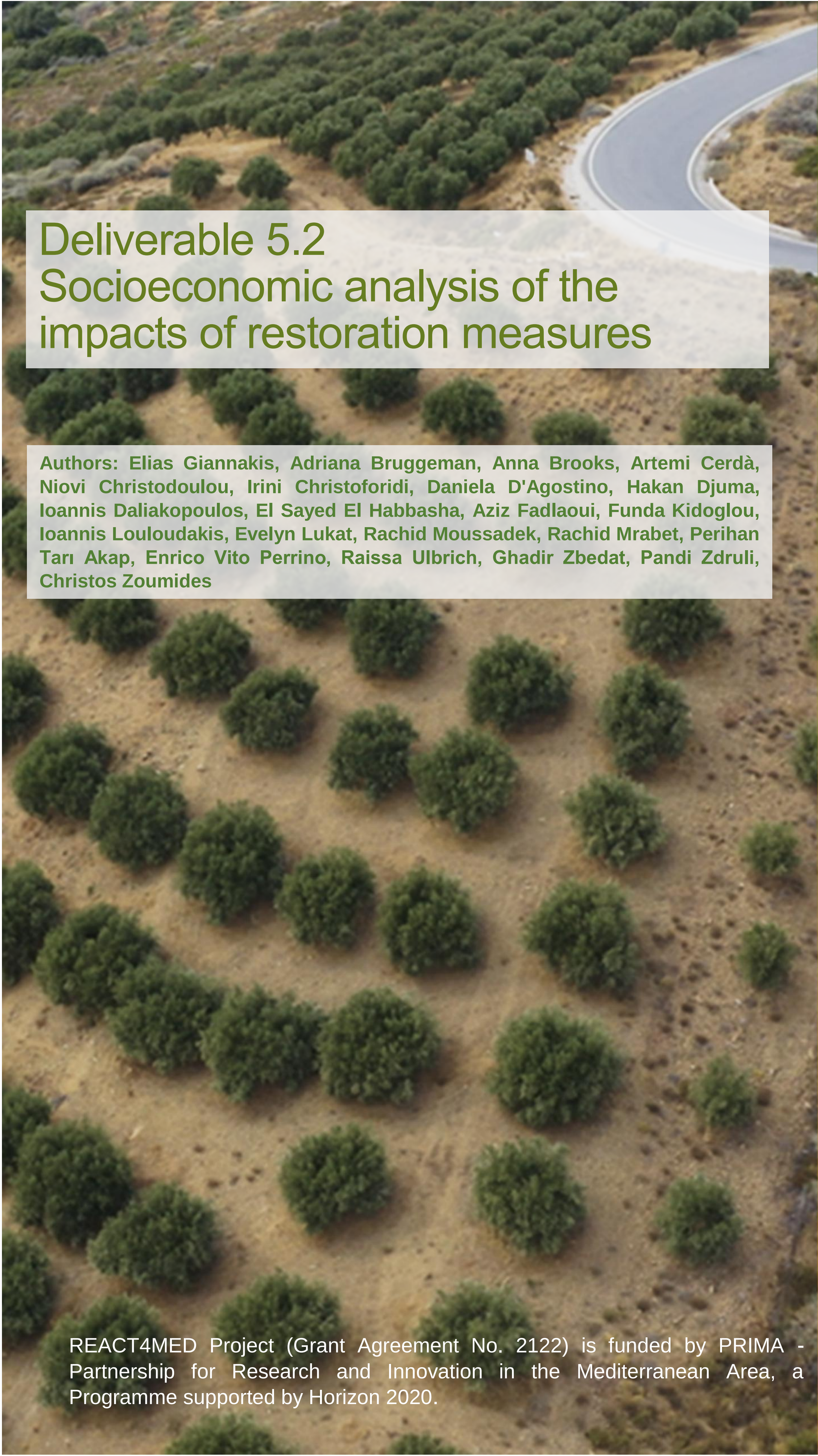

Deliverable 5.2 Socioeconomic analysis of the impacts of restoration measures

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Table of Contents

List of acronyms

BCR: Benefit-Cost Ratio

CY: Cyprus

D: Deliverable

CBA: Cost-Benefit Analysis

CM: Decision Maker

DoA: Description of Action

EG: Egypt

ERLL: Ecosystem Restoration Living Lab

GA: Grant Agreement

SP: Spain

IL: Israel

IT: Italy

GR: Greece

GE: Germany

LanDS: Land Degradation Decision-Support

M: month

ML: Machine Learning

MO: Morocco

MS: Milestone

NPV: Net Present Value

PA: Pilot Area

PAL: Pilot Area Leader

PP: Project Partners

SH: Stakeholder

SLWM: Sustainable Land and Water Management

TR: Turkey

WP: Work Package

W: Workshop

Summary

This report presents a comprehensive socioeconomic analysis of ecological restoration actions implemented across eight pilot areas in the Mediterranean region under the REACT4MED project framework. It builds on the implementation and biophysical assessment of the restoration actions presented in report D5.1. The analysis combines cost-benefit analysis (CBA) with social justice enquiries to evaluate both the economic viability and distributional equity of various restoration interventions over a 15-year evaluation period. Pilot areas span diverse Mediterranean contexts, from mountainous vineyards in Cyprus and marginal cropland in Crete to irrigated croplands in Egypt and Turkey, examining restoration practices including mechanized terrace construction, agroforestry establishment, and drainage system installations.

Results demonstrate that most restoration actions achieve positive economic performance, with Benefit-Cost Ratios (BCR) ranging from 1.03 to 2.26 and Net Present Values (NPV) from €7,290/ha to €83,891/ha across successful interventions. The Cypriot mechanized terraces with wine production showed the highest returns (NPV €48,456/ha, BCR 1.10), closely followed by the organic table grape farm in Italy (NPV 47,467, BCR 1.18). Restoration actions consistently delivered environmental co-benefits including improved soil health, enhanced water retention, increased biodiversity, and reduced erosion, though these were often not fully captured in conventional financial metrics. However, the analysis also revealed critical barriers to adoption: high upfront capital requirements (ranging from €3,350/ha in Egypt to €331,848/ha in Cyprus), knowledge gaps among farmers, and initial productivity lags during transition periods.

Social justice enquiries revealed significant equity concerns across all pilot areas. Benefits disproportionately accrued to larger landholders capable of absorbing initial investments, while smallholder farmers faced substantial barriers despite often being located in the most degraded landscapes. Off-site environmental benefits such as reduced pollution, carbon sequestration, and watershed protection were enjoyed by the general public without corresponding cost-sharing, creating a classic public goods dilemma. Stakeholders consistently identified the need for targeted financial support mechanisms, cooperative equipment-sharing arrangements, capacity-building programs, and market incentives (such as premium pricing for sustainably produced goods) to achieve more equitable distribution of costs and benefits. These findings underscore that economic viability alone is insufficient; successful scaling of restoration practices requires deliberate policy interventions to address distributional inequities and ensure that those who generate public environmental goods are adequately compensated.

1 Introduction

This report presents the economic and social impact analysis of restoration actions implemented across eight pilot areas within the REACT4MED project framework. The analysis evaluates both the economic viability and social implications of various restoration interventions through systematic application of cost-benefit analysis and a social justice assessment methodologies.

Section 2 establishes the analytical foundation by outlining the cost-benefit analysis framework and social justice assessment approach employed across all pilot sites. Sections 3.1 through 3.8 present detailed case-by-case analyses, with each section providing: contextual background of the implemented restoration practices; site-specific methodological adaptations and assumptions; data collection and assessment protocols; comprehensive cost and benefit estimations; calculation and interpretation of economic performance indicators; the results of the social justice enquiry; and synthesis of key findings and implications. The social justice enquiries were organized in cooperation with WP3. The enquiries were conducted with the stakeholders in Ecosystems Restoration Living Lab 3 and part of the findings were also reported in D3.3. No relevant social justice enquiries were conducted in Israel and Morocco.

This systematic approach ensures methodological consistency while accommodating the diverse ecological, economic, and social contexts characterizing each pilot area, thereby enabling both individual site assessment and comparative analysis across the REACT4MED restoration projects.

2 Methods

2.1 Cost-Benefit Analysis Framework

The economic evaluation of restoration actions employs a comprehensive cost-benefit analysis (CBA) approach that monitors the temporal evolution of cash flows, i.e., the inflows (benefits and revenues) and outflows (costs and expenditures) throughout the investment lifecycle. The net cash flow, calculated as the algebraic difference between inflows and outflows, is the metric used for investment assessment and decision-making. Positive net cash flows indicate value generation, while negative flows suggest economic inefficiency.

This analytical framework provides a systematic foundation for comparing diverse restoration alternatives, accommodating the unique characteristics of each intervention. The evaluation methodology focuses on projected cash flows attributed to restoration activities, with investment viability determined by the relationship between total benefits and total costs over time.

2.1.1 Net Present Value Analysis

The Net Present Value (NPV) criterion represents the primary evaluation tool for assessing the net economic benefit restoration investments. This approach offers several analytical advantages:

- Comprehensive scope: Incorporates all future revenues and expenses associated with restoration activities to evaluate overall economic impact.
- Temporal consistency: Addresses the time value of money by discounting future cash flows to present values, enabling direct comparison of monetary amounts across different time periods.
- Decision clarity: Provides an unambiguous decision rule where positive NPV indicates economic viability.

The NPV quantifies the extent to which the present value of benefits exceeds the present value of costs. Restoration actions yielding positive NPV are economically justified, while those with negative NPV should be rejected.

The mathematical formula for NPV is as follows (Boardman et al., 2018)[1]:

$$\boldsymbol{NPV = -CF_0 + \frac{CF_1}{(1+r)} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \cdots + \frac{CF_n}{(1+r)^n} = -CF_0 + \sum_{i=1}^{n} \frac{CF_t}{(1+r)^t}}$$

Where:

$\boldsymbol{CF_0}$: Initial investment outlay (paid at the end of period 0, i.e., before the investment begins to operate)

$\boldsymbol{CF_t}$: Net cash flow in period t (revenues minus expenses)

$\boldsymbol{r}$: Annual discount rate (constant across evaluation period)

$\boldsymbol{t}$: Time period index

$\boldsymbol{n}$: Evaluation timeframe (typically aligned with economic life of restoration investment).

2.1.2 Benefit-Cost Ratio Analysis

The Benefit-Cost Ratio (BCR) provides a complementary metric that measures the relative efficiency of restoration investments by comparing the present value of benefits to the present value of costs. This ratio-based approach is particularly valuable for comparing projects of varying scales and resource requirements.

[1] Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2018). Cost-Benefit Analysis: Concepts and Practice (5th ed.). Cambridge University Press.

The mathematical formula is as follows (Boardman et al., 2018):

$$BCR = \frac{\sum_{t=0}^{n} \frac{CF_t(Benefits)}{(1+r)^t}}{\sum_{t=0}^{n} \frac{CF_t(Costs)}{(1+r)^t}}$$

Where:

$\boldsymbol{CF_t(Benefits)}$: Benefit (revenue) flows period t;

$\boldsymbol{CF_t(Costs)}$: Cost flows in period t, including initial investment $\boldsymbol{CF_0(Cost)}$.

Interpretation criteria:

- BCR > 1: Benefits outweigh costs, indicating economic viability
- BCR < 1: Costs outweigh benefits, suggesting economic inefficiency
- BCR = 1: Break-even point where benefits equal costs

The BCR metric enhances NPV analysis by revealing capital utilization efficiency and facilitating comparison across restoration projects with different investment scales.

2.1.3 Application Across Pilot Areas

The cost-benefit methodology is systematically applied across all eight pilot areas through a standardized analytical protocol:

Cost Assessment: Comprehensive identification and quantification of restoration-related expenditures, including initial capital requirements, operational expenses, and ongoing maintenance costs.

Benefit Estimation: Systematic evaluation of restoration-derived benefits encompassing direct revenues (yields, market values), policy incentives (subsidies, payments), and avoided costs (environmental damage prevention).

Discount Rate Application: Implementation of appropriate discount rates reflecting the temporal distribution of costs and benefits, accounting for risk and opportunity cost considerations.

Performance Evaluation: Calculation of NPV and BCR indicators using discounted cash flow methodology to assess economic viability of individual restoration actions.

Comparative Analysis: Tested restoration actions against baseline reference conditions to identify the most cost-effective approaches.

This methodological approach ensures analytical consistency while accommodating site-specific conditions and stakeholder priorities across diverse restoration environments.

2.2 Social Justice Enquiry

The economic evaluation is complemented by a social justice enquiry that examines the distributional impacts and equity implications of restoration actions. This qualitative assessment addresses potential disparities in cost burdens, benefit distribution, and unintended consequences that may not be captured in conventional economic metrics.

While restoration measures may demonstrate favourable economic performance, they can generate differential impacts across stakeholder groups, creating winners and losers through uneven distribution of costs, benefits, and externalities. The social justice framework identifies these distributional effects and assesses their implications for social equity.

The social justice enquiry was conducted in a Living Lab setting. The methods were developed in cooperation with the colleagues from WP3 and practiced with the Pilot Area teams in an online session. Under the guidance of a facilitator stakeholders filled a 6 by 4 social justice matrix, identifying the financial, social and environmental costs and financial, social and environmental benefits (6 rows) of the tested ecological restoration practice for the four stakeholder groups: implementing farmers, other farmers, general public, and government (4 rows). The stakeholders used post-its (sticky notes) to fill in the 24 boxes of the matrix. Two 6 by 4 matrices are filled, the first one for on-site effects and the second one for off-site effects. The session was followed by reflections on the distribution of the costs and benefits and possible measures to reduce inequalities, per cost and benefit row in each matrix. The social justice enquiry was undertaken in the third Ecological Restoration Living Lab (ERLL) and the results are taken from the ERLL reports.

3 Cost-Benefit Analysis of Restoration Actions

3.1 Troodos Mountains (CY): agro-ecologically managed vineyards on modern (mechanically constructed) mountain terraces vs. vineyards on traditional terraces

3.1.1 General Information

Mountain agriculture, and in particular viticulture, in the Troodos Mountains of Cyprus has long depended on traditional dry-stone terraces, i.e., hand-built benches that hug the contours of steep ophiolitic slopes. Constructed and maintained over generations with basic tools, local stones and family labour, these terraces represent a living record of rural craftsmanship and cultural identity. Demographic change, land fragmentation and the physically demanding upkeep have led to their widespread neglect and abandonment. As walls loosen and maintenance lapses, topsoil washes downslope, terraces collapse and many plots fall out of production.

In recent decades a contrasting approach has emerged: modern, mechanically constructed terraces created with heavy earthwork machinery (i.e., excavators and bulldozers) and, where needed, reinforced by newly built dry-stone walls. These earthmoving and reshaping activities allow wider, more uniformly graded benches that can accommodate small tractors, drip irrigation lines and other precision-viticulture practices. In some of the newly developed terraces, farmers maintain a selective vegetation cover on the sloping terrace risers to enhance stability and reduce erosion. In the framework of REACT4MED, capacity-building events, mapping and monitoring activities have been reviving dry-stone wall building skills and new knowledge, in support of these re-engineered mountain slopes

The cost-benefit analysis (CBA) compares two vineyard terrace management options tested within REACT4MED's Troodos pilot area:

a) new terraces constructed using earth-moving machinery and reinforced by drystone walls with agro-ecological management practices and wine production ("Modern terraces"), and
b) continued use and minimal maintenance of existing dry-stone terraces with vineyards ("Traditional terraces").

In other words, the CBA sets the mechanised restoration scenario ("technology") against the traditional baseline ("reference") to assess and compare their financial feasibility.

Figure 1: Vineyards on modern, mechanically constructed terraces (left) and on traditional terraces (right)

3.1.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon (i.e., 2016 which was the establishment and intervention year for mechanically constructed terraces, plus 14 operating years up to 2030). Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. For the mechanically constructed terraces the per hectare investments and operational costs were derived from the total costs for the 13-ha vineyard area.

3.1.3 Benefits

Table 1 outlines the key benefit components derived from both scenarios. These include yield progression, farm-gate and wine-equivalent pricing, and resulting lifecycle benefits.

- **Yield**, in the case of mechanised terraces, increases gradually through intermediate steps, from year 3 to year 8; the latter is the year of full yield potential, when the newly planted vines mature. On traditional terraces, yield is held constant throughout the appraisal period, at the level existing observed yields.
- When grapes are marketed in bulk, revenue is calculated based on **farm-gate prices**. In the mechanised terraces, grapes are vinified on-farm, so benefits are derived instead from the bottled wine price and the conversion factor of grapes to a litre of wine are used. These elements generate a shadow price of grapes, thus the consolidated revenue is computed.
- **Subsidies** under the CAP **single area payment scheme** (SAPS) are another source of annual revenue. These subsidies apply equally to both systems. There is also a one-off investment in winery establishment for Y0 which is triggered in the case of the mechanical construction of (new) terraces.

Table 1: Annual Revenues

Variable (unit)	**Modern**	**Traditional**
Yield progression (ton/ha)		
Year 0 - 2	0	3.0
Year 3	0.4	3.0
Year 4	1.6	3.0
Year 5	2.8	3.0
Year 6	4.8	3.0
Year 7	6.0	3.0
Year 8 - 14	8.0	3.0
Revenue (€/ha)		
Farm-gate price (€/ton)	-	400
Wine price (€/litre)	20	-
Grapes needed per litre of wine (kg/ litre)	1.6	-
Price of grapes (as wine) (€/ton)	12,500	-
Total annual revenue (€/ha) *(Year 8 - 14)*	100,000	1,200
Subsidies (€/ha)		
Annual subsidy - SAPS (€/ha)	1,000	1,000
Investment subsidy – Year 0 (€/ha)	9,232	-
Total Lifecycle Benefits (€/ha)	**918,232**	**33,000**
Present Value of Benefits (€/ha)	**512,993**	**21,999**

3.1.4 Costs

Annual Operating and Maintenance Costs

Table 2 presents the recurring annual costs associated with terrace maintenance, inputs, and labour, in the two terrace systems. **Fertilizer** and **plant protection** costs reflect the nutrient and plant-health regimes adopted in each system. Mechanically constructed terraces follow an intensive, quality-focused schedule; traditional terraces apply lower rates consistent with more extensive management. Water use (irrigation) cost (€/ha) is computed based on irrigation (m^3/ha) and water prices (€/m^3) provided by the farmers. Only new terraces employ supplementary drip irrigation, whereas the traditional ones are predominantly rain-fed, thus assuming zero cost for the latter.

Regarding machinery cost, this includes annual fuel and parts replacement cost, whereas other costs refer to field consumables, routine soil sampling and lab analysis, as well as the cost of wine bottling (bottles, corks, labels), which is approximately €1 per bottle. The total wine bottling cost increases with time, together with the grape yields. Labour cost, as in the case of all costs, is computed at the same area scale (per ha), considering the total area, the labour hours and annual salaries per year, in each terrace system. Considering that the winery was a new development, the (relatively low) rental cost for the mountain land is included. For the traditional case, the land is owned by the family.

