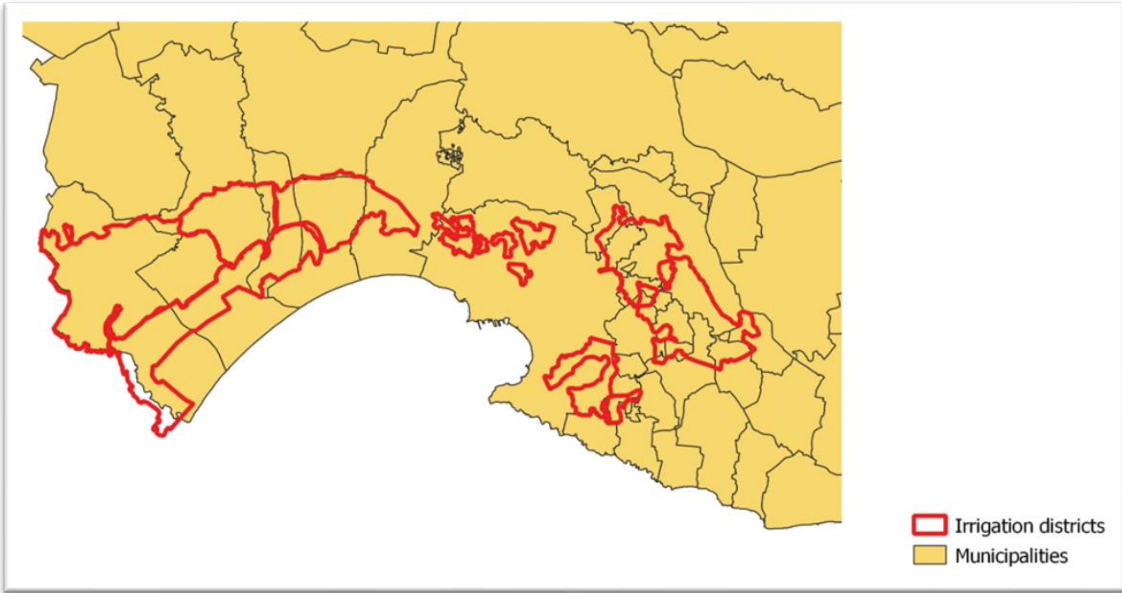
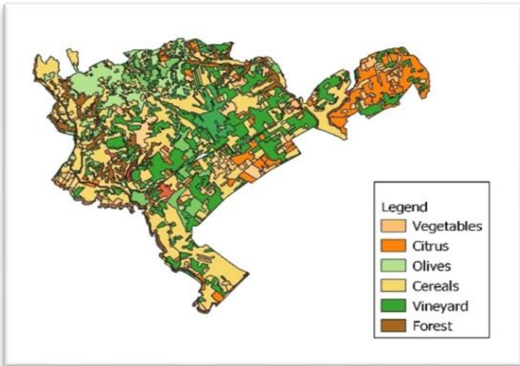
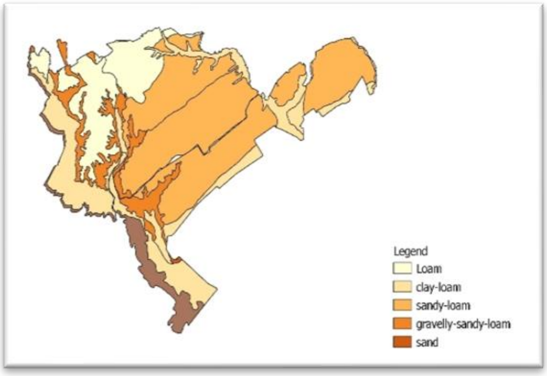
Study area

The Italian Pilot area named "Stornara and Tara" is a local irrigation consortium and water management authority. Its role is to supply water to farmers by means of large-scale pressurized and gravity distribution system.

The consortium serves the Sinistra Bradano irrigation scheme located in the Province of Taranto in southern Italy. The scheme covers an irrigated area distributed to many single farmers, large farms and cooperatives. Agriculture is highly market-oriented and strongly depending on irrigation, due to summer hot and dry climatic conditions and variable rainfall distribution.

The **Sinistra Bradano scheme** is supplied by the San Giuliano dam, located in the bordering region of Basilicata. The reservoir has a total capacity of 70 Mm^3. The overall amount of water withdrawn from the San Giuliano reservoir for irrigation purpose totals 23,6 Mm^3 but only 16,4 Mm^3 are effectively delivered to irrigation users because of the 30,5% of water losses in the distribution system.



	 *Location of Pilot area*
Surface	86,36 km^2
Bioclimatic conditions	Climate of the area is semi-arid to sub-humid and referred to as "Maritime-Mediterranean", which is typical of the coastal areas of the Mediterranean region. Precipitation ranges between a minimum of 400 mm, in south-eastern part of the scheme, and a maximum of 730 mm in the northern part of the scheme. The average yearly rainfall is around 550 mm, 35% of which occurring during the winter months, 32% during fall and 33% during spring and summer. There is very little summer precipitation, thus summer droughts are frequent, and irrigation is usually needed from April to September.
Geology, morphology, vegetation and Land use	The crops grown in the Consortium irrigated area are mainly citrus, table grapes, stones fruit, olive and summer vegetables. Soils are mainly of alluvial type and the applied water gets drained or evaporates in 2 or 3 days. Thus, the current irrigation delivery schedule (every 10 days) results not adequate for the prevailing farming conditions. The large distribution of sandy soils requires implementation of efficient irrigation systems in order to increase water use efficiency.  *Land use map of the pilot area*  *Soil texture classification map of the pilot area*

Canyoles (ES)	
Study area	The pilot area is located in the Valencia region, in Eastern Iberian Peninsula. The Valencia region covers the 4,6% of Spain and have 5 million inhabitants (10,6% of country). It is an active economic region and is the fourth one in Spain with a Gross Domestic Product of 125,416 million € and 24,094 € per inhabitant. Its economy is based on tourism and services, and agriculture is focused on the growth of commercial crops such as *Citrus* and *Persimmon*. The expansion of these two crops cultivation has a substantial impact on the water resources and ecosystem services with an increase in water demand and aquifer depletion, but also in an increase in soil erosion rates that needs solutions (Cerdà et al., 2018; Keesstra et al., 2019). The Canyoles River Watershed is located in the south of Valencia province and covers an area of 62,826 ha, with twenty-four municipalities. From West to East it can be found a change from rainfed to flood irrigated agriculture, although in the last 30 years the development of drip irrigation allowed irrigation in many traditional rainfed agriculture land. tThe municipality of Montesa was selected as a representative of the most intense changes in agriculture developed in the last three decades. Montesa is now mainly cropping a highly mechanized citrus production with drip irrigation and pesticides, which induced a quick soil degradation where soil compaction increased and soil erosion and runoff discharge were enhanced by bare soils (Cerdà et al., 2019; 2021). Drip irrigation is mainly affecting the groundwater throughout wells to pump water which resulted in the loss of springs that use to supply surface runoff to the traditional field-irrigated orchards.
Surface	23,255 km^2
Bioclimatic conditions	The average annual precipitation at the Canyoles river basis is 550 mm y^{-1} and the climate is classified as sub-humid. The average annual temperature is 16.5 °C with 3 to 5 months of summer drought. The eastern part of the Canyoles river Watersheds shows higher rainfall amounts (660 mm y^{-1}) and the western part values that reach 350 mm y^{-1}. The temperatures in the valley bottom can be below 0 °C during the winter due to thermic inversion, which creates damage to the crops. The orange plantations are found in the mountains and in the valleys.
Geology, morphology, vegetation and Land use	The geology of the Canyoles River Watershed is characterized by the large amount of limestone rocks with some marly areas. From a geological point of view, the Canyoles River Watershed is a very active area. The valley is the contact between the Iberian and Baetic mountain systems. The active fault allows the river Canyoles to flow from the Spanish Central Plateau (Meseta) to the Mediterranean Sea. This results in a deep valley surrounded by mountains with rounded and flat summits in the north of the valley and peaks in the south. The altitude is above 600 masl in 51.3% of the land due to the altiplano altitude and the two ranges. The soils are classified as Calcic cambisols (96%) and Eutric fluvisols (4%). The soils in the lower part of the valley are deep and used for agriculture, meanwhile the soils in the mountains are shallow and found in the pockets of the dissolution of the rocks. Figure 9 shows the example of shallow terra rossa soils and the accumulation in the lower part of the valley.

View of the "terra rossa" type of soil in the limestones in the Serra Grossa (left figure). View of the agriculture soils in the bottom of the valley where the sediments accumulate and where the crops of persimmon and citrus are found (right figure).

View of recovery (3 months) of the macchia after a wildfire (left figure). View of recovery (12 years) macchia with Aleppo pine after a wildfire (right figure).

In general, most of the soils of the study area are bare due to ploughing and herbicide use. Most of the soils at the Canyoles river watershed are managed today with glyphosate, although tillage was the millennia-old management in the study area.
The limitations of the orange plantations are the temperatures (no frost) and the water. The orange plantations used steam power, hydraulic power, and electric power to pump water at higher altitudes and achieve better climatic conditions that are relevant for the quality of the crops that catch premium prices in the European markets.

View of the terraces in rainfed mountainous agriculture land (left figure). View of an example of the activities of the SEDER research group to disseminate the importance of the terraces in the heritage of the Mediterranean (right figure).

View of the traditional irrigation systems at the Canyoles River Watershed.

View of apricot and persimmon crops under intense tillage at the Canyoles River Watershed pilot area.

Soil erosion in orange and almonds plantations. Both herbicide and tillage management results in high erosion rates.

Physical map	

Merchouch (MO)	
Study area	The area of study “Merchouch” is located in Bouregreg watershed, in central western Morocco (5.4-6.8W and 32.8-34N). It belongs to the provinces of Rabat-Sale-Kenitra and Beni Mellal-Khenifra. It includes three sub-basins and consists of three main rivers form the hydrographic network, namely: Bouregreg, Grou, and Korifla.

