








CarboNostrum

CLIMATE-SMART AGRICULTURE IN A CHANGING WORLD

Battery of Case Studies

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Battery of Case Studies

KA220-VET - Cooperation partnerships in vocational education and training

Climate-Smart Agriculture in a Changing World
CarboNostrum

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CarboNostrum Battery of Case Studies

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Abstract

It is widely accepted that climate change is a serious and rapidly evolving concern. Addressing this crisis calls for more resilient agricultural systems, recognized as a crucial component of climate change solutions. As a result, climate-smart agriculture was formally developed by the Food and Agriculture Organization and World Bank in 2010 as an approach to guide the transformation of agricultural business models.

The CarboNostrum Battery of Case Studies (ebook) comprises a collection of 2 prospective case studies per partner country. These case studies are based on desk research, interviews and field trips – supplemented by video recording. They clearly outline the necessary actions for transitioning to sustainable agriculture, which guarantees food security amidst our changing climate.

The challenges mentioned above will likely directly affect farmers' income, potentially increasing their production costs. These increased costs result from the requirement for new inputs to offset losses. The adoption of climate-smart solutions and sustainable practices is crucial to preserve the agro-ecosystems' integrity and preserve soil fertility.

In the ebook a variety of growers and cultivation systems are detailed and presented in order to address the strengths and challenges of their current agriculture and business models. Two selected case studies from each partner in the Mediterranean region are presented, considering abiotic characteristics such as land features, climate conditions, soil parameters, as well as biotic characteristics and management practices related to crop production. For each case study, distinct aspects of plant production, as well as the owners' views and concerns are presented and discussed.

Introduction

There is widespread and clear evidence that human induced climate change has already influenced and will continue to impact future European Union farming through changes in rainfall variability, rising temperatures, and an increase in the frequency, intensity, and quantity of extreme weather events (such as heatwaves, droughts, hail, storms, and floods) (Arona, 2019). As such, climate-smart agriculture is increasingly being adopted worldwide as an approach to transform and protect the agriculture sector (Chandra et al., 2018). As a result, building farmers' capacity to adapt and increase resilience to climate change impacts is of utmost importance for the agricultural sector at all levels.

One of the significant challenges of increasing crop yields in Mediterranean agriculture is the need to modify the current unsustainable farming practices by avoiding the unnecessary extensive use of water and exogenous nutrients as well as chemical pesticides. Furthermore, it's critical to protect the natural capital represented by the soils that characterize the different Mediterranean regions.

The issues mentioned above are anticipated to directly influence farmers' income, likely increasing their production cost due to the need for innovative inputs to offset the losses. High production costs and reduced yields may potentially force farmers to abandon their crops, resulting in direct and indirect economic and social impacts on the local communities. These impacts include job losses, unprofitable investments, rural area abandonment, and migration to urban areas. A shift in crop selection by farmers will also affect their associated trade organizations and cooperative enterprises, as the entire production, processing, and logistics structure will need to adapt. Without a shift in the current paradigm, significant socioeconomic costs will inevitably be experienced by nations and local communities. Furthermore, administrative authorities and policy makers will face the substantial challenge of providing support to numerous areas and farmers, leading to a significant economic and administrative burden (Branca et al., 2021). This transition will necessitate the development and implementation of new management and governance strategies.

Promoting climate-smart farming solutions and sustainable practices is thus essential to maintain the integrity of agro-ecosystems and soil fertility. Enhancing profitability for small farmers should also be prioritized in the transformation of farming activities.

Within this framework, Carbonostrum project is a course focused on climate-smart agriculture, with a goal to educate and inspire farmers towards more sustainable practices. This ebook features a comprehensive battery of case studies, showcasing farmers who are already implementing practices of climate-smart agriculture. These case studies delve into the farmers' histories, practices, results, and challenges, serving as insightful examples. These real-world experiences are not merely a critique of current agricultural business models, but rather provide valuable practical insights that can influence positive change in small farmers' practices and potentially improve their quality of life. This report presents case studies sequentially from western to eastern Mediterranean countries.

https://carbonostrum.eu/case-studies-3/

Case Presentation: Portugal

CASE STUDY 1 - HERDADE DE SÃO LUÍS

Herdade de São Luís is located in the municipality of Montemor-o-Novo in the central Alentejo region. This expansive 700-hectare regenerative farm is divided into 650 hectares for animal rotations and 50 hectares set aside for cereal plantations. Managed by Francisco Alves, the farm operates under the brands of Herdade de São Luís and Porcus Natura. It boasts a unique 'montado' farm, a traditional agroforestry system in Alentejo that's characterized by low-density cork trees intertwined with pastoral activities or agriculture.

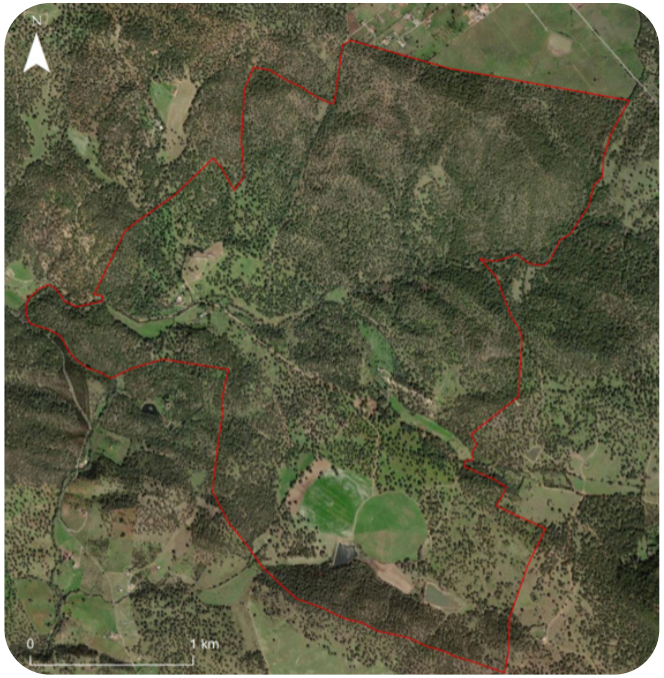

Figure 1. Aereal view of Herdade de São Luís.

Francisco, a native of Alentejo, has been working in the region for the last 20 years, and has dedicated six of these years to this project. Maintaining his family's tradition, the main activity at Porcus Natura is breeding Alentejano pigs, a venture that his father innovatively pioneered, beginning at the pigs' maternity stage.

A special area of the farm has been set aside specifically for breeding sows. This space is rich in shade and water, and dotted with huts. The sows spend two weeks here before giving birth. Once the piglets reach two months of age, the sows are moved to open areas where they can walk and graze freely.

Francisco holds a keen understanding of regenerative soil management. He employs a strategy of rotational grazing, which involves daily rotation of animal-covered spaces, to ensure both the quality of the pasture and the regeneration of the soil. One of the many beneficial side effects of this regenerative soil management technique is the carbon absorption by the soil, which counteracts the emissions produced by the animals.

In the practice of climate-smart actions at Herdade de São Luís, Francisco implements dynamic rotational grazing with different animals. This technique aims to rejuvenate the soil, ensure high-quality pastures, and balance carbon emissions. He also refrains from tilling the soil to preserve carbon storage, retain moisture, reduce compaction, and maintain the topsoil layer. Moreover, he has decided against the use of pesticides to avoid associated health risks, soil and groundwater contamination, and harm to local biodiversity.

Currently, Francisco is exploring the possibility of expanding the number and diversity of animals and species to optimize rotational grazing. He aims to strike the perfect balance by increasing the animal population without causing ecosystem disturbances or imbalances. Through the application of regenerative techniques, he has already noticed remarkable improvements in soil health and farm biodiversity. Adopting a trial-and-error approach, he continually experiments with various techniques, keenly observing, comparing, and learning.

Adhering to the traditional Alentejo agroforestry system, the property utilizes low-density cork trees in harmony with pastoral activities or agriculture. This means that irrigation plays only a minor role. At Herdade de São Luís, irrigation covers just 25 hectares, or 50% of the cultivated area. The remainder of the property, primarily improved pastures, relies on natural rainfall. The irrigated part of the farm draws water from pools and retaining ridges, and employs an irrigation pivot. The irrigation period lasts for two months each year.

ABIOTIC CHARACTERISTICS OF THE LAND

ALTIMETRY

The mean altitude of the area where the property is situated is around 300 meters above sea level. The terrain varies between 235.4 and 348.5 meters, with the cultivated areas located in the higher segments (Figure 2).

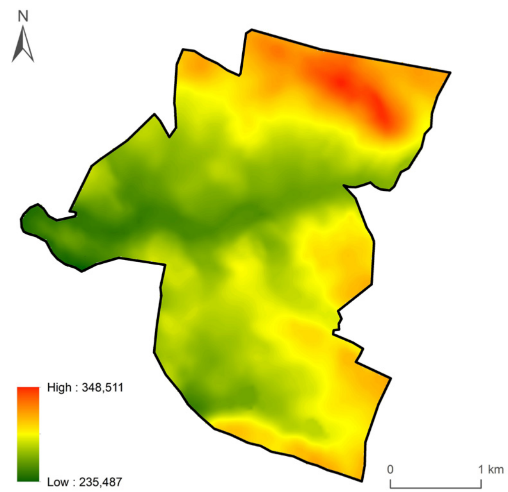

Figure 2. Altimetry map of the property for Herdade de São Luís.

SLOPE

The terrain of the property is primarily flat or gently sloping, with inclinations of less than 4 degrees. Approximately 30% of the land features more pronounced slopes, ranging from 4-12 degrees. With two main water courses traversing the study area, less than 10% of the land exhibits steeper inclinations due to water course-related topographical changes and valley formations (Figure 3).

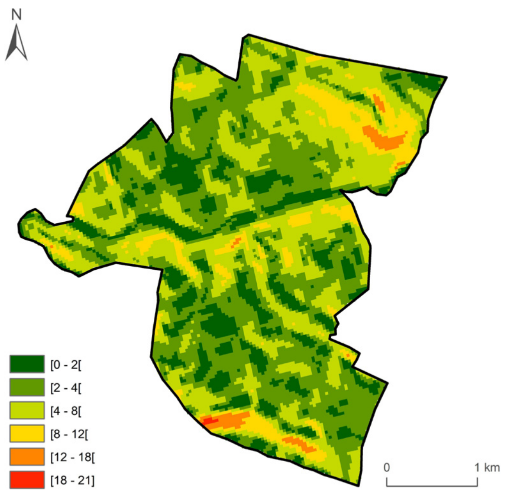

Figure 3. Slope map of Herdade de São Luís.

CLIMATE

The region is characterized by a distinct Mediterranean climate. Summers are hot and dry, often exceeding 40°C, while winter temperatures can dip below 0°C. The average annual temperature is 15.4°C, with a peak average of 32°C in July and a minimum average of 3.1°C in January. The hot season extends for 2.9 months, from June 19 to September 15, and the cold season lasts for 3.7 months, from November 16 to March 6 (Figure 4).

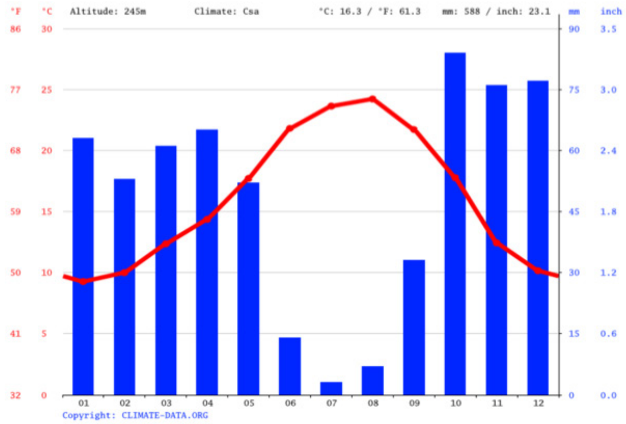

Figure 4. Thermopluviometric Chart for Montemor-o-Novo (near Herdade de São Luís). Source: Climate Data, Org in *https://pt.climate-data.org/europa/portugal/montemor-o-novo/montemor-o-novo-6982/#climate-table*

Climate data from the past 30 years (1991-2021) shows a mean winter temperature of 10.48°C, with the coldest average in January (9.3°C) and the warmest in March (12.4°C). Winter typically sees an average of 23 rainy days and 4 days of extreme cold. In contrast, the average summer temperature is 23°C, with the coolest average in September (21.7°C) and the hottest in August (24.2°C). Summers generally have an average of 8 rainy days and 15 days of extreme heat.

TYPE OF ROCK / SOIL COVER

The geological features of the area are typical for the region, dominated by metamorphic schists and sedimentary greywackes, with quartzitic intrusions. Most of the soil comprises slightly saturated Mediterranean clay soils, covering more than half of the property. The primary soil type is non-limestone, normal, Mediterranean brown, slightly saturated clay soils on gneiss or similar rocks, making up 23.8% of the total area. The soil types are detailed in Table 1 below.

SOIL TYPE	AREA (HA)	%	DESCRIPTION
Hydromorphic Soils, Without Eluvial Horizon, Para-Alluvial Soils (or Para-Colluvisols), alluvial or colluvial soils of medium texture	16,154153	2,2	Water-saturated soils are common in wet areas.
Incipient Soils - Low-lying Soils (Colluvisols), Non-limestone, of medium texture	6,500573	0,9	Young soils in lower areas, medium textured.
Incipient Soils - Modern Alluvial Soils, Non-Limestone, of medium texture	43,373135	6,0	Young soils made of materials carried by water, non-limestone, medium texture.
Litholic, Non-Humic Lowly Unsaturated, Normal, Granite Soils	4,225276	0,6	Thin soils over granite, low in organic matter.
Litholic, Non-Humic, Lowly Unsaturated, Normal Soils, from granites in transition to quartzodiorites	1,455231	0,2	Thin soils from granite transitioning to quartzodiorites, low in organic matter.
Litholic, Non-Humic, Lowly Unsaturated, Normal, Gneiss or related rock soils	44,341528	6,1	Thin soils over gneiss (a type of metamorphic rock), low in organic matter.
Litholic, Non-Humic, Lowly Unsaturated, Normal, light microphyric rock soils	32,363449	4,5	Thin soils over light microphyric rocks (fine-grained rocks), low in organic matter.
Lowly Unsaturated Clay Soils - Mediterranean Soils, Red or Yellow, of Non-Limestone Materials, Normal, of crystallophilic rocks	84,325823	11,7	Clay soils, typical in the Mediterranean, red or yellow, derived from non-limestone materials.
Lowly Unsaturated Clay Soils - Mediterranean Soils, Red or Yellow, of Non-Limestone Materials, Para-Clay, of diorites or quartzodiorites	1,528682	0,2	Similar to above but associated with diorites or quartzodiorites (types of intrusive igneous rocks).
Lowly Unsaturated Clay Soils - Mediterranean Soils, Red or Yellow, of Non-Limestone, Normal Materials, of gneisses or similar rocks	85,990956	11,9	Similar to above but associated with gneisses or similar rocks.
Lowly Unsaturated Clay Soils - Mediterranean Soils, Red or Yellow, of Non-Limestone, Normal Materials, of microphyric rocks (porphyry)	32,523606	4,5	Similar to above but associated with microphyric rocks.
Lowly Unsaturated Clay Soils - Mediterranean Soils, Red or Yellow, of Non-limestone, Normal, shale or greywacke materials	17,19405	2,4	Similar to above but associated with shale or greywacke (types of sedimentary rocks).
Lowly Unsaturated Clay Soils - Mediterranean, Brown, Non-limestone, Normal, crystallophilic rock soils	88,117558	12,2	Mediterranean clay soils, brown, derived from crystallophilic rocks (rocks rich in crystals).
Lowly Unsaturated Clay Soils - Mediterranean, Brown, Non-limestone, Normal, gneiss or similar rock soils	172,06968	23,8	Similar to above but associated with gneisses or similar rocks.
Lowly Unsaturated Clay Soils - Mediterranean, Brown, Non-limestone, Normal, shale or greywacke soils	90,182485	12,5	Similar to above but associated with shale or greywacke.
Lowly Unsaturated Clay Soils Red or Yellow, of Calcareous, Normal Materials, of crystalline limestones associated with basic crystallophilic rocks	2,66575	0,4	Clay soils, red or yellow, derived from limestone and associated with crystalline limestones and basic crystallophilic rocks.