Table 2: Annual Operating and Maintenance Cost (Year 8-14)

Variable (€/ha)	**Modern**	**Traditional**
Planting cost	0	0
Fertilizer cost	290	90
Plant protection costs	80	25
Irrigation cost	360	0
Machinery operating costs	823	150
Other costs	6712	16.67
Labour cost	8,100	2,400
Land rent	243	0

Capital (Year 0) Costs

This sub-section details the one-time investment costs associated with the new terrace establishment (Table 3). This includes the cost of earth work and landscaping by heavy machinery that are required to construct modern terraces; no equivalent costs are needed for the established traditional vineyards. Additionally, it includes **vineyard infrastructure**, i.e., purchase and installation of pipes, poles and trellis. Regarding the drystone wall cost, it is assumed that in each hectare there are 2500 m of running walls of 1.2 m height (and approximately 0.4 m width), and that the stone and labour cost per square metre (wall front) is €50; thus, the total cost of new drystone wall per hectare is €150,000. Finally, considering that the revenue source of mechanised terraces is from wine sales, we have included the cost of winemaking equipment in these initial investment cost, converted into per hectare equivalent.

Table 3: Initial Capital Cost

Category (€/ha)	**Modern**	**Traditional**
Earth work for terrace construction	150,000	0
Drystone wall cost	150,000	0
Installation (pipes, poles, etc.)	18,000	0
Winemaking equipment	13,848	0

Total Costs

The total costs - both undiscounted and present value – for the two terrace systems are summarized in Table 4. The mechanized terrace system entails substantial upfront investments - over €341,000/ha in capital expenditures. These include machinery, drystone walling, and professional vineyard installation and winemaking equipment. Additionally, operation and maintenance costs are higher due to the intensity of field work, irrigation, and skilled labour requirements. In contrast, traditional terraces have relatively minimal inputs and low operating costs, but their productivity is capped. Despite the high capital intensity of the mechanized system, the strong economic returns over time (as shown below) ensures its long-term viability.

Table 4: Total Cost

Category (€/ha)	**Modern**	**Traditional**
Total Lifecycle Costs	540,641	40,225
Present Value of Costs	464,537	26,805

3.1.5 Economic Performance Indicators

The cost-benefit analysis reveals a stark contrast in economic viability between the two terracing systems over the 15-year evaluation period. The mechanised terrace system demonstrates good financial performance with a positive Net Present Value of €48,456 per hectare, indicating that the investment generates substantial returns (Table 5). The Benefit-Cost Ratio of 1.10 for mechanised terraces exceeds the viability threshold of 1.0, demonstrating that for every euro invested, the system returns €1.10 in present value terms. This BCR indicates value creation and confirms the long-term financial attractiveness of the investment despite the substantial upfront capital requirements.

Table 5: Economic Performance

Indicator	**Modern**	**Traditional**
Net Present Value (€/ha)	48,456	-4,807
Benefit-Cost Ratio	1.10	0.82

In contrast, the traditional terracing system exhibits poor economic performance, with a negative NPV of €4,807 per hectare, indicating that the system fails to generate adequate returns over the evaluation period. However, the management and harvesting of the vines on traditional terraces are often done by non-paid family members. If we consider to account for half of the annual labor cost (1200 instead of 2400 €/yr), the Benefit-Cost Ratio changes from 0.82 to 1.49, showing a positive financial performance. However, a more ecological approach would be to increase the benefits of these terraced vineyards by improving the quality and quantity of the grape yield through improved management practices. The current economic underperformance likely contributes to the documented trend of terrace abandonment in Mediterranean mountain regions. The visual comparison of Net Present Values of the two scenarios (Figure 2) underscores the strong economic case for mechanized terrace restoration with wine production.

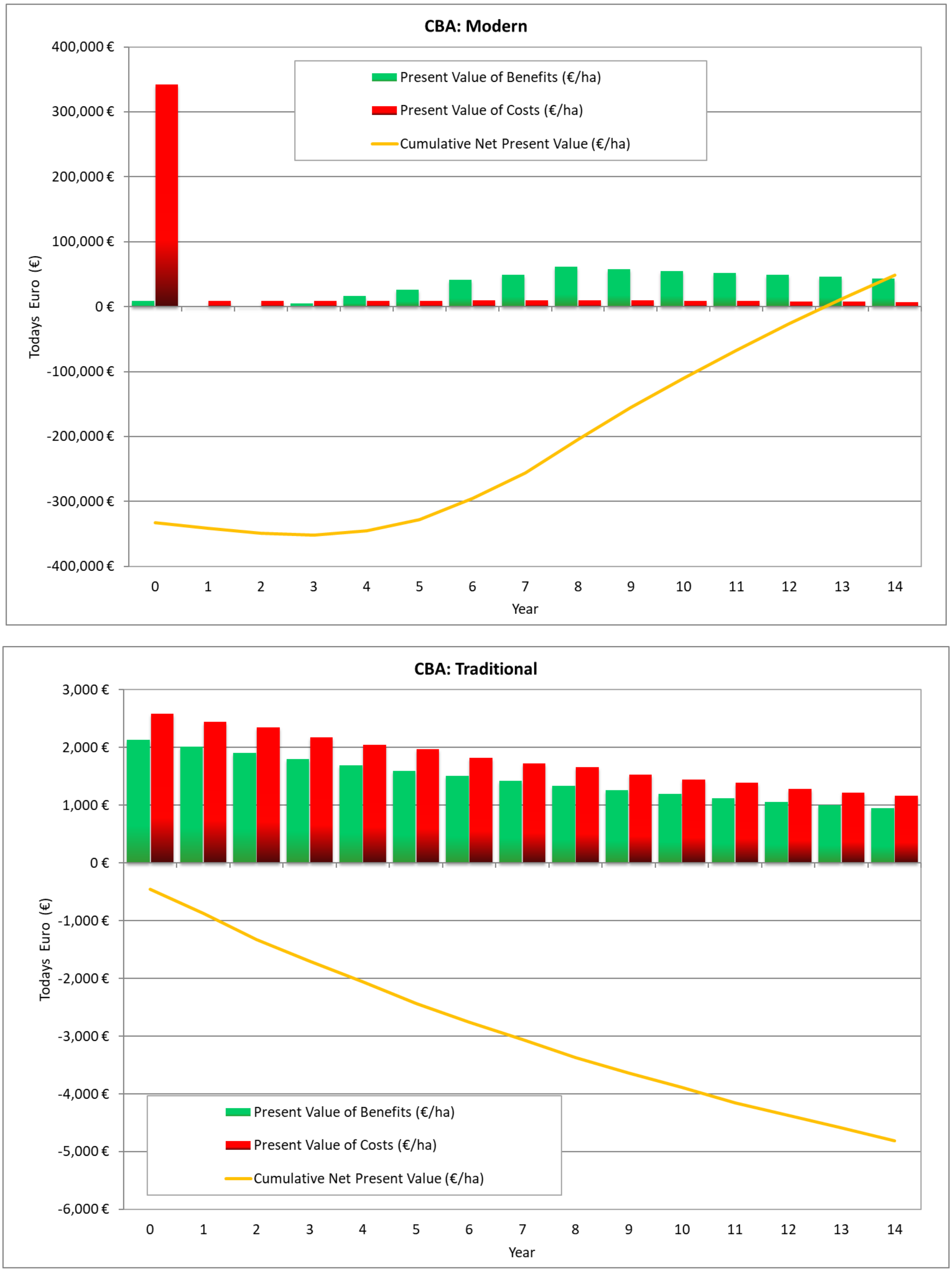


Figure 2: Present values of benefits and costs for the modern, mechanically constructed terraces, following the investment in their construction in Year 0 (top) and for the traditional terraces (bottom).

3.1.6 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

The restoration action analysed – mountain terraces primarily constructed with mechanised means was evaluated through stakeholder input (discussion) and questionnaire responses. The identified costs and benefits are categorised as on-site and off-site impacts and distributed across key actor groups.

Restoration action: Agricultural terraces (mechanised vs traditional/abandoned)

- Mechanised terraces: Mechanised terraces that may have been implemented without sufficient hydrological or environmental planning, potentially causing erosion, soil compaction, or habitat disruption.
- Traditional or abandoned terraces: Manually constructed terraces that, while culturally valuable, are less effective in addressing modern agricultural and environmental challenges. This includes previously managed traditional terraces that are now abandoned, leading to increased soil erosion, water runoff, and loss of agricultural productivity.
- In either system, there is currently limited or no hydrological planning/assessment when terraces are designed; they rely on empirical knowledge/design.

On-Site Costs and Benefits:

Costs and Benefits	**Implementing Farmer/Landowner**	**Other Farmers**	**General Public**	**Government (Support)**
Environmental Benefits	Improved soil quality, water retention	Indirect benefits through knowledge sharing	Better water management and reduced erosion	Progress towards national soil conservation targets
Social Benefits	Job creation during construction	Potential training opportunities	Agrotourism potential and improved landscapes/biodiversity	Support for rural revitalisation initiatives
Financial Benefits	Increased productivity and resilience	Future adoption opportunities	Access to higher-quality local produce	Long-term reduction in restoration costs
Negative Environmental Effects	Soil compaction and habitat disturbance; soil erosion if not constructed/maintained properly	Minimal impact	Habitat loss in affected areas	Monitoring and compliance costs
Negative Social Effects	High costs limit adoption by small farmers	Inequities in access	Disruption during construction	Strain on equitable resource allocation
Financial Costs	High implementation and maintenance costs	Minimal direct impact	Indirect financial burdens (e.g., infrastructure)	Subsidy requirements

Off-Site Costs and Benefits:

Costs and Benefits	**Implementing Farmer/Landowner**	**Other Farmers**	**General Public**	**Government (Support)**
Environmental Benefits	Reduced sediment flow and improved irrigation	Improved regional soil and water quality	Enhanced ecosystem health and biodiversity	Contributions to international environmental targets
Social Benefits	Community integration	Regional collaboration	Tourism potential and aesthetic appeal	Strengthened rural policies and programmes
Financial Benefits	Market expansion for high-quality products	Supply chain development	Economic uplift through agrotourism	Stabilised rural economies

Negative Environmental Effects	Erosion during construction, emissions (inc. dust) and noise	Minimal impact	Temporary pollution in adjacent areas	Oversight for unintended impacts
Negative Social Effects	Minimal direct impact	Minimal direct impact	Altered traditional landscape aesthetics	Balancing development with heritage
Financial Costs	Transportation and logistics costs	Minimal direct impact	Public resource allocation	High funding needs for support programmes

Reflection on how costs and benefits are distributed across groups

Participants discussed and reflected on the distribution of costs and benefits; the discussion focused on equity and social justice within the Troodos Mountain communities.

Economic Impacts:

- Farmers, particularly larger-scale ones, were seen as the primary beneficiaries due to productivity gains in the long run, while small-scale farmers faced challenges with the high implementation costs (partial inequalities due to scale/size of plots).
- Local businesses and the tourism sector benefitted from enhanced market opportunities and landscape improvements/aesthetic value.

Social Impacts:

- Job creation during the construction phase can boost local economies and social cohesion, in communities that still have relatively younger (and not only aged) population.
- Concerns about the marginalisation of small farmers and the loss of cultural identity associated with traditional terraces were mentioned.

Environmental Impacts:

- The environmental benefits, including reduced erosion and improved water management, were widely recognised.
- Concerns about habitat destruction and changes to the landscape prompted discussions on sustainable design of mechanised terraces.

Effect on the Community/Region:

- The mountain communities and the Troodos region as a whole experience mixed impact. While the restoration action can socio-economic resilience and sustain farming activities (and financially viable in the long run), inequities in the distribution of costs – particularly financial – posed challenges for smaller-scale farmers, marginalised communities or plots that are at higher elevations; these refer to sites that are less easily accessible.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

The main points discussed were

- Financial support for farmers (incl. small-scale) through targeted subsidies and grants.
- Preservation of cultural and aesthetic values by integrating traditional designs into mechanised terraces.
- Improved design of mechanised terraces to incorporate hydrological and soil considerations (better drainage, soil compaction reduction), to reduce negative environmental impacts.

- Increased awareness and training programmes to promote the adoption of restoration practices among farmers and agricultural workers

3.1.7 Summary and Policy Implications

This analysis shows positive financial results for the professional management and post-harvesting processing of vineyards in the mountainous areas of Cyprus, starting from the mechanical construction of mountain terraces that are efficiently supported by dry-stone walls. The positive NPV and BCR suggest that farmers who invest in modern terracing infrastructure can expect sustainable long-term returns. Though the upfront costs are significant, the long-term productivity gains and the shift to high-value wine production yield substantial returns.

To facilitate wider adoption, targeted financial support instruments - such as grants or low-interest restoration loans - could be introduced to help local farmers overcome capital barriers (see Deliverable 6.4). Furthermore, restoration programs should integrate capacity-building components, including training in mechanized operations and modern vineyard management, to ensure sustainable implementation and long-term success in rural communities.

The poor economic performance of traditional systems, while concerning from a heritage preservation perspective, helps explain the widespread abandonment of terraced landscapes across the Mediterranean. These findings suggest that without technological modernization or alternative support mechanisms, traditional terracing may struggle to remain economically sustainable under current market conditions.

Findings of the social enquiry indicated both negative environmental effects, especially during the construction of modern terraces and a need for the integration of mechanized construction and traditional drystone walls. The stakeholders also identified high costs and a need for subsidies to support the investments in the mechanized construction of terraced vineyards.

3.2 Heraklion (GR): Afforestation (*Ceratonia siliqua* plantation) versus grazing land

3.2.1 General Information

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

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

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

To address these environmental and socio-economic challenges, agroforestry and reforestation measures under programs such as the EU's Rural Development Policy have been implemented. The "Measure 221 - First Afforestation of Agricultural Land" exemplifies this strategy. By incentivizing the conversion of marginal or degraded cropland into forested areas, the measure aimed to reduce soil erosion, enhance carbon sequestration, and restore biodiversity, while providing farmers with compensation for income loss during the transition period. Such schemes not only mitigate climate risks such as drought and wildfire but also create new economic opportunities in rural areas through sustainable forestry and non-timber products. Similar agri-environmental measures, including support for permanent crops and organic farming, can diversify land use, reduce pressure from intensive livestock grazing, and help reverse the homogenization of agricultural landscapes. In the context of Crete, these interventions could stabilize rural demographics, improve water efficiency, and contribute to a more resilient, climate-smart agricultural system that balances production with ecological integrity.

Figure 3: Open grazing land as reference (left), forestation (right)

3.2.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon (actual year was 2003 but the we used costs that correspond to today's market). Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The forestation costs derived from interview with the owner of a 5-hectare plantation, where's the reference data came from the internet on based on press articles, government gazettes, government agencies, and the same interview.

3.2.3 Benefits

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

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

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

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

Table 6: Annual Revenues

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from crop yield (range) (€/ha)	1,516-9,747	2,713
Annual subsidy (€/ha)	5,764 (first 5 years), 1000 (following 15 years)	375
Investment subsidy – Year 0 (€/ha)	24,314	12,000
Total Lifecycle Benefits (€/ha)	**129,453**	**52,326**
Present Value of Benefits (€/ha)	**91,071**	**14,902**

3.2.4 Costs

Annual Operating and Maintenance Costs

Regarding the Restoration Action costs this refers to *Ceratonia siliqua* plantation as described in WOCAT. Fertilizer and plant protection costs reflect the nutrient and plant-health regimes adopted in this system. Water use (irrigation) cost (€/ha) is computed based on irrigation (m^3/ha) and water prices (€/m^3) provided by the farmers. Regarding machinery cost, this includes annual fuel and parts replacement cost, whereas other costs refer to field consumables, routine soil sampling and lab analysis. Labour cost, as in the case of all costs, is computed at the same area scale (per ha), considering the total area, the labour hours and annual salaries per year.

As for the reference case, Animal cost, feed, protection, etc, derived from interview and online market research. There are no machinery operation costs and no labour costs as this scenario is low tech, traditional and self-owned and operated endeavour. The number of animals is at the top end is of what the low would allow for Cretan region (15).

Table 7: Annual Operating and Maintenance Cost

Variable (€/ha)	Restoration action	Reference
Planting cost / Animal cost	0	0
Fertilizer cost / Feed	1,456	1,875
Plant protection costs / Animal Protection	100	180
Irrigation cost	8	20
Machinery operating costs	200	
Other costs / Insurance	0	300
Labour cost	2,850	0
Land rent	0	0

Capital (Year 0) Costs

Table 8 details the one-time investment costs associated with orchard establishment. Restoration systems incur higher initial costs due to planting (€2,100/ha), infrastructure, and machinery purchase (€8,000/ha). Fertilizer and plant protection inputs during establishment add €1,456 and €100/ha, respectively. Irrigation infrastructure costs are €8/ha for restoration and €73/ha for reference systems, reflecting differences in water management strategies.

Other costs in restoration systems (€13,000/ha) include orchard fencing, storage facilities, and basic equipment for carob processing. Labour during establishment adds €2,850/ha, covering planting and initial pruning operations. Reference systems, which rely on existing livestock infrastructure, have lower capital costs overall (€45,220/ha compared to €94,210/ha for restoration).

Table 8: Initial Capital Cost

Variable (€/ha)	Restoration action	Reference
Planting cost | Animal cost	2,100	1,800
Fertilizer cost | Feed	1,456	1,875
Plant protection costs | Animal Protection	100	180
Irrigation cost	8	73
Machinery operating costs	8,000	
Other costs | Insurance	13,000	300
Labour cost	2,850	

Land rent	0	0

Total Costs

Table 9 summarizes the total lifecycle costs and their present value for both systems. Restoration orchards entail substantial upfront investments over €94,210/ha in capital expenditures due to machinery, infrastructure, and intensive management practices. Annual operating costs are also higher because of fertilization, irrigation, and skilled labour requirements. In contrast, reference systems have relatively minimal inputs and low operating costs, but their productivity is limited by extensive management and reliance on livestock integration.

Despite the high capital intensity of restoration systems, the expected increase in carob yields and long-term economic returns ensures their viability over time. The present value of costs for restoration is €70,524/ha, compared to €33,027/ha for reference systems, highlighting the trade-off between initial investment and future productivity gains.