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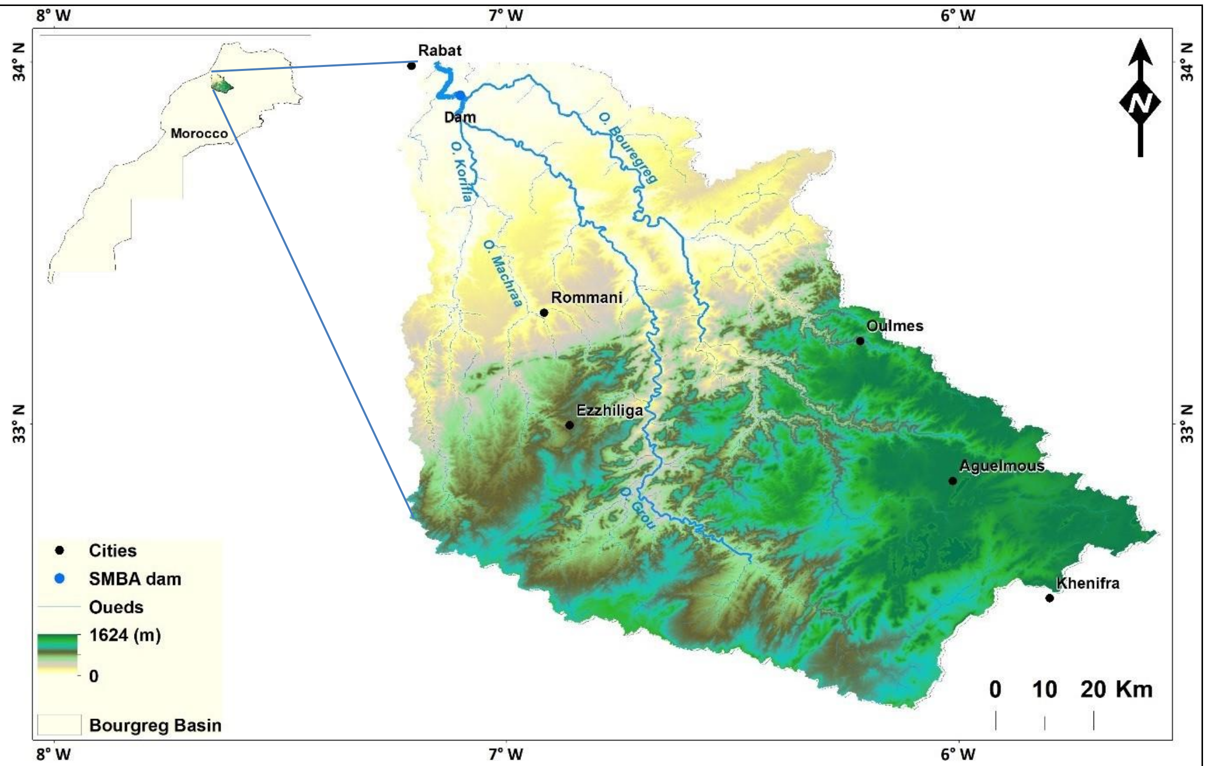

Bouregreg watershed with its stream networks. The inset maps show the position in the territory

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<td>Surface</td>
<td>9,500 km^2</td>
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<td>Bioclimatic conditions</td>
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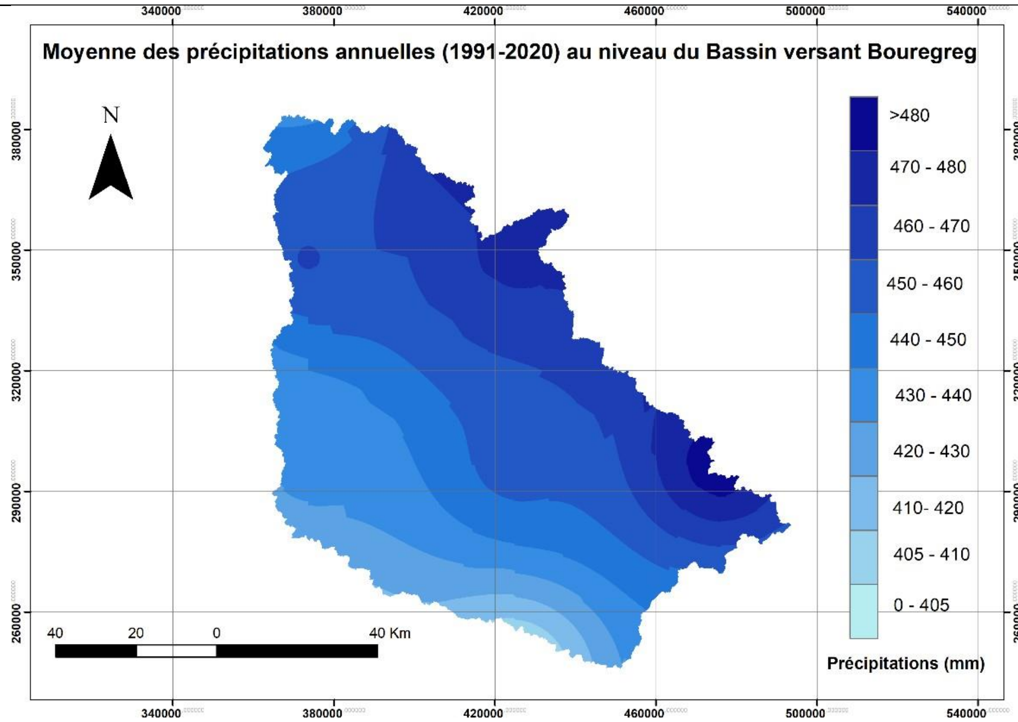

The climate of the study area is Mediterranean with an oceanic influence, with an average annual rainfall in the basin varying from 450 mm in Rabat in the northwest to nearly 750 mm in the mountainous area in the southeast.

Distribution of annual rainfall in the Bouregreg watershed

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<td>Geology, morphology , vegetation</td>
<td>Geologically, Bouregreg basin is embedded in the Moroccan Central Massif which is mainly constituted of Paleozoic formations undergoing the Hercynian orogeny. It is very diversified geochronologically and lithologically, and clearly dominated by schistose, sandstone and</td>
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</table>

and Land use

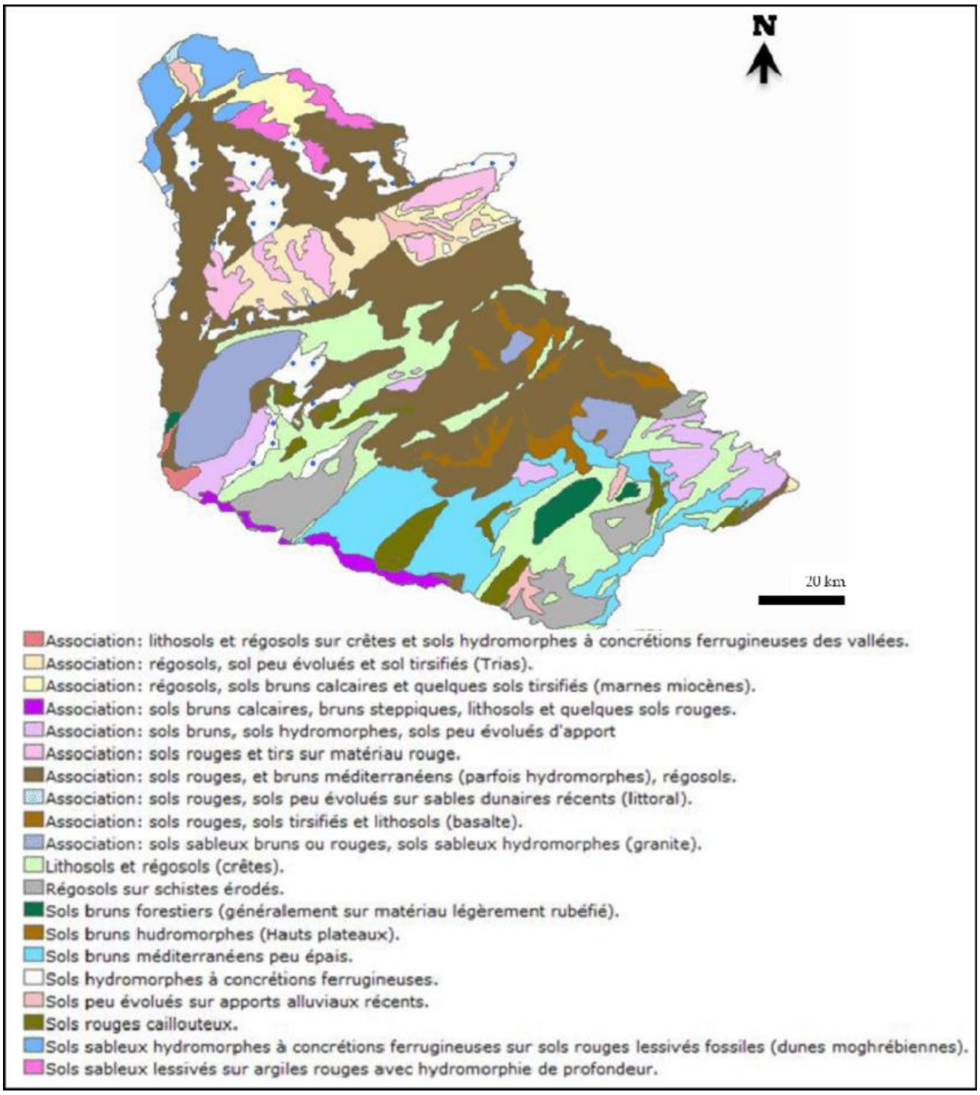
quartzite formations. This zone is characterized by a highly varying geographic and geomorphologic framework.

From a pedological point of view (figure below), we observe the predominance of three types of soil, mostly developed on shale formations (Bensalah, 2008):

• soils that have undergone little erosion, characterized by a low degree of alteration;
• brown forest soils whose depth varies from a few centimeters to several meters thick;
• fersiallitic red soils, characterized by their richness in free iron oxides.

At the level of the red clay and basalt formations, we also note the presence of soils rich in swelling clays, mainly on flat land and in depressions such as than Rommani, and isohumic soils on the low plateaux.

The Bouregreg basin has a population of 2.37 million inhabitants (HCP, 2004), including more than 80% is urbanized. The agricultural sector, bringing together nearly 14% of assets, is among the main sources of income for the majority of the population of Bouregreg. Useful Agricultural Area (UAA) is 519,558 ha, two-thirds being devoted to cereals. There are also legumes and fodder crops. Most of them are cultivated in bour (rainfed crops) and therefore depend essentially on precipitation.



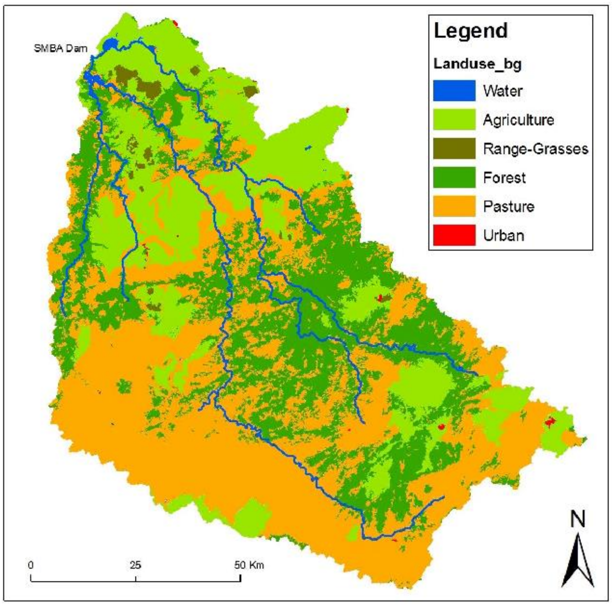
Distribution of soil type in the Bouregreg watershed

Soil unit name	Texture	Structure	bedrock	Land use
Calcimagnesic soils	Clayey, silty-clayey,	Polyhedral	Doleritic basalt (Triassic) andPliocene hard limestone	Mattoral, oleaster, palms

	sandy			
Fersiallisatic soils	Clay-sandy	Little hard	Sandstone-limestone	Cork oak, lavender, cysts, doum, cereals
Hydromorphic soils	Silty-clay-sandy	Monparticular	Granite - schists	Grasses, cereals, vines, palms
Isohumic soils	Polyhedral andgrainy	Little hard	Triassic red clay	Crops, dwarf palm
Raw mineral soils	Sandy	Monoparticular	_____	_____
Undeveloped soils	Silty-clay-sandy	Polyhedral	Paleozoic shists andquartzites	Sparse Mattoral
Vertisols and similarsoils	Clayey	Large polyhedral, motorized	Meiocene and Pliocene hardlimestone	Cultivated land

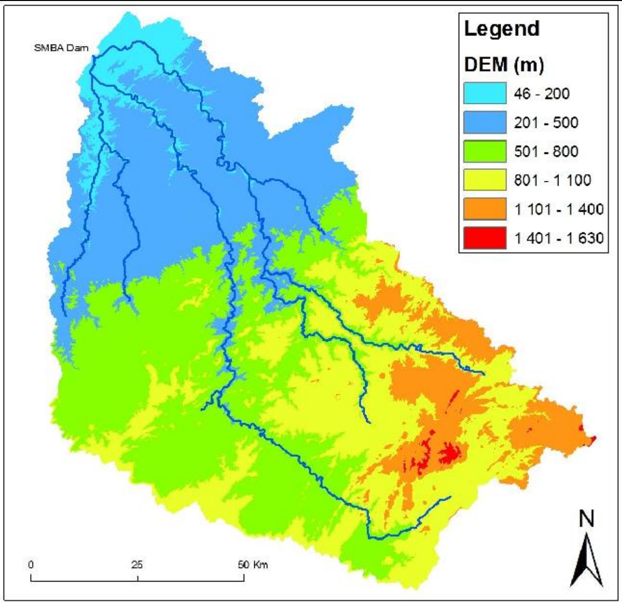
Table. Analytical data of the study area soil

The land use map (Figure below) was extracted through the processing of satellite Landsat image TM that has a spatial resolution of 30 m. The supervised classification and the photo-interpretation techniques were used to derive and distinguish the most present land use classes in Bouregreg basin. Six major classes are so identified. The dominant categories are pasture (46%), forest (28%) and agriculture (24%). The urbanized areas represent just 1% of the watershed.