Table 1. Soil types, area and proportions for Herdade de São Luís.

The soil types present on the property are quite diverse and heterogeneous, and it is possible to note the presence of alluvial soils and colluvial soils along the waterways that cross the property. These are generally the most capable soils in the region, while the remaining soils of the property are typically, for Alentejo, less capable soils (Figure 5).

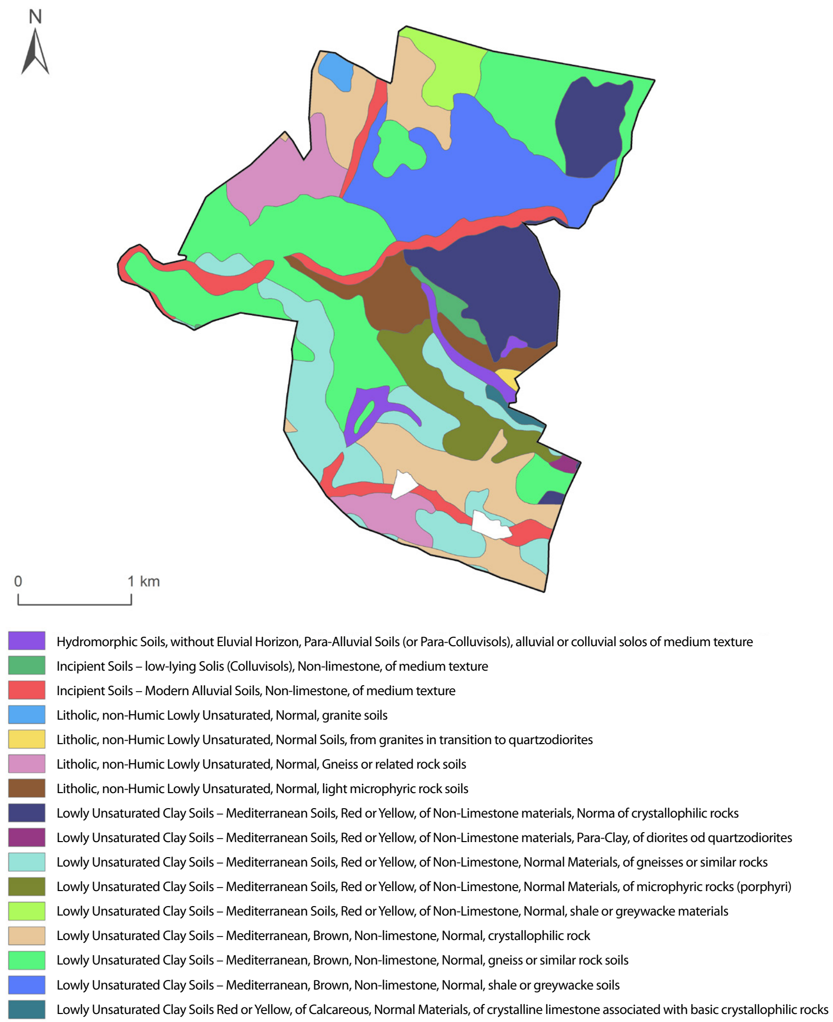

Figure 5. Spatial extent for soil types in Herdade de São Luís.

The soil composition in the closest and most representative sampling points has been determined as 48.2% coarse sand, 25.2% fine sand, 9.3% clay, and 17.1% silt. Organic matter content, determined from soil analyses conducted on the property, varies between 1.2% and 4%.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

The farm's open-field crops span 50 hectares, half of which are irrigated. Neither insecticides nor fungicides are used in cereal cultivation or the remaining pastures intended for animal rotation. Mediterranean-style fertilization is used, employing only organic sources, with the land benefiting from animal rotation and bio-fertilizer. This bio-fertilizer is created using nutrient multiplication methods. Pest and disease control relies on ecosystem services, and no significant issues have been reported for either plants or animals. Table 2 below provides an overview of the use of ecosystem services on the farm. These services are maintained, and the ecosystems preserved by the farm owners, as they play a crucial role in property management and contribute to economic gains.

ECOSYSTEM SERVICES	YES	NO	Partially	In the future
Control of pests and disease	x			
Regulation of Microclimate			x	
Decomposition of wastes	x			
Regulating nutrient cycles	x			

Table 2. Provision of ecosystem services at Herdade de São Luís.

In terms of genetics, the farm produces its own animal breeds and crop varieties without the use of genetic engineering. They engage in breed selection and allow natural processes to shape the adaptation of breeds to the local terrain, climate, and farming practices. This approach is applied to farm animals, while cereal crops are either purchased or saved from previous harvests.

The farm favours plant varieties that can withstand drought, considering Portugal's recent history of dry periods and extreme temperatures. Flooding, pests, and diseases are not major concerns as these issues are infrequent and not projected for the region.

Economically, the farm leverages partnerships to bring its products to market. Approximately 30% of the total production of animal meat and other products have access to packaging and storage facilities. The harvested cereals and forage are used within the property as feed and bedding for the animals.

HARVEST PROCESS

Animals: The farmhouses maternity facilities for native pigs, and adult pigs are selected for breeding or sale based on maturity. Similar processes apply to cows, sheep, and goats, without the maternity units. The animals are free to roam within 40 fixed parcels and additional temporary parcels, rotated daily.

Plants: Direct seeding is used for plantations, and harvesting is done with a tractor, which also handles seeding and tilling (surface tilling as necessary due to soil compaction).

Management and mechanization involve the use of vehicles for navigating the 700 hectares and a tractor, which consumes approximately 1,500 to 2,000 litres of diesel fuel annually. Solar energy partially power the property's critical systems and storage facilities, mitigating some related emissions.

The farm's finances indicate that it operates at a break-even point with production alone, further boosted by subsidies from the common agrarian policy. The total cost of operation is estimated to be between €100,000 to €120,000 per year. While the farm is a family business, it also employs between 1 and 10 external personnel.

https://carbonostrum.eu/case-studies-2/

CASE STUDY 2 - HORTAS DA RAINHA

Hortas da Rainha is the new project of Quinta do Alecrim, located in the village of Carreiro da Areia, belonging to the municipality of Torres Novas in the Central Region. This project is born from meeting objectives between its associates and derives from the local agriculture work developed by Quinta do Alecrim since 2011. It has a property of 34 hectares, in which they develop a regenerative agriculture project through complex agro-ecosystems and animal husbandry, namely sheep and chickens, with the animals in rotation on the land.

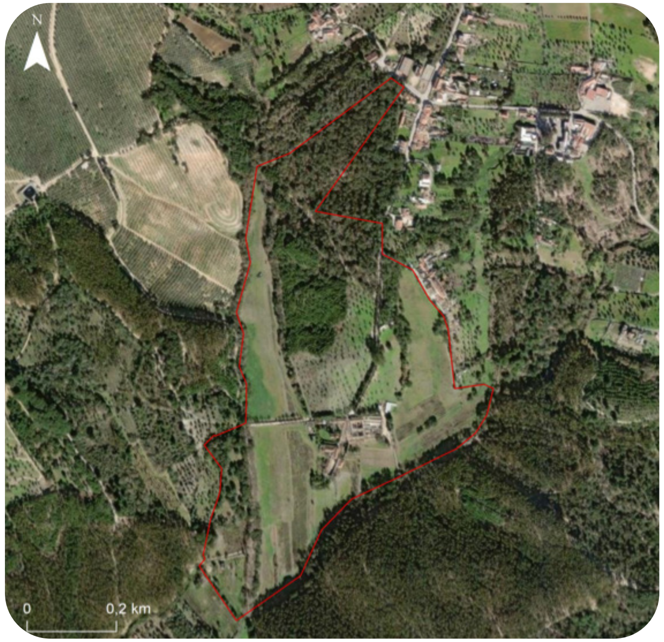

Figure 6. Aereal view of herdade das Hortas da Rainha.

This project is operated by the farm manager and farmer Denis Hickel, who already has 11 years of experience in these areas as a farmer. The main objective of the farmer and this project is to invest in regenerative agriculture as a method of conservation and restoration of natural ecosystems that brings together sustainable agricultural techniques, benefiting the vitality and resistance of the soil, biodiversity, and human health. Through this, caring for the soil and the ecosystem to produce healthier food, and uniting the community around a common cause. All products grown and produced on the farm are packaged, in customized baskets, and sold to the public directly at the farm or, also, through a partner store and its own website. These products are grown and harvested manually and sustainably, respecting the growth cycle of the crops and ecosystems.

ABIOTIC CHARACTERISTICS OF THE LAND

ALTIMETRY

Situated at an average elevation of about 95 meters above sea level, the property's altitude varies between 49,17 m and 94,37 m. The cultivated portions of the land predominantly occupied areas with gentler slopes, specifically the southern regions depicted in green (see Figure 7).

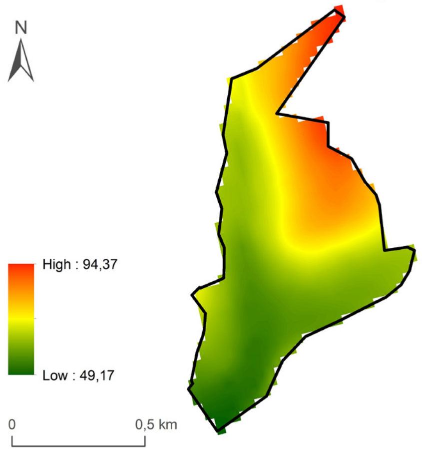

Figure 7. Altimetry map of the Hortas da Rainha property.

SLOPE

The property's terrain is largely flat or gently sloping, with inclinations less than 8 degrees. Two minor streams cross the property, exhibiting exceptionally low slopes under 2 degrees, represented in dark green (Figure 8).

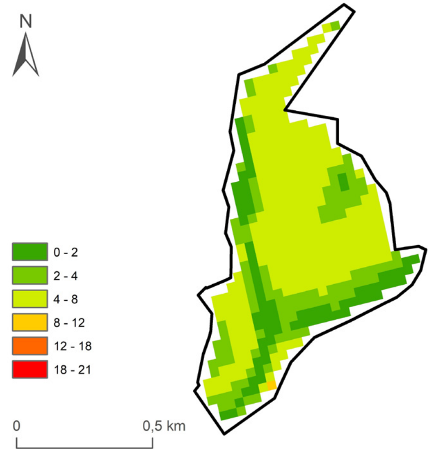

Figure 8. Slope map of the property for Hortas da Rainha.

CLIMATE

Based on the Köppen climate classification, the region's climate is temperate, characterized by rainy winters and hot, dry summers (Csa). Daily temperatures can exceed 30°C in the summer, with an average of around 22°C. The hottest month on record is August, with an average high of 30.4°C. Still, the summer months also experience a few days of rainfall. In contrast, the winter months average around 10.55°C, with occasional extreme lows of 5°C or below. The coldest and warmest months of winter are January (5.6°C) and March (17.6°C), respectively. Over the winter, rainfall occurred on 25 days.

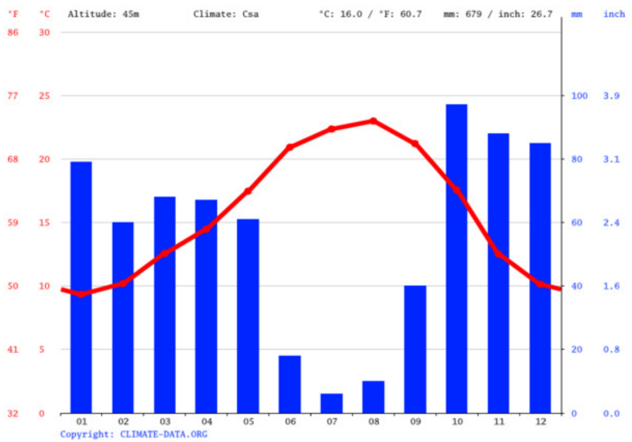

Figure 9. Thermopluviometric chart for Torres Novas (Close to herdade das Hortas da Rainha). Source: Climate data. Org in *https://pt.climate-data.org/europa/portugal/torres-novas/torres-novas-7099/*

As for the days of drought, according to the Portuguese Institute of Sea and Atmosphere (IPMA), for the months of February and March 2022, the region of Hortas da Rainha (Torres Novas) was in extreme drought on February 28, 2022, and in severe drought on March 15, 2022.

TYPE OF ROCK / SOIL COVER

The area's geology is typical of the region, with a predominant mix of granites, orthogneisses, granodiorites, and tonalites. The soil mainly comprises of, non-compacted limestone and brown soil from Xeric Regime Climates, which together account for around 25% of the property. This is followed by Lowly Unsaturated Clay Soils - Mediterranean Soils, Brown Limestone Materials, Para-Clays, of marl or marly limestone or associated non-compacted limestone (16%) and Brown Limestone Soils from Xeric Regime Climates, Para-Clays, marl or similar materials (15%). Further details on the soil types and their proportions within the property are provided in Table 3 and Figure 10.