Table 9: Total Cost

Category (€/ha)	**Restoration action**	**Reference**
Total Lifecycle Costs	94,210	45,220
Present Value of Costs	70,524	33,027

3.2.5 Economic Performance Indicators

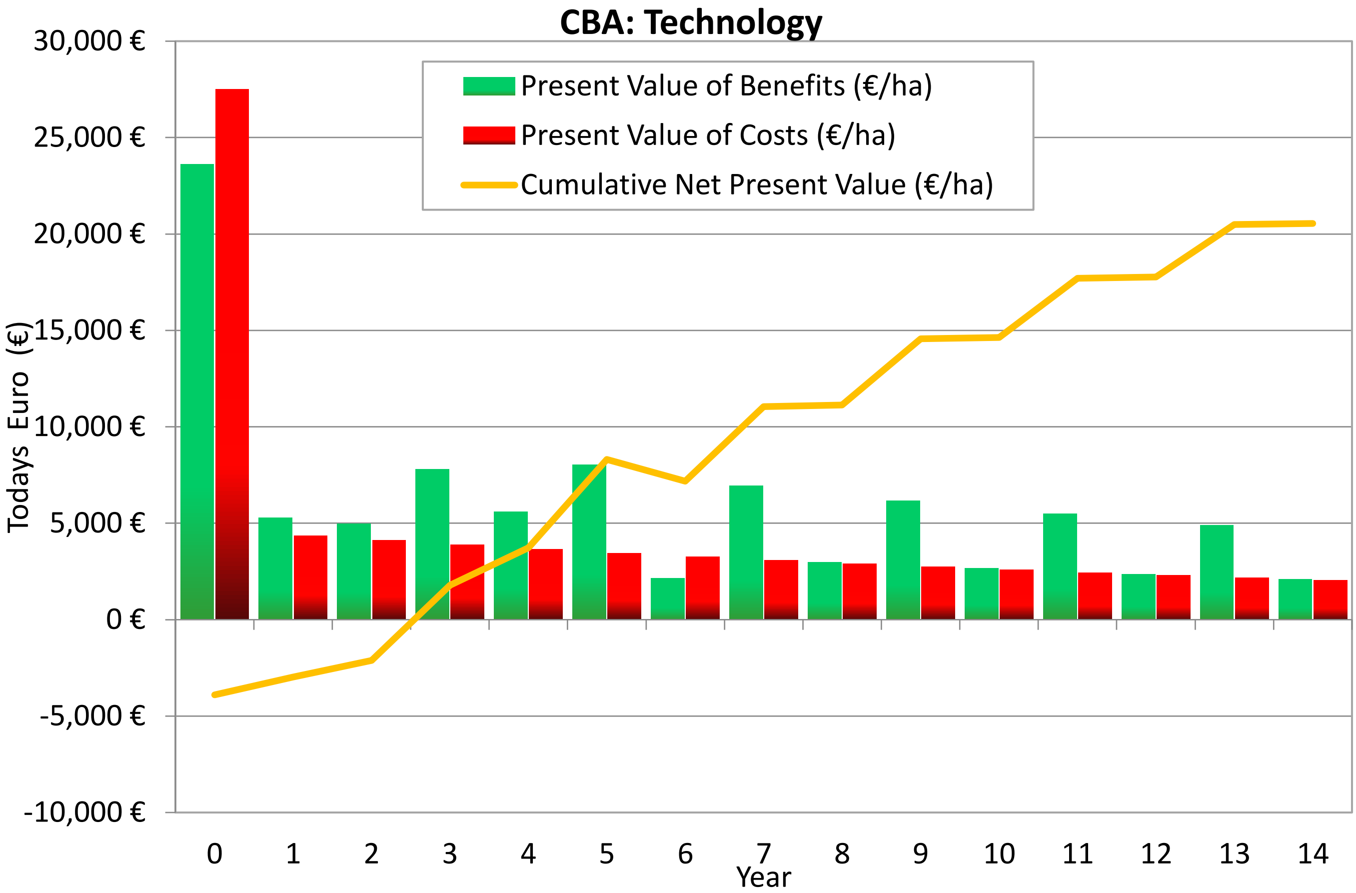
The cost-benefit analysis highlights a clear difference in financial viability between the two management scenarios over the evaluation period. The Restoration action scenario demonstrates strong economic performance, with a Net Present Value (NPV) of €20,547 per hectare, indicating that the investment generates substantial returns beyond its initial and operating costs (Table 10). The Benefit-Cost Ratio (BCR) of 1.29 exceeds the viability threshold of 1.0, meaning that for every euro invested, the system returns €1.29 in present value terms. This ratio confirms the financial attractiveness of restoration practices and suggests that, despite higher upfront costs, the long-term benefits justify the investment.

In comparison, the Reference scenario also achieves positive financial results, though at a lower magnitude. With an NPV of €5,397 per hectare and a BCR of 1.16, the reference system remains economically viable, albeit less profitable than restoration. The positive BCR indicates that even under extensive management, the system returns €1.16 for every euro invested. However, the relatively modest NPV reflects limited productivity gains and lower potential for revenue growth.

Table 10: Economic Performance

Indicator	**Restoration action**	**Reference**
Net Present Value (€/ha)	20,547	5,397
Benefit-Cost Ratio	1.29	1.16

Overall, the visual comparison of these indicators underscores the economic advantage of restoration-oriented management. While both systems surpass the minimum viability threshold, restoration offers a more robust return on investment, supporting its adoption as a financially sound strategy for long-term sustainability.



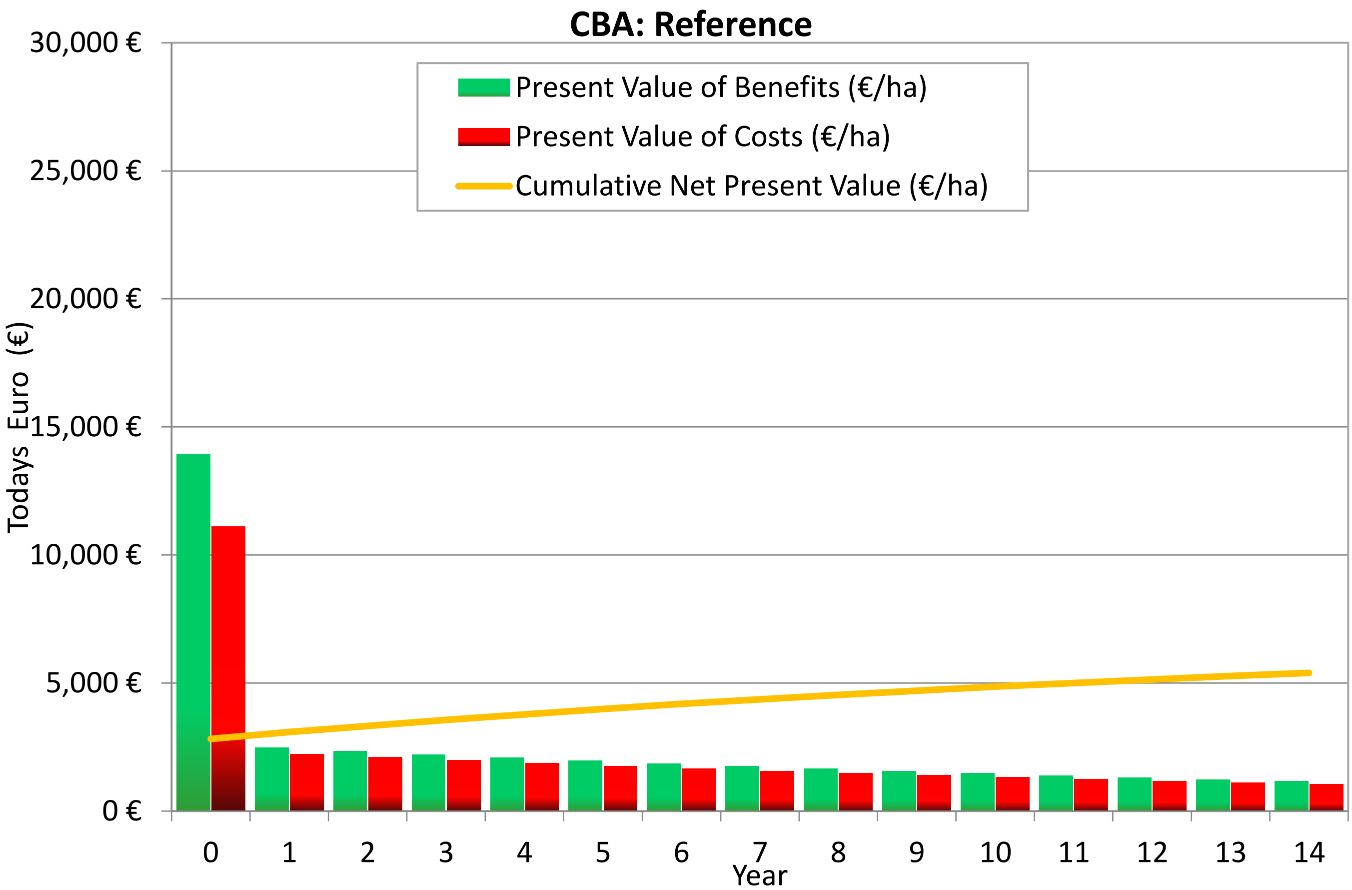


Figure 4: Present values of benefits and costs for the restoration action (top) and the reference case (bottom)

3.2.6 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

- Environmental Benefits
    - Reduction of soil erosion and flood risk
    - Improvement of soil physicochemical properties and restoration of soil health
    - Enrichment of groundwater reserves
    - Increase in biodiversity and wildlife refuge
    - Creation of tree-covered areas acting as a green lung
    - Improvement of local microclimate and temperature regulation
    - Method against soil desertification
- Social Benefits
    - Preservation of vegetated areas, vineyards, and olive groves
    - Development of neighboring areas and settlements
    - Recreational spaces for local communities
    - Agritourism and related activities
    - Employment opportunities for young workers
- Financial Benefits
    - Sustainable exploitation of resulting products
    - Additional income from potentially produced products
    - Increased plant-based food production
- Negative Environmental Effects
    - Increased risk of fire due to land-use changes
- Negative Social Effects
    - Potential abandonment of small rural areas and communities
    - Pressure on traditional farming systems and livelihoods
- Financial Costs
    - High cost of strategic planning and initial installation labor
    - Ongoing expenses for maintenance materials and irrigation water
    - Additional costs for awareness campaigns and stakeholder engagement
    - Need for alternative financing or employment due to reduced livestock activity
    - Reduction of arable land and agricultural zones
    - Decrease in plant-based food production

Reflection on how costs and benefits are distributed across groups

Economic Impacts:

- Farmers with larger landholdings are expected to benefit most from restoration actions due to long-term productivity gains, while small-scale farmers face challenges from high upfront costs for installation and maintenance.
- Local businesses and the tourism sector stand to gain from improved landscapes, agritourism opportunities, and new market prospects for carob-based products.

Social Impacts:

- Job creation during the establishment phase can strengthen local economies and provide opportunities for younger populations, reducing migration.

- Concerns were raised about marginalization of smallholders and the potential loss of traditional farming practices and cultural identity linked to livestock grazing.

Environmental Impacts:

- Broad recognition of environmental benefits such as reduced soil erosion, improved water management, and biodiversity enhancement.
- However, risks like increased fire hazard and changes in land use prompted discussions on sustainable design and integrated land management.

Effect on the Community/Region:

- While restoration actions can enhance socio-economic resilience and sustain farming activities in the long term, inequities in cost distribution particularly financial pose challenges for smaller-scale farmers and remote communities with less accessible plots.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

The main points discussed were:

- Financial support for farmers, especially small-scale, through targeted subsidies, grants, and CAP measures to offset installation and maintenance costs.
- Preservation of cultural and aesthetic values by integrating traditional elements into restoration designs and promoting local varieties.
- Improved technical design for restoration areas to incorporate hydrological and soil considerations, reducing environmental risks such as fire and erosion.
- Awareness and training programs to build capacity among farmers and agricultural workers, addressing knowledge gaps and promoting adoption of sustainable practices.
- Market development initiatives for carob and related products to ensure economic benefits reach local communities and reduce dependency on livestock income.

3.2.7 Summary and Policy Implications

This analysis provides strong economic justification for the professional implementation of forestation as a restoration strategy in the mountainous areas of Crete, compared to the traditional free-grazing system. The restoration scenario demonstrates substantial positive economic indicators, with a Net Present Value (NPV) of €20,547/ha and a Benefit-Cost Ratio (BCR) of 1.29, outperforming free grazing (NPV €5,397/ha; BCR 1.16) (Table 10). These results indicate that investments in forestation can deliver attractive long-term returns, despite the significant upfront costs.

Forestation involves high initial capital requirements €24,314/ha in investment subsidies and €94,210 total lifecycle costs (Tables 8 and 9) but generates lifecycle benefits of €129,453/ha and a present value of €91,071/ha, compared to €52,326 and €14,902/ha for free grazing (Table 6). Annual revenues from forestation range between €1,516–€9,747/ha, supported by substantial subsidies during the first five years (€5,764/ha) and maintenance support thereafter (€1,000/ha), which help mitigate early financial pressures (Table 6). Operating costs remain moderate, with labour (€2,850/ha) and fertilizer (€1,456/ha) as the main components (Table 7).

To facilitate wider adoption, targeted financial instruments such as grants or subsidies should be introduced to help local landowners overcome capital barriers. Restoration programs should also integrate capacity-building measures, including training in mechanized operations and sustainable forest management, to ensure long-term success and resilience in rural communities.

The poor economic performance of free grazing, while culturally significant, explains its declining viability under current market conditions. Without modernization or alternative support mechanisms, traditional grazing systems are unlikely to remain economically sustainable.

Beyond the economic dimension, forestation delivers significant environmental, social, and financial benefits for mountainous areas in Crete. Environmentally, it reduces soil erosion and flood risk, restores soil health, enriches groundwater reserves, and enhances biodiversity by creating wildlife refuges. Tree-covered areas act as a green lung, improving the local microclimate, regulating temperature, and serving as a method against soil desertification. Socially, forestation supports the preservation of vegetated areas, vineyards, and olive groves, fosters the development of neighboring settlements, and creates recreational spaces for local communities. It also promotes agritourism and generates employment opportunities, particularly for young workers. Financially, forestation enables sustainable exploitation of resulting products, offers additional income streams, and increases plant-based food production.

However, these benefits are accompanied by notable challenges. Environmental risks include an increased fire hazard due to land-use changes. Socially, there is potential abandonment of small rural communities and pressure on traditional farming systems. Financially, forestation entails high strategic planning and installation costs, ongoing maintenance and irrigation expenses, and additional costs for awareness campaigns and stakeholder engagement. Furthermore, reduced livestock activity may require alternative financing or employment solutions, while the conversion of agricultural zones could lead to decreased plant-based food production.

3.3 Stornara and Tara (IT): organic vs conventional table grape farming

3.3.1 General Information

In the Stornara and Tara area, farmers within the Consortium cultivate table grapes, together with citrus fruits, stone fruits, olives, and summer vegetables, primarily for major retail chains and export markets. The region features a maritime Mediterranean bioclimate, characterized by an average annual rainfall of 550 mm, mostly concentrated in autumn and winter. As a result, summer droughts are common, making irrigation essential from April to September.

Although farmers in the Consortium receive irrigation water, the scheduling is often inadequate. Compounding the issue, the soils in this area have low water retention capacity. Consequently, many farms depend on groundwater for irrigation. However, this reliance has led to aquifer overexploitation, resulting in increased water salinity and higher pumping costs.

By minimizing tillage and using high-quality fertilisers and irrigation water, soil health could be improved. Through organic farming and integrated crop management, a variety of benefits can be achieved. Furthermore, organically grown production can yield higher market prices

The cost-benefit analysis (CBA) compares two table farm production systems within the REACT4MED's Stornara and Tara pilot area in Italy:

a) organic table grape farm, and
b) conventional table grape farm.

In other words, the CBA sets a organic table grape farm ("technology") against a conventional table grape farming system ("reference") to assess and compare their financial feasibility.

(a) (b)

Figure 5: Restoration action (a) and reference case (b)

3.3.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon. Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The investment for the establishment of the organic table grape was made in 2021 (Year 0). Data for the analysis are derived from the 25-ha organic table grape farm and a 10-ha conventional table grape farm.

3.3.3 Benefits

The data in Table 11 compares the economic performance derived from both scenarios. Under the restoration action, annual grape revenues are significantly higher, ranging from €20,000 to €60,000 per hectare, compared to €20,000 to €37,500 in the reference case. Additionally, annual subsidies increase from €175/ha in the reference to €900/ha with restoration. An initial investment subsidy of €12,000/ha is also provided under the restoration scenario, which is absent in the reference. Over the entire lifecycle, the total benefits are greater under the restoration action (€529,970/ha) than in the reference scenario (€470,100/ha). However, the present value of these benefits is slightly lower in the restoration scenario (€313,156/ha) compared to the reference (€315,534/ha), indicating that while long-term benefits are higher with restoration, the timing of those benefits affects their discounted value.

Table 11: Annual Revenues

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from grape yield (range) (€/ha)	20,000 - 60,000	20,000 – 37,500
Annual subsidy (€/ha)	900	175
Investment subsidy – Year 0 (€/ha)	12,000	-
Total Lifecycle Benefits (€/ha)	**529,970**	**470,100**
Present Value of Benefits (€/ha)	**313,156**	**315,534**

3.3.4 Costs

<u>Annual Operating and Maintenance Costs</u>

Table 12 presents a comparison of annual operating and maintenance costs per hectare between the two scenarios. The restoration action introduces a small additional cost for organic certification (€60/ha), but significantly reduces labour expenses to €3,200/ha compared to €18,000/ha in the reference scenario, suggesting a shift in labour intensity or increased efficiency. However, costs for fertilizers and organic treatments are notably higher under restoration (€6,000/ha vs. €3,500/ha), likely reflecting the use of specialized organic inputs. Irrigation-related costs are lower in the restoration scenario for both energy (€40 vs. €145/ha) and water (€420 vs. €500/ha), possibly indicating more efficient water use. On the other hand, maintenance and consumables, as well as sales and distribution costs, are higher under the restoration action (€4,800 and €6,000/ha, respectively) compared to the reference scenario (€3,500 and €4,500/ha). These differences reflect trade-offs associated with transitioning to more sustainable practices, where some operational efficiencies are gained while others incur higher costs.

Table 12: Annual Operating and Maintenance Cost

Variable (€/ha)	**Restoration action**	**Reference**
Organic certification	60	
Labor (fixed and seasonal)	3,200	18,000
Fertilizers and organic treatments	6,000	3,500
Irrigation, energy cost	40	145
Irrigation, water cost	420	500
Maintenance and Consumables - total	4,800	3,500

Sales and Distribution - total	6,000	4,500

Capital (Year 0) Costs

Table 13 outlines the initial capital costs associated with establishing an organic table grape farm. The restoration action involves substantial upfront investment, totalling €60,500/ha across various categories, while no initial capital costs are reported for the conventional farm, reflecting an established operation with no recent setup expenses. For the organic farm, key cost components include land purchase (€20,000/ha), land preparation (€5,000/ha), and the purchase of vine cuttings (€4,000/ha). Additional investments include a drip irrigation system (€3,500/ha), which supports water efficiency critical for organic farming, and machinery and equipment, both basic (€25,000/ha) and specialized (€3,000/ha). These figures highlight the higher financial barrier to entry for organic farming, which often requires tailored infrastructure and equipment to meet certification and production standards. However, these investments can lead to longer-term sustainability, market premiums, and environmental benefits compared to conventional farming.

Table 13: Initial Capital Cost

Category (€/ha)	Restoration action	Reference
Land purchase	20,000	-
Land preparation	5,000	-
Purchase of vine cuttings	4,000	-
Irrigation system (drip)	3,500	-
Machinery and equipment: basic equipment	25,000	-
Machinery and equipment: tank and equipment	3,000	-

Total Costs

Table 14 compares the total costs associated with both scenarios. Despite the higher initial capital investment required for the organic farm, its total lifecycle costs amount to €368,300/ha, that is substantially lower than the €452,175/ha for the conventional farm. Similarly, when accounting for the time value of money, the present value of costs is also lower for the organic system (€265,687/ha) compared to the conventional one (€301,431/ha). This suggests that, over the long term, organic farming can be more cost-efficient than conventional farming, likely due to reduced labour, irrigation, and input costs, as reflected in previous tables. This challenges the common perception that organic systems are inherently more expensive and highlights their potential for financial sustainability alongside environmental benefits.