Land use in the Bouregreg watershed

For the Digital Elevation Model (DEM), it was extracted from the ASTER Global Digital Elevation Model (ASTER GDEM) which has a spatial resolution of 30 m.



Digital elevation model in the Bouregreg watershed.

Bethlehem of Galile (IL)	
Study area	Pilot area extends over 500km^2 land that include agricultural fields with a variety of land management practices.
Surface	500 km^2
Bioclimatic conditions	The average annual precipitation is 583 mm and the climate is classified as Mediterranean. Average annual temperature is 18.1 ℃ average minimal and maximal values of 13.9 and 22.3 ℃, respectively.
Geology, morphology, vegetation and Land use	A food forest, also called a forest garden, is a diverse planting of edible plants that attempts to mimic the ecosystems and patterns found in nature. The food forest (total updated area in 2020 is 500 km^2) in Bethlehem of Galilee, Israel, was established in 2017, planted in the middle of an agricultural area. Concerning mainly about the degraded soil and biodiversity loss associated with conventional agriculture and pointed to the regeneration of nature (and human health) as a major motivation for implementing this food forest. Since 2017, this action performs well on social-cultural and environmental criteria by building capacity, providing food, enhancing biodiversity, and regenerating soil. Food forest adopted basic principles of agroforestry that improve water cycle and soil formation, store carbon, regulate the microclimate, increase biodiversity, and create livelihood opportunities. This case study will set an example of sustainable food production by producing nutritious food, providing wildlife habitat, build soil, and sequester carbon. It also builds diversity of plants and animals while embracing the diversity of people.

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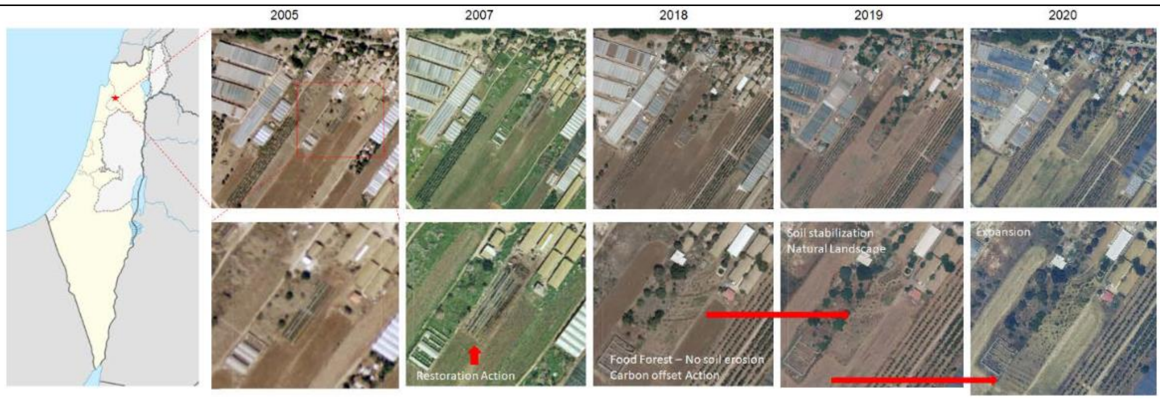
<tr><td></td><td>

Living lab – part of the case study area illustrating the degraded conditions before the restoration action, and its impact and expansion over the last years.</td></tr>
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<tr><th colspan="2">Lower Gediz (former Menemen) (TR)</th></tr>
<tr><td>Study area</td><td>The Gediz River Basin is one of the most important basins in the west of Turkey. The river is 401 km long and has a 60.48 $m^3 s^{-1}$ annual rate of flow on average. The Menemen Plain, located at the end of the River basin, and is flat with altitude is 10 m on average, It lies between 38°26'-38°40' north latitudes and 26°40'-27°07' east longitudes, and includes the Lower Gediz alluvial base as well as the adjacent side stream alluvial and colluvial skirts. The plain is surrounded by Yamanlar Mountain in the east and Foça mountainous region in the north (Topraksu, 1971).
The Gediz Valley ranks second among the four great plains in Western Anatolia in terms of basin and floor width.
Historical background of the Gediz River also referred its unstable flow. Especially Menemen part of the River was the riskiest areas for flood disasters that is why the name of “Mainomenos” was given to region which means furious in Hellenic language (Uhri, 2019). Therefore, as it is seen flood risk of the Gediz River is even known from ancient time and its power affect the region’s name.


Map of Lower Gediz Basin and its surroundings</td></tr>
<tr><td>Surface</td><td>17,500 km^2</td></tr>
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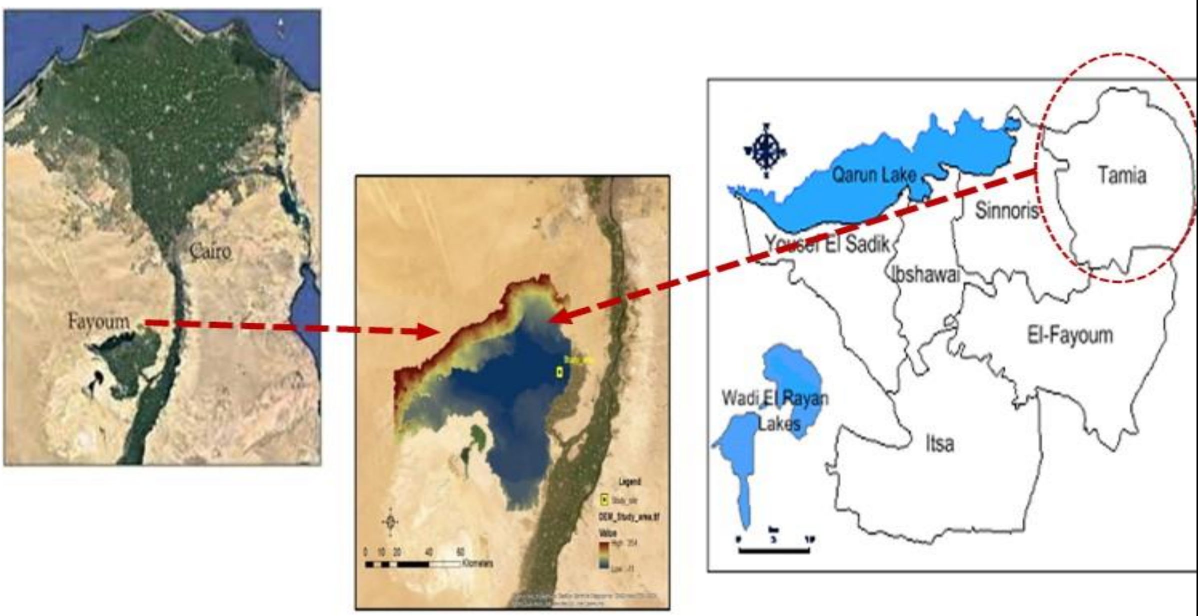
Bioclimatic conditions	The climate is Mediterranean with mild winters and hot summers. Average annual rainfall was 540 mm between 1954 and 2020. Average annual ET (evapotranspiration) is 560 mm. The Gediz River Basin, while the western and central parts of the basin are dominated by humid and semi-humid climates, the semi-arid climate is dominant in the eastern part. The average annual rainfall in Manisa is 708 mm and 688 mm in İzmir and 531 mm in Uşak (Basin Flood Control Action Plan in Turkey, 2013-2017). Menemen and Foça, in general, has the characteristics of the Aegean Region climate. As the character of the area, the temperature approach to the temperature of tropical regions in summer. In terms of precipitation regime, rainfall in Menemen is mostly seen in winter months, such as the Aegean region rainfall including the Mediterranean precipitation regime (Arslan, 2010). Lower Gediz falls into the Mediterranean climate type in terms of macro-climatic characteristics, and according to the climate classification of Thorntwaite (1948); it shows a mesothermal climate with hot and dry summers and mild and rainy winters. According to long-term average climate data; total annual precipitation is 530.91 mm, of which 51.38% falls in winter, 24.85% in spring, 23.5% in fall and 2.58% in summer. The average temperature is 16.6 °C, the hottest month is July with an average of 27.01 °C and the coldest month is January with an average of 7.85 °C. The average relative humidity is 57.38%, the highest in December with 68.01% and the lowest in July with 47.25%. Total evaporation was 1483.44 mm, the lowest monthly evaporation was 43.37 mm in December and the highest was 255.39 mm in July.
Geology, morphology, vegetation and Land use	Most of the soils of the Lower Gediz have medium to medium-heavy texture and are generally light on the edge of the old Gediz bed and become heavier as one moves towards the west. Menemen Plain covers alluvial lands and coluvial foothills. Steep sloping hills surround the plain from the east and north. The Gediz alluvial base is at an elevation of 0-6 m and the side alluvial are at an elevation of 6-30 m. The height of the surrounding mountains approaches 1,100 m. Although the soils on the alluvium and colluvium in the plain are well drained, the Gediz and airport soils are moderately and poorly drained, and the Gürle, Süzbeyli and Tuzcullu soils on the low-lying areas are poorly drained. The delta and plain filled by the Gediz River are suitable for agriculture, but there are salt marshes at sea level (Topraksu, 1971, 1978). Another factor affecting the distribution of population in Menemen is agriculture. The proximity of agricultural areas to Menemen constitutes the majority of the population. Because of this, people have not severed their ties with their fields, and they have either or through acquaintances. Of the working population, 58% work in agriculture, 23% in services, 14% in industry and 5% in construction. It is seen that the value of agricultural population is higher than other sectors (Arslan, 2010). Women's labour force is drawn from Türkiye. It is known that the country varies from region to region, and in Menemen, a large part of the population engaged in agricultural activities is female.