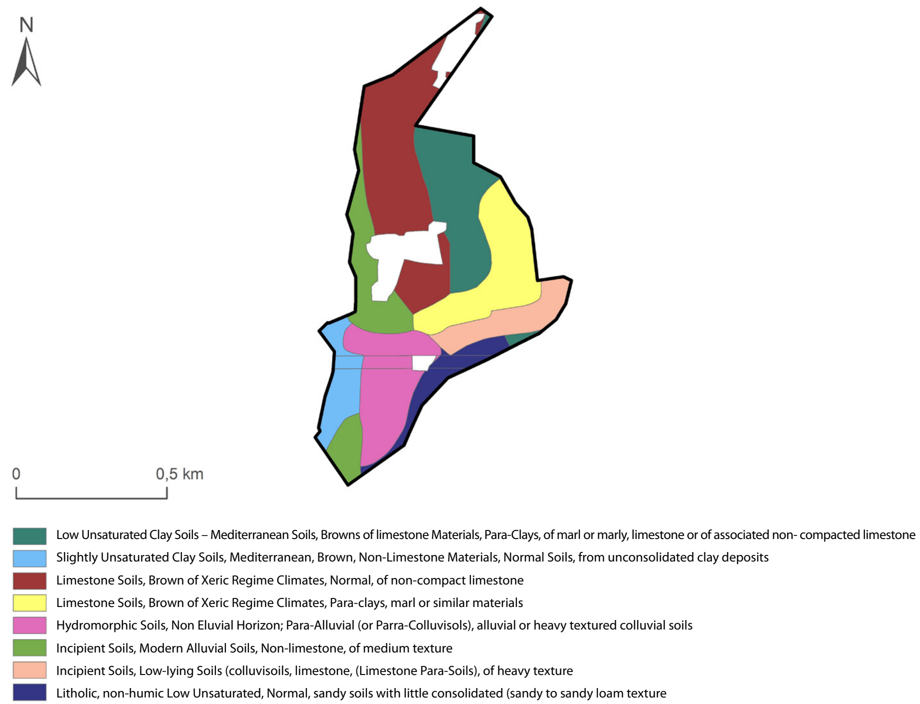

Figure 10. Geographic extent for soil types in Hortas da Rainha propriety.

SOIL TYPE	AREA (HA)	%	DESCRIPTION
Low Unsaturated Clay Soils - Mediterranean Soils, Browns of Limestone Materials, Para-Clays, of marl or marly limestone or of associated non-compacted limestone	5,393956	15,8	Clay and limestone-based soil, in Mediterranean climates.
Slightly Unsaturated Clay Soils - Mediterranean, Brown, Non-Limestone Materials, Normal Soils, from unconsolidated clay deposits	2,143837	6,3	Mediterranean-type clay soil with a mix of non-limestone materials.
Limestone Soils, Brown of Xeric Regime Climates, Normal, of non-compact limestones	8,473159	24,8	Soil consisting of non-compact limestone on dry climates
Limestone, Brown soils from Xeric Regime Climates, Para - Clays, marl or similar materials	5,082171	14,9	A mixture of limestone, brown soil, and clay
Hydromorphic Soils, No Eluvial Horizon, Para-Alluvial Soils (or Para-Colluvisols), alluvial or heavy textured colluvial soils	4,617929	13,5	Heavy textured soil with good water-holding capacity.
Incipient Soils - Modern Alluvial Soils, Non-Limestone, of medium texture	4,06014	11,9	Newer, medium-textured soil derived from river deposits.
Incipient Soils - Low-lying Soils (Colluvisols, Limestone, (Limestone Para-Soils), of heavy texture	2,465186	7,2	New, heavy-textured low-lying soil with limestone content.
Litholic, Non-Humic Low Unsaturated, Normal, sandy soils with little consolidated (sandy to sandy loam texture)	1,87085	5,5	Low-humus sandy soil with limited compaction.

Table 3. Soil types, area and proportion for Hortas da Rainha propriety.

The predominant soil composition on the property contains 36.9% sand, broken down into 13.4% coarse sand and 23.5% fine sand. Clay makes up a substantial portion, 48.6%, with silt contributing 14.5%. Analysis of the property's soils indicates that organic matter makes up about 0.43%.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

Primarily, the property boasts expansive open fields (constituting about 90% of the property) where a bounty of crops flourish under the warm sun. Nestled amidst these fields, there's a 10% stretch of land where crops are sheltered within a plastic greenhouse, providing an ideal environment for specific produce.

Spanning approximately 35 hectares, the property leverages artificial irrigation methods, specifically drip and sprinkle irrigation systems, for eight months out of the year. Sourcing its water from a dedicated borehole, the property ensures that the hydration needs of its crops are met effectively. Nonetheless, a portion of the land remains free of irrigation infrastructure, serving as a roaming area for animals.

A unique feature of this property is the complete absence of insecticides and fungicides in both crop cultivation and animal rearing. Instead, the property has dedicated itself to organic fertilization, dismissing any synthetic or inorganic counterparts. It taps into green manures and crop incorporation techniques to boost soil fertility and nutrient levels, nurturing a rich, healthy soil base.

The control of pests and diseases is undertaken with a strategic, ecologically sensitive approach, leveraging ecosystem services. The property also relies on these services for microclimate regulation and the decomposition of organic waste for soil enrichment. They contribute significantly to maintaining the nutrient cycles through organic fertilization methods. The summary of how these ecosystem services are implemented on the farm is depicted in Table 4.

In a committed effort to preserve and enhance these ecosystem services, the property owners ensure they are integrated into the core management practices. These services are not just valuable for their environmental contribution, but also for the economic gains they generate, establishing a mutually beneficial relationship between the land, its caretakers, and the larger ecosystem.

ECOSYSTEM SERVICES	YES	NO	Partially	In the future
Control of pests and disease	x			
Regulation of Microclimate	x			
Decomposition of wastes	x			
Regulating nutrient cycles and crop pollination	x			

Table 4. Provision of ecosystem services at Herdade das Hortas da Rainha.

In terms of plant genetics, the property focuses on cultivating 'bio seeds' — those with a proven capacity to adapt to the local climate and enable replanting. Considering Portugal's prolonged struggle with drought conditions and sporadic extreme temperatures, there's a clear preference for drought- and heat-resistant plant varieties. While the property owners don't prioritize flood-resistant plants due to the rarity of flooding events, they do seek out varieties with robust pest and disease resistance.

From an economic perspective, the products cultivated on the property reach consumers through multiple channels. The farm's website offers home deliveries of curated baskets, while a local partner store facilitates pick-up services. All market-bound produce undergoes packaging on-site, tucked into baskets and stored in dedicated facilities on the farm.

HARVEST PROCESS

Plants: The harvesting process primarily involves manual labour. The crops are sown directly into the ground, except for potatoes, which require mechanical assistance for their harvest. A compact tractor aids in unearthing these tubers.

Animals: In terms of livestock management, sheep graze freely across the property, rotating their grazing area daily.

MECHANIZATION AND FUEL CONSUMPTION

A small tractor, primarily employed in the potato harvest, is the main machinery on the property. Its fuel consumption is moderate, requiring refueling every 20 to 30 days.

Besides traditional energy sources, the property has made significant strides towards renewable energy utilization. It has installed photovoltaic panels that power the irrigation system, reducing dependence on conventional energy sources and their associated emissions.

https://carbonostrum.eu/case-studies-4/

Case Presentation: Spain

CASE STUDY 1 - CASA PAREJA

Casa Pareja is located on the municipality of Jumilla, Region of Murcia. The size of the farm is about 350ha and has belonged for centuries to the familiy that is currently exploiting it. The main production of the farm is organic olive oil with the whole cycle carried out there, from the tree to the commercialization. However, there are also a diverse set of crops and some herding. The farm includes one modern olive mill in a restored old barn (Figure 11).

The farm is owned by seven cousins and Juan Molina is the manager. He assumed the responsibility more than 30 years ago when the former manager (his uncle) retired. Since then, it has led the exploitation in three main lines: (i) to improve the environmental management as the base for crop production of high quality and sustainability; (ii) to translate all the agricultural and industrial processes to the farm; (iii) to innovate everyday both in processes and products.

Figure 11. Aerial view of Casa Pareja farm.

The cross in Figure 11 indicates the location of the olive oil mill. Pools for storing water for irrigation are in the lower right corner of the figure. Plots with big trees correspond to olive tree plantations, plots with darker surface corresponds to areas reforested with wild olive trees, and clear surface plots with no trees corresponds to cereal and vineyards.

When Juan assumed the management the olive mill was in the centre of the nearby town of Jumilla and was an old installation not good for quality production. The mill also worked for other producers. Its location in the town was a problem for modernization but also for an integral use of the by-products in managing both the business and the land. Then, a new mill was built in a rehabilitated barn in the centre of the farm. The mill has the latest technology which lets it increase the quality of olive oil. To have further control of the quality the new mill only works for the own farm production and not for other producers.

The location of the olive mill in the farm also allows the full use of wastes from the olive milling for improving soil quality. Although the central product is high-quality organic olive oil, the exploitation aims to have a diversified set of secondary crops and products, including canned olives, soap, wine, etc., that buffers market oscillations and actively search for new market niches.

In 2023 five hectares of cereal/fallow will be transformed into a photovoltaic plant.

Workforce is a small permanent staff of 4-5 people in charge of running the farm, the mill, the administration and commercial branches. Then there are several scores of seasonal workers for harvest and other short-time activities. The most important seasonal activity is olive harvest at the end of autumn. The pool of seasonal workers is composed basically of the same people through the years, which lets better management and quality in the process, besides to be socially sustainable.

ABIOTIC CHARACTERISTICS OF THE LAND

ALTIMETRY

The mean altitude of the area where the property is situated is around 420 m, with a range 400-450 meters above sea level.

SLOPE

The area is a gentle glacis-oriented NW, with very smooth relief and no geomorphological feature except the channel of an ephemeral river (rambla) running SE to NW in one of the borders of the farm. The slope gradient is close to 2% in all the area.

CLIMATE

The climate is Mediterranean semiarid. According to Spain's Meteorological Agency (AEMET) it belongs to the transition between BSk and BSh types of the Koppen classification of world climates (Figure 12). BS are semiarid climates where precipitation is under potential evapotranspiration but not so much like in deserts. BSk subtype is colder than BSh.

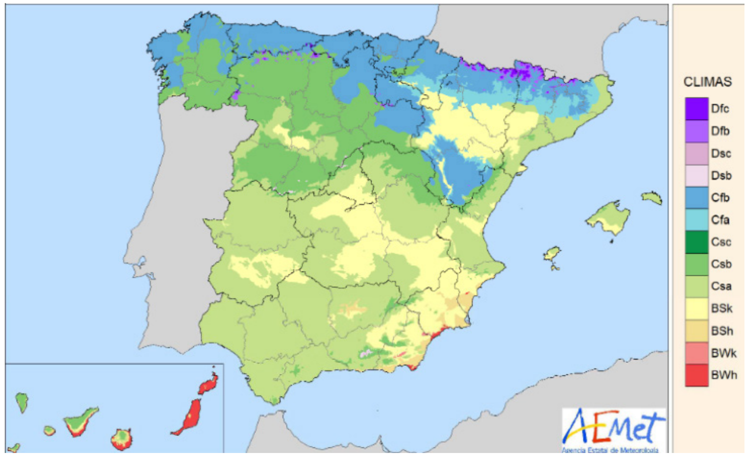

Figure 12. Koppen's climate types in Spain. Source: AEMET (2018)

The weather station of Cañada del Judío, run by the agrometeorological service of Murcia, is located 4 km WSW at 395 m, and its data can be considered fully representative of Casa Pareja. Data provided here are for the period 2000-2021.

The average annual rainfall is 267 mm, while the average potential evapotranspiration is 1269 mm. Average temperature is 16.3º, with an absolute maximum of 44.1º and an absolute minimum of -7.3º. Although coast is at 70 km the influence of the sea is little and the climate is more continental, as it can see in these extreme temperatures. Anyway, freezing conditions are scarce with an average of 58 hours per year.

The interannual variability is large, especially in precipitation as it is typical in semiarid Mediterranean climates. So, the lowest annual rainfall in the reported period was only 91.5 mm while the highest was 378 mm. Average temperature and evapotranspiration are less variable. The minimum annual average temperature was 15.3º and the maximum 17.2º, while the maximum annual evapotranspiration was 1416 mm and the minimum one 1143 mm. In this way, severe water deficit is constant, even in the years with higher than the average rainfall.

The annual cycle of temperatures, precipitation and evapotranspiration is typical of a semiarid Mediterranean climate with hot summers (Figure 13). Because it is a more continental context, the minimum absolute monthly temperature is < 0º from December to March.

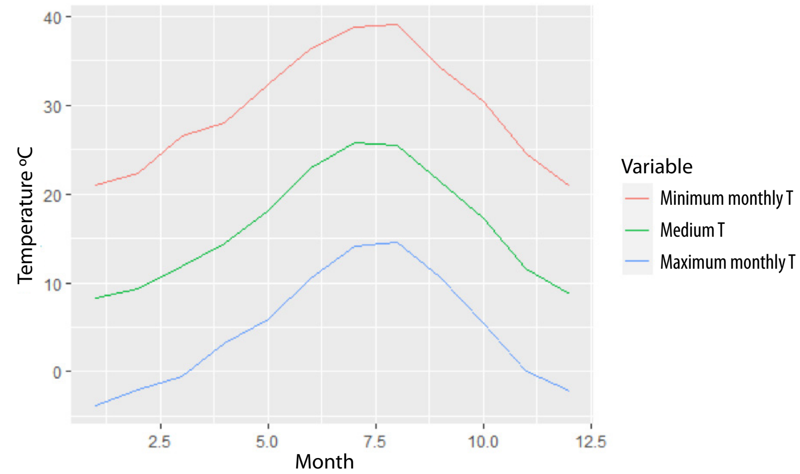

Figure 13. Annual evolution of temperatures in the area of Casa Pareja.

Rainfall shows the typical summer minimum of the Mediterranean climate, but in the rest of the year rainfall is not constant, and there are two peaks, one in autumn and one in summer (Figure 14). Potential evapotranspiration is always larger than rainfall and usually much larger.

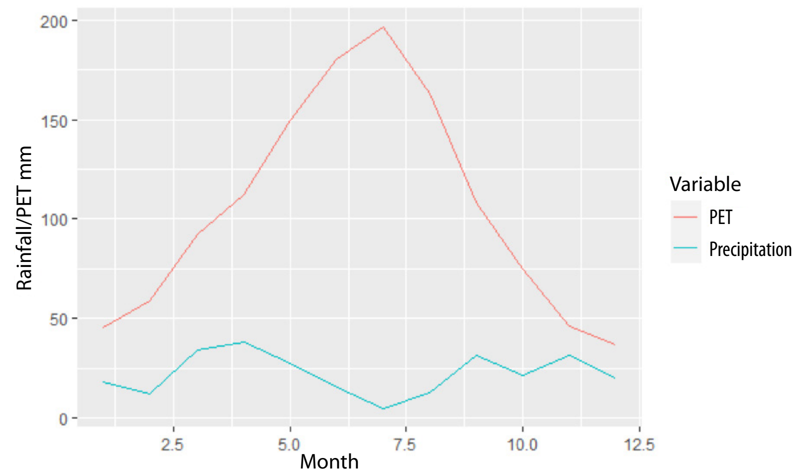

Figure 14. Annual evolution of rainfall and potential evapotranspiration in the area of Casa Pareja.