Table 14: Total Cost

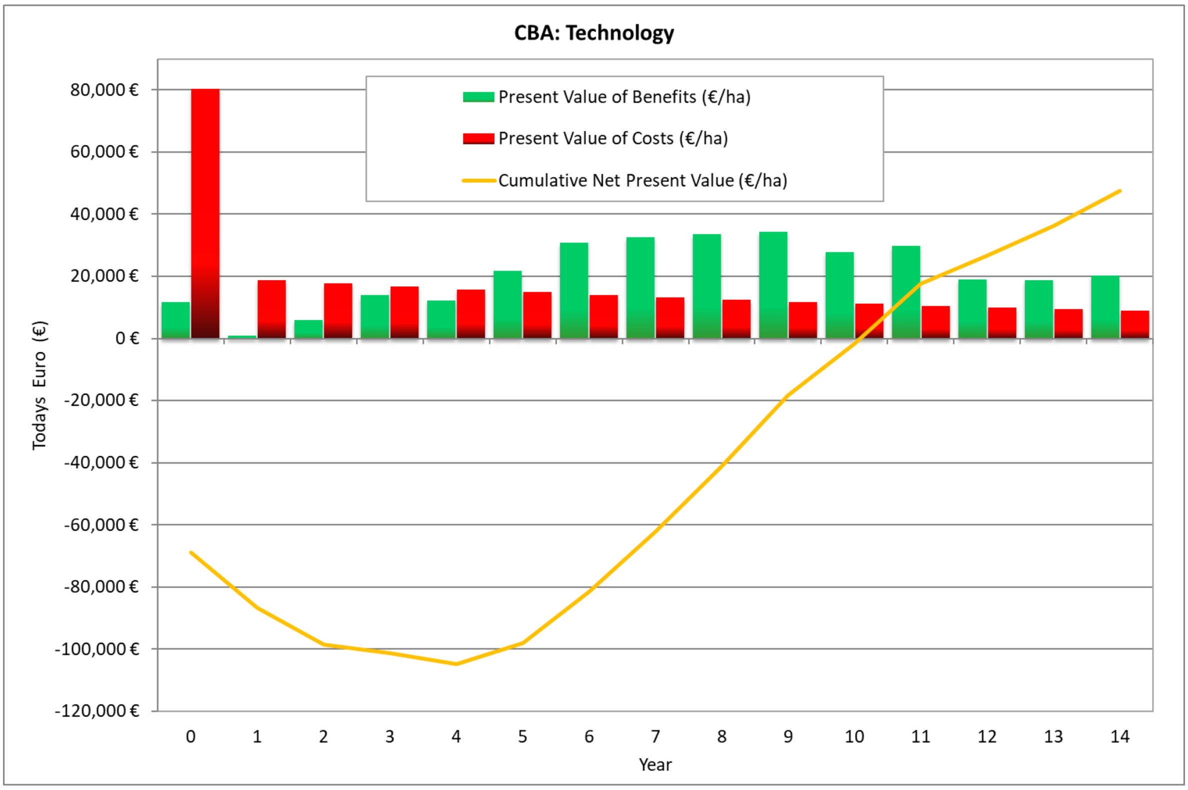
Category (€/ha)	Restoration action	Reference
Total Lifecycle Costs	368,300	452,175
Present Value of Costs	265,687	301,431

3.3.5 Economic Performance Indicators

Table 15 presents a comparison of the economic performance between the two scenarios. The data shows that the organic farm achieves a significantly higher Net Present Value (NPV) of €47,468/ha, compared to just €14,103/ha for the conventional farm. This indicates that, over time, the organic system generates greater net financial returns after accounting for all costs and the time value of money. Additionally, the Benefit-Cost Ratio (BCR) is more favourable in the organic scenario (1.18) than in the conventional one (1.05), meaning that every euro invested in the organic system yields a higher return. These results suggest that, despite higher initial investments and some increased operational costs, organic table grape farming in Apulia can be not only environmentally sustainable but also economically advantageous in the long term.

Table 15: Economic Performance

Indicator	Restoration action	Reference
Net Present Value (€/ha)	47,468	14,103
Benefit-Cost Ratio	1.18	1.05



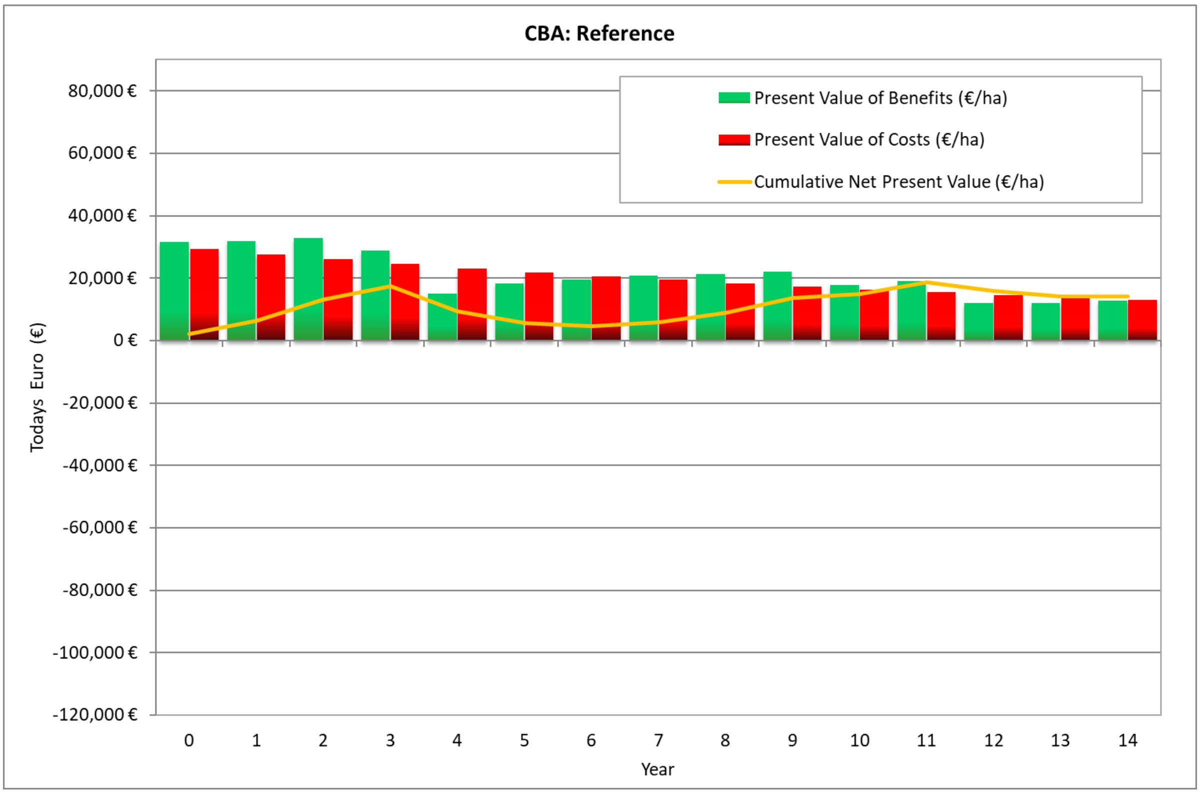


Figure 6: Present values of benefits and costs for the restoration action (top) and the reference case (bottom)

3.3.6 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

Main actor groups / Costs and benefits	**Implementing farmer/ land owner**	**Other farmers**	**General public**	**Government (support)**
On-site benefits/costs				
Environmental benefits	Biodiversity safeguard. Soil improvement. Better physical-chemical properties of soil. More environmental sustainability.	Improve organic matter in the soil	/	Application of environmental strategies for reaching programmatic objectives
Social benefits	Positive impact of health		Risk reduction related to the reduction in pesticides. Creation of a network for organic producers.	/
Financial benefits	Reduction of labor costs. More income.	Access to subsidies	Circular economy.	Respect of conditionality.
Neg. environmental effects	More perishability of consumables (e.g. need for use of more plastic in packaging). Less availability of products for pest management.	/	/	/
Negative social effects	/	/	Products are exposed to more quality alteration. Less labor means less job opportunities.	
Financial costs	/	/	Increase of product prices.	More investments. More controls.

Costs and Benefits of the restoration action and their distribution

The restoration action, centred on the adoption of organic farming, brings a range of environmental, societal, and financial benefits. Farmers benefit directly from improved soil quality and biodiversity, leading to more resilient ecosystems and reduced dependence on chemical fertilizers and pesticides. Over time, this translates into lower input and labour costs. On a societal level, organic farming supports environmental sustainability by integrating ecological principles into organizational practices and aligning agriculture with broader sustainability goals. Financially, both farmers and the public benefit through the promotion of circular economy principles, which emphasize resource efficiency and waste minimization. However, there are also notable costs. Consumers often face higher prices for organic products due to increased production costs and shorter shelf life, while labour-saving technologies may reduce job opportunities in the sector.

Reflection on how costs and benefits are distributed across groups

The distribution of costs and benefits among stakeholder groups is uneven. Farmers tend to gain most of the long-term environmental and economic benefits, particularly through improved soil health and reduced reliance on chemical inputs. Organizations also benefit by achieving sustainability goals and enhancing their environmental credentials. In contrast, consumers bear a disproportionate share of the financial costs, as they pay more for organic products and must manage issues like shorter shelf life and more limited availability. Additionally, certain labour sectors may be negatively affected due to reduced demand for manual work as organic farming becomes more technologically efficient. Thus, while the environmental benefits are broadly shared, the economic burdens fall more heavily on the general public and segments of the workforce.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

To create a more equitable distribution of the costs and benefits of organic farming in the table grape production, several strategies could be implemented. Providing subsidies or tax incentives for organic products can help reduce financial pressure on consumers, making sustainable food more accessible. Supporting farmers through training programs, technical assistance, and transition funding can ease the shift to organic practices and promote fair market access. Job retraining and upskilling initiatives for displaced workers would help mitigate employment impacts from reduced labour demand. At the policy level, governments could encourage community-supported agriculture models and introduce regulations that internalize the environmental costs of conventional farming, thereby levelling the playing field for organic producers and ensuring a fairer sharing of both the advantages and challenges of sustainable agricultural practices.

3.3.7 Summary and Policy Implications

This analysis provides a strong economic justification for organic table grape production by demonstrating its long-term environmental, social, and financial benefits, while also identifying critical areas for policy support. The transition to organic farming promotes biodiversity, improves soil health, and aligns with sustainability goals. It reduces dependence on chemical inputs and supports resilient agricultural systems, thereby fostering ecological balance and long-term productivity. Economically, organic methods can lower input and labour costs over time, supporting farmers' financial sustainability and contributing to broader public goods through the principles of the circular economy.

However, the transition also faces significant barriers, including high initial investments, a shortage of qualified personnel, limited dissemination of information, and insufficient political coordination. Unequal cost distribution also raises equity concerns. To address these challenges, a multi-dimensional policy approach grounded in sustainability, innovation, rural development, and inclusive governance is suggested.

Key policy implications include the need to support sustainable agricultural practices such as crop rotation and intercropping, provide targeted financial aid and training for farmers and technicians, and expand access to affordable, user-friendly technologies like AI tools. Strengthening rural tourism networks and promoting local culture can further valorise organic agriculture, while better communication with young people and educational institutions can ensure generational renewal in the sector. Additionally, policies must focus on simplifying regulations, improving political will, and empowering local cooperatives to enhance participative governance.

By addressing these systemic barriers and capitalizing on identified opportunities, policymakers can ensure that the benefits of organic table grape production are equitably distributed, economically viable, and environmentally sustainable in the long term.

3.4 Canyoles (ES): Orange plantations on sloping terraces with chopped pruned branches versus orange plantations with bare slopes

3.4.1 General Information

Intensive, chemical, irrigated, high investment and bare soils citrus production farms are widespread in the Eastern Spain, the northern location of a citrus production area in the world and close to the European market. The high quality of the oranges in Spain result is premium prices and the expansion of the citrus production for more than a century resulted in the colonization of the slopes and then the removal of the traditional dry-stone terraces to allow intense mechanization. New mechanically constructed terraces created with heavy bulldozers reshaped the slopes and induced high erosion rates. The sloping terrain and the bare soils (herbicides) results in high erosion rates. The REACT4MED research project studied the use of chipped pruned branches (instead of the traditional burning) as an option to reduce the non-sustainable soil erosion rates and to recover the soil health after decades of compaction, abuse of herbicides and pesticides.

The cost-benefit analysis (CBA) compares two citrus plantations along the last 15 years in the same slope and biophysical conditions (soils, topography, parent material, management with herbicides, orange variety) but under bare and chipped pruned branches mulch covered soils:

a) Orange plantation on sloping terrain with bare soils due to the abuse of herbicides. The chipped pruned branches (each March) are chopped with a tractor and the chopping machine in the inter-row.
b) Orange plantation on sloping terrain with bare soils due to the abuse of herbicides. The pruned branches (each March) are collected with a tractor and burnt.

Here we use the CBA sets the new restoration action (chipped pruned branches as a mulch cover) scenario ("technology") against the traditional bare soils as a consequence of the burning of the pruned branches ("reference") to assess and compare their financial feasibility.

3.4.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon. Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The investment for the restoration action was made in 2016 (Year 0). Data for the analysis are derived from the 1-ha restoration action and a 1 ha reference case. The reference and control plots are located in the Municipality of L'Alcúdia de Crespins in the province of Valencia and are a studied by the Soil Erosion and Degradation Research Group since 1996. The measurements done in this pilot areas with their owners and workers are related to infiltration rates, soil erosion, runoff generation, bulk density, plant cover, soil organic matter and soil fertility. We also assess the economic and social changes along the study period of three decades.

Figure 7: View of the pruned branches in the inter-row (upper left), chopped pruned branches (upper right), detail of the chopped pruned branches (lower left) and the bare inter-row due to the removal of branches (burnt) (lower right).

3.4.3 Benefits

We present the data in Table 16 which compares the economic impact of the cultivation of 1 ha of oranges (Navel Lane Late) in the Municipality of L'Alcúdia de Crespins under the restoration action and under the reference plot. The restoration action parcel shows an annual orange revenues of 118000 € for the 15 years of production. The revenue is similar 118000 € in 15 years for both farms. However, the annual subsidies increase from 30000 €/ha in the reference to 21000 €/ha. An initial investment subsidy of €2,000/ha is also provided under the restoration and 1400€ in the reference parces. Over the entire lifecycle, the total benefits are greater under the restoration action (148000 €/ha) than in the reference scenario (139000 €/ha). The present value of these benefits is slightly higher in the restoration scenario (88404 €/ha) compared to the reference (82404 €/ha), indicating the use of chipped pruned branches is beneficial for the economy of the farmers.

Table 16: Annual Revenues

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from crop yield (range) (€/ha)	118000	118000
Annual subsidy (€/ha)	30000	21000
Investment subsidy – Year 0 (€/ha)	2000	2000
Total Lifecycle Benefits (€/ha)	**148000**	**139000**
Present Value of Benefits (€/ha)	**88404**	**82404**

3.4.4 Costs

<u>Annual Operating and Maintenance Costs</u>

The research of the Soil Erosion and Degradation Research team in citrus plantations under chipped pruned branches management and burnt chipped pruned branches shown slight differences in the economic results. The restoration action with chipped pruned branches and the burnt chipped pruned branches shows the same cost in planting (5000 €), fertilization along the 15 years (33000 €) of investigation and machinery operation cost (4500 €). However, there are some few differences from the restoration practice and the reference one. The plant protection cost is found slightly more expensive (9000 €/ha) along the fifteen years of study since more insects that damage the crops are found with bare and crusted soils. The soils under the cover of the chipped pruned branches spent 7500 €/ha in the plan protection cost. The irrigation cost was also lower in the chipped pruned branches parcel where the mulch of the branches resulted in a proper cover to reduce evaporation and increase infiltration such as we measured in the field with rainfall simulators, ring infiltrometers and plots, then less water was lost due to surface runoff and more soil was storage instead to be lost. The results shown a cost of 19200 €/ha in the restoration action site and 33200 €/ha in the reference one. Labor cost was also lower in the restoration plot with 21400 €/ha of cost along 15 years meanwhile the one with the reference (chipped pruned branches versus burnt pruned branches) resulted in a cost of 21900 €. The land rent was the same for both plots.

Our measurements with the economic budget shown that these differences reflect benefits associated with transitioning to avoid the use of fire to remove the pruned branches, and then the use of chopping machinery to transform the branches into a mulch is very beneficial to reduce expenses (labour, pest control and water for irrigation) which make very promising the restoration action management.

Table 17: Annual Operating and Maintenance Cost

Variable (€/ha)	**Restoration action**	**Reference**
Planting cost	5000	5000
Fertilizer cost	33000	33000
Plant protection costs	7500	9000
Irrigation cost	19200	33200
Machinery operating costs	4500	4500
Other costs	0	0
Labour cost	21400	21900
Land rent	-	-

Capital (Year 0) Costs

Table 18 shows the cost of establishing the use of chipped pruned branches, which is 6000 € to adapt the tractor with a tool to chop the branches. This is an initial investment that the reference plot does not have and this is an extra expensive that make the farmers to withdraw from the use of the chipped pruned branches strategy.

The differences shown above reflect trade-offs associated with transitioning to more sustainable practices such as the chipped pruned branches. This is mainly a problem for farmers older that 60 as they see that the investment will not impact their economy. This is an example of the constrains that farmers found to change their management.

Table 18: Initial Capital Cost

Variable (€/ha)	**Restoration action**	**Reference**
Machinery and equipment: basic equipment	6,000	0

Total Costs

Table 19 shows the total costs of the chipped pruned branches and burnt pruned branches. The restoration action with chipped pruned branches shown a total amount of cost of 125,300 €/ha, meanwhile the reference one with the use of fire to remove the chipped pruned branches results in 106,600 €/ha along the 15 years of study. The Present Value of Costs is of 81,114 €/ha in the restoration action (chipped pruned branches) and 67,199 €/ha in the reference (burnt pruned branches). The measurements of the total lifecycle costs and Present value of cost suggest that, over the long term, restoration action can show higher costs.