Tamia (EG)	
Study area	Fayoum (Tamia site): Fayoum governorate is a large depression located about 90 km south-west of Cairo, Egypt; it occupies a portion of Eocene limestone plateau at the northern part of the western desert. Agricultural lands in Fayoum governorate are gaining significant importance at the environmental and economic levels. It represents an extension of the physical environment of the Nile River in terms of the nature of the soil formation as well as the waters of the Nile River, as well as being an environmental system characterized by the complexity of systems which controlled by the desert ecosystem characteristics. Generally, at El-Fayoum depression, the alluvial aquifer is currently under contamination stress due to agricultural activities and extensive use of agrochemical fertilizers and pesticides as well as wastewater disposal. In addition, the alluvial soils are being degraded mainly due to

	waterlogging and salt accumulation. Mismanagement of agricultural fertilizers and pesticides, reuse of drainage water for irrigation, wastewater disposal and inadequate land use planning have a major impact on degradation of groundwater and soil quality in the study area (Abd-Elmabod et al. 2019). An economic study performed in 2018 showed that one that Fayoum Governorate lost about 4,947.19 ha during the period from 1987 to 2017 of its productive agricultural lands and that according to the prices of the season 2016-2017, the province has lost an estimated financial income of 9,738.2 USD within just one season in the form of financial losses and cash directly as a result of the desertification of its territory. The research area lost about 213,791.6 USD as a result of the loss of these areas of agricultural acres (Abdel Hamid, 2018).  Study area
Surface	344,4 km^2
Geology, morphology, vegetation and Land use	Tamia it is found that in the soils of Tamia District, ECe ranged between 1.22 and 22.4 dS m^{-1}, about 91.5% of Tamia soils present ECe > 4 dS m^{-1}, indicating that salt-affected soils are distributed throughout the area. About 94.5% of Tamia soils is calcareous (>10% $CaCO_3$ eq), due to the nature of parent material from which these soils are evolved. Soil pH of more than 8.00 was found in about 3.25% of Tamia soils, whereas the soils with pH >8.5 are 3.96% in Tamia. The organic matter contents seldom exceeded 1% in Tamia soils. Soil texture is clay, sandy clay, sandy clay loam, sandy loam and sandy.

1.2 Implementation of restoration outscaling

Troodos Mountains (CY)	
Main restoration actions	The restoration actions in Cyprus are focused on terraced agriculture in the Troodos Mountains. Throughout the Mediterranean region, the tough working conditions of terraced agriculture and the pull of jobs and services in urban agglomerations have resulted in the abandonment of mountain terraces. With this, the intangible cultural heritage, i.e., the knowledge and experience of dry-stone wall construction is slowly disappearing. Over time, terraces on abandoned lands are collapsing. However, we also see that in many areas nature will take over and stabilizes the land (Djuma et al., 2017). Djuma et al. (2020) found deeper soils on productive wine terraces than on neighbouring abandoned terraced land. However, higher soil organic contents in the topsoil of abandoned land, where nature had

taken over, resulted in similar soil carbon stocks for productive and abandoned land. Even though terrace abandonment is ongoing, we also see new agricultural developments in the mountains. Now land is shaped with earthwork machinery, such as excavators and bulldozers. Most newly developed terrace slopes are for vineyards, with smaller numbers for fruit trees and vegetables.
These mechanically-shaped terraces are constructed based on local experience. The construction often results in loss of fertile topsoil, while many terraces have unstable, steeply sloping risers, resulting in erosion and small land slides. In a number of cases, the terraced slopes are partially protected by dry-stone walls.
This actions aim to contribute to the sustainable development and management of agricultural mountain terraces. Guidelines for the design of mechanically terraced slopes will be developed and the art of dry-stone walls construction will be supported through capacity building and dissemination events.

Detailed restoration actions
Detailed actions, derived from our Ecological Restoration Living Labs, field visits and discussions with winery managers, can be summarized as follows.

- New terraces are established on sloping abandoned or degraded agricultural land.
- Most terraces are designed for minimal two rows of vines (more in less steep areas). The width of the terraces is governed by the width of the small tractor.
- Distances between two vine rows is 1.8-2 m, around 0.7 m should be left on the outside of the vine rows (between the vines and the up- and downstream terrace edges).
- The terraces follow the contour lines of the land, outlined using the 5-m contours from the Department of Lands and Surveys portal, overlaid on a satellite image
- Earthwork is done by bulldozer or excavator; the last is easier to control.
- First a steep sloping road (track) is constructed alongside the area to be terraced
- Starting from the top of the slope, the terrace outline (top edge) is marked (e.g. by poles).
- The excavator starts from the road, moving the topsoil behind itself, on the current, newly formed terrace. Sometimes soil is moved downslope.
- The terraces have sloping risers (up to 200%).
- Natural, shrubby vegetation (e.g., sage, oregano, rock rose) grows, and thereby protects, the sloping risers. Vegetation that uses too much water is removed.
- Near-vertical dry-stone walls are built along the steeper risers and along the roads and terrace entries. Walls are generally around 1-m high (a construction permit is needed for walls exceeding 1.5 m).
- Stones (diabase) for the walls are obtained from a nearby quarry.
- Compost (manure) is applied on newly established terraces and legumes (vetch, faba) are planted to improve soil fertility.
- Vines are planted on trellies and irrigation drip lines are fixed along the trellies.
- Minimal irrigation is applied, based on leaf water potential measurements, to maintain the quality of the wine
- Irrigation water is pumped from groundwater boreholes.
- Nutrients are applied based on soil fertility testing. Nitrogen (and sometimes potassium) is applied through fertigation.
- Annual vegetation growing on the benches is mowed and left to dry.
- Shallow tillage is conducted approximately once every 4 years to reduce compaction and possibly improve soil fertility.
- Pruned branches are chipped and returned to the terraces.

Research actions

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- Selection of mechanically constructed terrace slope as pilot research site in Oikos (Marathassa Winery) near Kalopanagiotis community in 2023; a second site was selected in Agros (Tsiakkas Winery) in 2024.
- Characterization of the Oikos site, with drone survey (digital terrain model), field observations of terrace and dry-stone wall geometries, geomechanical characterization of stable and unstable dry stone walls, soil depth observations, sampling and analysis of soil bulk density, volumetric moisture content, soil organic carbon and soil texture.
- Characterization of nearby reference vineyard site on a slope with degraded terraces (soil depth, soil sampling and analysis).
- Slope stability analysis with GeoStudio (https://www.seequent.com/products-solutions/geostudio/)
- Installation of meteorological station at the second site in Agros.

Reference site and research site at Oikos

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<td>Main outscaling actions</td>
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Outscaling Activities for Mountain Agriculture Restoration in Troodos
The Cyprus Institute continues to lead efforts in the restoration and sustainable management of mountain agriculture (Bruggeman et al., 2023; Zoumides et al., 2017), focusing on drystone terracing, currently in the framework of the REACT4MED project. Three key events have recently taken place as part of this initiative, aiming to build capacity and raise awareness.

- Capacity-Building Event in Kyperounda (May 17-18, 2024)

A successful two-day workshop in Kyperounda brought together farmers, winery managers, and agricultural workers from the region. The event. co-organized by the Cyprus Institute and Kyperounta Winery, engaged multiple stakeholders, including ICOMOS Cyprus and the Office of the Environment Commissioner. The Commissioner, Ms. Antonia Theodosiou, delivered a presentation on the global significance of drystone techniques, emphasizing their ecological benefits. Practical sessions followed, where participants applied these techniques under expert guidance, reinforcing the importance of traditional knowledge in sustainable agricultural practices.

- Farmakas Site Visit (September 30, 2024)

As an outcome of our dissemination activities, the mountain community of Farmakas approached us for cooperation. Cyprus Institute researchers visited Farmakas to assess semi-abandoned terraces near the village and active but deteriorating vine terraces outside the village. The site near the village, previously used for vegetable production, holds significant potential for agricultural revitalization, including an irrigation system once integral to high-value crops, particularly tomatoes. Discussions with local landowners are planned, with the possibility of co-organizing future events with community authorities to explore restoration efforts and the sustainable use of terraces and water resources.

- Screening of the Documentary Petra sti Petra (October 30, 2024)

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	The Cyprus Institute, along with other institutional stakeholders such as the Cyprus National Commission for UNESCO and the Cyprus Scientific and Technical Chamber (ETEK), is supporting the premiere of *Petra sti Petra*, a documentary to be screened in Nicosia. The film explores ancient drystone building practices in Cyprus, their role in shaping agricultural landscapes, and their modern applications in biodiversity conservation and desertification control. Following the screening, Cyprus Institute researchers will join a panel discussion with experts to delve into the relevance of these practices in contemporary environmental restoration and sustainable agriculture.   *Capacity building event at Kyperounda Winery*
Heraklion (GR)	
Main restoration actions	The solutions that are financially feasible are those that are supported by the CAP that are compatible with the local agroecosystem. • Non-productive investments towards the establishment of forest cultivations (1st phase of afforestation to create forest areas on agricultural land): Afforestation of agricultural land contributes to the protection of the environment, the expansion and improvement of forest resources and, by extension, the strengthening of anti-corrosion, anti-flood and anti-fire protection, the preservation of biodiversity, the mitigation of impacts and adaptation to climate change as well as the regulation of water quality and quantity. The beneficiaries of the measure may be natural or legal

	entities or their associations, owners or managers of agricultural land (such as tenants or other authorized persons); • Afforestation and creation of forest lands (2nd phase of afforestation covering maintenance costs and compensation for loss of income). The maintenance cost is given up to the twelfth year from the date of grant of the aid. The intervention of the second phase of afforestation contributes to the protection of the environment, the expansion and improvement of forest resources and, by extension, the strengthening of anti-corrosion, anti-flood and anti-fire protection, the preservation of biodiversity, the mitigation of climate changes through the increase of carbon storage, the adaptation to climate changes, the regulation of water quality and quantity, the strengthening of natural regeneration in certain areas; • Non-productive investments to protect against erosion, to retain soil water and nutrients, through the construction of new terraces. The "dry stone" terraces with mudstone structures (without binding mortar) are characteristic elements shaped by agricultural activity over the years from classical antiquity to the present day. These elements are essential to protect against erosion, to retain soil water and nutrients, they are an important habitat for wildlife and at the same time they are an integral component of the rural landscape. Beneficiaries of the measure may be: • *owners of agricultural land in areas where dry stone structures are a documented feature of the landscape;* • *owners of agricultural land in areas with a slope that justifies (>15%) the construction of terraces, for reasons of dealing with erosion.* • Use of resistant and adapted species and varieties: Supporting producers for the introduction of new and/or innovative and/or innovative use of crops resistant to dry heat conditions and the changes expected due to climate change. • Implementation of improved crop cover practices while enhancing biodiversity: • *seeding the understory and creating zones in the margins;* • *understory seeding and margin zoning using host plants;* • *planting catch crops during the period of heavy rainfall;* • *planting catch crops during the heavy rainfall period using host plants.* Maintenance and improvement of crops on terraces.
Main outscaling actions	• Establishing lines of communication between stakeholders from the administrators to farmers and vice versa • Evaluating socioeconomic aspects of actions and their implementation, together with stakeholders • Establishing connections with farmers to promote sustainable management practices • Disseminate and promote monitoring actions and results to stakeholders • Promoting restoration actions to administrators • Establishing a base line on ground data for satellite monitoring
Stornara and Tara (IT)	
Main restoration actions	The proposed restoration actions (RA) are related to organic farming of the vineyards in the pilot area, both by reducing the use of pesticides and increasing plant biodiversity. The RA are mainly based on implementing a production system that minimizes the incidence of disease and pest and consequently reduce the use of pesticides, without compromising crop productivity. A successful approach was to consider the vineyard as an agro ecosystem where every resource is optimized to maintain a rich cultivar biodiversity contributing to decrease pest and disease pressure. In addition, the increasing of plant biodiversity is obtained through the green infrastructures along the edges of the fields, populated with local wild plants, typical of the Mediterranean Basin, whose presence reduces the populations of pathogens.