TYPE OF ROCK / SOIL COVER

As explained before, the area where Casa Pareja is located in a large glacis with colluvium of Quaternary origin. Soils are homogenous and are classified as Calcic Xerosols according to FAO classification of soils. Xerosols are typical of arid areas and they have a simple structure with a superficial ochric horizon. This is an A horizon of pale color because the low organic carbon content. Because the calcareous nature of nearby hills (where the colluvium is originated) and mountains the soils are very rich in calcium carbonate. As precipitation is very low the calcium carbonate dissolved in the surface with the rain infiltrated water migrates to deeper but close layers in the soils in such a way a petrocalic horizon is formed at less than 1.25 m depth, but usually closer to surface. This petrocalic horizon is a hard layer difficult to be penetrated by roots, hampering the development of vegetation.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

Casa Pareja farm harbours diverse crops in its 350 ha. There are 100 ha of olive trees, 50 ha of vineyard and 25 ha of almond trees. Cereal fields rotating with legumes and/or fallow (depending on autumn/winter rain) extend over 100 ha, and usually cereal occupies 40-50% of the surface per year. A part of the farm (45 ha) was reforested with wild olive trees (*acebuche*), the wild plant from which the domestic olive tree was evolved. *Acebuches* are part of the potential natural vegetation in the region. There are also minor plots for vegetable production and mulberry trees.

Olive trees and vegetable plots are irrigated by drip irrigation, water coming from groundwater of adequate quality. Groundwater is not extracted from a little private well but a large well operated by a water user association extending in part of the municipality. Drip irrigation is applied in a regime of deficit irrigation in such a way that water is not supplied to the trees in order to maximize production but in critical moments necessary to support production and quality. This reduces the water demand and crop but, smartly applied the water consumption reduction is proportionally higher than crop reduction in respect of its maximum potential, and water use efficiency is increased. The rest of the crops is not irrigated and depends completely on rainfall.

Production is organic, so no pesticides neither inorganic fertilizers are used. For dealing with pests, they use preventive treatments authorized for organic agriculture like sulfur for powdery mildew in the vineyard or copper for combating fungi in almond and stone fruit trees. However, most of the pest management is based on biological control enhancing the populations of natural enemies. In such a way the farm has established hedgerows of a diverse set of plants in mainly in the borders between plots, but also along of the channel of the ephemeral river crossing the farm. The hedgerows also have the function of physical barriers to the pesticides used in contiguous conventional farms. The farm is a member of a regional association promoting the use of multifunctional hedgerows in agriculture as a mean to enhance natural enemies, pollinator populations, control of runoff and sediment transport and favoring biodiversity and renaturalization in agricultural lands (*www.setorm.org*).

The main objective of the management is to maintain or enhance soil quality. As explained in previous paragraphs local soils are naturally poor in carbon, and traditional management with heavy plowing, burning of pruning wastes, loss of soil conservation measures only contributed to worsen the problem. To accomplish the objective local production of compost and minimum tillage is adopted. Pruning wastes are shredded on site and mixed with soils. All the wastes of the whole agro-industrial processes are reused. Most of the wastes are mixed with sheep and goat manure for producing compost that is added to soil to improve carbon content and nutrients. Sheep and goats are grown in a little exploitation within the farm, and the races are local ones. The olive stone is shredded and used for heating.

Regarding adopting Climate Smart Agriculture (CSA) techniques, four areas are to be pointed out. The most important is to enhance soil quality over time. Better soil quality means the higher capacity of water infiltration and it increases the resilience of the farm about the forecasted decrease in rainfall and increase in intensity of the rain. Improving soil infiltration capacity reduces runoff and increases the share of the rain converted into green water. In the Mediterranean most of the surface runoff is produced by infiltration excess. This means that infiltration capacity of the soil is exceeded by rainfall intensity. The soil has water storage capacity available, but it has not enough infiltration capacity, the maximum rate of infiltration is lower than rainfall intensity. Therefore, increasing infiltration capacity of the soils will be a critical aspect of CSA in the Mediterranean. Second area is the reduction of external inputs characteristic of the organic agriculture that contributes to reduce emissions of greenhouse gases. Likewise, the olive oil mill is located in the farm, which reduces all the necessity of transport of the harvest and locally produce raw material for compost, that has not to be imported. Finally, the partial reforestation of some plots as well as the establishment of hedgerows contributes to sequestering carbon in biomass and the soil.

https://carbonostrum.eu/case-studies-5/

CASE STUDY 2 - DEL BANCAL A CASA

Del Bancal a Casa (*From the plot to the home*) is an atypical but very interesting case study. The firm does not own most of the land where they grow crops, but most plots are rented. This is because of the special peculiarities of the landscape they are embedded on.

In the eastern part of Spain (Valencia and Murcia regions) in the floodplains of the rivers there are traditional irrigated lands that date back to the Middle Ages. They divert water from the rivers to a complex network of channels delivering water to each plot. Because big cities grew associated with these rich agricultural areas, today the agricultural landscape has been strongly impacted by urban and infrastructure development and today are basically suburban areas (Figure 15). Plots are typically small or very small and professional farmers are very scarce.

Figure 15. El Esparragal in the floodplain of Segura River near to Murcia city.

Figure 15 shows the intensity of the urbanization process as well as the division of lands into multiple little plots.

Most of the crops are exploited by part-time farmers who have got another main job. Despite the high quality of the soil and the water availability for irrigation many plots are abandoned as they cannot compete with professional farmers. These professional farmers and companies are today centered in the new irrigated lands created in the last 100 years, and especially in the last 40 years, in areas out these floodplains. In the Middle Ages it was only possible to divert water from rivers to the adjacent floodplain. Currently, water resources are moved hundreds of kilometers with complex infrastructure and high energy costs or are obtained from the sea by desalination.

Del Bancal a la Casa was originally founded by two partners: Alfonso Ruiz, a young agricultural engineer with no experience in organic agriculture and Paco Navarro, the son of local farmers who wanted to become a farmer. They began to cultivate a small plot owned by their families in the area of El Esparragal, 7 km NE of Murcia city, and created a business model consisting in selling directly production to the final consumer, first through WhatsApp messages and later with an elaborated webpage. They incorporated abandoned plots to the business renting them and expanded production and distribution, also incorporating products for third party producers. The production is organic and at the present they cultivate > 2 ha and employ 7-8 persons in cultivation, store, direct selling in weekly markets and distribution to homes of the clients.

ABIOTIC CHARACTERISTICS OF THE LAND

ALTIMETRY

The altitude of the area where the plots are located is 30 m asl.

SLOPE

The area is the large floodplain of the Segura River extending from the western border of Murcia municipality (60 m asl) until the mouth of river in the sea 50 km east. The average slope is close to 0.1 %, that is to say the land is completely flat.

CLIMATE

The climate is Mediterranean semiarid. According to Spain's Meteorological Agency (AEMET) it belongs to the BSh type of the Koppen (Figure 12), which is a semiarid climate with hot summers.

The weather station of Beniel, run by the agrometeorological service of Murcia, is located 6 km E and is also at 30 m asl, so its data can be considered fully representative of the plots managed by Del Bancal a Casa. Data provided here are for the period 2000-2021.

The average annual rainfall is 292 mm, while the average potential evapotranspiration is 1222 mm. Average temperature is 17.6º, with an absolute maximum of 44.3º and an absolute minimum of -4.0 º. The floodplain is open to the sea, but thermal inversion originating in the nearby reliefs is common.

The interannual variability is large, especially in precipitation as it is typical in semiarid Mediterranean climates. So, the lowest annual rainfall in the reported period was 163 mm while the highest was 523 mm. Average temperature and evapotranspiration are less variable. The minimum annual average temperature was 16.7º and the maximum 18.3º, while the maximum annual evapotranspiration was 1327 mm and the minimum one 1138 mm.

The annual evolution of temperatures is typically Mediterranean, with hot summers (Figure 16). The winter is mild and therefore very adequate for winter vegetable crops.

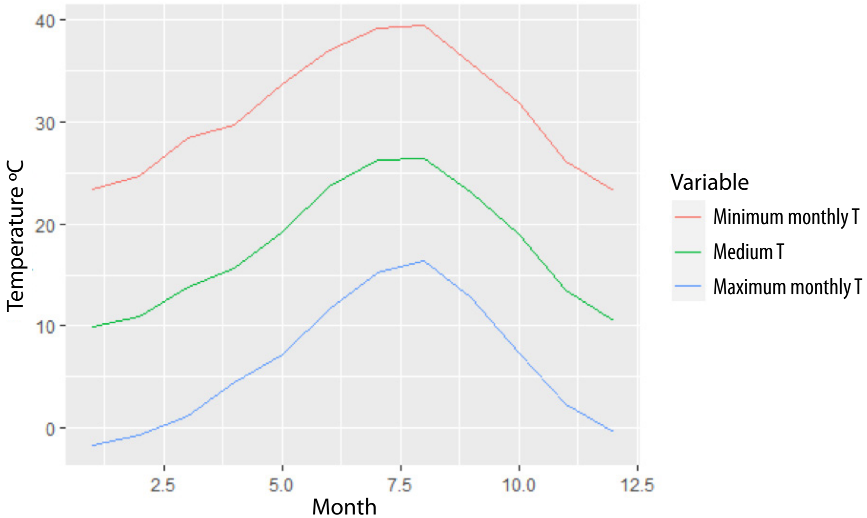

Figure 16. Annual evolution of temperatures in the area of Del Bancal a Casa.

The annual evolution of rainfall is also typically Mediterranean with high evaporative demand but minimal rainfall in summer (Figure 17). Rainfall two-peaked, in spring and autumn. Potential evapotranspiration is always larger, and usually much larger than rainfall except for December, when rainfall and potential evapotranspiration are similar.

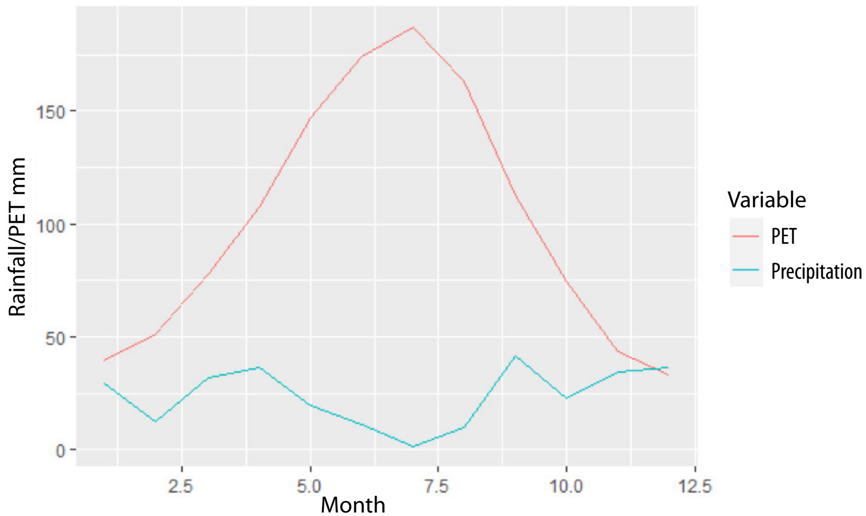

Figure 17. Annual evolution of rainfall and potential evapotranspiration in the area of Del Bancal a Casa.

TYPE OF ROCK / SOIL COVER

The alluvial floodplain is integrally filled with Quaternary sediments and the soils are calcic fluvisols typical of this kind of environment. The soils are deep and with good quality. There are no gravels or stones. The texture is mainly clay-silt. Its structure is simple with A and C horizons. Organic carbon content is higher than in other mainly agricultural soils, but not especially high and oscillates between 1 and 2 %.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

Because of the local socioeconomic structure and the business model based on renting abandoned plots, the 'farm' is not a contiguous unit but a set of scattered plots usually of only 0.1-0.2 ha. In total, the cultivated land is 2 ha. The production is mainly vegetables, and some fruit especially lemon trees. In respect of vegetables Del Bancal a Casa cultivates a large range of crops and varieties, many of them local varieties that have nearly disappeared. The objective is to supply clients with a rich variety of options.

All the crops are irrigated. The area is irrigated since the Middle Ages with a structure created by the Arabs, which is maintained today very similar to its original form. The water is diverted from the river and at the present is of good quality as in the region was implanted a massive system of wastewater treatment plants that reverted the high pollution situation found in the 1980s. In these traditional irrigated lands water is provided free to the farmers, but they have to pay for the maintenance of the system. Although the region suffers strong and recurrent droughts, in the last years the water supply to the traditionally irrigated lands did not experience special problems. The large proportion of unused land because the low profitability of the land structure and the near absence of professional farmers probably reduces the pressure on water shortages.

Del Bancal a Casa practices organic farming but also it has been especially important the work to recover abandoned plots that have been rented. Many of these plots had a lot of rubbish mainly produced by the expansion of urban areas embedded in the traditional irrigated lands. The recovery of these plots implied removing rubbish and restoring soil quality. The first steps for restoring soil quality is made by sowing cereal and legumes as green manure. Later manure is added regularly, mainly in form of pellets.

The business model was the direct distribution from the producer to the final client (from the plot to home) and this is operated through a well built and user-friendly webpage where clients can place orders. There are fixed routes designed in such a way that the metropolitan area is divided in sectors, so each sector is served once a week. The logistics for this service is owned by Del Bancal a Casa, but they can also serves the rest of the region through agreements with standard courier services. Additionally, the products are sold in three street weekly markets in the metropolitan area.

The effort in creating an internet and delivery infrastructure has been optimized by assuming the role of dealers of other local and regional organic producers as well as of other business in all Spain.

From the perspective of CSA there are three actions that can be pointed out in respect to Del Bancal a Casa. The business model directly from the plot to the final client, which is mainly local reduces the steps for commercialization and the long transport chains contributing to the reduction of greenhouse gases. The second point is the recovery of abandoned plots with degraded soils. This recovery reduces the necessity of creating new irrigated lands for supplying population with vegetables. This is important because the new transformation to intensive crops is soil destructive. Moreover, the recovery of the soils to a good health implies the improvement of its carbon status and enhancing sequestration. Thirdly, organic rafing reduces the necessity of external inputs.

https://carbonostrum.eu/case-studies-6/

Case Presentation: Italy

CASE STUDY 1 - AZIENDA AGRICOLA "TERRA MADRE"

The Terra Madre farm is located in the Molise Region (central Italy), between the towns of Fossalto and Salcito. The altitude ranges from 510 to 700 meters above sea level, in the middle of the central southern Apennines, and it is a decidedly hilly territory within the Morge Park.

The farm manager is Giuseppe Gallo, who is 40 years old, and has a degree in architecture. Giuseppe started farming in 2014 after earning a degree in architecture and deciding to bring his life and knowledge back to the region of his birth, Molise. The family's farming origins directed the decision to take over and re-launch the family's farming business by giving new impetus and a new vision to the business management, thus founding "Terra Madre," a family-owned organic farm whose name is suggestive of a return to its origins.

All the land cultivated on the farm, covering an area of about 30 hectares, is owned by the family, and the management involves, in addition to family members, a number of seasonal workers and volunteers who come to the farm seasonally to do experiential tourism, deepening the knowledge of the rural reality, as well as fostering tourism development and knowledge of the area.