Table 19: Total Cost

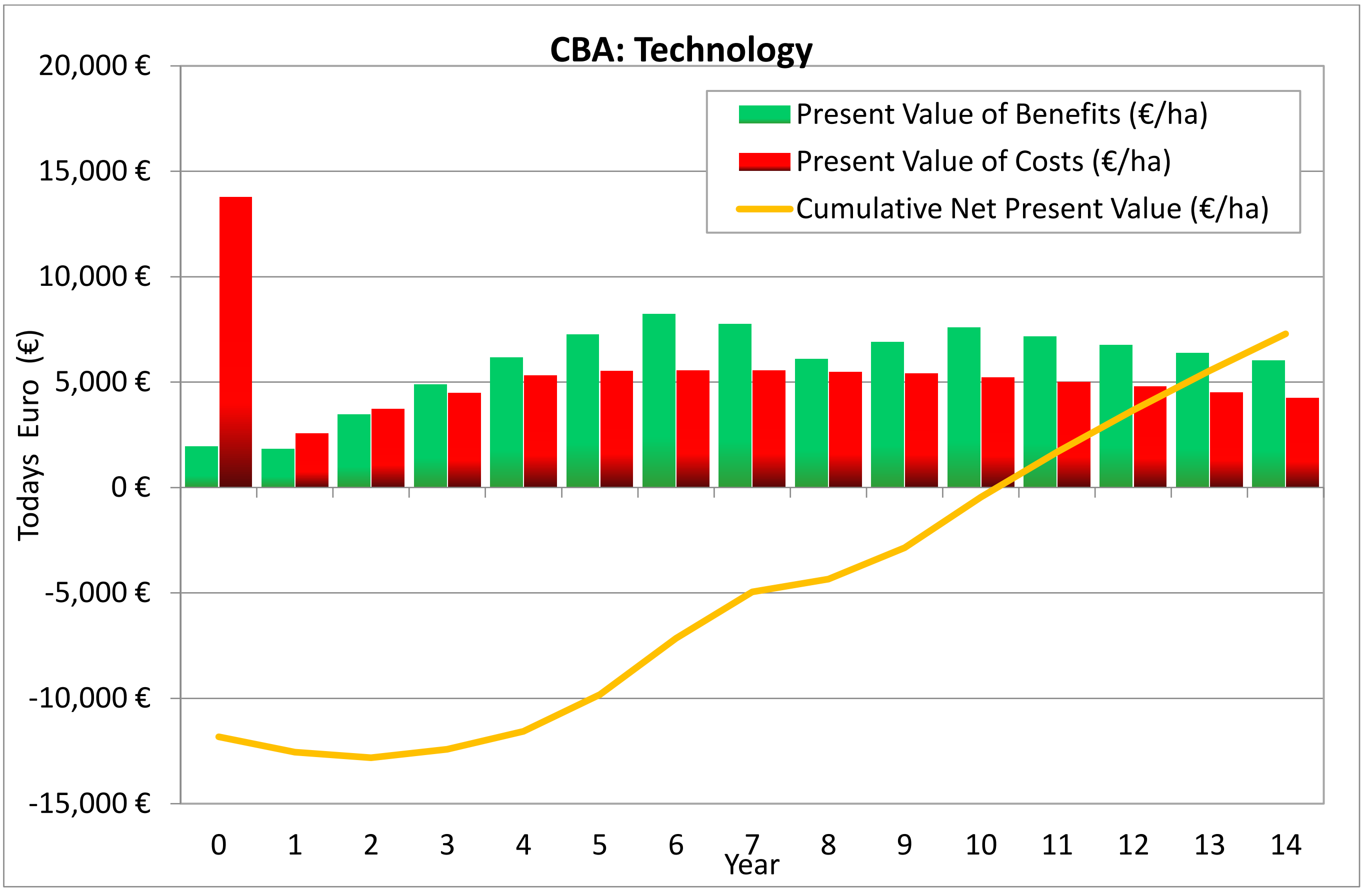
Category (€/ha)	Restoration action	Reference
Total Lifecycle Costs	125,300	106,600
Present Value of Costs	81,114	67,199

3.4.5 Economic Performance Indicators

Table 20 presents a comparison of the economic performance between the two scenarios: chipped pruned branches (restoration) and burnt pruned branches (reference). The data shows that the chipped pruned branches achieve a significantly lower Net Present Value (NPV) of 7,290 €/ha, compared to higher value €15,205 €/ha on the farm that burn the branches. This indicates that, over time, the burnt pruned branches generate greater net financial returns after accounting for all costs and the time value of money. Additionally, the Benefit-Cost Ratio (BCR) is more favourable in the burnt pruned branches scenario (1.30) than in the chipped pruned branches one (1.18), meaning that every euro invested in the burnt pruned branches yields a higher return. These results suggest that the transition to the use of burnt pruned branches are difficult mainly due to the initial investment in new machinery.

Table 20: Economic Performance

Indicator	Restoration action	Reference
Net Present Value (€/ha)	7,290	15,205
Benefit-Cost Ratio	1.18	1.3


CBA: Technology
Present Value of Benefits (€/ha)
Present Value of Costs (€/ha)
Cumulative Net Present Value (€/ha)
20,000 €
15,000 €
10,000 €
5,000 €
0 €
-5,000 €
-10,000 €
-15,000 €
Todays Euro (€)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Year

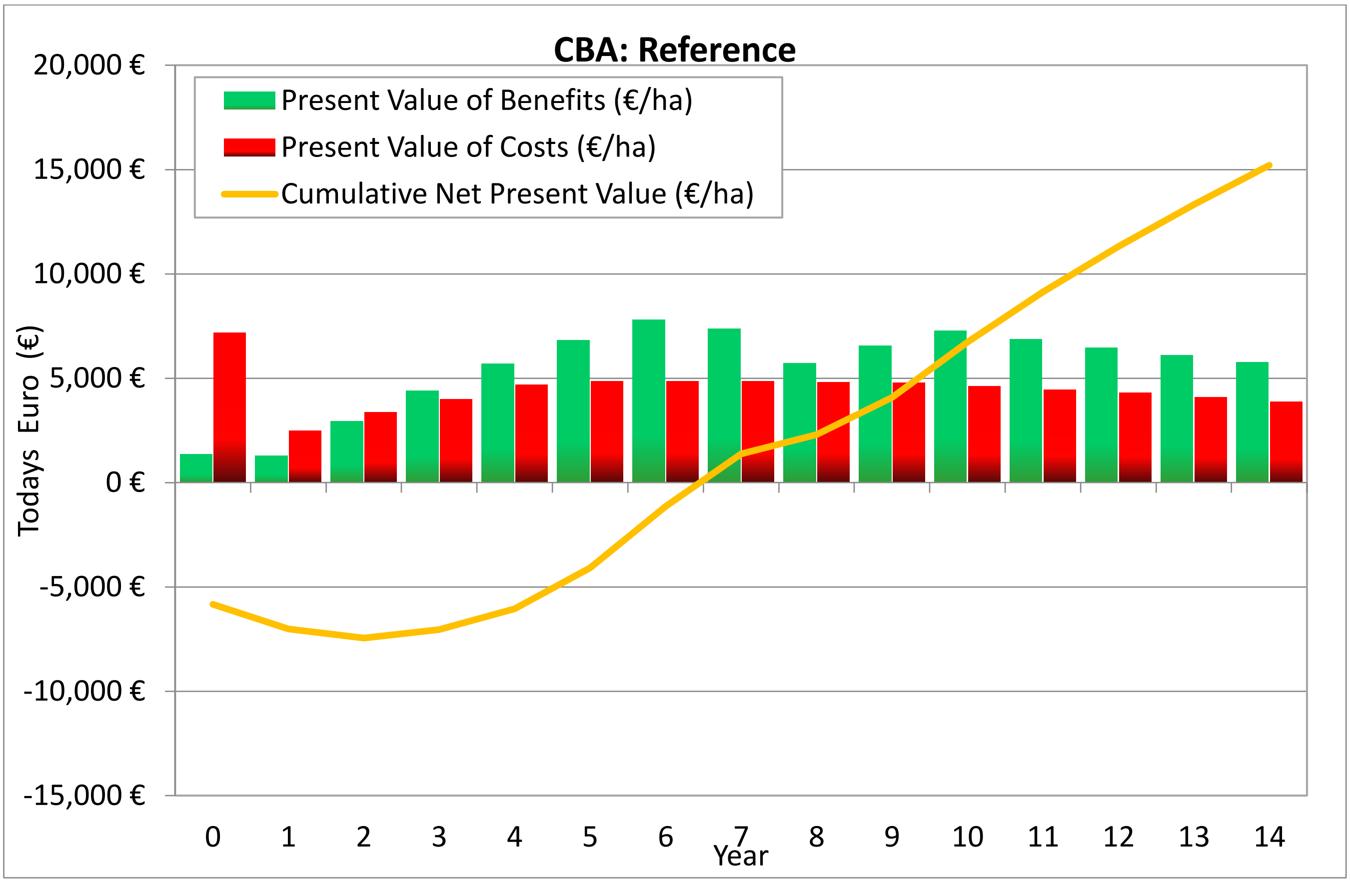

CBA: Reference
Present Value of Benefits (€/ha)
Present Value of Costs (€/ha)
Cumulative Net Present Value (€/ha)
20,000 €
15,000 €
10,000 €
5,000 €
0 €
-5,000 €
-10,000 €
-15,000 €
Todays Euro (€)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Year

Figure 8: Present values of benefits and costs for the restoration action (top) and the reference case (bottom)

3.4.6 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

Main actor groups / Costs and benefits	**Implementing farmer/land owner**	**Other farmers**	**General public**	**Government (support)**
On-site benefits/costs				
Environmental benefits	Soil improvement. More biota. More water infiltrated. Act as a mulch. Bring the fields to behave as a forest.	Improve organic matter in the soil and reduce the high and low temperatures in the soil,	They do not know the effect	Improve the quality of the soil and biodiversity
Social benefits	The tasks are mechanized, easier than burnt the branches	Better quality of jobs, higher salaries as the chipping machines request from a more specialized worker.	They do not see any impact	Improve the rights of the workers and permanent jobs
Financial benefits	There are subsidies that cover the expenses. No necessary labour.	The subsidies are relevant.	They do not know	At long term is more beneficial due to the long-term investment in machinery and reduction in labor costs
Neg. environmental effects	There is a lot of "dirt" as burning make the soil clean, and the plot tidy.	We see more pests	They do not know	No one
Negative social effects	Reduction of labour, less people will be contracted.	Immigrants will not have jobs when chipped pruned branches are applied as they are the lower class of workers (they use their hands)	They do not know	No one
Financial costs	It is more expensive in small fields	The increase in cost of benzine, machinery, reparations….	They do not know	It is more expensive at short time
Off-site benefits/costs				
Environmental benefits	Better regulation of the hydrological cycle, clean water in the rivers	We do not see any environmental benefit	They do not know	Improve the health of the ecosystems and agriculture land move to be managed as a forest
Social benefits	Improve the quality of the jobs as they are more qualified	The difficult works of burning branches is gone.	They do not know	Less workers but higher quality of jobs
Financial benefits	We power the industry that develops the machinery and the trade	More investment in machinery, which support other sectors	They do not know	At long term is a clever investment

Neg. environmental effects	Fungi and pests. Difficult to irrigate with flood irrigation	The arrival of wild board as a pest thanks to the chipped pruned branches and the improve in the soil biology	They do not know	No one
Negative social effects	Less workers are needed. Lower class of workers (no qualified) are not anymore necessary	Less jobs for the lower-class farmers. Immigrants.	They do not know	Reduction of the labour, and more unemployment in the immigrant's sector
Financial costs	It is more expensive	It is more expensive in small plots	They do not know	More expensive at short time.

The use of Chipped Pruned Branches as a restoration action to react against the land degradation of the Mediterranean on agriculture land is based on the effect of the chopped branches as a mulch. The use of Chipped Pruned Branches contributes to environmental benefits. The soil recovers the organic matter, increase infiltration, reduce soil and water losses due to surface flow and increase the biodiversity. Moreover, landowners receive subsidies from the European Union and this encourage them to use these strategies.

Along time, the improvements are reinforced due to the recovery of the soil quality, soil health and soil biodiversity. The constrain to the use of the chipped pruned branches is based on the perception of the farmers that the mulch from the chopped branches is dirt. This is due to a lack of knowledge on a generation of farmers educated in the Green Revolution, this means, with the use of pesticides and herbicides.

The use of chipped pruned branches contributes to a higher income with the subsidies but there are more costs due to the expenses to improve the machinery. The use of chipped pruned branches reduce the pesticide use (herbicides) and increase the water availability, however, the results is that the investment on new machinery induces the main cost and the difficulties to change the management.

Reflection on how costs and benefits are distributed across groups

The cost and benefits are contrasted. The farmers with large properties are more efficient in the investment in new machinery as the cost per ha is lower that on farms of small plots. The studies at the Soil Erosion and Degradation Research Group demonstrate that the use of chipped pruned branches is dependent on the size of the plots. The importance of the cooperatives is low in the production of citrus, and they can not help to reduce the cost of the machinery. The environmental benefits of the use of chipped pruned branches mulches are well known within the scientific community but is not relevant and well accepted by the farmers. The landowners use chipped pruned branches mulches when they can be economically viable, and this is in properties with more than 5 ha.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

To create a more equitable distribution of the costs and benefits with the use of chipped pruned branches mulches are two: i) increase the subsidies to encourage the acquisition of the new machinery to chop the branches; ii) and facilitate the use of machinery by a group of farmers, and then it is necessary to promote the Unions and Cooperatives.

There is a third option to shift into the use of chipped pruned branches mulches. This is the increase in the literacy of the farmers. This will help to boost the shift from burnt chipped pruned branches and chipped pruned branches. A fourth option is to provide subsidies or tax incentives for the use of chipped pruned branches.

3.4.7 Summary and Policy Implications

The research of the Soil Erosion and Degradation Research Group analyse the impact of chipped pruned branches on citrus plantations. Our research demonstrates that the cost of the machinery to chop the branches is the main constrain to expand the use of the restoration action. Farmers with the large properties are applying the new strategy as it is less costly that for small properties. The subsidies are relevant in the decision of the farmers, and the reduction in cost of pesticides and irrigation, however, the main constrain is the cost of the new machinery. The new policies must: i) support the farmers to buy the machinery; ii) encourage the development of cooperatives; iii) increase the subsidies; and, iv) increase the literacy of the farmers.

3.5 Merchouch (MO): No-till vs conventional farming

3.5.1 General Information

No-till or zero tillage is a technology that originated to combat erosion and to cope with rising energy prices. It consists of three pillars designed to ensure jointly the protection and strengthening of soil health, both physically and biologically, namely: 1) Eliminating tillage; 2) Maintaining permanent ground cover; and 3) Practicing long and diverse crop rotations. At the farm level, no-till leads to reduced mechanization, fuel, and labor costs. Integrating other crops, particularly legumes, into the rotation further reduces nitrogen fertilization costs. Improved water use efficiency and stable, or even increased, yields in the medium and long term are additional benefits for farmers (Figure 9).

However, no-till also presents costs for agricultural producers. This practice require the acquisition of specialized equipment for seeding and the application of additional herbicides, at least during the first growing seasons, for weed management. Indeed, eliminating tillage deprives farmers of their primary means of weed control. The transition from conventional mode (tillage) to no-till mode leads to changes in soil biological processes and weed composition. It should be noted, however, that crop residues left in the fields also represent a potential cost, especially for small and medium-sized farms with highly integrated crop and livestock systems. These residues are used in animal feed.

Figure 9: Restoration action (a) and reference case (b)

In Morocco, research on no-till began in 1983 and has continued to this day. Regarding technology transfer, numerous actions have been undertaken since the early 1990s. In 2009, this technology was retained as an adaptation measure within the framework of the national plan to combat climate change. Subsequently, it was integrated into the implementation of projects under the agricultural strategy «Green Morocco Plan 2008-2020" completed in 2020. During this period, the ceilings of incentives for the acquisition of seed drills for no-till were revised upwards. The ongoing agricultural strategy "Generation Green 2021-2030" has reiterated the interest in no-till by dedicating a program to it aimed at reaching one million hectares by 2030.

The REACT4MED research project studied the use of no-till as an option to reduce soil erosion and to recover the soil health as an alternative to conventional mode (tillage). A cost-benefit analysis (CBA) was carried out for a farm (project promoter), over a 15-year planning horizon, considering two alternatives:

a) No-till farming mode (restoration action) :
b) Conventional farming mode (reference case) :

In other words, the CBA compares the alternative of total conversion of the farm under consideration to no-till (restoration action) with the alternative of continuing the practice of the conventional mode (reference case) in order to assess and compare their financial feasibility.

3.5.2 Methodological assumptions

As mentioned previously, the CBA focussed on the conversion of a farm to no-till. The farm is located in the Zaer region, which has a Mediterranean climate, with cool, wet winters and hot, dry summers.The farm's production system is based on the integration of crops and sheep farming. The farm has an agricultural area of 400 ha. The crops grown are soft wheat (267 ha/year) and lentils (133 ha/year). The analyses carried out covered both crops grown. However, the results presented below only concern the cultivation of soft wheat under the two production modes considered. All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon. Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The investment for the restoration action was made in 2024 (Year 0). Data for the analysis are derived from the 267-ha restoration action and a 267-ha reference case.

3.5.3 Benefits

Table 21 shows the annual revenues, investment subsidies, and profits for the two soft wheat cultivation management systems considered. The benefits taken into account relate to the production of grain, straw as well as the grazing of stubble by farm animals. Regarding stubble grazing, we considered the rental price applied at the Zaer area (opportunity cost) for plots managed conventionally; while for those managed with no-till, we only considered two-thirds of this price because farmers should leave at least one-third of the stubble on the plots.

Table 21: Annual Revenues

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from crop yield (range) (€/ha)	1300.00	1125.00
Annual subsidy (€/ha)	-	-
Investment subsidy – Year 0 (€/ha)	291.38	260.88
Total Lifecycle Benefits (€/ha)	19500.00	16875.00
Present Value of Benefits (€/ha)	12999.18	11249.29

Under the restoration plan, annual revenues from soft wheat crop amount to 1300 €/ha/year, compared to 1125 €/ha/year for the reference scenario, representing an increase of nearly 16%. The amounts of investment subsidies are 291.38 €/ha for the restoration scenario and 260.88 €/ha for the reference scenario. Over the entire lifecycle, the total benefits are greater under the restoration action (19500 €/ha) than in the reference scenario (16875 €/ha).

3.5.4 Costs

Annual Operating and Maintenance Costs

When establishing the annual operating and maintenance costs, we considered the current practices of agricultural producers who, for the no-till mode, are in their early stages. In other words, although adopting no-till mode allows for savings in seeds and fertilizers in the medium to long term, we considered the same doses of these inputs for both modes considered (Table 22). For the estimation of these costs per ha, the standards used (fuel, labor, etc.) were established on the references consulted supplemented by interviews with agricultural producers. The prices of agricultural inputs applied correspond to those observed during the 2024-2025 agricultural campaign. Family labor was assessed through the daily wage of the local agricultural labor market (opportunity cost).

Table 22: Annual Operating and Maintenance Cost

Variable (€/ha)	Restoration action	Reference
Planting cost	59.25	59.25
Fertilizer cost	99.50	99.50
Plant protection costs	90.50	69.50
Irrigation cost	-	-
Machinery operating costs	82.50	128.75
Other costs	-	-
Labour cost	32.38	34.75
Land rent	175.00	175.00

For conventional mode, land rent accounts for 31% of total annual variable costs, followed by machinery operating costs (23%) and fertilizers (18%). For no-till mode, land rent accounts for 32% of total annual variable costs, followed by fertilizers (18%) and plant protection (17%). The transition from conventional to no-till farming results in increased costs associated with crop protection (30.2%) on the one hand, and reductions in operating costs for machinery (-35.9%) and agricultural labor (-6.8%) on the other. These changes correspond to a total annual operating and maintenance cost reduction estimated at nearly 5%.

Capital (Year 0) Costs

The required investments in agricultural equipment for each farming method were elaborated based on interviews with experienced farmers who practice conventional farming and those who practice no-till farming. Taking into account the planning horizon chosen (14 years) and the depreciation duration, a program for the implementation and renewal of agricultural equipment was designed for each production mode considered. Subsequently, interviews with officials responsible for granting agricultural subsidies and the sellers of agricultural equipment made it possible to generate the prices (excluding subsidies) of the identified equipment. Based on the rates and subsidy ceilings, financial prices were generated and made it possible to calculate the total investment required for each production mode considered. The net investment amounts were estimated by taking into account the residual values of agricultural equipment calculated on their depreciation durations and their annual depreciation charges.