	Detailed actions: - Reduce the number of ploughings per year and where possible carry out minimal tillage or no till; - Increase plant biodiversity through the green infrastructures along the edges of the fields, with local aromatic and medicinal plants, typical of the Mediterranean scrubs and is better if endemic plants such as *Thymus spinulosus*, *Satureja montana, Satureja cuneifolia, Salvia fruticosa* subsp. *thomasii*, are used whose presence reduce the populations of pathogens of plant origin (fungi and bacteria) and insects; - Use agricultural waste to produce compost together with any other organic source or manure produced on the farm; - Use natural products to control any plant diseases, which often develop when plants are debilitated or stressed by critical environmental issues, such as water shortage. - Reduce at an accepted minimum the use of agricultural practices with a high environmental impact, such as abusing with pesticides, herbicides, chemical fertilization and excessive irrigation; -Limit as much as possible the use of heavy mechanical means, which destroy soil structure, damage the rooting system and soil biodiversity so painfully built up by microorganisms and mycorrhizae; - Adopt agronomic practices that allow the soil to be regenerated, maintaining or increasing Soil Organic Matter (SOM) as much as possible to the ideal score of 5%. - Maintain a good proportion between SOM, the mineral part close to the range 45%-50%, and that of air and water close to 25% each. These percentages for agricultural soils are ideal to avoid either accelerated water permeability or water stagnation excesses; - Carry out agricultural operations artfully designed and rightly implemented in close correlation with time period and physiological stage of the grapes and also according to the climatic trend (rainfall and temperature), bearing in mind that especially when grapes are under stress conditions, an error in the pruning methods and times can not only compromise crop yield, but also cause health and longevity problems.
Main outscaling actions	The applicability, replicability and outscaling of the proposed restoration actions is linked to many factors: - Active involvement of stakeholders for deep learning of the resulting benefits from the restoration actions; - Encourage them for the use of more suitable crop types in terms of water consumption, in order to reduce the use of groundwater and the risks of salinity built up as well as consequently, management costs; - Planting native wild plants for "greening" or creation of new green infrastructures with the involvement of experts, nurseries and research institutions, with the purpose to reduce the risks of pathogens attacking the vineyards (instead pathogens would be attracted by wild species of green infrastructures surrounding grapes); - Demonstrate and disseminate technological adaptations and innovations for farmers, local staff and researchers, already identified in local meetings within activities 3.1; - Establish an efficient monitoring system to evaluate the long-term effectiveness and efficiency of the identified restoration actions. To do so quantify the amount of water used for irrigation in close correlation with the variety of vines, check soil quality especially soil chemical composition; - Check of economic aspects related to social justice and environmental analysis of the restoration measures and their impacts on young people or women that are involved in restoration actions (including social benefits); - Evaluate cost-benefits and cost-effectiveness of restoration actions; - Adjust the policy framework to facilitate the upscaling of restoration actions and promote solutions to land and water degradation challenges.
Canyoles (ES)	

Main restoration actions	The impact of tillage during millennia and the abuse of herbicides along the last four decades resulted in compacted and crusted soils in agriculture land of Eastern Spain. The Canyoles river watershed is a pilot area where the use of chemicals and tillage in agriculture has affected the citrus, vineyards, persimmon and olive plantations. It is a challenge therefore to restore the soil quality once the soil system has been weakened by the loss of organic matter, soil crusting, soil sealing, soil compaction and the loss of soil structure. There is also a loss of plant cover and a change in species richness. The proposed restoration actions (RA) are related to recover the soil quality, reduce soil erosion and enhance organic matter and water infiltration in all the crops that need to prune the trees. We selected a strategy that can be applied by all the crops, easy to accept by farmers, a nature-based solution that can be subsidized by the local, regional, national and European governments. Chipped pruned branches reduce the carbon dioxide emissions as the farms use to burnt them, and the organic material decompose in the soil enriching the soil biota and soil organic matter. With this restoration action the impact can be found in all the crops since they are planted. **Detailed actions**: - Measurement in the field and laboratory of the amount of biomass produced in the experimental plots. - Experiments to determine the impact on soil erosion and runoff delivery on paired plots (control and chipped pruned branches). - Soils are sampled in the field and analysed in the laboratory. - Measurements in the laboratory of the characteristics of the chipped pruned branches. - Interviews with farmers and other stakeholders to study their perception of the use of chipped pruned branches as a mulch in the fields.
Main outscaling actions	The use of chipped pruned branches is supported by the EU via subsidies, it is a nature-based solution that imitate nature and reduce the cost to the farmers. In REACT4MED, the Soil Erosion and Degradation Research Group from the University of València researches the impact of the restoration strategy with chipped pruned branches via the evolution of the use of the RA. The research approach is based on interviews with the farmers to get information from the plot: year of the first use of chipped pruned branches, area of the plot, soil management (herbicide, tillage, No-Tillage/No Herbicide). With this information we will be capable to develop a map of the spread of the RA in six study sites. **Findings:** The spread of the use of Chipped pruned branches depends on: - Improvement of the technology. There has been a quick improvement in the mechanization of the machines to chop the branches that makes easier and faster to chop (instead of burning) them. - It has been an increase in the subsidies for the mechanization and the yearly subsidy per farm has increased. - From an economical point of view the farmers see this RA as more sustainable rather than use the fire. - Fire has been prohibited along seasons and some locations due to the risk of forest fire. - Farmers are changing their mind about how the chipped pruned branches are moving from a dirt to a resource to improve the soil. - The meetings of REACT4MED are contributing to change the perception of the farmers. - There are some constrains to use widely the chipped pruned branches: small size of the plots, ageing of the farmers, bad perception (dirt) of the chipped pruned branches) and reduction in the income of the farmers. The maps that we are developing for the spread of the chipped pruned branches in the region demonstrate that there is a general spread of the technique although in small plots it is not the case. We selected 6 study sites to show the different out scaling with rainfed olive and vineyards, drip irrigation in citrus and persimmon, and flood irrigation on citrus and

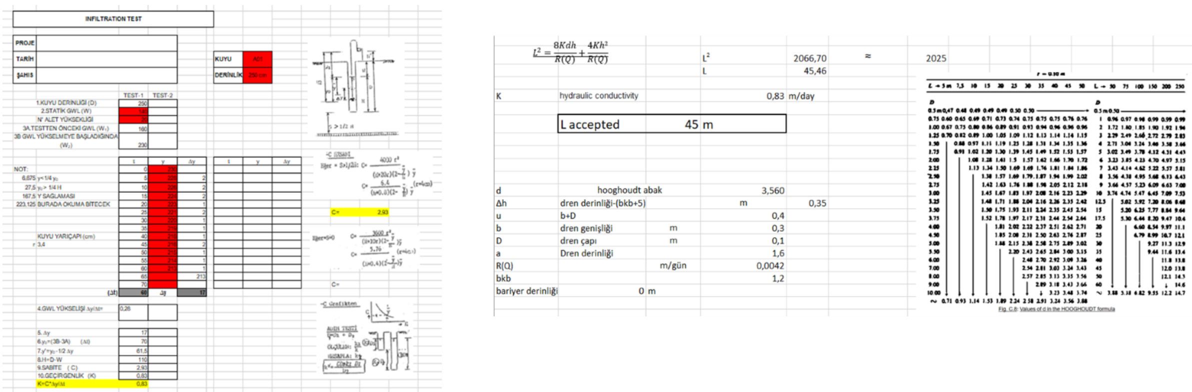
	persimmon. The SEDER Soil Erosion and Degradation Research Group of the University of València is following the evolution of the chipped pruned branches used as a mulch and we found out a spread of the technique encouraged by the subsidies and technological advances, but also identified some constrains such as the ageing of the farmer's community and the small size of the properties/plots.
Merchouch (MO)	
Main restoration actions	CONSERVATION AGRICULTURE (Directing seeding, crop rotation and residue management) with best management practices in terms of crop seeding, harvesting, fertilization and protection.
Main outscaling actions	The agricultural policy of Morocco (Green Generation 2020-30) has set a Road Map in 2021: 1 million hectares of CA in 2030 across all agricultural regions and for wide diversity of farming systems. The region will have 200,000 ha of CA by 2030. At the laving Lab (MO), we have three long-term sites experimenting CA and conventional agriculture under crop rotations and crop residue management. Fertilizer application and management as well plant health and development are considered. In addition, we have 19 satelite sites with farmers in order to confirm or affirm the results under different scenarios and land and environment variables. The main achievements of CA during the period 2022-24, CA allowed simultaneously: a) High improvement of crop grain yields b) Significant cost savings c) Improved profit margins **The implementation for the first years are as follow:** With the 6 years of droughts (2018-2024), the ministry of agriculture and its regional/local entities as well farmers are more convinced with the positive impacts of CA under such constrained climatic conditions and a CA implementation strategy was set up in accordance with the all stakeholders involved or interested in the mainstreaming of CA.

Year		**2022**	**2023**	**2024**
Planned Area	Ha in CA	20,000	35,000	60,000
Achieved Area		18,060	38,605	59,350
Conservation Agriculture	Wheat Grain Yield (T/ha)	1,2	1,6	1,3
Tillage-based Agriculture		0,3	1,2	0,6

CA Road Map implementation strategy up to 2030:

- Establishment and activation of a regional steering committee and sub-committees for the program for supervision of the program and establishment and monitoring of annual action plans.

	- Execution of action plans Program for promotion and dissemination for increased adoption of CA (content, supports, demonstration platforms, budget): To be established by extension services and INRA. - Training program for advisors, service cooperatives and farmers (training modules, beneficiaries, planning, etc.). - Creation of service provision cooperatives in direct seeding through support from ministry for the acquisition of direct seeders. - Intensification of Applied research program to support the regional plan in all aspects of sustainability, policy, institutions and adoption trajectories of CA systems. - Maintaining incentives under the Agricultural Development Fund (FDA) for the acquisition of direct seeding seeders and encouraging local production; (50% of the cost of the seeder is supported by FDA and capped at 10K USD). - Establishment of a digital platform for monitoring the program. - Implementation of a Virtual Direct Seeding Farmer Food Schools. This strategy is integrating international organization (ICARDA, World Bank, FAO, PRIMA) and all the national and local institutions of the ministry along the value chain (Seed sectors, Fertilizer industry (OCP/AlMotmir), Service providers, Extention services (ONCA), regional and provincial directorates of agriculture in addition of several NGOs. The strategy is leaded by INRA. The project React4Med team is fully involved in the CA Road Map and in the implementation of its strategy.
Bethlehem of Galile (IL)	
Main outscaling actions	The site was an abandoned agricultural area with degraded flat bare soil. Considering the climatic condition, the main impact of this action is its water conservation and soil formation measures for water (e.g., drip irrigation, rainwater harvesting) and soil (e.g., chop-and-drop, mulching, Terra Preta) together with high species diversity and cultivation of rare varieties (flora), undisturbed areas for fauna, connection to green corridors throughout the area.
Main outscaling actions	• Economic system: Land erosion and degradation of agricultural areas are neither represented nor visible in the economy. • Economic benefit: short vs long term benefit (hard for people to see) • Policy: Soil carbon policy is required. • Little investment in clean technologies • Intensive agriculture leads to surface runoff and soil erosion • High demand on food production due to growing population • Meat industry and high meat consumption which demands plenty of resources (agricultural spaces, water, energy) • Conflicts between authorities and farmers over regulations and subsidies • Uncovered soil due to use of pesticides that lead to soil erosion • Monoculture leads to less biodiversity • Soil compaction (heavy rain, agricultural machinery) • Climate change effect: there is less stability and predictability of precipitation, the soil contains less organic matter. • Income level changes the balance between soil conservation and economy. Pesticides and fertilizers cost even more now • People's perception of soils: soils are seen as an inert instead of integrated system. Alternatively, soil can be seen holistically: treat problems not only symptoms (pest control for example)