From 2014 to the present, the effects of climate change have been observed to be advancing due to the gradual onset of increasingly hot and dry summer seasons. The effects of climate change have also not been slow to be felt on the side of forest fires, which in 2021 damaged part of the farm property, burning about 2 hectares of the farm's forests.

The main crops the company is dedicated to are horticultural, leguminous, forage, cereal, and forest crops.

Among the measures taken to cope with the lack of water resources were early sowings of about 60 days, with old native varieties recovered from Joseph and put back into cultivation. The results were positive, as they allowed the crops to complete the vegetative and reproductive cycle while bearing good fruit, without incurring excessive drought periods. Compared to previous years, when the harvest was almost nil, earlier sowing allowed a good share of production to be preserved.

Another measure implemented was the recovery of rainwater through the roofs of rural factories, piped into storage cisterns, which allowed emergency irrigation for the most drought-sensitive crops, such as horticulture, during periods of absent rainfall. In the absence of rainfall and consequently poor accumulation of rainwater in the cisterns, they resorted to raising water from wells managing to cope with periods of 40 to 50 days of drought. The orography of the terrain, which is mountainous-hilly and at risk of erosion and landslides, does not allow for large irrigation systems, and there are no agricultural irrigation consortia, in addition to the fact that the local climate until a few years ago never made it necessary to irrigate crops. However, for the past three years or so, it has become essential to resort to watering, albeit minimal, under conditions of water emergency.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

Existing crops are all grown in the open field for 90 percent of production, and less than 10 is carried out in the greenhouse. Irrigation use of water is limited to emergency drought irrigation.

Conduct under Organic Farming determines that there is no use of insecticides or fungicides in production, and fertilization is typically Mediterranean of organic origin, so no chemical fertilization is used.

The soil is fertilized in its entirety by burying plant residues, manuring, and from a circular economy perspective, agricultural wastes find reuse in mulches or in biofertilizer implementations.

Management from an ecosystem perspective of crop cycles, rotations and rotations, as well as the recovery of ancient native cultivars that are resistant to certain adversities, has enabled the control of pests and diseases. Table 5 below summarizes the use of ecosystem services in the property.

ECOSYSTEM SERVICES	YES	NO	Partially	In the future
Control of pests and disease	x			
Regulation of Microclimate				x
Decomposition of wastes				x
Regulating nutrient cycles and crop pollination				x

Table 5. Provision of ecosystem services at Terra Madre.

HARVEST PROCESS

The farm processing cycle is totally self-managed and ranges from the production of seed that will be put back into cultivation in the following year, to the processing and packaging of seed marketed for both food and crop purposes.

Management and mechanization, are partial because certain crops do not allow mechanization and the orography of the land does not facilitate mechanization. Fuel consumption (Diesel) per year has not been estimated.

An 11 KW photovoltaic system has been installed to provide electricity for the production and processing facilities of agricultural products for trade.

The farm under organic farming receives subsidies from community policy measures of which, however, the annual amount could not be estimated.

The family-run farm employs between 1 and 10 workers at different times of the year, depending on the production cycle, and relies on seasonal skilled labor.

https://carbonostrum.eu/case-studies-7/

CASE STUDY 2 - "MASSERIA SAN PAOLO" FARM

The proprietors are Michele Valiante, a 44-year-old agricultural entrepreneur with 20 years of experience and a degree in agriculture, and his wife Veronica, a lawyer who manages the administrative affairs of their two-family farms. Michele's agronomic background enables him not only to handle the daily operations of the farm but also to introduce innovative techniques to adapt to the effects of climate change on their business. Michele frequently attends seminars, refresher courses, and conferences to stay informed about new techniques and equipment that could be beneficial to their farm.

After earning his degree in agriculture, Michele chose to invest his knowledge and passion into the region of his birth, Molise. The family-run business employs between four to six operators, depending on the agricultural tasks at hand.

The primary focus of the farm is animal husbandry. They maintain a large in-house cattle herd, alongside smaller herds of sheep, goats, pigs, chickens, ducks, and horses. Additionally, they cultivate grains and fodder and produce small quantities of legumes and fruits and vegetables.

The farm also hosts educational programs, primarily welcoming school groups and students interested in hands-on learning experiences within nature.

Spanning over 30 hectares, the farm resides in a valley roughly 550 meters above sea level. The unique location influences the choice of crops and determines the timing of planting and harvesting.

The farm operates in a closed-loop system. The grains and fodder they produce are entirely reused within the farm, primarily for animal husbandry and seed reproduction for the following year. The manure produced by the animals is fully recycled as an organic fertilizer for the nearby productive land, minimizing transportation to distant lands to reduce fuel costs. The farm practices a seven-year crop rotation with a legume grassland for three to four years, utilizing a mixed crop system involving the intercropping of sainfoin and Sulla (Hedysarum coronarium), a legume plant extensively used as fodder. The intercropping of these plants enhances the nitrogen fixation and improves soil structure. The harvested crop is used as fodder for the animals.

The pigs on the farm are raised in free-range outdoor paddocks. A large fence has been erected within a forest, where the pigs will soon be relocated to grow more harmoniously within the natural environment, offering them more freedom and a diverse diet. The piglets are later raised for fattening at the farm center and eventually processed into cured meats and sausages sold at the farm store, ensuring a zero-kilometer supply chain.

In recent years, the farm has experienced a water shortage, leading to reduced production. However, since the farm does not practice intensive agriculture, the impact of water scarcity is lessened compared to other farms. The use of traditional cereal and legume cultivars has proven beneficial as they're less affected by climate change and rising temperatures. The farm's production has remained stable in comparison to modern cultivars that have experienced a 50 percent yield contraction. This is largely attributed to the traditional local varieties, which are more effective at optimizing soil resources, resulting in an increased availability of organic matter and nutrients.

To mitigate the impacts of climate change, the farm has adopted several measures: maintaining grassland cover, reducing plowing, and practicing mulching in the vegetable garden.

BIOTIC AND MANAGEMENT CHARACTERISTICS OF THE LAND

Existing crops are all grown in open field for 100% of production. Irrigation use is not carried out. There is no use of insecticides or fungicides in production, and fertilization is typical Mediterranean of organic origin, so chemical fertilization is not used. The soil is fertilized in its entirety by burying plant residues, manuring, and from a circular economy perspective, agricultural wastes find reuse in mulches or in biofertilizer implementations. Management from an ecosystem perspective of crop cycles, rotations and rotations, as well as the recovery of ancient native cultivars that are resistant to certain adversities, has enabled the control of pests and diseases.

Management to make use of ecosystem services partially employs measures to foster pest and disease control, regulation of microclimate and nutrient cycles as well as crop pollination. Table 6 below summarizes the use of ecosystem services in the property.

ECOSYSTEM SERVICES	YES	NO	Partially	In the future
Control of pests and disease			x	
Regulation of Microclimate			x	
Decomposition of wastes				x
Regulating nutrient cycles and crop pollination			x	

Table 6. Provision of ecosystem services at Masseria San Paolo.

HARVEST PROCESS

The harvest process combines mechanization and manual labor. The annual fuel consumption on the farm is low. Currently, there are no renewable energy production facilities providing electricity for the production and processing facilities of agricultural products for trade. However, the installation of a photovoltaic system is planned for the near future.

The family-run farm employs between 4 and 6 operators, depending on the time of year and the production cycle. Seasonal skilled labor is utilized to meet these varying demands.

ABIOTIC CHARACTERISTICS OF THE LAND OF BOTH CASE STUDIES

ALTIMETRY

Terra Madre's cultivated lands are located in an altitude range between 510 meters above sea level and 700 meters above sea level. Given the small farm size, which amounts to only 30 ha of cultivated land, Terra Madre does not have land mapping by composition, aggregation, and orography. The lands cultivated by Masseria San Paolo are located in an altitude range between 500 meters above sea level and 700 meters. Given the small size of the farm, which amounts to only 30 ha of cultivated land, the farm does not have a map of the land by composition, aggregation and orography.

SLOPE

Although the Terra Madre farm's land is family-owned, it is relatively fragmented and straddles two municipalities on the hilly part of the south-central Italian Apennines. Ninety percent of them have a slope greater than 10 percent, making them incomplete for mechanization for the agricultural practices to be carried out. Masseria San Paolo farm's land is in a valley in the central southern Italian Apennines. About 50% of the cultivated land is basically flat, while the other 50% is sloping. Activities and work are carried out in a mixed manner between manual and mechanized operations, except for cereals for which crop operations are totally mechanized.

CLIMATE

In Salcito and Jelsi, summers are short, warm, dry, and mostly clear, while winters are long, very cold, and partly cloudy. During the year, the temperature generally ranges from 2 °C to 29 °C and is rarely below -2 °C or above 33 °C. The hot season lasts about 3 months, from mid-June to mid-September, with a daily maximum temperature above 24 °C. The hottest month in this territory is July, with an average maximum temperature of 28 °C and minimum of 18 °C. The cool season lasts about 4 months, from mid-November to mid-March, with an average daily maximum temperature of less than 12 °C. The coldest month of the year in Salcito and Jelsi is January, with an average maximum temperature of 2 °C and minimum temperature of 8 °C (Figure 18).

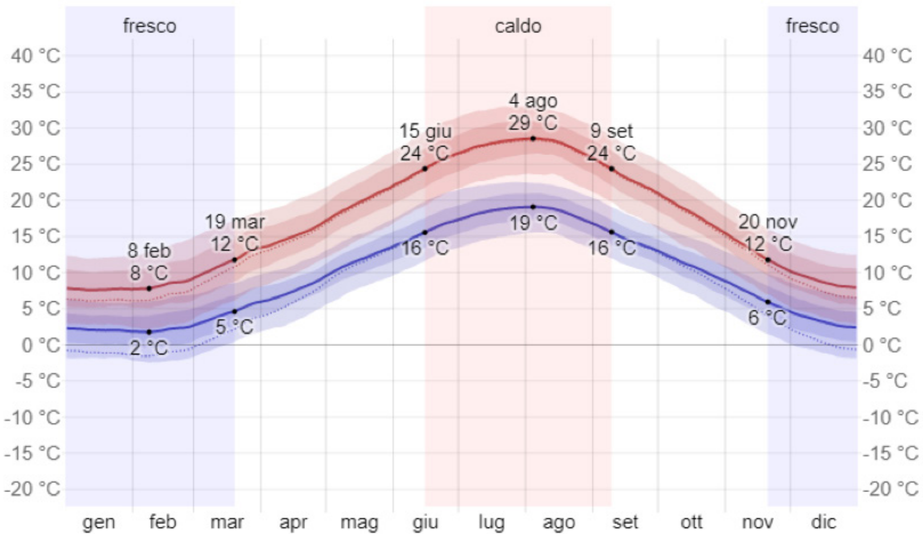

Figure 18. Annual temperature in Salcito and Jelsi.

In Salcito and Jelsi, the average percentage of cloudy skies is accompanied by moderate seasonal variations throughout the year. The clearest time of year in Salcito and Jelsi begins in June and lasts approximately 3 months. The sunniest month in this area turns out to be July, with mostly sunny or partly cloudy conditions in 87 percent of the period. The clearest phase of the year begins around mid-September, lasting about 9 months. The cloudiest month turns out to be January, with mostly cloudy conditions in 50% of the period (Figure 19).

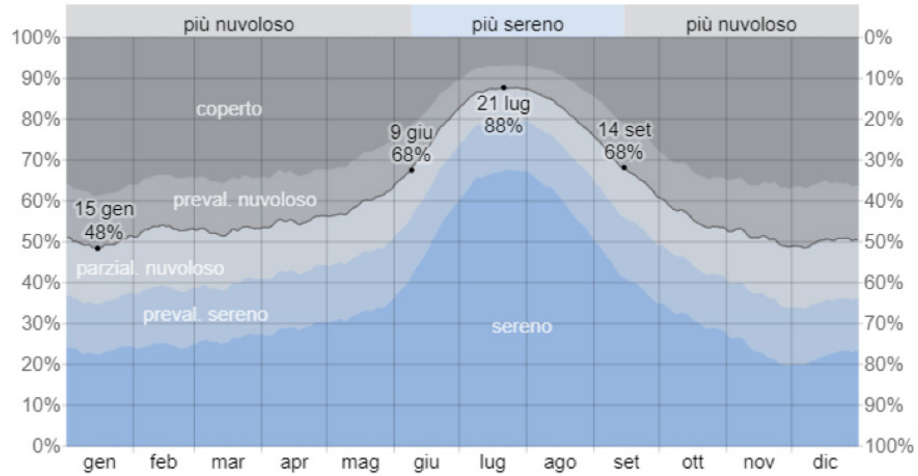

Figure 19. Annual sunshine in Salcito and Jelsi.

It's considered a "wet" a day if there is at least 1 millimetre of liquid precipitation or water equivalent. The chance of rainy days in Salcito and Jelsi varies throughout the year. The wettest season lasts 7.5 months, between September and April, with a probability of more than 22 percent that a given day will be rainy. The month with the most rainy days turns out to be November, with an average of 9.3 days of at least 1 millimeter of precipitation. The driest season lasts 4.5 months, between April and September. The month with the fewest rainy days in this territory is July, with an average of 3.8 days of at least 1 millimeter of precipitation (Figure 20).

To show the variations over the months and not just the monthly total, we show the accumulated rainfall over a 31-day moving period centered on each day. Rain falls throughout the year. The month with the highest amount of rain is November, with an average rainfall of 69 millimeters. The month with the least amount of rain is July, with an average rainfall of 20 millimeters.

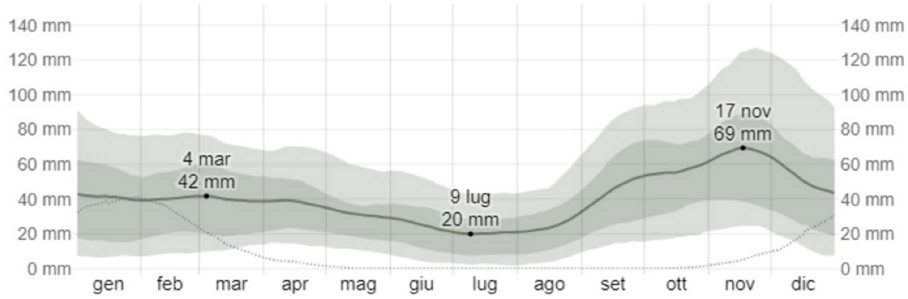

Figure 20. Annual precipitation in Salcito and Jelsi.

The area between Salcito and Jelsi, sees some seasonal variations in monthly snowfall. The snowy period during the year lasts about two months, between December and February, with at least 25 millimeters. The month with the most snowfall is January, with an average snowfall of 38 millimeters. The period of the year without snow lasts about 10 months, between February and December.