Table 23: Initial Capital Cost

Variable (€/ha)	Restoration action	Reference
Tractors	189.00	189.00
Tillage equipment	-	114.00
Sowing equipment	98.00	63,00
Fertilizer and pesticide equipment	39.15	39.15
Harvesting equipment	378.48	378.48
Transport equipment	35.00	35.00

Table 23 shows the amounts of initial net investments required, expressed in euros/ha, broken down according to the types of agricultural equipment and according to the two production modes retained. For the conventional mode, harvesting equipment represents 46% of the net
investment followed by tractors (23%) and ploughing equipment (14%). For no-till mode, harvesting equipment represents 51% of the net investment followed by tractors (26%) and sowing equipment (13%). The transition from conventional to no-till farming reduced the net investment by almost 10%. It should be noted, however, that this observed decrease in investment is explained by the fact that we considered seed drills manufactured in Morocco and not imported ones, which are more expensive.

Total Costs

Table 24 presents the total costs of the two alternatives considered for the production of soft wheat. Total lifecycle costs amounts to 8226.88 €/ha for the restoration action related to the no-till mode and to 9320.25 for the reference situation associated with the conventional mode. The present value of costs is 6486.14 €/ha for the reference situation and 6130.91 €/ha for the restoration action, representing a reduction rate of approximately 5.5%.

Table 24: Total Cost

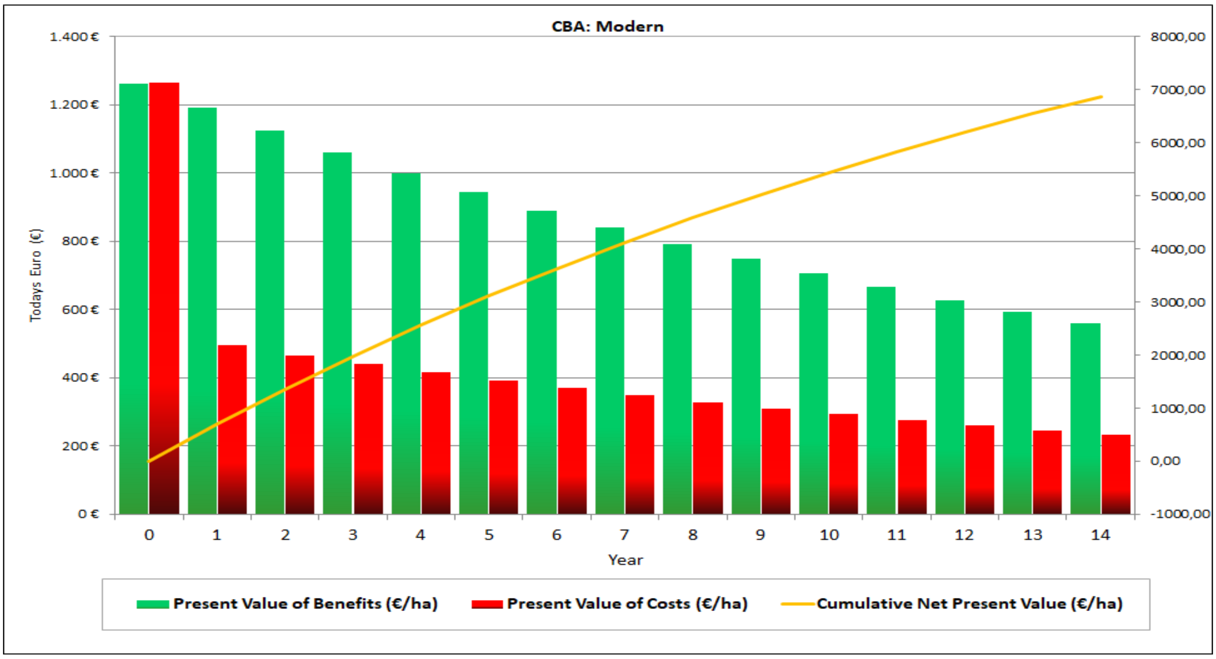
Category (€/ha)	**Restoration action**	**Reference**
Total Lifecycle Costs	8826.88	9320.25
Present Value of Costs	6130.91	6486.14

3.5.5 Economic Performance Indicators

Table 25 presents a comparison of the economic performance between the two alternatives: no-till and conventional modes. The data shows that no-till achieves a net present value of 6868.27 €/ha, significantly higher than that associated with the conventional mode (4763.15 €/ha). Additionally, the Benefit-Cost Ratio is more favourable in the no-till alternative (2.12) than in the conventional alternative (1.73), meaning that every euro invested in the no-till yields a higher return. These results suggest that, despite initial investments and some increased operational costs (weed management), no-till farming in Zaer region can be not only environmentally sustainable in the long term but also financially advantageous for agricultural farms.

Table 25: Economic Performance

Indicator	**Restoration action**	**Reference**
Net Present Value (€/ha)	6868.27	4763.15
Benefit-Cost Ratio	2.12	1.73



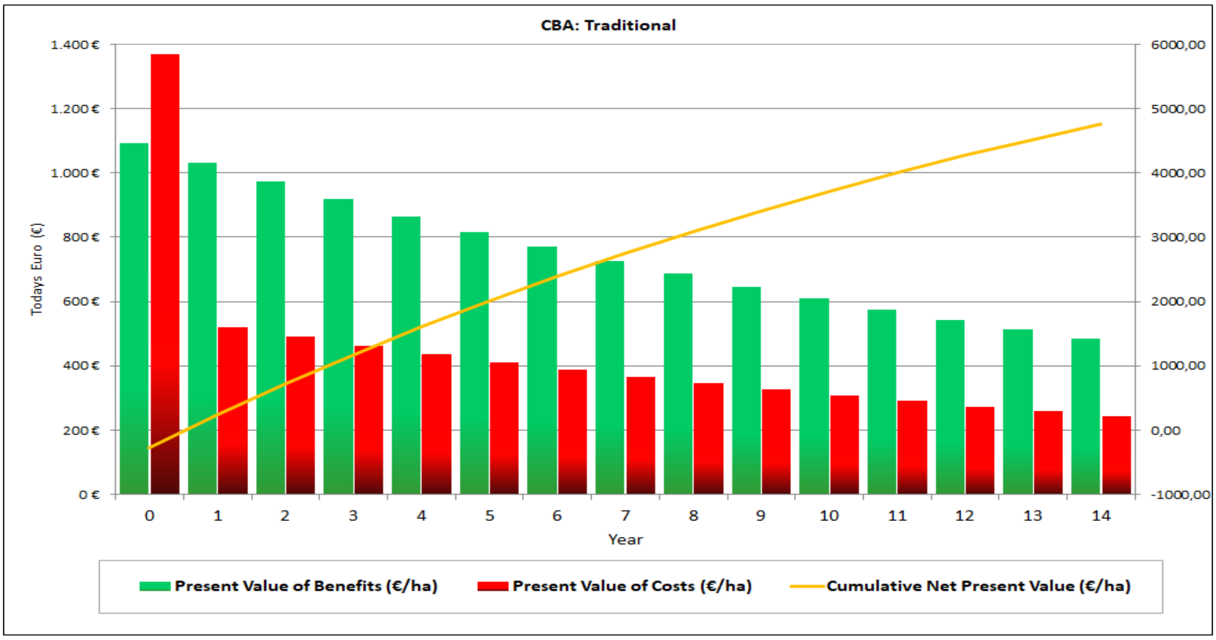


Figure 10: Present values of benefits and costs for the restoration action (top) and the reference case (bottom)

3.6 Bethlehem of Galile (IL): Food forest versus natural forest

3.6.1 General Information

The Bethlehem of Galilee pilot area, located in northern Israel, represents a pioneering example of agroforestry-based ecological restoration in a semi-arid Mediterranean environment. The site, formerly an abandoned agricultural field, has been restored since 2017 through the establishment of a Food Forest, integrating diverse perennial trees, shrubs, and ground cover crops under regenerative principles. The restoration action aims to enhance soil fertility, water retention, biodiversity, and landscape resilience while generating local food production. The reference site used for comparison is the Alonie Aba Natural Forest, a nearby undisturbed woodland that serves as a stable ecological benchmark for long-term ecosystem integrity.

The cost-benefit analysis (CBA) compares the restored Food Forest (“technology”) with the Alonie Aba Natural Forest (“reference”) over a 15-year horizon (2017–2031), assessing the economic feasibility and ecosystem service returns of restoration under Mediterranean dryland conditions.

The cost-benefit analysis (CBA) compares:

a) The restored *Bethlehem of Galilee Food Forest*, and
b) the *Alonie Aba Natural Forest* as a natural reference.

Figure 11: Restoration action (a) and reference case (b)

3.6.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 4.5% over a 15-year horizon. Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The investment for the restoration action was made in 2017 (Year 0). Data for the analysis are derived from the 0.6-ha restoration action and a natural forest reference case.

3.6.3 Benefits

For the Food Forest restoration site, the benefits derive primarily from ecosystem services and social value rather than direct crop yield. These include enhanced soil moisture and fertility, improved vegetation cover, carbon sequestration, biodiversity support, and community engagement through educational and ecotourism activities. The restoration area exhibits consistent gains in vegetation indices and surface moisture (NDVI, SMCI), reflecting improved ecological function. Monetary benefits are derived from the coffee shop, ecotourism and educational events.

In contrast, the Natural Forest (reference) provides mature ecosystem services such as high carbon storage, stable hydrological regulation, and biodiversity habitat but generates limited new economic activity. The comparative CBA thus reflects non-market environmental benefits and avoided degradation costs as the main sources of value for the restoration case, while the reference remains a benchmark of ecological stability.

Table 26: Annual Revenues for 0.6 ha

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from crops and coffee shop (€)	5,082 – 17,789	0
Annual revenue from events (€)	13,371	0
Annual subsidy (€)	1,000	0
Investment subsidy – Year 0 (€)	1,000	0
Total Lifecycle Benefits (€)	387,843	0
Present Value of Benefits (€)	267,982	0

3.6.4 Costs

Annual Operating and Maintenance Costs

Table 27 summarizes the recurring annual costs related to the management of the Bethlehem of Galilee food forest compared to the adjacent natural forest reserve, Alonie Aba. The main cost components include labour, irrigation, organic inputs, and maintenance of agroforestry infrastructure. Inputs in the food forest are mainly organic - including compost, mulch, and biochar- produced or sourced locally. Fertilizer and chemical plant-protection costs are negligible, as biological pest control and soil enrichment through composting replace synthetic inputs. Water use is managed through drip irrigation fed by reclaimed water and rain-harvesting systems, resulting in moderate but steady irrigation expenses.

Labour represents a major share of total annual costs in the food forest, as pruning, mulching, planting diversity maintenance, and harvesting are carried out manually or with light machinery. Other costs include the purchase and maintenance of small-scale tools, composting materials, and routine soil and vegetation monitoring. The total cost increased over time with the maturing and expansion of the food forests, with approximate total annual cost ranging between 13,000 €/ha at the start of the food forest development and 21,000 €/ha in year 15.

Table 27: Annual Operating and Maintenance Cost in year 15

Variable (€/ha)	**Restoration action**	**Reference**
Planting cost	1,100	0
Fertilizer cost	870	0
Plant protection costs	900	0
Irrigation cost	3,549	0
Machinery operating costs	850	0
Other costs	5,582	0
Labour cost	8,500	0
Land rent	0	0

Capital (Year 0) Costs

The establishment of the food forest required moderate initial investments (Table 28), primarily for land preparation, planting, irrigation infrastructure, and composting facilities. These data were also reported (in USD for the 0.6 ha site) in the WOCAT technology database. Unlike mechanized systems, no heavy earth-moving machinery or terrace construction was needed. Instead, costs were driven by the diversity of tree and shrub species, installation of drip irrigation lines, and soil-health infrastructure such as mulching pits and compost bins. In contrast, the adjacent Natural Forest represents an unmanaged reference ecosystem, with no capital or operational costs, as no restoration actions or maintenance are applied.

Table 28: Initial Capital Cost

Variable (€/ha)	Restoration action	Reference
Labor	31518	0
Tools	7167	0
Tractor	10320	0
Seedlings	20067	0
Compost	15050	0
Irrigation system	20783	0
Total	114,222	0

Total Costs

Table 29 presents the total life-cycle costs of the food forest. The food forest involves relatively high early-stage and labour-related expenditures due to its regenerative management approach and continuous maintenance needs. However, these investments contribute to improved soil health, higher biodiversity, and reduced dependency on external inputs. Over time, the system's self-regulating dynamics and lower reliance on chemicals are expected to stabilize or even reduce costs relative to conventional management.

Table 29: Total Cost

Category (€/ha)	Restoration action	Reference
Total Lifecycle Costs	367,172	0
Present Value of Costs	289,367	0

3.6.5 Economic Performance Indicators

The cost-benefit analysis of the Bethlehem of Galilee Food Forest over the 15-year period (2017–2031) reveals that, although the system incurs high establishment and annual management costs, it provides long-term ecological and social returns that justify its investment. The total lifecycle costs amount to approximately €321,483, with a present value of costs of €243,678 when discounted at 6% (Table 29). The restoration site generates modest but steady annual revenues derived from educational activities, and small environmental grants, with an estimated present value of benefits around €267,982 for the 0.6 ha site (Table 26). Theoretically, this would convert to €446,637 per ha. Based on this theoretical assumption, the food forest would exhibit a positive Net Present Value of €157,270 per ha and a positive benefit-cost ratio (1.54), showing that the investment is financially profitable.

The food forest's primary returns are non-market ecosystem services- including soil fertility enhancement, biodiversity recovery, microclimate regulation, and carbon sequestration- that are not captured in direct monetary terms. When these non-market benefits are considered through avoided degradation and social co-benefits (education, recreation, community engagement), the system demonstrates strong ecological and social viability, even if short-term financial profitability is negative.

This finding highlights a central insight of the REACT4MED analysis: in dryland restoration contexts, low-input, multifunctional systems such as the food forest can achieve significant long-term resilience and ecosystem value, even when initial financial returns are modest. The Natural Forest reference, by contrast, incurs no costs and no new revenues, serving solely as an ecological benchmark rather than an economic alternative.

Table 30: Economic Performance

Indicator	Restoration action	Reference
Net Present Value (€/ha)	157,270	0
Benefit-Cost Ratio	1.54	0

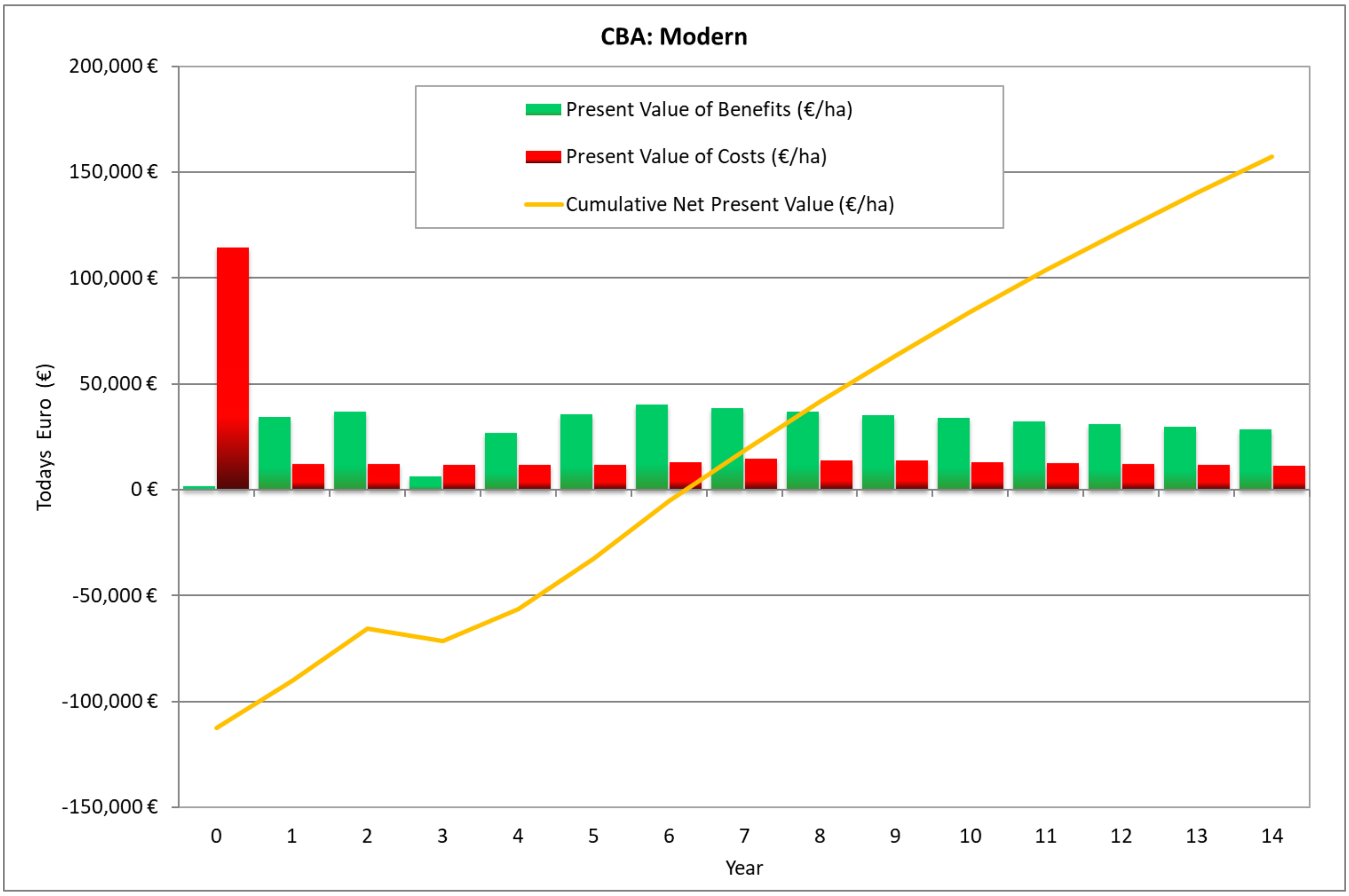


Figure 12: Present values of benefits and costs for the restoration action.

3.6.6 Summary and Policy Implications

This analysis highlights the multi-functional and long-term ecological value of the food forest system implemented in Bethlehem of Galilee, Northern Israel. While the natural forest reserve, Alonie Aba serves as an undisturbed ecological benchmark, the food forest demonstrates how human-assisted restoration can achieve comparable or even enhanced resilience under Mediterranean climatic stress. Despite high establishment and maintenance costs, the Food Forest delivers substantial co-benefits- including improved soil structure, enhanced biodiversity, and microclimatic regulation- that are not captured by traditional financial indicators.

From an economic perspective, the system's low Net Present Value reflects the absence of significant market revenues, yet this does not diminish its social and ecological profitability. The site provides educational, recreational, and community engagement benefits, positioning it as a living laboratory for sustainable land management.

To support the replication and scaling-up of similar restoration actions, policy frameworks should:

- Recognize ecosystem services (e.g., soil fertility, carbon storage, biodiversity) as measurable economic assets within cost-benefit assessments.