	  First group of volunteers planting the overstory tree layer (left), Restoration action in 2017 (right)
Lower Gediz (former Menemen) (TR)	
Main restoration actions	As is known, the most important factor limiting plant growth in arid and semi-arid climates is the lack of useful water in the root zone (Falkenmark and Rockström, 1993; Lal, 1991). For this reason, dry and semi-rainy drought-irrigated agriculture inevitably continues. Irrigated data source and water activation will lead to more food production in the future (Yudelman, 1994) and because of the mentioned episode, the demand for water in the world will increase significantly due to the increasing population. Recommended restoration action begins with establishing appropriate drainage systems for the field. It is aimed to reduce salinity by applying leaching water to fields that have an appropriate in-field drainage system, where cotton and corn are commonly grown. However, in addition to salinity, the main restoration action is the application of beneficial microorganisms such as PGPR and the alkalinization problem, which is more difficult to reverse, as mentioned before. In addition, sulphur and gypsum application are also required to reduce soil pH. Sustainable agriculture will be possible with less tillage and green manure applications in soils where soil organic matter and salinity levels improve.  *Figure 1.1 Drainage Calculations (auger method)*
Main outscaling actions	**Detailed actions:** - Reduce the number of annual ploughing and carry out minimum tillage where possible -Use it as green manure (mix it into the soil), especially when planting legume crops - Use well-burnt, desalinated organic fertiliser - Install an in-field drainage system suitable for your fields where seasonal production is made and irrigation is required especially in summer,

- Have fertility and salinity analyses done by taking soil samples every year and apply fertiliser according to the results of the analyses,
-apply wash water if necessary
- Adopt agricultural practices that enable soil regeneration, maintaining Soil Organic Matter (SOM) as much as possible or increasing it to the ideal value of 5%.

Date		%	ppm	meq/lt				%	ds/m	
04.08.2023	Depth	Exch. Na (ESP)	Exch. B	Extract Ca	Extract K	Extract Mg	Extract Na	Saturation	EC (Extract)	pH (Exract)
Zone 1	0-30	**62,90**	1,64	27,7	2,77	29,08	100,96	69	**14,48**	7,65
	30-60	**67,65**	1,34	30,12	1,73	34,09	137,91	63	**17,73**	7,47
	60-90	**71,98**	0,93	18,67	0,57	25,07	113,83	50	**15,36**	7,48
Zone 2	0-30	**53,22**	1,1	14,45	2,26	12,38	33,09	66	**5,95**	7,93
	30-60	**59,01**	0,94	10,55	0,89	10,82	32,04	50	**5,33**	7,71
	60-90	**60,86**	1,08	14,66	0,48	15,78	48,07	56	**7,67**	7,48

Figure 1.2. Soil analyses

	
Tamia (EG)	
Main restoration actions	The proposed restoration actions are related to using agro-ecosystems approaches, organic and biofertilizers fertilizations with the different cultivated crops in Tamia pilot area i.e., wheat, onion, sugar beet, barley, clover and Faba bean, improving the soil structure and texture, reducing the use of chemical fertilizers by compensate partially with using the organic fertilizers and use salinity tolerance crops as well as increase the plant biodiversity. **Detailed actions**: - Use some good agricultural practices that have a positive environmental impact i.e., reduce the chemical fertilization and compensate partially by using the organic fertilizers; -Use natural and bio products as a foliar application to increase the tolerance of the plants to the environmental issues i.e., salinity stress as well as water shortage. - Reduce the number of ploughings per season where carry out minimal tillage to keep the structure and physical characteristics of the soil; - Increase plant biodiversity through using the salinity tolerant crops i.e., wheat, onion, sugar beet, barley - Use agricultural waste as well as animal manure to produce compost and organic fertilizers on the farm levels; - Carry out number of experiments to study the different agro-ecosystems approaches under the Tamia environmental conditions where analysis soils and plant samples will measured
Main outscaling actions	- Encourage the farmers and stakeholders to use and apply different agro-ecosystems approaches and cultivate the salinity tolerance crops and study its effects - Evaluate cost-benefits and cost-effectiveness of restoration actions; - Disseminate technologies and innovations for farmers and stakeholders in Tamia area through the training and workshop events

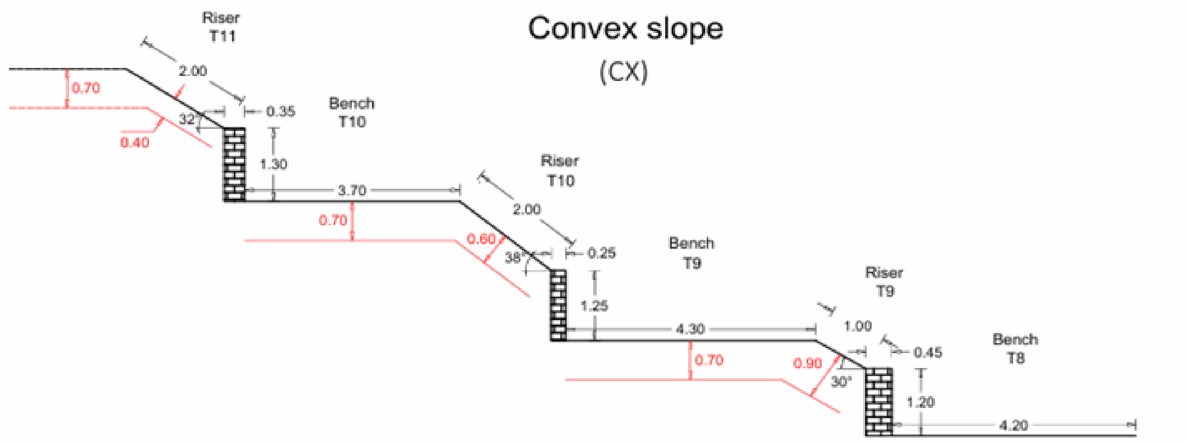
1.3 Biophysical assessment of implemented actions

Troodos Mountains (CY)	
Status of implemented actions	A summary of the results of the pilot and reference site characterisation andongoing research work is presented here. The annual average rainfall of the Oikos site is 534 mm (1980-2010) (Camera et al. 2014). Soil texture samples of the 0-10 and 10-20 cm depths at the Oikos pilot site were dominated by sandy loam (n=5), two samples were sandy loam and one was sand (10-20 cm depth). Soil bulk density (core samples) ranged between 1.47 and 1.75 g/cm^3. The reference site was too stony to collect samples. Soil depths (n=19) at the pilot site, measured by hammering in a pin along an up-down transect, ranged between 63 and 100 cm. Soil depths (n=11) measured along a 48-m up-down transect at the reference site ranged from 0 to 100 cm. The average soil depth was 78 cm at both sites.

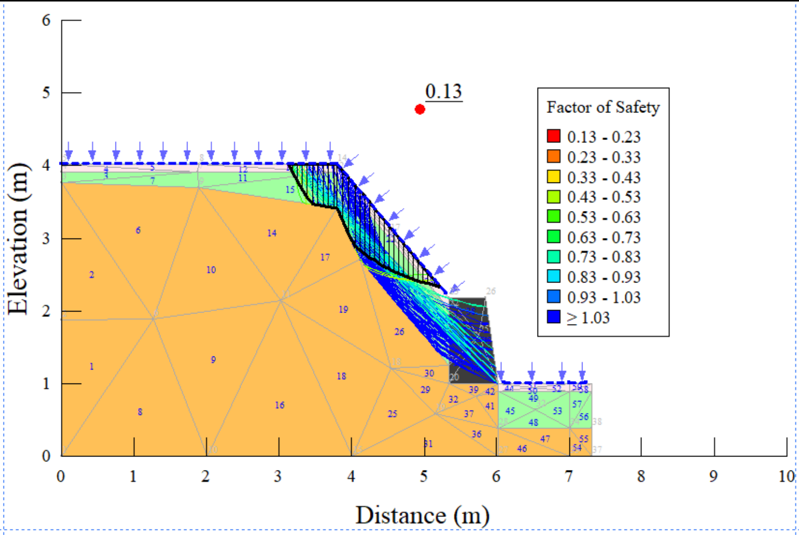
The analysis of the soil organic carbon samples are presented in the table. Sample locations 2 and 4 were taken from the riser. The average soil organic carbon from the vine growing areas at the pilot and reference sites are nearly similar.

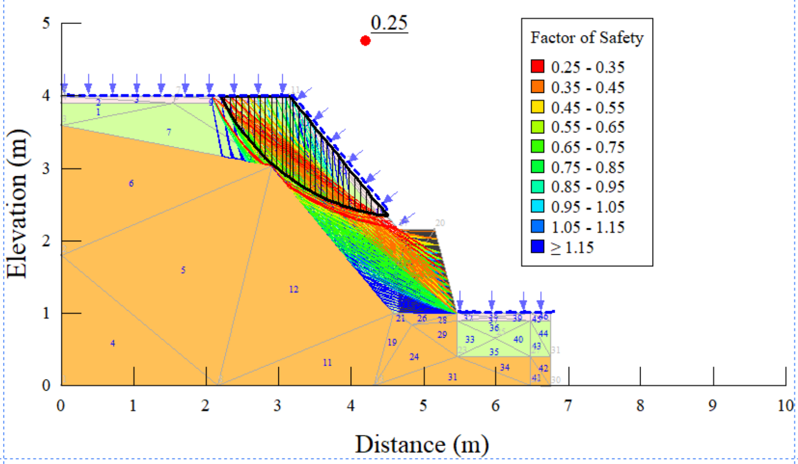
Sampling location	Soil depth (cm)	Reference Site	Pilot Site
1	00-10	3.7	4.4
	10-20	3.0	3.2
2	00-10	3.7	3.0
	10-20	2.9	3.0
3	00-10	3.9	3.3
	10-20	2.9	1.9
4	00-10	N/A	2.5
	10-20	N/A	2.1
Average	**00-10**	**3.8**	**3.9**
	10-20	**2.9**	**2.5**

An illustration of the geometry of a terraced section for the convex part of the slope at the pilot site is presented in the below figure. The results of the slope stability analysis for a terraces with a dry-stone wall in good and poor conditions are also shown.



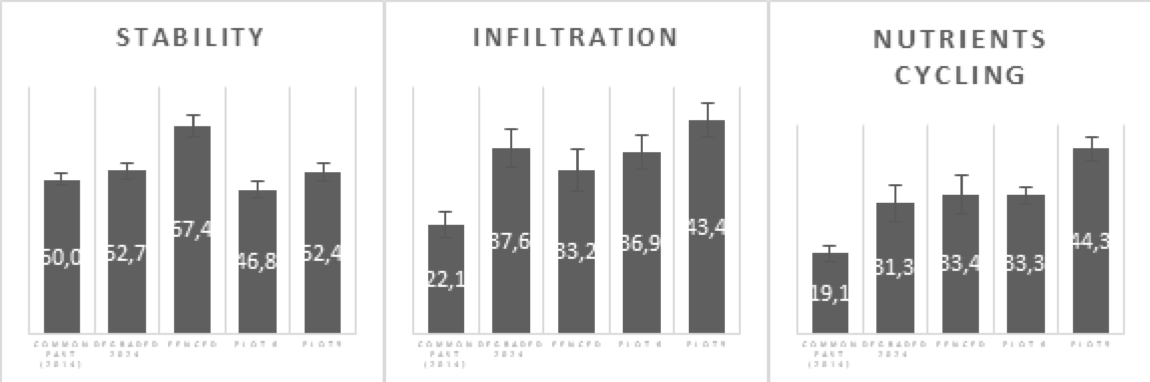
Terrace geometry of the convex section in the Oikos research site (Lucina et al., 2024)





Slope stability analysis at the Oikos site for a terrace with an dry-stone wall in good conditions (top) and poor conditions (bottom), showing an unstable situation (Factor of Safety less than 1.0) under saturated soil water conditions (Kumar Meena et al., 2024).