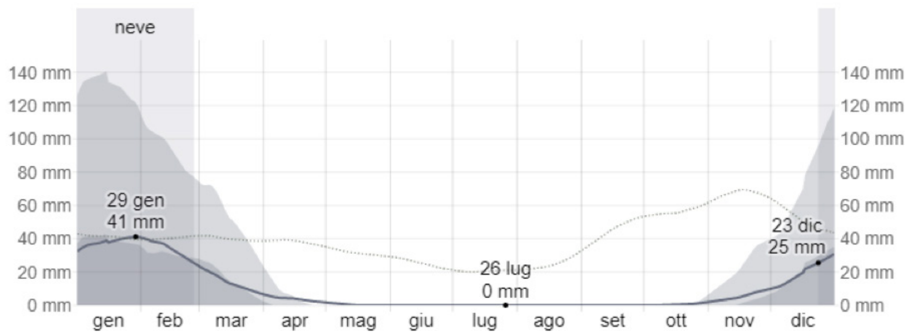

Figure 21. Annual snowfall in Salcito and Jelsi.

** climate data reported are not punctual, as no meteorological stations were installed in the reference area, they are rather interpolated from 4 neighboring meteorological stations.*

***MERRA-2 Modern-Era Retrospective Analysis della NASA. Land use data were obtained from the Global Land Cover SHARE database, published by the Food and Agriculture Organization of the United Nations (FAO). Elevation data extracted from the Shuttle Radar Topography Mission (SRTM), published by NASA's Jet Propulsion Laboratory. Maps are contributed ©OpenStreetMap.*

TYPE OF ROCK / SOIL COVER

The area in which the farms under study are located can be placed, according to the standards of the Manual of Procedures vers. 1.0 of the European Soil Boureau, in Soil Regions 61.1 (Cambisol-Regosol Region, with Luvisols and Vertisols of East of Italy). Specifically, in the territory of Molise, the areas most susceptible to erosion are those located in the central portion of the soil region of the upper and middle hills (61.1 in Figure 22), specifically those colored red in Figure 23 and, to a lesser extent, those colored orange.

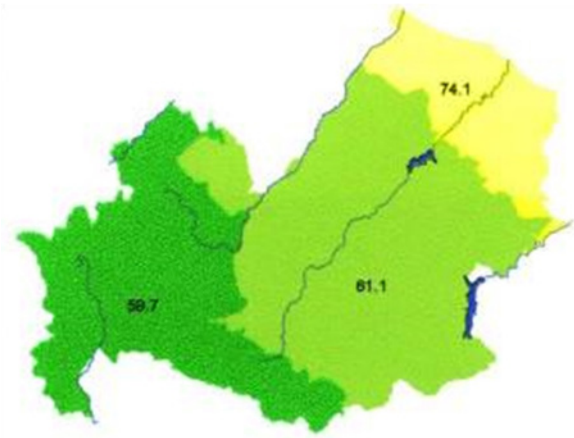

Figure 22. Soil map of Molise Region.

The areas colored red are those with high relief power and high drainage density on clay lithotypes. They consist of shallow fine-textured soils with A - Cr profile that belong to the Typic Ustorthent subgroup (according to Soil Taxonomy classification). Slightly deeper soils (subgroup of Vertic Haplustepts) are usually found in subplanar and convex summits of tectonic nature. In the orange-colored areas,given the variability and considerable extent (about 94,000 hectares), the relationships between soils and landscapes are changeable and different are the different soil types. For example, in the presence of limestone relief or very steep slopes or with shelves on lithoid materials, lithic subgroups (Lithic Haplustoll and Lithic Ustorthent) dominate. Vertic subgroups (Vertic Haplustept, Vertic Calciustept and Vertic Ustorthent) are found on complex slopes and colluvial areas. (*Data: ARSARP MOLISE - Regional Agency for Agricultural, Rural and Fisheries Development*).

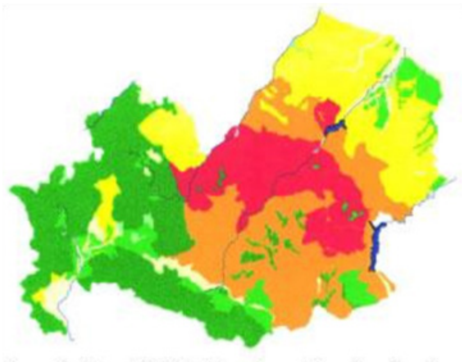

Figure 23. Areas most susceptible to erosion in the territory of Molise Region.

Due to the limited size of both farms, the analytical measurements were never made to the texture and compositions of the soils, which do, however, present themselves to the observer as highly varied and uneven, with a mixed composition, even within the same plot, where areas of loose sandy composition can be found a few meters away from more tenacious and compact areas of predominantly clay compositions.

https://carbonostrum.eu/case-studies-8/

Case Presentation: Greece

CASE STUDY 1 - AGIA PARASKEVI, ATHENA KONSTANTINIDOU (LAHANOKIPOS)

Athena Konstantinidou, a young (34 years old) female is a local vegetable farmer in the region of Agia Paraskevi, Thessaloniki (23°06'E, 40°49'N) (Figure 24). She has been an Agronomist since 2011 and holds a BSc from the School of Agriculture, Aristotle University of Thessaloniki, Greece. As a young person she has good knowledge of English and computer use. She has not attended training programs but is willing to participate in training programs on environmentally friendly farming methods.

Figure 24. Aereal view of Lahanokipos.

Athena stated that she is aware of environmentally friendly practices. They incorporate techniques such as the use of compost (5-10% of the total fertilization), rotation of vegetables in the same field, sowing wheat to reduce weeds and diseases. They also use some formulations approved for organic farming, and they participate in a denitrification program. They perform soil analyses, and apply the necessary amounts of N-rich fertilizer to reduce run-off to groundwater. However, they do not apply other environmentally friendly practices due to the increased cost but also due to their reduced income, since the formulations need to be tested for such large cultivation lands. In general, she thinks that "environmentally friendly practices should be implemented because soil is neither a renewable resource nor infinite and we need to protect it so that it can provide for us in the future".

Athena works in her family business which was established by her grandfather in 1987, at Agia Paraskevi, Thessaloniki. The business is located in the area where the family originates and lives. There are private fields and also rented fields. Athena has been working professionally for the past ten years, since she entered the School of Agriculture. The family works in this business, as well as a seasonal staff of five people occupied with the harvests. The family business is characterized by friendly atmosphere. Even though there is clear hierarchy and everyone has their own responsibilities, there is trust and understanding among the people involved.

This business produces about ten vegetable products; spinach (60% of the total production), endive, lettuce, broccoli, cabbage, cauliflower, beetroot. They also produce wheat for crop rotation. For the past six years they have been marketing their own products. Every December the family members plan the following year's crop species and quantities to be grown. They take into account a 3-year evaluation of previous years, based on market demand. In 10 years, Athena imagines that the business will be smaller in land area in order to be more manageable. This can be achieved by the inclusion of greenhouse crops and hydroponics.

ABIOTIC CHARACTERISTICS AND MANAGEMENT OF THE LAND

The land consists of 30 ha of vegetables. The soil is variable, typically consisting of about 52% sand, 31.3% silt, and 16.7% clay. pH is high; 8.1 units, while organic matter is almost absent; only 1%. Electric conductivity is quite high at about 4.45 mS/cm. The business uses mainly (90%) inorganic fertilization and secondarily (10%) organic fertilization. The latter is mainly achieved through incorporation of crop residues. The land is inclined with gentle slopes ranging from 3 to 5%.

The business also exploits a 200 m^2 greenhouse for the production of seedlings. The greenhouse is not equipped with heating and cooling systems. They use varieties tolerant to drought, flooding, insects and diseases, and extreme temperatures.

Sprinkler irrigation is conducted all year round, with water being available through two drillings. Harvesting is done by hand, except for spinach which is harvested mechanically. Sowing and planting are also done mechanically, leading to increased use of diesel fuels. No renewable energy sources and no water collection are employed by the business. The absence of packaging and storage space means that all the production must rapidly be marketed in order to limit the losses.

The climate in the area is dry and thermal, rainy in spring, hot in summer (Figure 25). Quality problems arise due to pathological causes enhanced by extreme events. The business selects varieties resistant to extreme conditions to cope with the effects of climate change. As Athena quotes "in the past three-four years, the seasons have shifted back one month. Spring and summer were extended, with summer lasting from April to September". The varieties are selected according to sowing season and drought resistance. The use experimental plots in order to select the optimum varieties. The business applies the integrated crop management principles.

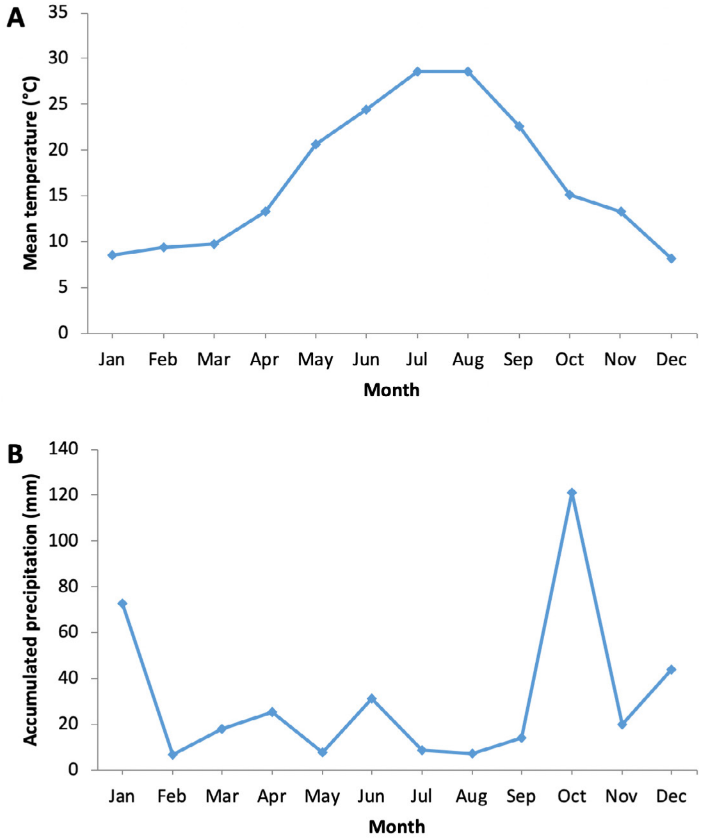

Figure 25. (A) Mean temperature and (B) accumulated precipitation in the region of Agia Paraskevi in 2021.

https://carbonostrum.eu/case-studies-9/

CASE STUDY 2 - SAPES, NIKOLAOS KAPOULAS

Nikolaos Kapoulas, 55 years old, is an organic vegetable farmer in the region of Sapes, Komotini (25°70'E, 41°02'N) (Figure 26). He is an Agronomist with knowledge of crops growing under cover (i.e. greenhouse with heating-cooling systems). Nikolaos holds a PhD in Agriculture, University of Novi Sad, Serbia. He is a fluent English speaker and a computer and internet user.

Figure 26. Aereal view of Sapes.

Nikolaos stated that he is aware of environmentally friendly practices. He stated that environmentally friendly practices are necessary to maintain sustainability. He quoted that "farmers should apply environmentally friendly practices because they have no right to destroy the environment. Also, farmers should avoid unnecessary use of pesticides, while they should do soil and foliar analysis to intervene with it when needed".

However, he believes that the cost to implement them is very high. They require high capital investments and are better fitted for large facilities, while they must be supported by the government. He believes that such methods are not implemented due to their high cost. For example, there are difficulties in storing solar energy and heating water to increase the temperature in the greenhouse. This would also lead to lower costs in the market.

He has not attended a training program on environmentally friendly practices, but he does a lot of personal research to improve his crops. Moreover, he is involved as an agricultural advisor in training young agronomists on climate change. He would definitely like to participate in a training program on environmentally friendly farming methods. Especially if it helps to reduce production costs so that the price of the products is more affordable for the consumer.

Nikolaos works in his family business, mainly along with his brother, with the help of up to 8 family members, in the region of Sapes, Komotini, Greece. He is an organic farmer inclined towards cultivation since he was young. He quotes "I liked the land, the vegetation, the nature. The land gives me life". His family home is within the organic farm premises. He believes that in the next ten years small farmers should have direct access to the market to sell their products directly to the consumers otherwise, they will not be able to survive.

The business produces spring vegetables under cover (in low-tech greenhouses); tomato, eggplant, eggplant flasks, bell pepper, bell pepper, as well as winter vegetables such as lettuce, spinach, and rarely cabbage due to the relatively small area of cultivation. He believes that application of crop rotation is necessary to increase profit depending on the season and market demand. Certification of the greenhouse for organic production was conducted by private bodies approved by the Ministry of Agriculture, under Regulation (EC) No 834/2007 and the Regulation No 889/2008.The height of plastic tunnels was 3.5m, they were covered by EVA film- Kritifil 180 m, a 3-layer, long life, thermic plastic (Plastika Kritis, Heraklion, Crete, Greece). The plastic was characterized by the following optical properties: total light transmission 89%, diffusion 45% and infrared transmission <17%.

ABIOTIC CHARACTERISTICS AND MANAGEMENT OF THE LAND

The composition of soil is 13.52% organic matter, 8% clay, 20% silt and 72% sand. $CaCO_3$ content is 4.1%, pH is 7.03 and EC is 7.43 mS/cm. Soil's content in nutrients is as follows: N (total) 266 ppm, P (Olsen) 311 ppm, H3COONH4 - exchangeable K 1156 ppm, Mg 1890 ppm and Ca>2.000 ppm were determined according to Sparks et al. (1996), Fe 17.76 ppm, available Zn 13.16 ppm, Mn 4.61 ppm and Cu 0.43 ppm extracted with DTPA (Lindsay and Norvell 1978) and B 18.20 ppm extracted with hot water (Keren 1996).

Nikolaos decided to go organic since natural production yields products of higher quality without the input of chemicals. His decision was supported by personal research without interfering with the environment; a many-year effort. He quotes that "with organic farming, the soil is alive, there are no residues to spoil the soil".

The cultivation area is poor in terms of soil quality. Interventions were made for soil improvement such as manure incorporation. The region has high potential as the winter conditions are not harsh. The land consists of 500 m^2 of vegetables. Drip irrigation is employed using water by the national grid which has medium hardness, is rather clean and do not cause additional problems. Nikolaos cultivates specific varieties demanded by the local market. He utilizes crop residues for fertilization, as well as bombus for successful and enhanced pollination. Also, fertilization in the context of organic farming is digested manure from his own very small livestock unit which consists of goats, so the soil is constantly enriched. Typically 4.17 t/ha goat manure is used with 1.92% N; 1.14% P2O5; 2.05% K2O on a fresh weight basis as basal fertilization. There are no nutrient and trace element deficiencies, the plants are robust.

The greenhouse microclimate is regulated, while the pests and diseases are controlled biologically. Nikolaos only applies formulations approved for organic farming. The absence of packaging and storage space means that all the production must rapidly be marketed in order to limit the losses. Harvesting is done by hand. The soil is tilled with a gasoline-powered tiller. No renewable energy sources are exploited. His income from the small business is about 3000 €, while the expenses are about 1500 € without considering his personal labour. His main income comes from different sources outside of the agricultural sector.