- Introduce payment-for-ecosystem-services (PES) schemes or green subsidies that reward land managers for ecological restoration.
- Encourage the integration of community-based agroforestry models into rural development and agri-environmental programs.
- Promote capacity-building and knowledge transfer for farmers, municipalities, and young practitioners interested in regenerative land management.

Overall, the results highlight the importance of collaborative and locally adapted restoration approaches. Small-scale agroforestry initiatives, such as the food forest in Bethlehem of Galilee, demonstrate strong potential to strengthen rural livelihoods, improve food self-sufficiency, and enhance environmental awareness, making them key components of climate-resilient Mediterranean landscapes.

3.7 Lower Gediz (former Menemen) (TR)

3.7.1 General Information

The restoration action tested in the Lower Gediz (Menemen Plain) pilot area is the installation of subsurface drainage systems to alleviate salinity–sodicity and shallow groundwater pressure. The reference case is non-drained fields under current farmer practices. Cotton is the main crop in both scenarios, and yield, input use and financial indicators were collected from side-by-side fields under the same agro-climatic conditions. The restoration measure comprises buried lateral drains, collector connections and routine maintenance. Expected impacts include: (i) reduced salt accumulation in the root zone, (ii) improved plant water and nutrient uptake, (iii) timely access to fields and higher labour efficiency, and (iv) yield stabilisation in the medium term.

The cost–benefit analysis (CBA) compares:
a) cotton production with subsurface drainage (restoration action), and
b) cotton production without drainage (reference case).

Figure 13: Restoration action (a) and reference case (b)

3.7.1 Methodological assumptions

All cash flows are expressed per hectare (€/ha) in constant 2024 euros, discounted at 6% over a 10-year horizon, reflecting the economic lifetime of the drainage system. Recurrent items are considered as mid-year flows, while lump-sum investments are discounted from the start of the relevant year. Year 0 is 2023, with data derived from a 3-ha drained field (restoration) and a 3-ha undrained field (reference).

3.7.2 Benefits

Drainage improves cotton yield and gross revenues. The drained case achieves annual revenues in the range of €3,143–6,701/ha compared with €3,143–5,438/ha in the reference. Direct income support payments are slightly higher in the drained scenario (€206–300/ha) than in the reference (€206–257/ha). No investment subsidies are considered. As a result, total lifecycle benefits are €59,500/ha for the drained case and €52,619/ha for the reference, with present values (PV) of €44,000/ha and €39,280/ha, respectively (Table 31).

The main mechanism is improved root-zone conditions through drainage, which prevents salt and waterlogging stress. This not only increases average yields but also reduces year-to-year variability, leading to higher and more stable farm income.

Table 31. Annual Revenues (€/ha) – Lower Gediz Pilot Area (Cotton)

Variable (unit)	Restoration action (with drainage)	Reference (without drainage)
Annual revenue from crop yield (range)	3,143 – 6,701	3,143 – 5,438
Annual subsidy (€/ha)	206 – 300	206 – 257
Investment subsidy – Year 0 (€/ha)	0	0

Total Lifecycle Benefits (€/ha)	59,500	52,619
Present Value of Benefits (€/ha)	**44,000**	**39,280**

3.7.3 Costs

Annual Operating and Maintenance Costs

… Annual operating and maintenance costs show moderate differences. Fertiliser, machinery and labour costs are slightly higher in the drained field due to increased productivity (e.g., labour €555.6–634.9/ha vs. €444.5–508.0/ha in the reference). Other input categories remain similar, with details provided in Table 32.

The restoration requires a one-time capital investment of €3,333/ha for the drainage system in Year 0 (Table 33). No such investment is needed in the reference case.

Table 32. Annual Operating and Maintenance Costs (€/ha) – Lower Gediz Pilot Area (Cotton)

Variable (€/ha)	Restoration action (with drainage)	Reference (without drainage)
Planting cost	152.0	152.0
Fertilizer cost	381.0 – 613.7	381.0 – 583.0
Plant protection costs	0	0
Irrigation cost	57.1 – 64.0	57.1 – 63.5
Machinery operating costs	63.5 – 111.1	63.5 – 89.0
Other costs	51.0 – 79.4	51.0 – 63.5
Labour cost	555.6 – 634.9	444.5 – 508.0
Energy cost	429.0 – 476.2	429.0 – 476.2
Maintenance and repair	38.5 – 63.5	38.5 – 51.0
Land rent	260.0	260.0

Capital (Year 0) Costs

The restoration scenario required a one-time investment of €3,333/ha for the installation of subsurface drainage infrastructure. This cost represents the purchase and installation of buried lateral pipes and collector connections. In the reference case, no capital expenditures were made, as fields were managed under existing farmer practices without drainage improvements.

Table 33. Initial Capital Cost (€/ha) – Lower Gediz Pilot Area (Cotton)

Variable (€/ha)	Restoration action (with drainage)	Reference (without drainage)
Drainage system	3,333	–

Total Costs

Over the 10-year appraisal period, the restoration case (with drainage) and the reference case (without drainage) show similar total lifecycle costs, despite the upfront drainage investment. The drained fields incurred €24,694/ha in total lifecycle costs compared with €25,217/ha in the reference. When expressed in present value terms, costs amount to €19,465/ha for the drained case and €16,346/ha for the reference (Table 34). This indicates that while drainage requires an initial capital outlay, operational efficiency and stabilised input use offset these costs over time, resulting in comparable overall expenditures.

Table 34: Total Cost

Category (€/ha)	**Restoration action**	**Reference**
Total Lifecycle Costs	24,694	25,217

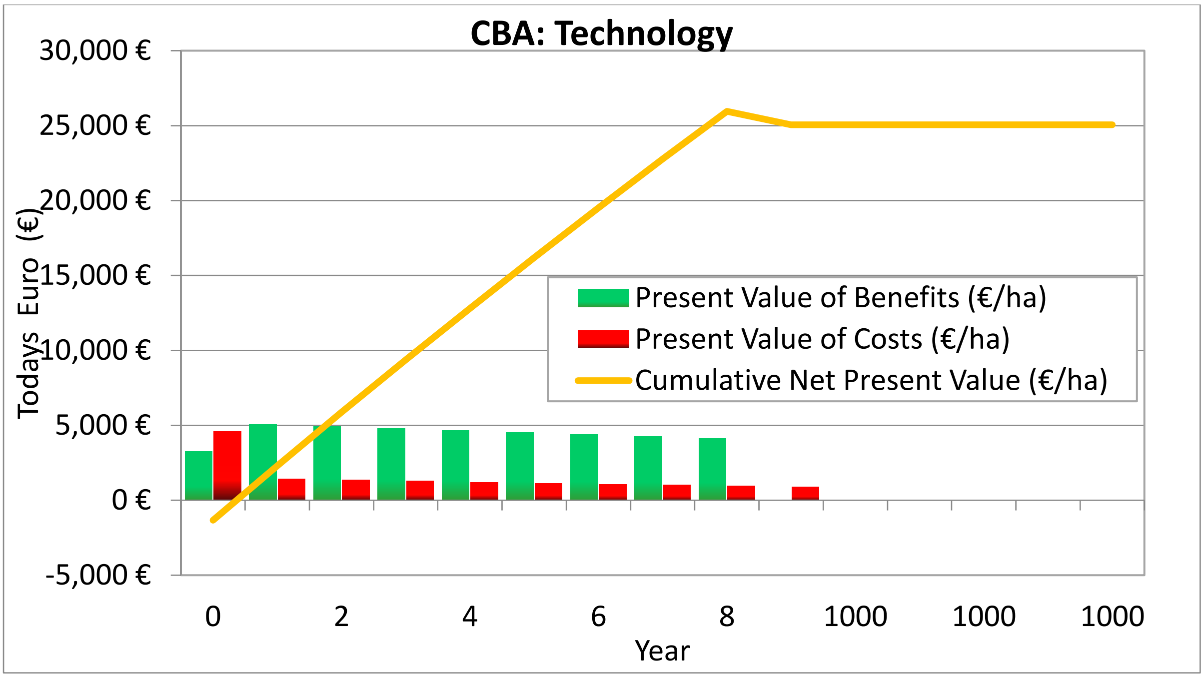
Present Value of Costs	19,465	16,346

3.7.4 Economic Performance Indicators

The Net Present Value (NPV) is €24,536/ha in the drained case, compared with €22,934/ha in the reference. The Benefit-Cost Ratio (BCR) is 2.26 for drained and 2.40 for the reference (Table 35). Although the BCR is slightly higher for the reference due to its zero-investment nature, the drained option clearly creates more absolute net value (higher NPV) and provides yield stability, making it a more secure choice for farmers.

Table 35: Economic Performance

Indicator	**Restoration action**	**Reference**
Net Present Value (€/ha)	24,536	22,934
Benefit-Cost Ratio	2.26	2.40



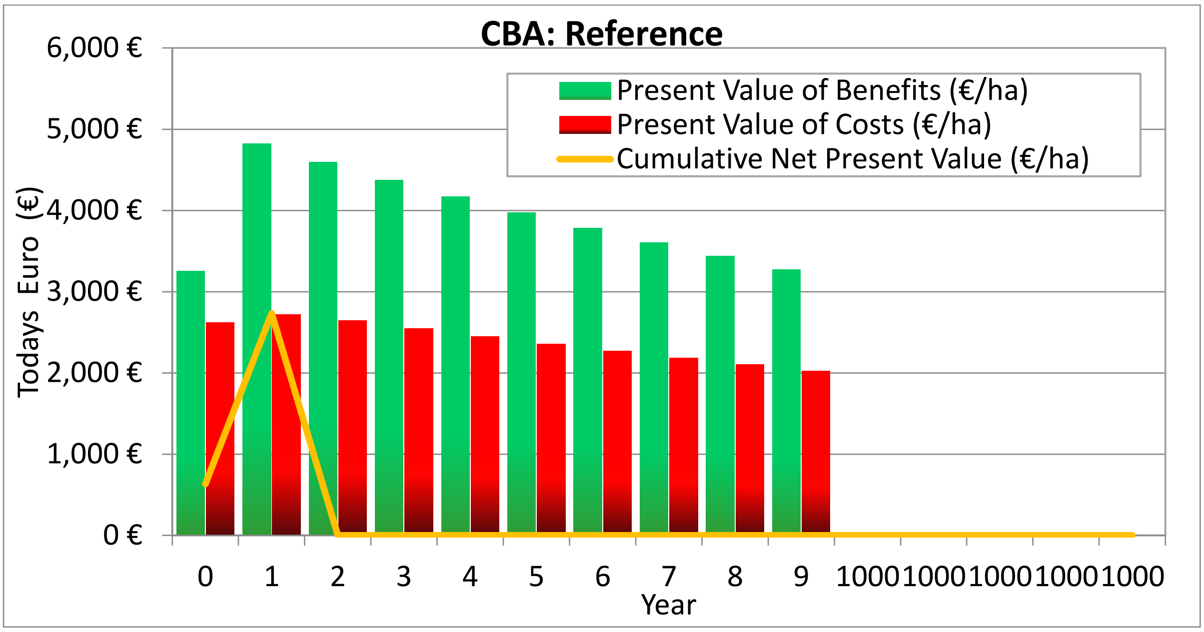


Figure 14: Present values of benefits and costs for the restoration action (top) and the reference case (bottom) over a 10 year horizon (year 0-9)

3.7.5 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

The social enquiry indicates that the implementing farmer directly benefits through higher and more stable revenues, while other farmers benefit indirectly through knowledge sharing and demonstration effects. The general public gains from reduced salinity risks and better long-term land productivity, while the government incurs monitoring and support costs.

On-site effects include increased income and better working conditions for implementing farmers, while off-site effects involve reduced secondary salinisation and improved landscape quality. The distribution of benefits and costs highlights the need for targeted public support to ensure equity, particularly for smallholders who may face barriers to financing the drainage investment.

Reflection on how costs and benefits are distributed across groups

The enquiry discussions revealed that the majority of economic benefits accrue to implementing farmers, who enjoy higher yields and more stable revenues. Other farmers benefit from knowledge spillovers, but without drainage infrastructure they cannot replicate the gains. The general public benefits from reduced environmental degradation and improved long-term agricultural productivity, but these effects are more indirect and slower to materialise. The government bears part of the costs through monitoring, regulation, and potential subsidies, but also benefits from enhanced food security and reduced need for remediation of saline soils. Overall, the distribution is uneven, with higher direct financial gains concentrated among adopting farmers.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

To balance the distribution, targeted financial support such as subsidised credit or cost-sharing schemes could help smallholders overcome the barrier of high upfront investment. Extension services and demonstration projects can enhance knowledge transfer and reduce inequality between adopters and non-adopters. Public monitoring of drainage water quality and support for collective drainage management can also ensure that off-site environmental impacts are minimised. Policies linking subsidies to environmental safeguards (e.g., safe reuse of drainage water, monitoring salinity levels) could further align private and public benefits, creating a more equitable outcome across all stakeholder groups.

3.7.6 Summary and Policy Implications

The cost–benefit analysis for the Lower Gediz pilot area shows that subsurface drainage generates higher net present value (NPV) and more stable farm income compared with undrained fields. Despite the need for an upfront investment, the drainage scenario improves long-term productivity, reduces production risks from salinity and shallow groundwater, and ensures more resilient cotton production under Mediterranean conditions.

From a financial perspective, both scenarios present benefit–cost ratios above unity, but the restoration option creates greater absolute value and reduces yield variability, offering farmers a safer long-term strategy.

From a social perspective, most direct benefits accrue to adopting farmers, while indirect gains are shared by neighbouring farmers and the general public through knowledge transfer and environmental improvements. Government institutions bear additional costs for monitoring and potential subsidies, but also benefit from improved land productivity and food security.

Policy implications include:

- Promoting subsurface drainage through targeted subsidies, cost-sharing, or low-interest credit schemes, particularly for smallholders.
- Linking financial support to environmental safeguards, such as monitoring and safe disposal/reuse of drainage effluent, to protect public goods.
- Supporting collective or cooperative drainage management structures to spread costs and benefits more equitably.
- Integrating drainage investments into broader salinity management and climate adaptation strategies at basin scale.

Overall, subsurface drainage is a financially viable and socially desirable measure, provided that policies ensure equitable access and adequate safeguards for environmental sustainability.

3.8 Tamia (EG): wheat production with subsurface drainage and organic and foliar fertilizer versus conventional wheat production

3.8.1 General Information

Tamia area is about 344.4 km^2. Agriculture is the main activity in the area. The main problems constraining sustainable agriculture and limiting agricultural production in Tamia are salinization, alkalization, calcite, low organic matter, closed drainage systems, high-water table and root zone soil salinity. The use of drainage water from agriculture fields mixed with fresh Nile water for irrigation is common in many areas in Tamia. The electrical conductivity of saturated soil extracts (ECe) ranges between 1.22 and 22.4 dS m^{-1}. About 91.5% of Tamia soils present ECe > 4 dS m^{-1}, indicating that salt-affected soils are distributed throughout the area. About 94.5% of Tamia soils is calcareous (>10% $CaCO_3$ eq), due to the nature of parent material from which these soils evolved. Soil pH of more than 8.00 was found in about 3.25% of Tamia soils, whereas soils with pH >8.5 cover 3.96% of Tamia. The organic matter contents seldom exceed 1% in Tamia soils. Soil texture is found as clay, sandy clay, sandy clay loam, sandy loam and sandy. Consequently, in a context of exploitation of areas for agriculture, there is a crucial need to assess soil health in these areas, in order to apply the proper strategies for soil conservation aiming to combat soil degradation and desertification and increase the productivity of agricultural lands. Improving soil drainage is considered one of the important tools for improving soil characteristics and soil ventilation, while of salt-tolerant crop genotypes could also improve agricultural productivity. Also, the use of salt tolerant genotypes from crops that are already cultivated in this area or the natural generation of new genotypes is considered an important tool for the Tamia pilot area.

Figure 15: Wheat production field with subsurface drainage (right) and without drainage (left)

The cost–benefit analysis (CBA) compares:
a) Wheat production with subsurface drainage, organic fertilizer and foliar application (restoration action), (right), and
b) Wheat production without drainage (reference case) (left)

3.8.2 Methodological assumptions

All monetary flows are expressed per planted hectare (€/ha) in constant 2024 euros and discounted at a discount rate of 6% over a 15-year horizon. Recurrent items are treated as mid-year cash flows, whereas lump-sum investments are discounted from the start of the year in which they occur. The investment for the restoration action was made in 2023 (Year 0). Year 0 is 2023, with data derived from a 4-ha drained field (restoration) and a 1-ha undrained field (reference).

3.8.3 Benefits

The data presented in Table 36 reveals a compelling financial case for the restoration action despite an initial parity in subsidies. While both systems receive identical annual payments (€150/ha) and no upfront investment grants, the restoration system generates substantially higher annual revenue from crop yield (€1,500/ha versus €1,125/ha), translating directly to greater annual operating profit. This consistent yearly advantage, driven by a 33% higher productivity, compounds significantly over time. The long-term metrics underscore this superiority: the Total Lifecycle Benefits are much higher for the restoration action (€24,750/ha) than for the reference (€19,125/ha). Furthermore, the Present Value of Benefits—the discounted sum of all future incomes and benefits—is markedly higher for restoration (€16,499/ha) than for the reference (€12,749/ha). This €3,650 per hectare advantage in discounted benefits demonstrates that the restoration system creates significantly greater long-term financial value.

Table 36: Annual Revenues

Variable (unit)	**Restoration action**	**Reference**
Annual revenue from crop yield (range) (€/ha)	1500	1125
Annual subsidy (€/ha)	150	150
Investment subsidy – Year 0 (€/ha)	0	0
Total Lifecycle Benefits (€/ha)	24,750	19,125
Present Value of Benefits (€/ha)	16,499	12,749

3.8.4 Costs

Annual Operating and Maintenance Costs

Planting Cost: Restoration Action (85 €/ha) compared to the Reference (85 €/ha). This cost is identical for both systems. It covers expenses for seeds, seedlings, or other planting materials required annually. **Fertilizer Cost:** Restoration Action (375 €/ha) compared to the Reference (225 €/ha). This is the largest cost difference where this cost includes organic fertilizer in addition to the normal chemical fertilizers. The Restoration Action incurs €150 per ha. This significant difference indicates the need for specialized, slow-release organic soil amendments to kickstart ecosystem recovery and higher initial nutrient requirements to establish new, non-crop vegetation to remediate degraded soils. The Reference system uses a standard synthetic fertilizer regimen at a lower cost. **Plant Protection Costs:** Restoration Action (0 €/ha) compared to the Reference (50 €/ha). This is a key environmental and economic benefit of the Restoration Action. The €50 saving indicates a complete elimination of expenditures on synthetic pesticides, herbicides, or fungicides. This implies the restoration system relies on natural pest control, biodiversity, and resilient plant communities, reducing chemical inputs and associated environmental risks. **Irrigation Cost:** Restoration Action (55 €/ha) compared to the Reference (55 €/ha). Irrigation costs are identical. This suggests water use infrastructure and volumes are similar for both scenarios in the accounting year, or that irrigation is a fixed regional cost not impacted by the land use change at this stage. **Machinery Operating Costs:** Restoration Action (150 €/ha) compared to the Reference (45 €/ha). The Restoration Action costs (€105 more). This substantial increase points to more intensive or specialized mechanical operations such as, site preparation (e.g., contouring, micro-basin creation). **Other Costs**: Restoration Action (150 €/ha) compared to the Reference

(100 €/ha). **Labour Cost**: Restoration Action (150 €/ha) compared to the Reference (150 €/ha). Labour costs are equal. This implies the total number of paid labour hours required per hectare over the year is similar for both systems, though the type of work (skilled ecological management vs. conventional farming tasks) may differ. **Land Rent**: Restoration Action (300 €/ha) compared to the Reference (300 €/ha). This is a fixed cost, representing the annual opportunity cost of using the land. Its equality confirms the comparison is for the same type and quality of land.