	 *Soil depth and soil sampling at the Oikos pilot site, installation of meteorological station at the Agros research site.*
Heraklion (GR)	
Status of implemented actions	The program of afforestation of agricultural land could constitute an ecosystem recovery solution as it is a multi-year program and the main commitment of the beneficiaries. In Heraklion, the ecosystem monitoring follows the “Landscape Function Analysis” (LFA) framework and the initial results of the ongoing investigations is presented: LFA is a field procedure that uses readily observed indicators to assess and monitor soil properties as they affect plant growth at the hillslope and patch scale. The indicators represent physical, chemical and biological soil properties in terms of dynamic processes. These processes are comprised of 11 indicators which together result in the “soil stability” or “resistance to erosion”, “water infiltration rate” and “nutrient cycling processes”. There are 4 sites that have been assessed so far. One (Degraded) has background data collected following the same method (here “common past”). One of them, the “Fenced” was part of the afforestation program which was subjected to fire less than a year after the plantation destroying everything apart from the fences and is here considered as a “Fenced” plot with the recovery method as “natural”. Plot 6 is part of the afforestation program neighboring both the “Degraded”/ “Common Past” and “Fenced” plots, and lastly, “Plot 9” is the “Lighthouse”/Reference plot.




Transect on the Fenced plot


Transect on the Degraded plot

Stornara and Tara (IT)

Status of implemented actions	The soil's quality and health in relation to bio-physical and hydraulic indicators in vineyard production has been assessed by conducting 2 repetition of field survey for the collection of soil samples in 2 representative farms (one organic; one conventional). Laboratory analyses established that in the organic farm the implementation of restoration actions as minimal/no tillage, use of good quality irrigation water and use of mineral fertilizer allowed to maintain the electrical conductivity at negligible levels, the organic matter at normal levels and the soil water holding capacity higher respect to the other farm.

Canyoles (ES)

Status of implemented actions	The restoration action at the Canyoles river watershed applied is the use of chipped pruned branches to reduce the soil losses and runoff delivery from the agriculture fields. The restoration action is growing in the use by farmers in the six study areas selected. We researched the growth of the use in the restoration strategy since 1990 and we found an acceleration of the use due to the subsidies by the EU and due to the increase in labour cost that encourage farmers to mechanize and chop the prunes branches. The study areas in rainfed agriculture are applying the restoration action in 20 % of the fields, meanwhile in the irrigation land the use of chipped pruned branches as a mulch is very popular (80%) of the land, where drip irrigation is stablished. On flood irrigation land the use is below 50 % of the land. The study areas with small properties shown a very little success to the use of

	chipped pruned branches because of the difficulties to access to the fields by the heavy machinery. The measurements done in the fields shows an increase in infiltration rates, reduction in soil erosion and runoff because of the increase in the mulch cover. In citrus plantation we registered a reduction in 20 % of runoff and 60 % of soil erosion immediately after the application of the restoration strategy. Similar values were found in olive plantations but much less on vineyards (10% and 32 % respectively). We are measuring the changes in soil erosion and runoff generation on soils covered with chipped pruned branches since 2002 and we found a positive recovery of the soil health. The socioeconomic research shows that farmers are changing the management of the farms due to the economic cost, and the subsidies, but there is still little environmental consciousness to the use of chipped pruned branches as a mulch as most of them see them as a dirt in the field.
Merchouch (MO)	
Status of implemented actions	In 2024, 59,350Ha are under CA in the region. This represents more than 25% of the planned CA area in the region. This is a fivefold increase since 2020 (in 4 years).
Bethlehem of Galile (IL)	
Status of implemented actions	The restoration in the food forest was completed by regenerating soil in a slow, laissez-faire approach with a naturally occurring groundcover. The hydrological processed are managed to prevent soil erosion and degradation by mulching and by using strata and succession-based management for efficient water storage and biomass production. Cost-benefit of restoration The presented food forest is a part of multifunctional space and organizational hybrid with diverse services, products, and income sources. Apart from producing food, it offers social-cultural and environmental services. The study case food forest contains many practices from conservation agriculture. Those practices could be used as an inspiration for farmers and policy makers for partial adaptation to agricultural land and to spaces to be restored.
Lower Gediz (former Menemen) (TR)	
Status of implemented actions	One farmer's field was selected through sampling studies and the applications are carried out there. Salinity and alkalinity analyses were performed and evaluated in the selected field soil. It was determined that the farmer's field has low organic matter (1- 1,2 %) and alkalinity problem. Based on the hydraulic conductivity and other calculations, the installation of the in-field drainage system was completed in February by finding the appropriate lateral depth and spacing. After that, washing water was calculated and applied and cotton planting was realised in May. Cotton was harvested in the middle of October and soil samples were taken at the end of harvest. Before cotton sowing, the field was divided into three parts and one part was treated with sulfur at the rate of 50 kg/da, the second part was inoculated with PGPR and the third part was separated as a control plot. Soil analyses and phenological observations will continue in the coming periods. We are also planning to organise a field day with farmers and policy makers in the coming period.
Tamia (EG)	

Status of implemented actions	Many of field experiments were conducted in Tamia pilot area where soil samples were collected from the sites in order to evaluate the chemical and physical characteristics of the soil in connection to bio-physical and hydrological indicators in the cultivated crops. According to the results of the soil analysis, the organic farming and agro-ecosystems approaches, enhancement the organic matter comparing the conventional and traditional treatments, and a higher soil water-holding capacity, drainage and ventilation than the control by implementing restoration measures like minimal or no tillage, using the salinity tolerant crops, and applying mineral fertilizer.

1.4 Main constraints for implementing and outscaling restoration actions

Troodos Mountains (CY)
• Willingness of stakeholders to participate or stay involved. Lack of trust between stakeholders and lack of trust for the benefits of the proposed restoration actions; • Acceptance by stakeholders to implement good practices may be low; • Regulatory barriers may hinder the timely implementation a long-term funding strategy for mountain terrace construction and maintenance
Heraklion (GR)
Main constraints (as mentioned in the ERLL) include: • Fragmented tenure, often inaccessible; • Investment in tourism and limited interest to the agricultural sector (desertification of rural areas); • Two extreme farmer types, either intensive farmers or part time farmers; • Limited communication between the farmer and the authorities/experts/institutes; • Lack for education (environmental but also specialised, good practices etc.) or accessible information; • Uncontrolled grazing (overgrazing, wildfires); • Overexploitation of natural resources (groundwater over-abstraction, soil mismanagement, etc.); • Poorly distributed/managed subsidies; • Aging farmer population; • Small profit margin for farmers (limited motivation, lack of labour force, limited ability to reinvest profits in infrastructure and technology); • Limited use of scientific methods (soil and water sampling, yield quality) It seems evident that without the financial motivation provided by the CAP, a class of farmers would have no incentive to cultivate the land (i.e., costs would be higher than profits).
Stornara and Tara (IT)
• Lack of synergy in matching empirical needs with scientific ones; • Lack of real constructive interaction between different stakeholders; • predominance of old-aged farmers, unaccustomed to smart and precision agriculture. Need for policies to incentivize the involvement of young people and female in the agricultural sector.

Canyoles (ES)
The constrains found to the use of chipped pruned branches are: • higher cost to chip the branches than to burn; • perception of the farmers that see the chipped pruned branches are dirt and will never decompose; • lack of subsidies; • when subsidies exist is very costly from the bureaucratical point of view; • some farmers see the chipped pruned branches the source of pestes; • chipped pruned branches are being seen as example of bad farming (dirt, lazy, lack of responsibility); • the aging of the farmers population induces limited changes, and the most important one is the issue of preferring the field clean and tidy, with nothing else than the crop; • farmers do not see the chipped pruned branches as a source of nutrients and a soil protection; • farmers see the option to chop the branches as the way to remove them from the field; • farmers see the crop as the objective, the pruned branches are dirt and need to be remove from the groves and orchards; • In the last ten years some changes arise that contribute to a current shift to the use of chipped pruned branches. The machinery to chop the branches is now easy to find and cheaper, which reduced the cost of chopping dramatically. Moreover, the CAP developed some subsidies that help to shift to the use of chipped pruned branches. However, those subsidies are not available for organic farmers, which means that some organic farmers burn the pruned branches, and the chemical (conventional) ones chop the branches.
Merchouch (MO)
• There is a lack of knowledge about best feasible solutions for agroecosystems restoration and other options to enhance the soil quality (such as manure, composting, biochar, etc); • The bureaucratical process and low response from the local and regional administration to have access to NT planters, create problems for increasing the adoption of direct seeding by farmers as the best climate smart practice in this rainfed area.
Lower Gediz (former Menemen) (TR)
• Although there are sufficient technical personnel, researchers, research institutes and universities, the results of the researches carried out and good results obtained cannot reach the farmers. the information obtained by spending many years of effort remains only in articles accessible only to the academic community. extension activities, field days and demonstration activities are not sufficient.
Tamia (EG)
• Due to the importance and seriousness of the phenomenon of desertification worldwide the objective of No main constraints for implementing the restoration actions found, where the project teamwork through the last period determined the different problems and obstacles which might hamper the workflow in the project and applied the different strategies.

Bethlehem of Galilee (IL)
The main constrain is financial. There are opposing interests. With no subsidies, conventional agriculture is still more profitable in the short term. Conserving biodiversity using known methods (with cover crops for example) is reducing the yield and therefore reduces the overall financial benefit of the agricultural business. There are however ways to integrate other income generating activities in farms, like courses, processed products etc. Those new models need however a new set of tools and skills. In a report by the ministry of agriculture, some obstacles were mapped. Reluctance, tradition, prejudice, and risk aversion are among the main factors that influence the non-adoption of the conservative processing of the soil. Among these farmers, you can hear arguments such as "willing to adopt new technologies only if there is no risk in them"; "agriculture is a business only market forces should affect it"; and "the state should not require soil conservation actions". Below is a breakdown of the barriers: • The perception of agricultural activity only as a business, where only market forces should influence. The lack of relevance in the eyes of the farmer of the environmental issue compared to the importance of agricultural production and profitability; in this case only economic certainty will motivate the farmer to adopt a conservation approach. In addition, when the farmer does not have a significant economic profit in the existing crops, as for example in the areas cultivated in Ba'al agriculture in the Negev south of the drought line, he will not invest in switching to new processing methods. • Lack of faith in soil conservation methods and the belief that they cannot improve the condition of the soil and the environment. These farmers are less concerned about the damage of conventional farming methods, and are less aware of the connection between soil erosion and cultivation methods. Also, there is a widespread opinion that the responsibility of protecting the environment should rest with the state alone. • Lack of theoretical knowledge and professional accompaniment - a farmer who lacks personal guidance and close professional accompaniment will change the land processing methods less. Farmers who have not attended seminars on conservation tillage at all do not adopt a no-till approach. Farmers who do not know and work with the soil conservation working groups in their districts often will not adopt conservation tillage. • Lack of a supportive environment - farmers in their environment who do not have others who adopt conservation agriculture or who know fewer farmers who implement conservation processing methods, will be less inclined to switch to these methods. Also, conservation agriculture farms are perceived negatively in their eyes and are less effective. Furthermore, the unstable political situation in Israel, visible in the frequent election in the last decade, prevents any major implication of long-term plans and strategies.