Nikolaos states that exceptional weather events occur in his area such as sudden weather changes, high rainfall, and heat waves. Temperature extremes can be down to -11 °C and up to 42 °C (Figure 27). Weather conditions and phenomena are recorded by a private meteorological station. These fluctuations and extreme temperatures have an impact on plants including reduced production. During extreme conditions, cooling is used in the greenhouse to balance plant growth.

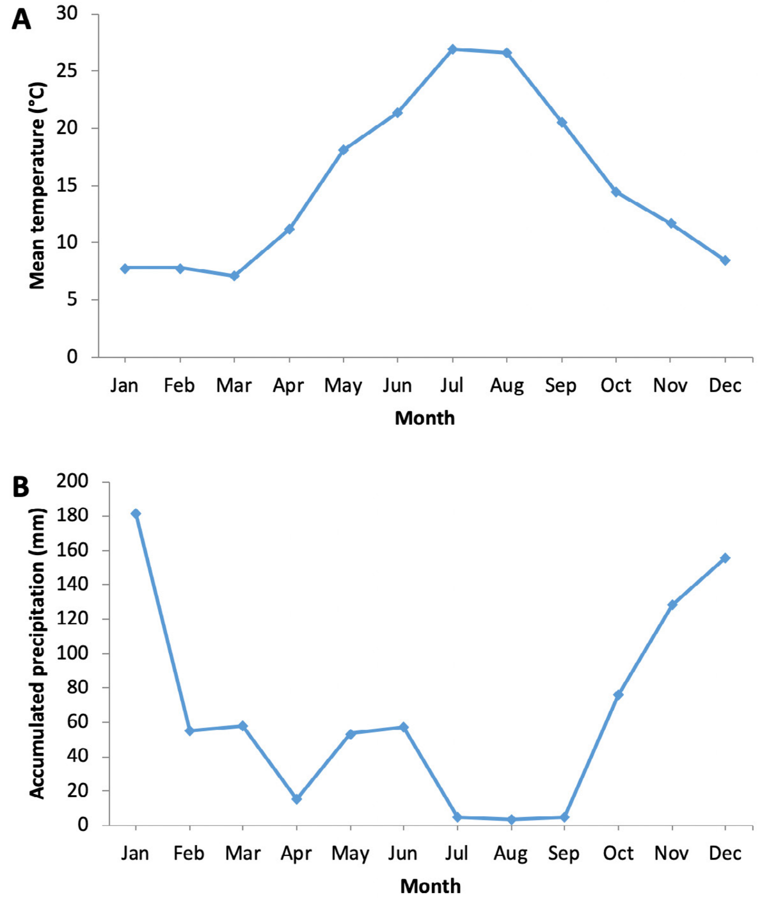

Figure 27. (A) Mean temperature and (B) accumulated precipitation in the region of Sapes in 2021.

https://carbonostrum.eu/case-studies-10/
https://carbonostrum.eu/case-studies-11/

Case Presentation: Turkiye

CASE STUDIES 1 AND 2 - MR. MÜFIT ÇAĞLAYAN AND CEVİZBAĞI FARM

The partner Maylog Nakliyat has chosen two farmers from the same region to observe the differences and advantages of practices used in the same type of soil character. Mr. Müfit ÇAĞLAYAN is a farmer who uses modern methods to recycle manure in biogas form. He runs the business with family members and gets support from the paid workforce, with 300 people working on the farm. His main concern is the effectiveness of production through the methods he has practiced. He wants to establish a sustainable ecosystem with Eco-friendly energy. They have established facilities for this. Most importantly, their facility complies with the VCS standard 'Verified carbon standard'. They wanted to make it real by establishing an agricultural ecosystem project to benefit the country and the world. Corn, barley, wheat, and sunflower seed, which are grown in our region, are processed to degrease, and later, they send sunflower grains to a flour factory; they combine it with bran that they have processed from the factory. They feed our animals with it. The food they produce for the animals is produced in the factory from their waste materials from the cultivated grains. Energy production and fermented fertilizer production are their two basic activities. They use manure to enrich the soil and increase the amount of organic matter. Using manure, let us dispose of that carbon as ch4 in methane gas. Because our soil is poor, poor in terms of organic matter. They can feed these lands again with the fertilizer from the Biogas facility. The amount of organic matter in the soil drops a lot. The farm enriches the soil from that Biogas production.

The second case Mr. Özcan KULAKSIZ the owner of the CEVİZBAĞI Farm, presented us with his methods regarding the eco-friendly implementations in his farm. as one of the leading farmers of the region to use and implement modern techniques. He is retired, but when working in a public institution, he established the Farm in Yelek village of KAMAN District as a family business with his late father. He planted all the fruit trees he could produce in the region, next to walnuts, on the farm, and they got good results. The farm has 160 acres of walnuts. They inarched by detecting some foreign and domestic varieties that were productive. Currently, there are 3000 trees on the farm. Within the scope of organic agriculture, the Ministry of Agriculture has an organic agriculture regulation, and people have to act within the framework of the regulation. The regulations help farmers support non-toxic agriculture among the people; they don't use pesticides or chemical fertilizers anymore. The people who deal with cattle in the villages around bring the manure of the cattle spread in the pasture, and farmers use them. The soil is sandy and loamy, inferior in organic material, and high in PH ratio. The soil needs a lot of water; dry summer lasts longer now, and spring is drier. Mr. Kulaksız mentioned afforestation should be done on the land and around it, especially in the pasture areas of the villages of Anatolia; forestation is very important. He added the biggest factor is chemical fertilizers that pollute the waters. He suggested that agriculture education should be given at the primary school level. Children should be made aware of environmental issues.

The general idea is mainly based on the framework for supportive farming. The cultivation of the crops and animal breeding must be mutually run by the Farmers so that there may be an ongoing production and consumption cycle among the different sections of the farm.

Both farms facilitate the services by using dairy products to fertilize the land. The economic aspect of the farm covers the sales of milk and crops produced each year.

The agricultural methods applied; In addition to reducing emissions in terms of input and application, it is also essential to increase the soil's biological cycles and productivity and create more effective organic matter forms in carbon production. In addition, the integration of animal husbandry and plant production, the use of traditional local knowledge, and the use of natural vegetation that increases the effectiveness of soil microorganisms that provide carbon stabilization are also essential in slowing climatic change.

People in this region earn their living from agriculture and animal breeding. While some still follow traditional methods, some farmers have turned to technological ones. Families generally run businesses. There are also workers. The number of workers varies according to the enterprise's seasons and scale. Farm weed control is done by hand in organic agriculture. Not using pesticides and chemical fertilizers saves energy. In addition, using fossil fuels in the agricultural industry, which is disadvantageous in polluting the environment, raises the importance of using environmentally friendly energy from vegetable oils.

Farmers usually buy grains and seeds from certified dealers. Those certified products are generally from the "Agricultural Enterprises General Directorate - TIGEM". They sell to the Grain Board and Traders Union, supported by the state, and are assisted by TIGEM dealers for seed supply and use social media to contact dealers. They call it by communicating with different stakeholders. For example, barley, chickpeas, beans, and lentil seeds are supplied through the seeds they planted in previous years or farmers buy from dealers and traders.

In this region, farmers grow products by considering the market's needs and expectations. They also produce what they need in their farms and husbandries.

Smashed corn, clover, corn grain, and barley are grown and used for feeding. People in the husbandry business produce meat and milk.

Farmers use solar panels for energy in their farms. Manufacturers are pleased with the widespread use of solar energy because it reduces costs. Global warming affects the whole country and, of course, farmers as well. Especially products such as barley and wheat are affected. In the entire cultivation cycle, compared to the past, there are delays of about one month between the times they planted before. Frost risk has also risen. However, producers try to apply measures to ease the side effects. Maintaining Water endangers the life and health of all living things, especially humans, indirectly through the contamination of underground and surface water resources by agricultural pesticides and other chemicals used and directly by mixing with drinking water. Farmers are trying to increase efficiency with the Water they get from wells. They apply methods to be affected at the lowest degree by climate change. They apply them in vineyards, gardens, and fields. They try to use the underground Water through pools on the ground. Our farming methods keep the organic carbon in the soil as a hummus. Giving importance to local products and growing products adapted to the region also reduces the use of inputs to a minimum. It is also crucial in climate change that the markets where our products are sold are local and that the product is offered to the market over short distances.

Waste from animal manure is stored in wells to be used again as fertilizer on the farm. Artificial fertilizers and pesticides are used at the lowest level. Thus, farmers minimize the use of chemical fertilizers. Protective tillage, minimum tillage, cover crops, natural mulching applications, recycling-based compost, mulch compost, vermicompost, green manuring, and similar applications are used, and the natural defense mechanisms of plants are strengthened. Besides, Disease and pest control are carried out with biological control and many applications. Instead of herbicides, weed management comes to the fore.

The use of fossil fuels is minimal, the carbon footprint is deficient during agricultural activities, and biological wealth is significant in production. In addition, the aim is to enrich biodiversity. Living things considered harmful in terms of conventional agriculture are not dangerous to us in agriculture. They are part of that ecosystem. Natural biological cycles are active, and these cycles are used as methods. For example, no weed needs to be destroyed, there is wild vegetation, and the herbicide does not kill natural vegetation. It is used. Like in other agricultural systems, many destructive or repellent measures are taken for wild animals, while we are pleased that wild animals consume the product.

The Ministry of Agriculture, TIGEM, and dealers provide certified products and support producers with their experienced staff during cultivation. The government gives support in the cultivation and sale of our wheat procedures. It provides fuel and fertilizer support. Farmers also get support for chickpeas, legumes, and other products. In addition, farmers also receive technical support from government officials.

In the use of pesticides, they receive a lot of support to get the most out of high efficiency. Producers are in constant communication with the authorities. Before planting, they communicate with the support staff during planting, especially during seasonal changes such as early spring. Due to pre-planned meetings, engineers cooperatively decide the methods to be developed during the production period at Provincial and District Directorates.

During the pesticide period, what chemical to take, what to use, and how to use topics are decided mutually with district agriculture officials and dealers. They contact, learn and produce after getting soil analyzed and plant products according to the analysis results. Communication with the experts is never skipped, even after the cultivation.

Local people in this area indicate that young farmers have decreased significantly. They also state that when they direct young farmers to these jobs, they do it with pleasure and contribute to production. There were even some young farmers who started beekeeping.

Furthermore, young farmers are supported by the state. The aim is for fertile lands to fill in, and production to continue. For this reason, they receive sufficient minimum support from the state. In addition to the license, state institutions organize training in villages. There is training in which you can practice in many fields. Some activities include using tractors, hoes, beet harvesting, etc.

ABIOTIC CHARACTERISTICS OF THE LAND

ALTIMETRY

The average altitude of the area where both properties are situated, is around 1200 meters above sea level, with a population of 15000 people (Figure 28).

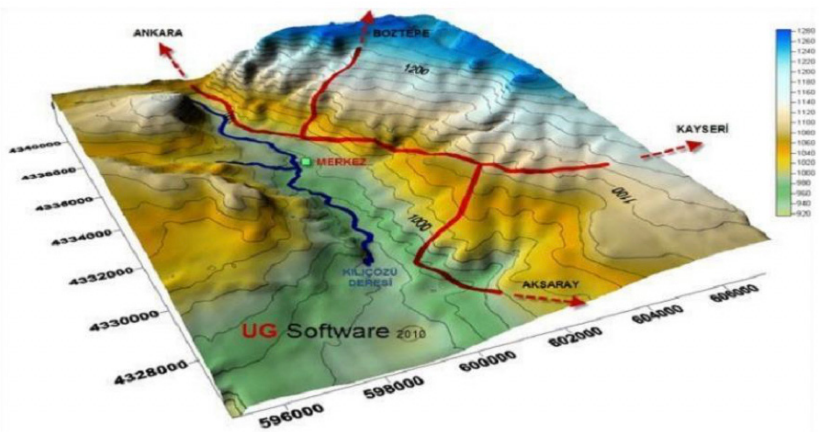

Figure 28. Kırşehir's altitude map.

SLOPE

In Kırşehir (Figure 29), which is located in an arid and tectonic region, soil properties vary depending on climate and main material. The main soil groups and their characteristics in the province can be listed as follows (Table 7).

Figure 29. Map of the Kırşehir Region in Turkiye.

A large part of the Kırşehir province area is covered with brown soils. Brown soils on unconsolidated limestones are common soil types in the arid Central Anatolian belt.

The plateaus in the northwest and south of Çiçekdağı, southwest of Kaman, and south of the Central district are covered with red-brown soils. Brown forest soils are generally seen in parts of Çiçekdağı exceeding 1000 m. These are mature soils rich in organic matter. Forests are seen in places on these lands. Erosion is severe in areas where forest cover is thinned. In the southern part of the mountain, the elevations under the forest soils are covered with chestnut-colored soils. A part of the area between Bayındır-Boyacık towns in the west of Çiçekdağı district and south of Kaman is covered with non-calcareous brown soils. Such soils are suitable for dry farming.

LAND USE	PARAMETERS	
	AREA (ha)	RATIO (%)
Cultural Land Existence	454720	69.14
Field Crops Planting Area	426767	64.89
Vineyard Area	10260	1,56
Orchard Area	3815	0.58
Vegetable Planting Area	4736	0.72
Poplar tree covered Area	6182	0.94
Agricultural Unused Land	2960	0.45
Meadow Pasture Area	132450	20.16
Forest and Plantation Area	25063	3,74
Non-Agricultural Area	45446	6,76

Table 7. Land use capability subclasses areal quantities.

The north, west, and south of Seyfe lake and Kırşehir Kılıçözü and Delice river valleys are covered with alluvial soils. These soils are dark-colored soils brought by rivers from the environment and rich in organic matter. In addition, there are colluvial soils in transition with alluvial soils on the valley floors. These soils are suitable for growing all kinds of plants.

Apart from these main soil groups in Kırşehir, bare rocks in the high parts of the Baran Mountain fill the area between the Central District and Kaman and barren soils around the Seyfe Lake due to salinity. Such lands have no agricultural value.

When evaluated as a whole, the land assets of the province area are as follows:

The total of cultivated and planted areas is 68.2%. 40% is field crops cultivation area, 25.3% is fallow land, 2.6% is vineyards and gardens, and 0.3% is unused land suitable for agriculture. Meadow and pasture areas in the province are 19.9%, forest area is 3.7%, and the area not suitable for agriculture is 8.2%.

When viewing spatial distribution amounts of land use capability subclasses of Kırşehir province, 62.80% of the total area is damaged by soil insufficiency, slope, and erosion. The area exposed to slope and erosion damage and soil insufficiency was calculated as 109307.14 hectares. Slope and erosion damage throughout the province is determined that occur in areas corresponding to 7.64% of the area. The soil where flood damage corresponds to 1.33% of the total area in the province.

Considering the entire province of Kırşehir, Cultural Land Existence 69.14%, Field Crops Planting Area 64.89%, Vineyard Area 1,56%, Orchard Area 0.58%, Vegetable Planting Area 0.72%, Agricultural Unused Land 0.45% and Non-Agricultural Area 6,76%.