Table 37: Annual Operating and Maintenance Cost

Variable (€/ha)	**Restoration action**	**Reference**
Planting cost	85	85
Fertilizer cost	375	225
Plant protection costs	0	50
Irrigation cost	55	55
Machinery operating costs	150	45
Other costs	150	100
Labour cost	150	150
Land rent	300	300

Capital (Year 0) Costs

Based on the provided data, the initial investment costs for implementing the restoration action are substantial and represent a significant upfront financial barrier that the reference system does not incur. Specifically, the restoration project requires a €2,500 per ha investment for a new drainage system, an additional €500 per ha for organic fertilizer application, and €350 per ha for foliar treatments, bringing the total initial capital outlay to €3,350 per hectare.

Table 38: Initial Capital Cost

Variable (€/ha)	**Restoration action**	**Reference**
Drainage system	2500	0
Organic fertilizer	500	-
Foliar application	350	-

Total Costs

The long-term cost analysis reveals a fundamental divergence in the economic structure of the two land-use systems. While the Total Lifecycle Costs are significantly higher for the restoration action (€22,325/ha versus €15,150/ha), this metric is misleading if viewed in isolation as it already nets out benefits. The more critical insight comes from the Present Value of Costs (PVC), which sums the discounted value of all future expenses. Here, the restoration action's PVC is substantially greater at €15,999 per hectare compared to €10,999 for the reference, indicating a much larger absolute investment in operations and capital over time. This cost is primarily driven by the substantial initial investments in the drainage systems and higher annual operating costs for items such as specialized fertilizers, as previously detailed. Crucially, this higher financial commitment is justified because it enables the restoration system to generate an larger stream of benefits, as evidenced by its superior Present Value of Benefits. Therefore, the higher Present Value of Costs does not indicate inefficiency but rather reflects the necessary capital and operational intensity required to transition to and maintain a more productive and ecologically beneficial system, with the net result (Total Lifecycle Benefits/NPV) being overwhelmingly positive.

Table 39: Total Cost

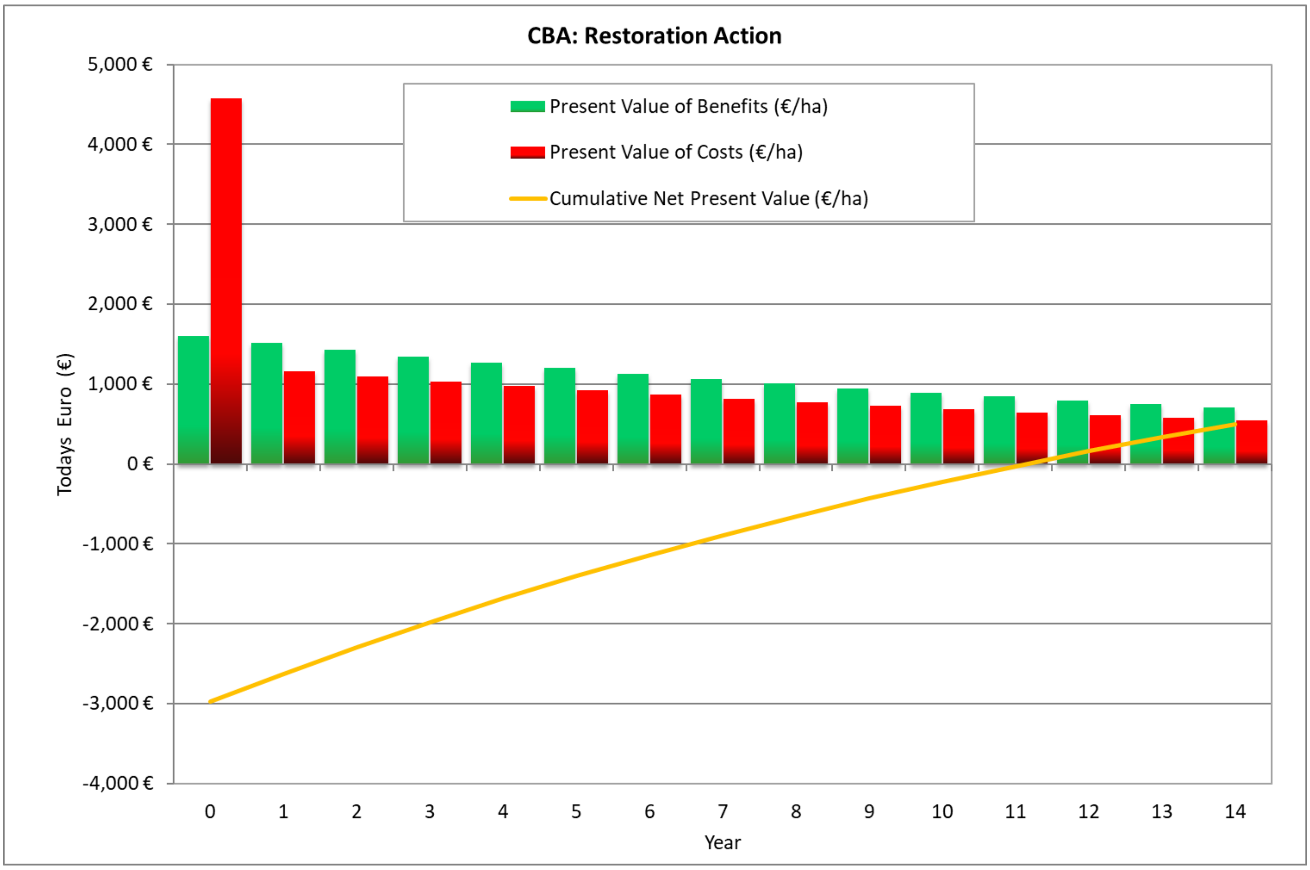
Category (€/ha)	Restoration action	Reference
Total Lifecycle Costs	22,325	15,150
Present Value of Costs	15,999	10,099

3.8.5 Economic Performance Indicators

It can be seen in Table 40 that the restoration action has a lower NPV than the reference (€500 vs €2665 per ha). The Benefit-Cost Ratios (BCR) of both systems are positive. However, the restoration action has a lower BCR (1.03 vs 1.26). This means that the restoration action returns €1.03 in benefits compared to €1.26 for the reference system. However, if half of the cost of the initial investment of the restoration action would be subsidized (€1675), the NPV would reach €2127 and approach that of the reference. Similarly, the BCR would increase to 1.13.

Table 40: Economic Performance

Indicator	Restoration action	Reference
Net Present Value (€/ha)	500	2650
Benefit-Cost Ratio	1.03	1.26



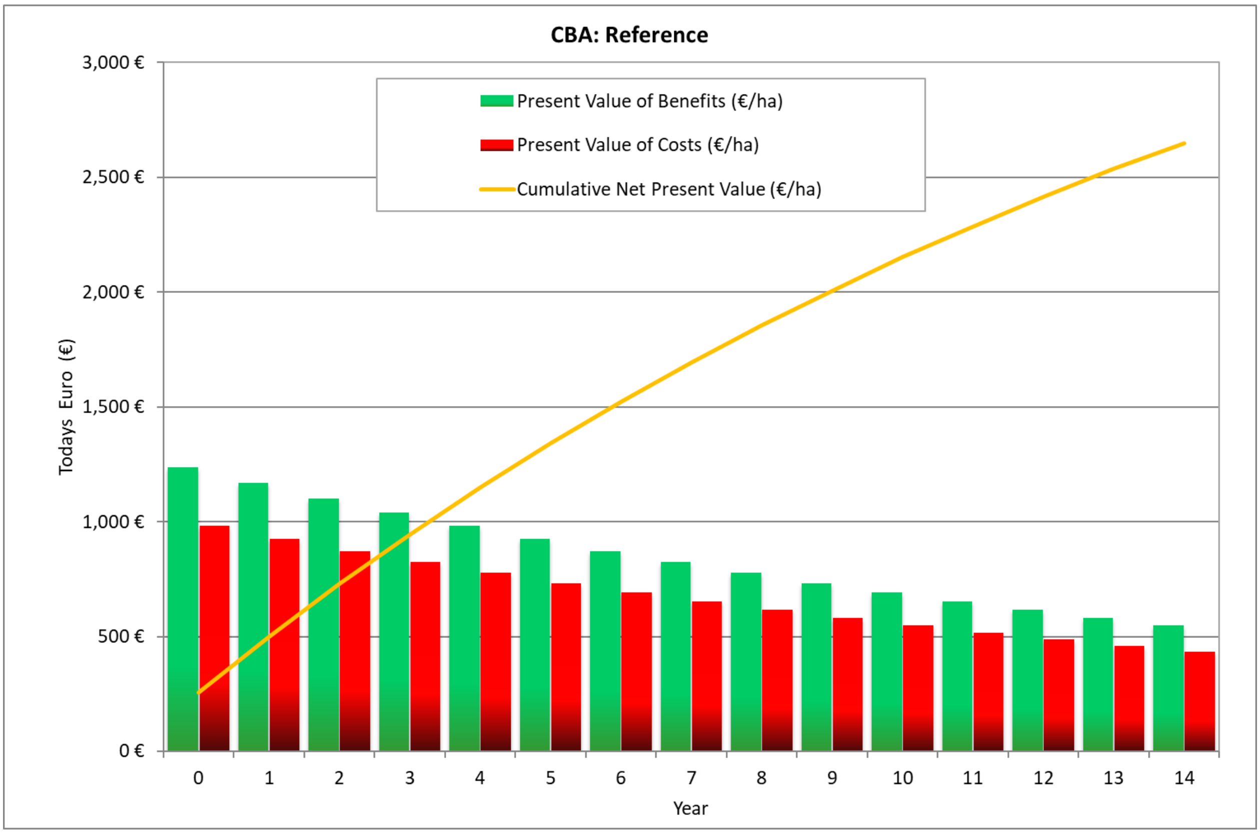


Figure 16: Present values of benefits and costs for the restoration action (top) and the reference case (bottom)

3.8.6 Social justice enquiry

Costs and Benefits of the restoration action and their distribution

The social justice enquiry focussed on the purchase of a shredding machine to support the production of organic compost. The cost and benefit mapping indicated that the implementing farmer is the direct beneficiary of on-site advantages like improved soil health, water retention, and reduced fertilizer expenses, leading to greater resilience and income potential. However, this farmer also shoulders the primary financial costs, especially the high initial investment for the shredding machine, creating a significant barrier to adoption. Other farmers benefit indirectly from knowledge sharing and a cleaner local environment but are generally not willing to share these upfront costs. The general public and government gain substantial off-site benefits such as reduced air and water pollution, carbon sequestration, and lower public health costs without bearing the investment burden. While seen as potential funders, current support from associations and government is insufficient. This mismatch where private costs prevent actions that deliver public goods underscores the critical need for targeted public or cooperative support. Grants, cost-sharing programs, and simplified subsidies are essential to ensure equity, enable farmer adoption, and secure the broader environmental and community benefits.

Reflection on how costs and benefits are distributed across groups

The social justice enquiry shows that direct financial and soil health benefits are concentrated with the implementing farmer. Other farmers gain only indirect knowledge and environmental spill overs without the means to achieve the same results. The general public and government receive substantial long-term, off-site environmental and health benefits, but these are diffuse and not linked to any cost-sharing. While seen as logical funders, government and associations currently avoid the major upfront cost, creating a critical investment gap. This uneven distribution private costs for public benefits makes the current model unsustainable and strongly justifies public or cooperative investment to enable widespread adoption.

Potential mitigation strategies to reach a more equal distribution of cost and benefits

To foster a more equitable distribution, a coordinated strategy must address the core financial, social, and market barriers. The first priority is establishing targeted financial support, such as government grants or cooperative cost-sharing schemes, to directly absorb the high initial cost of the shredding machine that currently blocks individual farmers. Parallel to this, knowledge and resource sharing must be institutionalized through farmer-led demonstration plots and community equipment pools to ensure benefits spread beyond a few adopters. Creating economic incentives is also critical; a trusted "Compost-Grown" label or certification would allow farmers to capture premium market prices for their sustainable produce. Furthermore, because the practice delivers public environmental goods, public policies should provide payments for ecosystem services, directly compensating farmers for benefits like carbon sequestration and pollution reduction that currently benefit society for free. Finally, all support mechanisms must be made accessible through simplified, low-bureaucracy application processes. Together, these measures would effectively redistribute the upfront investment burden, democratize access to the practice's advantages, and align private farm profitability with the generation of widespread community and environmental benefits, creating a fairer and more sustainable system for all stakeholders.

3.8.7 Summary and Policy Implications

The social justice enquiry for the Tamia pilot area reveals that producing organic fertilizer from crop waste offers significant agronomic and environmental benefits, including improved soil fertility, water retention, and reduced pollution. Despite the clear long-term advantages of higher resilience and lower input costs, widespread adoption is critically hindered by the high upfront investment required for the shredding machine, a cost that falls entirely on the individual farmer. While the practice generates valuable public goods—such as cleaner air, enhanced carbon sequestration, and reduced public health burdens—these off-site benefits are not financially rewarded, creating a fundamental mismatch between private costs and public gains.

From a financial perspective, the practice is viable and profitable over time due to savings on mineral fertilizers and increased soil productivity. However, the initial capital barrier makes it inaccessible without external support. From a social perspective, direct benefits are highly concentrated with the adopting farmer, while indirect benefits like knowledge spill over and a healthier local environment are shared with neighbours and the general public. Government and agricultural associations, as key potential enablers, currently avoid the crucial upfront investment, leaving a funding gap that stalls progress.

Policy implications include:

- Promoting compost production through targeted grants, cooperative cost-sharing models, or subsidized leasing programs for shredding equipment, with a focus on supporting smallholder farmers.
- Linking financial and technical support to the adoption of verified best practices, ensuring the production of high-quality compost and maximizing on-farm and environmental benefits.
- Supporting the formation of farmer cooperatives or associations to manage shared equipment, facilitate bulk input purchasing, and develop collective marketing strategies for "compost-grown" produce.
- Integrating compost production into national and regional strategies for soil health, circular economy, and climate adaptation, recognizing its role in waste reduction, carbon farming, and sustainable agriculture.

Overall, on-farm compost production is an agronomically sound and environmentally beneficial restoration measure. Its successful scaling depends on policies that ensure equitable access to initial financing and that create mechanisms to reward farmers for the public environmental services they provide, thereby aligning private incentives with public good for a more sustainable and equitable agricultural system.

4 Conclusions

The cost-benefit analysis across eight Mediterranean pilot areas demonstrates that ecological restoration practices can be economically viable investments for farmers and land managers, though performance varies substantially by context, practice type, and evaluation timeframe. All restoration scenarios analysed achieved a positive Net Present Value (NPV) and Benefit-Cost Ratios (BCR) exceeding 1, indicating robust economic returns that justify the initial capital investments and ongoing operational adjustments. The highest-performing interventions were drainage systems in Turkey (BCR 2.26), and no-till farming in Morocco (BCR 2.12), shared common characteristics: they addressed severe biophysical constraints (waterlogging, soil degradation, erosion), generated measurable productivity gains within 3-5 years, and integrated well with existing market structures for high-value products.

However, the economic analysis also revealed critical challenges that constrain widespread adoption. Upfront capital requirements create significant entry barriers, particularly for smallholder farmers who dominate many Mediterranean agricultural landscapes. Initial investments ranged from €3,350/ha for drainage and organic amendments in Egypt to over €330,000/ha for mechanized terrace construction with winery facilities in Cyprus, with most interventions requiring €25,000-95,000/ha. These capital intensity levels far exceed the financing capacity of average Mediterranean farmers without external support. Furthermore, several restoration practices showed high upfront costs while the benefits appeared only after a few years. For example, mechanized terraces needed 3-8 years before reaching full productivity, even though maintenance costs continued throughout that period.

Critically, the analysis demonstrates that restoration practices delivering the greatest environmental benefits do not always show the strongest financial performance in conventional terms. The Spanish chipped pruned branches system, despite clear soil health and pollution reduction benefits, showed lower NPV (€7,290/ha) compared to the reference burning practice (€15,205/ha), primarily due to machinery investment costs. Similarly, the Italian organic grape farming system achieved positive returns (BCR 1.18) but required a transition period with certification costs and yield adjustments. These cases illustrate that practices that generate substantial public environmental goods may require ongoing subsidies or payment-for-ecosystem-services mechanisms to compete financially with conventional alternatives.

The social justice enquiries conducted across six pilot areas (no enquiries in Israel and Morocco) revealed systematic patterns of inequity in how restoration costs and benefits are distributed among stakeholder groups. The most consistent finding across all contexts was that implementing farmers bear disproportionate financial risks while generating diffuse benefits that are captured by other farmers, the general public, and ecosystems without corresponding compensation. This misalignment between private costs and societal benefits represents a fundamental barrier to scaling restoration practices and raises serious questions about the fairness and sustainability of current policy approaches.

Equity concerns manifested most acutely along three dimensions: farm size, generational divides, and geographic accessibility. Large-scale commercial farmers consistently demonstrated greater capacity to adopt capital-intensive restoration practices, benefiting from economies of scale in equipment acquisition, better access to credit, and ability to absorb short-term income fluctuations during transition periods. In contrast, smallholder farmers, who often operate on marginal lands most in need of restoration, faced substantial barriers. In the Spanish citrus case, farmers with holdings below 5 hectares found machinery costs prohibitive, while Cypriot stakeholders noted that mechanized terrace construction was economically viable only for larger consolidated plots, effectively excluding operators of small traditional terraces at higher, less accessible elevations. The generational aspect was also important. Older farmers looked at restoration investments over a shorter time horizon, knowing they would not personally benefit from long-term gains. As a result, they tend to invest less in practices that need 10–15 years to pay off, even if these practices are highly profitable in the long run.

Environmental justice concerns emerged in multiple forms. In several cases, restoration practices reduced demand for manual labour, disproportionately affecting immigrant workers and economically vulnerable populations in Spanish agriculture. While mechanization improved working conditions and job quality for those who remained employed, it simultaneously reduced employment opportunities for the most marginalized groups. Conversely, in Cyprus and Crete, job creation during restoration implementation (construction, planting) provided temporary economic benefits to rural communities.

Stakeholder discussions across pilot areas converged on several common themes regarding equitable solutions. First, there was an almost universal recognition that subsidies alone are insufficient; they must be designed to preferentially support smaller operators, accompanied by technical assistance, and structured to reward environmental outcomes rather than simply offsetting costs. Second, cooperative and collective arrangements were identified as crucial for democratizing access to expensive equipment and spreading risk, though existing cooperative structures in Mediterranean agriculture were often weak or absent. Third, market-based mechanisms such as certification schemes, premium pricing for local products, and direct payments for ecosystem services were seen as potentially fairer than pure subsidy approaches, as they create lasting incentives aligned with environmental goals rather than dependency on government payments.