1.5 Regional, national and international initiatives

Troodos Mountains (CY)
Initiatives that are positively affecting the implementation of projects' actions • The current interest of winemakers to expand their vineyards; • The currently available subsidies for the building of dry-stone walls; • The increasing public interest in safeguarding the environment and the climate. *Negatively affecting*

Regulatory barriers or lack of funding can negatively affect the development and implementation of a long-term funding strategy for mountain terrace construction and maintenance.

Heraklion (GR)

Regional and national initiatives:

- Greening measures through the CAP
- Forestation measure of CAP: The program of afforestation of agricultural land could constitute a sustainable carbon farming solution as it is a multi-year program and the main commitment of the beneficiaries is to plant their agricultural land with forest species and to maintain and preserve the forest plantation from 13 to 20 years. Furthermore, such forestation actions could have a positive impact on the local microclimate offsetting the impacts of climate change (Meier et al., 2021). The CASCADE project (Daliakopoulos & Tsanis, 2014; Jucker Riva et al., 2017a, 2017b, 2018; van den Elsen et al., 2020) highlighted among other measures, afforestation actions with carob trees have proven to be a sustainable solution against land degradation that is compatible with the local ecosystem.
- Forestation actions from the forestry service.
  - ✓ In 2014, a technical manual for forestation actions was issued by the Ministry of Agriculture (https://ypen.gov.gr/wp-content/uploads/legacy/Files/Dash/Dasotexnika%20Erga%20-%20Anadaswseis%20-%20Fytwria/Egxeiridio_efarmogis.pdf)
  - ✓ Sustainable forest management: http://www.ci-sfm.org/uploads/Documents/2012/Virtual%20Library/Country%20reports%20page/Greece_%20english(1).pdf
  - ✓ Forest land ownership change in Greece: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_GREECE.pdf

International initiatives:

- https://trilliontrees.org/
- EU 3 Billion Trees Pledge (https://mapmytree.eea.europa.eu/#/home)
- Global tree initiative (https://plantgrowsave.org/impact/)
- https://goforest.be/
- https://agreena.com/

Stornara and Tara (IT)

Regional initiatives:

- water meters installation in order to control the effective water consumption at farm level;
- reduction the private systems own, in order to control the salinity content in the soil;
- modernization of all the irrigation system

Regional/national initiatives:

- The Apulia Region applies the CAP rules with minor changes;
- Possible support sources are envisaged on the basis of European projects after approval of the Ministries of Agriculture and the Environment.

Other:

- transition to innovative irrigation systems using specific sensors, properly calibrated settled in the same soil, and special containers for fertigation, each containing only one type of nutritional element (e.g. nitrogen, phosphorus and potassium);
- technician specialized in software management through specific application on the cell phone in order to manages the whole irrigation system.

Canyoles (ES)
Local initiatives. The municipalities control the agenda as to when it is allowed to burn agricultural residues (pruned branches) in the fields. If the municipality restricts the use of fire, then more pruned branches will be chopped. The use of fire is allowed only in some seasons and under strict regulations by the districts. Municipalities should promote the chopping of the pruned branches of their own trees, as the trees of the municipality produce a large quantity of biomass that can be used as a source of nutrients and carbon. This is a task that few municipalities have in mind to develop. The use of city organic garbage must be also developed as this is the right option to produce a stable and rich compost. *Regional/national initiatives*. The Valencia region applies the CAP rules with minor changes. There is a subsidy of 60 € per ha. National. No other policies are applied for the chipped pruned branches. The Spanish government applies the CAP rules throughout the regions, including the Valencia region. No other policies are applied for the chipped pruned branches. *International initiatives*. The CAP is the main ruler and they support the use of chipped pruned branches. PAC 2020 related to the use of chipped pruned branches. Over the next few years, the European Green Deal, the Biodiversity strategy, the farm-to-fork strategy, and the climate action must promote the use of mulches as they can help to protect the soil and improve agriculture production.
Merchouch (MO)
National/Regional initiatives • million hectare Conservation Agriculture National Plan under new Generation Green strategy (*Ministry of agriculture*); • Green Generation Plan (water productivity and resilience pillars): connect Master Plan for the Integrated Development of Water Resources (PDAIRE) and National Irrigation Water Saving Program (PNEEI) (*Ministry of Agriculture and water authorities*); • Groundwater contract : Improve Participatory groundwater co-management (Cross sectoral dialogue to enable effective and sustainable "Contrat de nappe") (*Ministry of water*)
Lower Gediz (former Menemen) (TR)
Regional initiatives: • modernization of drainage system; • regular maintenance of the installed drainage system; • remotion the private systems own, in order to remove the salinity because the surface irrigation is still intensively practiced in the region and the drainage system is not functioning; • transition to pressurized irrigation systems together with efficient drainage systems in order to greatly reduce the land degradation problems. *National initiatives:* Since irrigation water reaches the field with the open canal system in the region, farmers who want to irrigate with pressurized irrigation systems cannot switch to modern irrigation systems. • Transmission of water with a closed system will be a solution to this issue. In order to switch to a closed system, the region should take initiatives nationally and carry out large-scale projects.
Tamia (EG)
Project initiatives at regional and national level Due to the importance and seriousness of the phenomenon of desertification worldwide the objective of the United Nations Convention to Combat Desertification (UNCCD) is: "to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and

partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas.
In 2005, Desert Research Center in Egypt has published the Egyptian National Action Program to Combat Desertification which was one of the main references of desertification status in Egypt, UNCCD-NAP (2005). The country is endowed with four main agro-ecological zones having specific attributes of resource base, climatic features, terrain and geomorphic characteristics, land use patterns and socio-economic implications. Each agroecological zone has significant variations in environmental conditions and can be classified as follow:

- The Nile Valley: encompassing the fertile alluvial land of Middle and Upper Egypt, the Nile Delta region and the reclaimed desert areas in the fringes of the Nile Valley;
- North Coastal zone: including the coastal area stretching east ward from North-Western coast to North coastal area of Sinai;
- The Inland Sinai and the Eastern Desert with their elevated southern areas;
- The Western Desert: encompassing oases and southern remote areas, including East Uweinat, Tushka and Darb El-Arbian areas.

Number of the past and on-going projects

- Project entitled "A simulation model for predicting water distribution under self-compensating gated pipe irrigation technique for small holdings". Funded by Science and Technology Development Fund in Egypt, from 2014 to 2017.
- Project entitled "Water Saving under Surface and Sub-Surface Drip Irrigation: Field and Modelling Study" Funded by Science and Technology Development Fund in Egypt, from 2017-2020.
- Project entitled "SALTMED Simulation Model to Predicting Water Distribution under Automatic Irrigation Scheduling.". funded by Science &Technology Development Fund in Egypt, from 2017-2020.
- Project titled: strategies for improving the tolerance of canola plants to Abiotic stress " JKI, Germany and NRC, Cairo, Egypt, Funded by BMBF and STDF (Project ID : 23134). From 2018-2021
- Project entitled "An Innovative Technology for Improving Irrigation Water Use in the Mediterranean Region Using Geotextile Material". Funded by Science, Technology and Innovation Funding Authority. Egyptian-Spanish Joint Technological Co-operation Program / International Cooperation Grants, from 2020 to 2022.

Bethlehem of Galilee (IL)

The ministry of agriculture initiated a working group: Soil conservation and conservation agriculture. The working group has released a strategy note on the 7th of August 2017. There are five main points in their workplan:

- **Multidimensional approach** - giving emphasis on a large number of public interests over narrows solutions (basin and long-term management, strengthening environmental aspects)
- **Prevention** - preferring solutions that prevent the formation of problems rather than dealing them after their occurrence;
- **Professionalism** - the department must be a focus of knowledge development and assimilation in addition to being a supervisory and auditing body;
- **Empowerment of regional stakeholders** - the regional stakeholders, including the ministry's districts, drainage authorities, farmers, local communities, are central stakeholders in the assimilation of the approach;
- **Cooperation** - deepening and expanding collaborations among all stakeholders: governmental offices, NGOs, KKL, farmers and any other relevant stakeholder.

At a national level, the recognition of food forests as agricultural fields may grant such projects access to subsidies and governmental grants that are given to agricultural fields. Furthermore, considering

ecosystem services such as fixation of CO_2 (carbon farming) and preserving soil biodiversity in the amount of governmental support may encourage and help such projects to exist and be economically feasible. At an international level Israel awaits examples of integrating climate laws in bigger political entities (the EU for example) that show positive effective implications of conservation agriculture that can be replicated in Israel or used as inspiration for formulating new laws.

1.6 Next steps

Troodos Mountains (CY)
• Field meetings with stakeholders to understand current soil and terracing practices and knowledge gaps; • Development of support tool for sustainable mountain terrace design and construction; • Hands-on capacity-building events for transferring the technical skills for dry-stone wall construction; • Living Labs on the development of policy guidelines (environmental regulations) and long-term funding strategy for mountain terrace construction and maintenance.
Heraklion (GR)
• Map successful and unsuccessful restoration actions in the case study area, see what works and what not, to provide guidance to future restoration actions.
Stornara and Tara (IT)
• Keep all interested stakeholders updated about the main progresses and outcomes of the project; • Organize other stakeholders meetings to better understand the knowledge gaps; • Build-up of Living Labs on the policy normatives (environmental regulations) with evaluation of a long-term funding strategy for supporting farmers; • Adopt innovative irrigation systems as observed in some local farms; • Promote extensive agriculture without the use of pesticides and herbicides.
Canyoles (ES)
The contribution of the REACT4MED project will be: • To maintain the study of the effect of chipped pruned branches on the soils; • Develop a long-term measurement and experimental setup; • In future studies the implementation of the new Green Deal targets will be evaluated.
Merchouch (MO)
At regional and local level, more details will be collected in order to: • monitor the best feasible solutions for agroecosystems restoration at farm level; • identify the constraints of adoption of those solutions.
Lower Gediz (former Menemen) (TR)
In order to raise the awareness of the farmers in the region it is expected: • installation a drainage system in a selected field with a practical demonstration in the field to the stakeholders (farmers, managers, extension agents, researchers);

- show the farmers in the region that appropriate and correct practices can improve land degradation through extension activities.

Tamia (EG)

In the last period, we organized 2 days' workshop: the first day for the agriculture administrations, advisors, researchers and the second day was organized for the farmers and stakeholders to announce about our project among them as well as to know the problems which face in their soils which effect on the soil productivity.
In this period we took number of soil and water samples to make physical and chemical full analysis to know the current situation of the soil and water.
In the next period we will start our work in the open field through the summer season cultivation, where will start soil preparation and adding the compost as well as choose the salt tolerance varieties. Through these field work we will organise number of field days for the farmers and stakeholders to show them how the project team carry out the different procedures and treatments in every stages.

Bethlehem of Galilee (IL)

Throughout this project the benefits of conservation agriculture will be quantified. This is expected to prove the added value demonstrated in less soil erosion, higher organic matter, higher biodiversity, and healthier soil.
The added value for soil quality will be quantified and best practices will be shared with other farmers and policy makers for further outscaling.

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