CLIMATE

Kırşehir has a continental climate with cold and snowy winters and hot and dry summers. According to Thorntwait's climate classification, Kırşehir has a semi-arid climate. The annual average temperature in the province is 11.3 °C, and the annual precipitation is less than 400 mm (Figure 30).

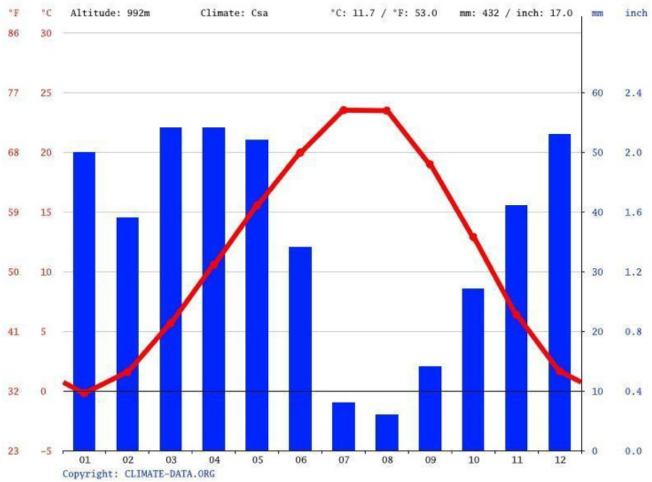

Figure 30. Kırşehir Climate.

Temperature: The annual average temperature difference between the mountainous and plain areas in the province is not much. The temperature difference between the districts is around 1 °C. While the annual average temperature is 11.3 °C in the central district, it is 10.9 °C in Kaman and 12.2 °C in Çiçekdağı. The temperature difference between Kırşehir and the surrounding provinces is still around 1 °C. 11.7 °C in Ankara, 10.9 °C in Nevşehir, 9.0 °C in Yozgat. Depending on the climate in Kırşehir, there is a significant difference between day and night temperature values.

During the 66-year observation period in Kırşehir, In August 1954, the highest temperature was 39.4 °C, and in January 1942, the lowest temperature was -28.0 °C. Precipitation: The annual precipitation average in Kırşehir is 350-400 mm. varies between According to 62 yearly data in the central district, the annual rainfall is 378.1 mm. Annual precipitation is 455 mm in Kaman and 322 mm in Çiçekdağı District. The annual precipitation amounts of the provincial centers adjacent to Kırşehir; 377.7 mm in Ankara, 388 mm in Nevşehir, and 539 mm in Yozgat appears to be.

TYPE OF ROCK / SOIL COVER

Kırşehir, which is within the steppe belt of the Central Anatolia Region, is generally devoid of forest cover, and the dominant natural vegetation is steppe. The region, which was covered with forests in ancient times, lost its forest cover due to negative human effects and irregularity of the precipitation regime. While the forest area covers 2% of the total surface area of the province, this rate has increased to 3.7% due to recent studies. Due to its terrestrial climate characteristics, the province, which cannot achieve natural cover by itself, will only be able to reach forest areas through tree planting and maintenance. There are forests consisting of oak, black pine, and cedar trees in the northern parts of Çiçekdağı and around the town of Akçakent. These forests are degraded groves and coppices. There are also bushes in places within the borders of the province.

Overgrazing in the province and converting natural pastures to fields over time has decreased herbaceous species such as alpha grass and tufted meadows and increased shepherd's cushion and moth species. Poplars and orchards in the river valleys divide the province area from various directions. On the plateaus, there is no vegetation other than annual meadow grasses.

In recent years, the degraded forests in the province have been taken into care, transformed into groves, and forests have been created around the settlement areas. For this purpose, the Nursery Chief, established in 1965, was transformed into the Forest Nursery Directorate in 1967, started to meet the sapling needs of the province, and continues its activities today. Since 1966, the Nursery Directorate has produced approximately 46 million saplings and met the province's needs with a part of it. Approximately 7 million saplings were planted on 3400 hectares in Kırşehir from 1977 to the end of 1997 by the Afforestation Chief and Chief Engineering Department affiliated with the Ministry of Forestry. Within the 1998 program, 1,200,000 saplings will be planted on 600 hectares of land in Kervansaray. The Forest Nursery Directorate has also worked on developing modern poplar cultivation. Apart from larch, cedar, and poplar, maple trees, ash trees, and ornamental plants are also grown in the nursery.

The total forest area in our province is 24,591 hectares. These forests are the Productive Grove consisting of larch, cedar, and poplar, the Bozuk Grove consisting of larch and cedar; and the Cleavers consisting of oaks. Considering the distribution of the province by districts in terms of forest area size, Akçakent ranks first, followed by Çiçekdağı, Merkez district, Kaman, and Mucur, respectively. The Kırşehir Forest Management Directorate carries out the maintenance and management of existing forests.

In Kırşehir, located in an arid and tectonic region, soil properties vary depending on climate and main material. The main soil groups and their characteristics in the province can be listed as follows.

A large part of the Kırşehir province area is covered with brown soils. Brown soils on unconsolidated limestones are common soil types in the arid Central Anatolian belt.

The plateaus in the northwest and south of Çiçekdağı, southwest of Kaman, and south of the Central district are covered with red-brown soils. Brown forest soils are generally seen in parts of Çiçek Mountain exceeding 1000 m. These are mature soils rich in organic matter. Forests are seen in places on these lands. Erosion is severe in areas where forest cover is thinned. In the southern part of the mountain, the elevations under the forest soils are covered with chestnut-colored soils. A part of the area between Bayındır-Boyacık towns in the west of Çiçekdağı district and south of Kaman is covered with non-calcareous brown soils. Such soils are suitable for dry farming.

The north, west, and south of Seyfe lake and Kırşehir Kılıçözü and Delice river valleys are covered with alluvial soils. These soils are dark-colored soils brought by rivers from the environment and rich in organic matter. In addition, there are colluvial soils in transition with alluvial soils on the valley floors. These soils are suitable for growing all kinds of plants.

Apart from these main soil groups in Kırşehir, bare rocks in the high parts of the Baran Mountain fill the area between the Central District and Kaman and barren soils around the Seyfe Lake due to salinity. Such lands have no agricultural value.

When evaluated as a whole, the land assets of the province area are as follows:

The total of cultivated and planted areas is 68.2%. 40% is field crops cultivation area, 25.3% is fallow land, 2.6% is vineyards and gardens, and 0.3% is unused land suitable for agriculture. Meadow and pasture areas in the province are 19.9%, and the forest area is 3.7%. The amount of area not suitable for agriculture is 8.2%. (*www.kirsehir.gov.tr*)

HARVEST PROCESS

Animal: Both properties have cows and sheep as the animals are completing the cycle to manage fertilizers and compost plants for animal food. The animals are kept in a special open-air barn to keep the climate exposure high, as the animals are terrestrial breeds. The milk produced is sold, and each animal is carefully selected to be breeding or sent to the facilities for meat production.

Plants: Plantations are done by direct seeding and are harvested using a tractor, also used for seeding and tilling. The tractors and equipment used by the farmers are all owned by them and not rented. In rare cases, the tractors are rented to the farmers in need in the province. The main fossil fuel consumers are tractors, as solar panel systems handle water irrigation.

The inflation rates and higher prices in all the sectors dramatically affected the costs of running the farms. Most of the time, farmers are having problems with supply as they need to prepare the next year's plantation procedures in advance. The total cost of the operation changes each year, but the Çağlayanlar farm has a 1.000.000 to 2.000.000 euros potential, while the Cevizbağı farm has around 50.000 to 100.000 euros per year. Both farms are family business, but it also employs outside people, between 10 and 1500.

The ecosystem services are presented in Table 8. The groundwater resources are getting lower farmers are now more dependent on underground water. The wells vary from 50 to 120 meters deep, and each year the water level decreases due to the higher need for irrigation systems used by farmers to meet the demand of consumers. The plantation used in the fields has changed during the last decade as the farmers are trying to plant seeds that need less water. The costs are high, and the farmers need support from the state. The Middle Anatolia region is the base for grain production, and the farmers are trying to keep the cultivation level high to earn enough to run their businesses. In economic terms, products have market access through dealers from the city center, and the government provides a base price for each crop to subsidize the farmers. The farmers do not have a problem selling their products as Turkiye's demand is already high.

ECOSYSTEM SERVICES	YES	NO	Partially	In the future
Control of pests and disease	x			
Regulation of Microclimate	x			
Decomposition of wastes	x			
Regulating nutrient cycles and crop pollination	x			

Table 8. Provision of ecosystem services .

Discussion

The Mediterranean region is a biodiversity hotspot that faces unique climate challenges. As such, climate-smart agriculture practices that are tailored to this context hold significant potential for sustainable development. The experiences of farms across different countries in this region, namely Portugal, Spain, Italy, Greece, and Turkey, illuminate a rich tapestry of strategies for tackling these challenges.

In Portugal, the montado farm of Herdade de São Luís stands as a unique illustration of traditional agroforestry systems in Alentejo. It is typified by sparse cork trees integrated with pastoral activities or agriculture. This farm implements climate-smart practices, such as dynamic rotational grazing with diverse livestock, aimed at regenerating the soil, enhancing pasture quality, and balancing carbon emissions. Concurrently, Hortas da Rainha in Portugal carries out a project centered on regenerative agriculture. This involves intricate agro-ecosystems and animal husbandry, primarily sheep and chickens, that rotate through the land. The farmer's primary goal is to harness regenerative agriculture as a means of conserving and restoring natural ecosystems. This approach amalgamates sustainable farming techniques, benefiting soil vitality, biodiversity, and human health.

In Spain, two recurring themes unite the case studies on CSA: (i) organic farming, and (ii) soil as a central production factor. Organic farming, due to its lower input requirements, correlates with reduced greenhouse gas emissions, thus mitigating climate change. Both case studies, Del Bancal a Casa and Casa Pareja, prioritize soil quality enhancement. Del Bancal a Casa invested significant efforts to restore heavily degraded soils and maintain their quality. Conversely, Casa Pareja consistently improves soil quality. Both use cereals and legumes in rotation to enrich the soil with carbon and nitrogen. While Del Bancal a Casa imports manure, Casa Pareja produces the majority, if not all, of its needed organic matter locally. Casa Pareja has also implemented deficit irrigation with drip technology.

In Italy, Terra Madre farm employs strategies such as early sowing with heritage varieties to handle water scarcity. The farm has also implemented rainwater harvesting from the roofs of rural buildings. They fertilize the soil entirely by burying plant residues and applying manure. The farm manages crop cycles and rotations from an ecosystem perspective and reintroduces ancient native cultivars resistant to certain adversities, which has helped control pests and diseases. An 11 KW photovoltaic system supplies electricity for their production and processing facilities. Michele Valiante and his wife Veronica operate Masseria san Paolo engaging in both animal husbandry and crop cultivation. The farm also provides educational programs and maintains a local supply chain by selling farm-produced cured meats and sausages. Despite water shortages, the farm uses traditional farming methods and crop varieties that have allowed for stable production. The farm implements measures such as maintaining grassland cover, reducing plowing, and practicing mulching to combat climate change.

In Greece, organic farmer Nikolaos Kapoulas integrates several Climate Smart Agriculture techniques, such as shade nets and drip irrigation. He also manages a small livestock unit that produces manure from various animals. In contrast, Athena Konstantinidou, a typical Greek conventional farmer, employs fewer CSA techniques. However, she enhances her field's biodiversity by cultivating ten different vegetable species with multiple cultivars, which also exploits each vegetable and cultivar's adaptability to diverse climate conditions. Furthermore, she occasionally uses formulations approved for organic farming to manage plant diseases and pests.

In Turkiye, Mr. Müfit ÇAĞLAYAN, a modern farmer, recycles manure into biogas. Significantly, his facility adheres to the 'Verified carbon standard' or VCS standard. At CEVİZBAĞI Farm, the underlying concept revolves around a supportive farming framework. Crop cultivation and animal breeding mutually sustain each other, fostering a continuous production-consumption cycle across the farm's various sections. Both farms house cows and sheep, which is essential for managing fertilizers and compost plants for animal feed. Over the last decade, the farms have adapted their crops to require less water. These farms utilize dairy products for land fertilization, avoid pesticides and chemical fertilizers to conserve energy, and employ solar panels for their energy needs. They incorporate practices like protective tillage, minimal tillage, cover cropping, natural mulching, recycling-based composting, mulch composting, vermicomposting, green manuring, and other methods to boost plants' natural defense mechanisms. Biological controls and numerous other applications are utilized for disease and pest management. Additionally, these farms strive to augment biodiversity.

In examining the case studies, we find compelling evidence for the transformative potential of Climate Smart Agriculture. Despite the contextual differences, several shared themes crystallize, revealing the following essential aspects of CSA:

COMMITMENT TO ORGANIC FARMING: The prevalence of organic farming across multiple case studies underscores its significance in climate change mitigation and desertification prevention. This farming style mitigates greenhouse gas emissions, bolsters biodiversity, and nurtures soil health, showing that it is a compelling strategy irrespective of geographical or cultural context.

RESOURCE INNOVATION: The creative and efficient use of resources is a standout element in these studies. This theme manifests through practices like employing alternate fertilizers such as manure and cover crops, rainwater harvesting, and converting farm waste into biogas, all demonstrating the innovative resourcefulness at the heart of CSA.

PRIORITIZING BIODIVERSITY AND SOIL HEALTH: Another prevalent theme is the emphasis on biodiversity conservation and soil health improvement. Both facets contribute significantly to the resilience and longevity of agricultural systems, underscoring the indispensable role of CSA practices in farming sustainability.

INTEGRATION OF TECHNOLOGICAL ADVANCES: The case studies reveal the marriage of traditional farming wisdom with cutting-edge technology. This synergy is evidenced through the adoption of tools and techniques like drip irrigation systems, photovoltaic energy sources, and the deployment of drones and autonomous robots, amplifying efficiency and mitigating environmental impact.

HARMONIZING LIVESTOCK AND CROP PRODUCTION: Many of the farms exhibited the integration of livestock with crop production. This harmonious approach optimizes resource utilization while catalyzing symbiotic effects that enhance both soil vitality and overall farm productivity.

ADAPTING TO LOCAL CIRCUMSTANCES: CSA practices embody the ethos of adaptation and flexibility, molding themselves to the nuances of local conditions. Whether through the cultivation of native pest-resistant crop varieties, water-efficient crops in regions with scarce water resources, or the emulation of traditional agroforestry systems, CSA celebrates diversity and emphasizes localization.

CARBON SEQUESTRATION: Many of the shared practices, such as cover cropping, manure application, and crop rotation, also function as effective carbon sequestration strategies. This means that these farms don't just embody sustainability; they actively contribute to combating climate change.

Despite the variety in the specific applications of CSA, the fundamental principles of sustainability, efficiency, and adaptability are universal. By adopting a holistic model that harmonizes environmental health, economic viability, and social equity, CSA paves the way forward. These case studies, each presenting its unique take on these intertwined strategies, inspire farmers, policymakers, and stakeholders. We hope this will ignite consideration for CSA as a robust and efficacious approach to sustainable agriculture in the Mediterranean and across the globe.

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